



MIGRATING TO A MORE CERTAIN FUTURE

Preparing for the imminent F-gas regulation with low pressure SF₆-free medium voltage gas insulated switchgear



The migration has already begun

The reduction of emissions from fluorinated greenhouse gases has been underway since the European Union (EU) passed its first F-gas Regulation in 2006, a move that stabilized EU F-gas emissions four years later in 2010.

The regulations were revised in 2015 and replaced with Regulation (EU) 517/2014 which sets a deadline of 2030 for cutting the region's F-gas emissions by two-thirds compared with 2014 levels. With a fixed goal in sight, the move towards less global reliance on F-gases has gathered pace in the last half a decade, and now, less than nine years from achieving the EU's mission, a third regulatory review is underway.

Initiated by the publication of a new regulation proposal, the EU has now outlined its plans to go further. It proposes that SF₆ is banned in new medium voltage electrical equipment installations in two stages.

Using SF₆ in new applications up to 24 kV would be prohibited from 2026-01-01, followed by applications up to 52 kV from 2030-01-01. The proposal notes however, that prohibiting SF₆ equipment from being placed on the market in this way, is only achievable if suitable GWP<10 solutions are available.

Consultations, stakeholder meetings and debates within the EU parliament will be held over the next 12-18 months to finalize the new regulation and pass it into law.

As we move towards the mass specification of SF₆-free MV switchgear, it is important that businesses prepare for the change. To help, the specialists at ABB Distribution Solutions have produced this whitepaper. It will explore the importance of migrating towards a more certain future, with SF₆-free MV switchgear projects, the legislation that will govern it and most importantly, how to succeed without compromising on reliability, availability, and safety of network operations.

Drawing on the success of existing pilot projects in the field, this paper offers:

- **A clear explanation of the current landscape and the expected pathway towards achieving a total global installed base of SF₆-free MV switchgear**
- **Tangible advice on how to begin specifying SF₆ switchgear, including a four-step roadmap to success**
- **An overview of market leading SF₆-free alternative switchgear to support future purchasing decisions**



Understanding fluorinated gases and the greenhouse effect

Fluorinated gases are a family of man-made gases used in essential industrial applications such as refrigeration and air-conditioning systems, fire protection, gas insulated switchgear (GIS) and semiconductor production. However, some fluorinated gases are powerful greenhouse gases that build up in the earth's atmosphere with a global warming effect that is up to 25,200 times greater than carbon dioxide (CO₂).

The restriction of fluorinated greenhouse gases

Sustained use of fluorinated greenhouse gases since their development in the late 1920s has played a major role in increasing the greenhouse effect – something that was not known until around 70 years later. Now, governments all over the world are working to restrict their use.

By restricting the use of fluorinated greenhouse gases, cumulative emissions savings in the region of 1.5 Gigatonnes of CO₂ equivalent is expected by 2030, increasing to 5 Gigatonnes by 2050.

To put this into perspective, 5 Gigatonnes of CO₂ equivalent is more than the CO₂ produced by a billion return flights from Paris to New York, and more than the sum of all greenhouse gases emitted in the EU during one year.¹

These projections cannot be ignored. The restriction of fluorinated greenhouse gases is essential to controlling the global warming effect and preserving the habitable state of the planet.

SF₆ – the most potent greenhouse gas

Sulfur hexafluoride (SF₆) is a synthetic fluorinated compound that offers unique dielectric properties, making it an extremely popular electrical insulation solution for power systems, as well as being widely used for current interruption in the transmission and distribution of electricity.

Despite its favorable characteristics, SF₆ is also the most potent greenhouse gas known to-date with research stating that over a 100-year period SF₆ is 25,200 times more harmful than CO₂. SF₆ is also a very stable chemical, with an atmospheric lifetime of 3,200 years which creates a substantial buildup of the chemical in the atmosphere even when usage is reduced.²



Understanding Regulation (EU) 517/2014 and the forthcoming changes

The impending changes to the F-gas regulation will strengthen the legislation that is already in place, so understanding the current guidance and the impact of April's EU Commission proposal will make any imminent legislative changes easier to follow. Here are some key highlights from the current F-gas regulation:

Banning the use of some fluorinated greenhouse gases in certain new equipment

Preventing emissions of fluorinated greenhouse gases from existing equipment

Regular equipment checks, maintenance and servicing were made mandatory for some existing equipment and the recovery of the gases at the end of the equipment's usable life became law. When this regulation was made mandatory in 2014, the use of SF₆ in switchgear was not limited, but a further review into the availability of alternative technologies specifically for Medium Voltage Gas Insulated Switchgear (MV GIS) started in June 2021.

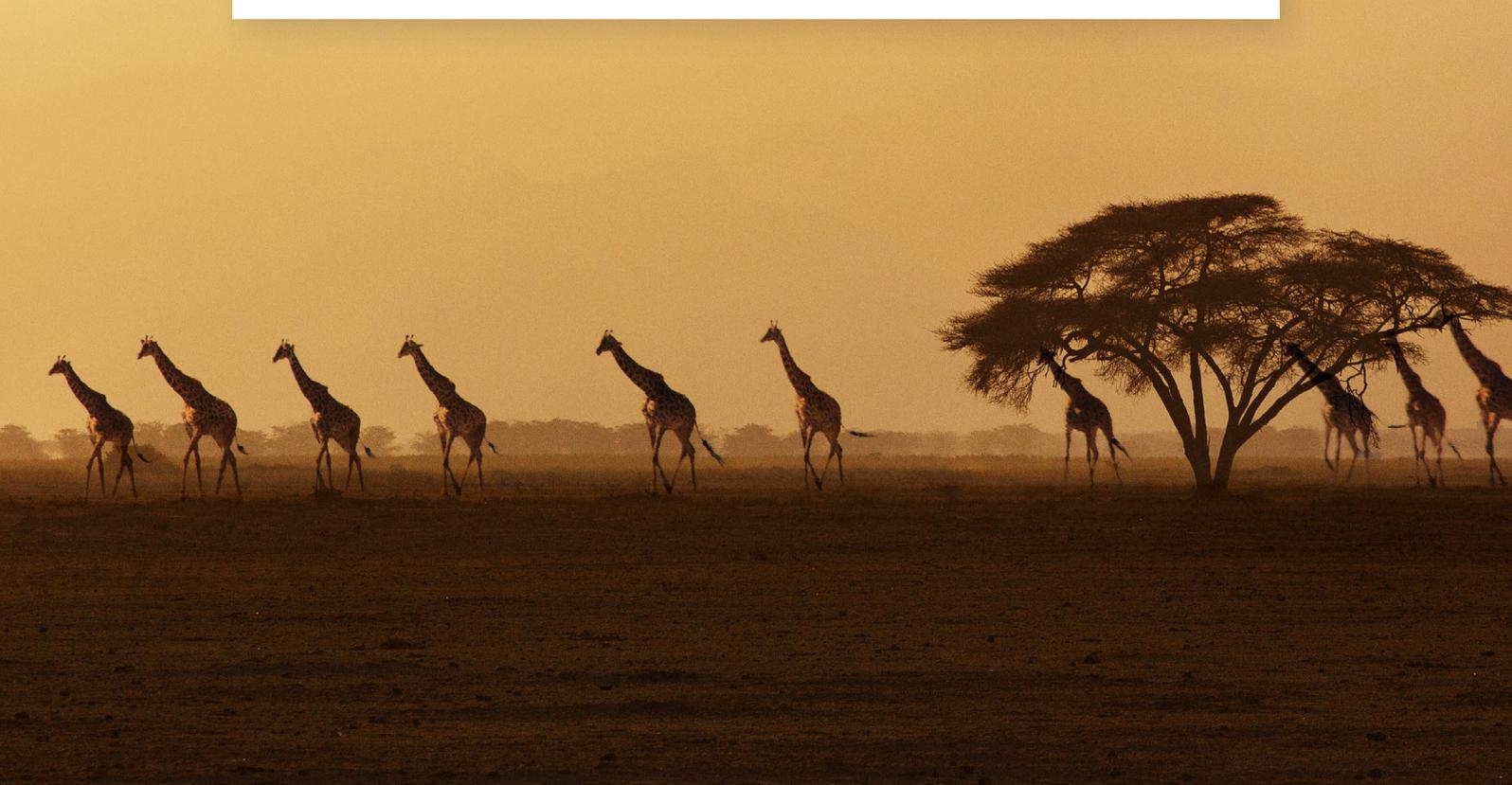


How does the F-gas regulation affect switchgear?

The current F-gas regulation stipulates careful management practices of operational SF₆ switchgear, focusing on leak prevention, record keeping and the use of certified technicians for switchgear containing over 6kg of SF₆. It does not however prohibit the use of SF₆ in high or medium-voltage switchgear and this will continue to be the case now that the commission proposal is released, despite further restrictions that will shape its use and regulate the placing on the market of new equipment.

As with any imminent change in legislation, it is vital that organizations begin to take action sooner rather than later, if suitable alternatives are available for their application, to avoid potential delays that may result in rushed installations once the changes come into force.

Read on to learn how many forward-thinking network providers and large industrial organizations all over the world have already begun their migration to SF₆-free switchgear, and how to make your journey a success.



Case study:

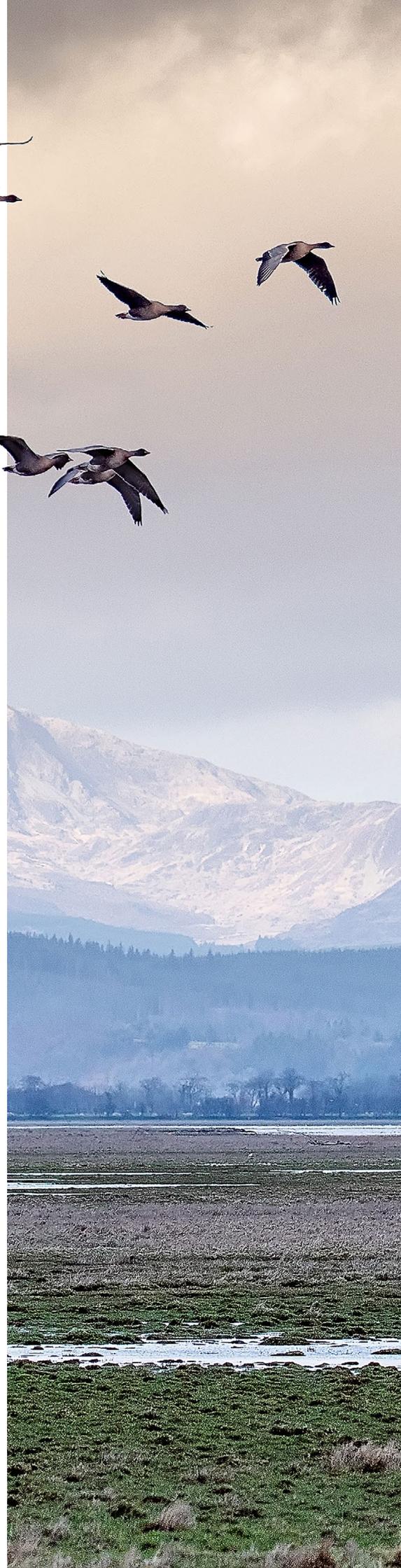
ABB and UK Power Networks switch to a sustainable future with the world's first 36 kV double busbar AirPlus™ switchgear

UK Power Networks, which provides power to 8.3 million homes and businesses, has commissioned ABB to supply the world's first 36 kV medium-voltage double busbar AirPlus Gas Insulated Switchgear (GIS). It features AirPlus gas, which acts as an insulator with almost zero global warming impact.

As part of its Environmental Action Plan to pass on a sustainable planet for future generations, the UK's biggest electricity distributor, UK Power Networks will use AirPlus, ABB's innovative sustainable alternative to SF₆ switchgear, at its substation in Kent.

As Europe moves towards tighter regulation on the traditional gas (SF₆) used in switchgear, ABB's AirPlus provides a compelling eco alternative. Unlike SF₆, which is a potent greenhouse gas with a global warming potential 25,200 times greater than that of carbon dioxide (CO₂), ABB's AirPlus gas has almost zero global warming impact. It is designed to drive high reliability and fulfill upcoming environmental regulations for segments like utilities.

Commenting on the installation, Alessandro Palin, President of ABB's Distribution Solutions division explained: "As part of our 2030 Sustainability Strategy, ABB is committed to helping customers and suppliers reduce their emissions. AirPlus is a key part of this strategy, and we are proud to work together with utilities such as UK Power Networks to make the switch to eco alternatives, that not only provide reliable power but will also protect our planet. A pioneer in this field, ABB has installed thousands of SF₆-free solutions globally. Moving from SF₆ to an SF₆-free portfolio is an important milestone towards enabling a low carbon society."



Transitioning to AirPlus will help UK Power Networks to achieve its sustainability targets, as it offers the same footprint and similar performance as an SF₆ switchgear and operates at lower-tank pressures. The higher the voltages, the higher the pressure in the switchgear, but thanks to AirPlus, ABB's switchgear can handle the pressure, having a safe low-pressure design with similar dielectric insulation benefits and footprint as an SF₆ switchgear. The double busbar design gives the additional benefit of reliability by reducing the risk of unplanned downtime and offering more flexibility in sharing the power load.

In addition to enhancing the collaboration with UK Power Networks, this contract confirms the acceptance of AirPlus technology as a reliable alternative to SF₆ for utilities in the UK.

Barry Hatton, director of asset management at UK Power Networks, said: "We have clear goals to reduce the environmental impact of our operations and help enable the country's transition to net zero carbon emissions, while maintaining reliable electricity supplies for more than eight million homes and businesses. Our new AirPlus switchgear supports our strategy and delivery of our Environmental Action Plan."

ABB was one of the first companies to offer SF₆-free switchgear solutions for MV ranges up to 40.5 kV, with the largest global installed base of over 9,000 ecoGIS™ switchgear installations since 2015.



The current migration landscape

Economic development, the drive to replace fossil fuels, urbanization, a rising global population and technological developments in electrification are all creating a sharp rise in the consumption of electricity – a figure that has continued to rise over the last half a century to approximately 23,900 terawatt hours in 2019. ³ To meet this demand, the electricity distribution network is expanding and installing new networks capable of delivering more, high quality power to both existing regions, and lesser developed areas.

With new legislation shaping the specification of SF₆ switchgear around the corner, the current migration landscape is one of two halves. There is a clear drive to switch to SF₆-free switchgear sooner rather than later, with many successful pilot projects underway, but there are also many organizations choosing not to act until legally necessary, which is a risky strategy.

It is important to note, that even once SF₆-free switchgear is mandatory for all new installations, there will be a substantial period of co-existence between newly installed SF₆-free products and the pre-existing global installed base of SF₆ GIS.

With the typical lifespan of switchgear in the region of 40 years, it is our duty to off-set the impact of the global installed base as much as possible by rolling out SF₆-free alternatives sooner rather than later.



Start planning now for a problem-free migration

It can be tempting to leave change to the last minute, but this rarely has a satisfactory outcome.

With such growth anticipated for the electricity distribution sector, and new legislation set to change the course of switchgear specification permanently, planning your migration sooner rather than later will:

- Allow your organization enough time to pilot or trial different SF₆ alternative switchgear, evaluate performance and assess cost alongside other deciding factors to prevent rushed purchasing decisions
- Enable you to build relationships with reputable manufacturers that can offer consultative expertise throughout your SF₆-free switchgear migration
- Give you enough time to plan for when SF₆ is formally banned to make sure your business and your pipeline projects are compliant
- Help you avoid delays which may result in rushed installations should you miss the deadline

Piloting is underway

Many large organizations and network providers are already trialing SF₆-free alternative switchgear on small, well controlled pilot projects that are easy to monitor for performance analysis.

By segregating a small pilot project, these organizations can trial and select the right SF₆ alternative switchgear with minimal impact on wider operations.

Here Dr. Maik Hyrenbach, Senior Principal Engineer for medium voltage gas insulated switchgear, at ABB Distribution Solutions, answers questions on several recent pilot projects:

Q: Describe the types of pilot projects you are seeing at the moment:

“We are seeing a notable increase in network providers and organizations trialling a number of different SF₆-free switchgear in well-controlled environments that are easy to analyse over the course of 12-months or more. It is commonplace to have three vendors on an approved supplier list, which is usually the aim of the pilots.”

“Currently, we are supporting customer pilots of all sizes, from a few extension panels or blocks to complete substations.”



Q: How should an organization decide which SF₆-free switchgear to pilot?

“When it comes to migrating to SF₆-free MV switchgear, there are two main alternative technologies. One is based on keeping the low-pressure design requiring a new insulation gas at voltages above 12 kV, the other uses compressed air for the complete voltage range but with significant increased pressure above 12 kV. Usually, customers embark upon a period of research and then get in touch with us to discuss their intended trial period, including the details of the pilot they want to run.”

“We offer a technical presentation of our solution and answer any questions they may have. This isn’t a formal tender process, but customers piloting our SF₆-free GIS receive consultative expertise and ongoing support – we believe this is an important part of working together as an industry to migrate towards a safer future.”

Q: How should customers evaluate the success of their product trials?

“The most important part of these product pilots is to ensure the SF₆-free alternatives perform as well as the switchgear they will be replacing. Engineers will usually conduct regular inspections throughout the pilot to identify any abnormal working conditions such as loss of pressure. Also if these pressure losses will most likely not happen in the trial phase, customers should consider the consequences if this would happen. As ABB’s low pressure design will allow safe operation in case of lost overpressure (run-flat) we see this as an important advantage of our technology.”

“There are of course other factors to consider such as cost, ease of installation, product availability and customer support.”

Q: How long after a successful pilot does specification of SF₆-free GIS begin?

“Now the legislation is drawing closer, we are seeing more organizations begin volume-specification of SF₆-free GIS, but many are still waiting for the legislation deadlines to be agreed.”

“Working with the most experienced supplier and imbedding your volume specification of SF₆-free GIS ahead once your pilot is complete will put you in a better position to comply with the regulatory changes once they do come into effect.”



How to begin your migration

Beginning your migration towards a more certain SF₆-free future does not have to be complicated. There are four simple steps to follow:

Step 1 ———— Taking time to learn about the change that is happening and the solutions that are available within the market to help you succeed is an important starting point. Educating yourself using reliable sources on the new legislation and access information from leading manufacturers on their SF₆-free switchgear.

Education

Webinars, consultations, presentations and literature are all positive ways to broaden your understanding on the topic.

Step 2 ———— Piloting alternative switchgear is an important part of such a considerable specification change. By affording yourself enough time to complete pilots and subsequent performance analysis without the time pressures of looming regulatory deadlines, will enable more thorough investigations and prevent the need to make rushed decisions.

Piloting

This is not a stage that can be missed, so starting pilots now will mean there is plenty of time to roll out specification changes before the EU deadlines.

Be sure to work with manufacturers that offer consultative expertise during an active pilot. They should support you in interpreting performance results and ask for feedback of your experience.

Step 3 ———— Make changes to your specification processes, by discussing your needs with your chosen manufacturing partners. In some instances, they may be able to drive time efficiencies by fulfilling your specification needs before the latest GIS technologies have reached the open market. This could be in line with key dates outlined in the new commission proposal. Be sure to communicate the changes throughout your team and ask your chosen vendors to present their solutions to your specifiers if required.

Specification

Step 4 ———— Begin volume installation for all new projects and replacement of installed base. Aim to reach this step in line with EU legislation by working closely with manufacturing partners that can meet your ongoing volume installation requirement.

Volume installation

Introducing ecoGIS™ from ABB

ABB's MV ecoGIS switchgear uses AirPlus technology as alternative insulation gas to SF₆, without compromising performance, safety, or reliability. AirPlus retains the low-pressure design at voltages above 12 kV with the advantage to offer operational safety even in case of gas leakages with increased reliability and no risk of non-planned outages.

Retaining the compact footprint of an SF₆ switchgear, AirPlus has a GWP of ≤0.29, compared to the GWP of SF₆ which is 25,200.

Technology benefits:

Sustainable

- Vastly reduced global warming potential

Reliable

- Dielectric properties similar to SF₆
- Uses the same compact product platform
- Common solution for primary and secondary switchgear
- Same or similar footprint

Available

- Solutions for the whole MV range (up to 40.5kV)
- Low pressure in the gas compartment
- Maintenance-free
- No additional operations or training required

Safety

- Low pressure design to meet strict boundary conditions above 12kV



Why choose AirPlus for MV GIS above 12 kV?

Our portfolio is the first in the world to offer options up to 40.5 kV.



	SF ₆	Dry Air	AirPlus
Global warming potential (GWP)	25,200	0	≤0.29
Lifetime in atmosphere	3,200 years	n/a	≤16 days
Harmful to climate	Yes	No	No
Affected by political regulations	Yes	No	No
Hazard to operators	No	No	No
Maintenance free	Yes	Yes	Yes
Relative gas pressure	≤0.4 bar	12kV, ≤0.4 bar 24kV, ≥0.9 bar 36kV, ≥ 1.8 bar	≤0.4 bar
Reliability	High	12kV - High 24kV & 36kV *	High - thanks to run-flat technology

* In case of abnormal leaks leading to total loss of over-pressure, the dielectric performance is significantly reduced, risking an internal arc failure if not de-energized.

AirPlus – an independently verified solution

Our AirPlus solutions use 3M™ NOVEC™ Insulating Gas which, like all new chemicals has been brought to market compliant with chemical laws and in line with the correct regulatory requirements.

Whilst different regions may take different approaches to certifying new chemicals, the standards they test against are based on the same objectives – to avoid unreasonable risk to human health and the environment.

The tests and standards required will be dependent on the composition of each new chemical but could include environmental- and toxicity tests or physio-chemical tests like skin and eye irritation, acute toxicity, mutagenic testing, and carcinogenic testing.

The tests are pre-defined and agreed as part of the registration process and a chemical cannot be sold unless it is fully registered for each intended market. Often, the tests also depend on the volume of chemical being manufactured or imported into each geographical market and consider the collective body of knowledge generated from testing at lower volume bands.

All chemical testing is conducted by independent third-party laboratories following agreed test protocols according to the Organization for Economic Cooperation and Development (OECD).

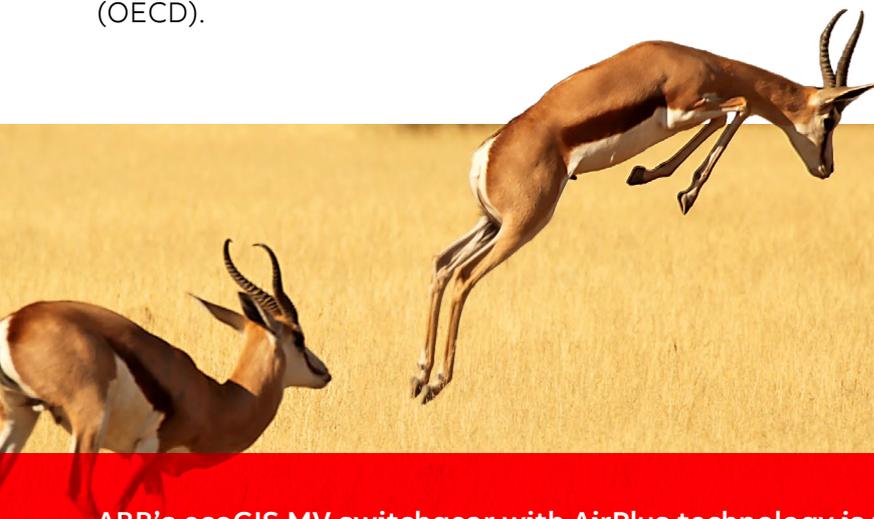
Testing NOVEC Insulating Gases

NOVEC Insulating Gases in particular, have been characterized as non-mutagenic with low acute inhalation toxicity and low repeat-dose inhalation toxicity, through a range of toxicological tests in compliance with REACH for Europe and equivalent bodies around the world.

The 3M medical department also uses all available data to calculate the Occupational Exposure Limits (OEL). OELs are airborne concentrations of chemical to which an employee can be exposed in an occupational lifetime without experiencing adverse health effects. It was concluded that NOVEC Insulating Gases are safe for well over what would be considered an occupational lifetime of exposure.

AirPlus testing and safety

As a secondary layer of safety testing, ABB has conducted its own substantial performance analysis across a number of pilot projects to ensure the performance and safety of its 'sealed for life' AirPlus GIS. These evaluations included rigorous testing and analysis to confirm no performance issues and no deterioration of the gas or the material of the panel.



ABB's ecoGIS MV switchgear with AirPlus technology is the most established SF₆-free switchgear on the market and is volume-manufactured to meet mass installation requirements. ABB has delivered its proven ecoGIS technologies around the world, with more than 9,000 ecoGIS units sold – a substantial number of which are already successfully installed and in operation. This level of experience is unrivalled in the field of SF₆-free alternative technologies for MV switchgear. ABB is the most experienced solutions provider in the market, and the partner of choice for many decision makers in the utilities, data center, and industrial markets.

Case study:

Enel to provide reliable and sustainable electricity across Italy and Spain with world's first 24kV SF₆-free ring main units

Enel Global Infrastructure & Networks will reduce greenhouse gas emissions and provide reliable and sustainable power across its networks in Italy and Spain thanks to the installation of ABB's innovative SF₆-free Ring Main Units (RMUs), specifically designed for Enel's requirements.

The project represents an important step towards delivering increasingly sustainable power grids, as ABB's low pressure 24kV solution has the same footprint, safety and reliability as traditional SF₆ solutions. The pilot installation involves 20 new ABB SafePlus AirPlus Medium Voltage (MV) RMUs in Enel's secondary substations across Italy and Spain and will contribute to minimize their global warming potential, while making switchgear operation and maintenance safer for personnel.

Gas insulated switchgear, widely used in MV secondary substations, conventionally contain SF₆ – which has excellent dielectric and arc extinguishing properties, but at the same time is the world's most potent greenhouse gas, with a global warming potential 25,200 times that of CO₂.





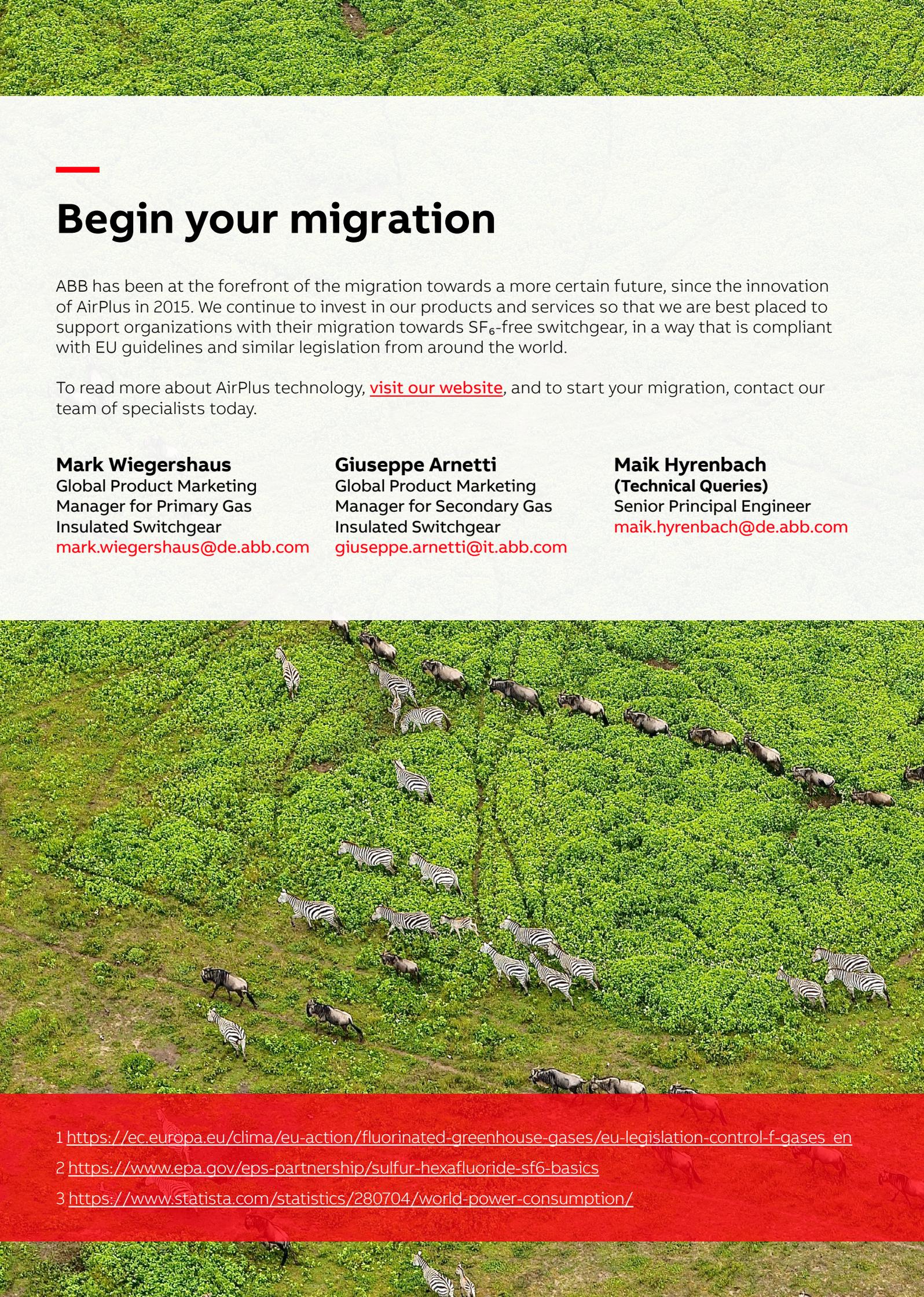
The new SafePlus AirPlus, part of ABB's ecoGIS family of products, features innovative Load Break Switches (LBS) optimized for SF₆-alternative gases. Unlike traditional alternatives, the switch is based on puffer interrupter technology and functions as both a load break and disconnect switch for maximum safety. ABB's SafePlus AirPlus low-pressure design with its 1.4 bar limit, reduces the risk of leaks or explosions and makes it very safe to operate, even in the case of abnormal gas leakages where high pressure alternatives would need to be switched off immediately. Therefore, in the unlikely event of a leakage, ABB's low-pressure design based on AirPlus as an eco-friendly SF₆ alternative, ensures highest availability and reliability of the network.

Alessandro Palin, Division President of ABB Distribution Solutions, comments: "The installation of the world's first SF₆-free SafePlus AirPlus Ring Main Units is another example of ABB working in partnership with customers to create sustainable solutions that are better for our planet and our society. With ongoing political discussions about a complete ban of SF₆ in new installations, including the EU's latest

proposal, this proves that migrating to a more certain future with SF₆-free alternatives, which practically offer the same known and proven benefits, is possible, and possible now."

"To reach our Net-Zero goals, sustainability must be at the core of our present and future business. For this reason, at Enel we started integrating new principles in all our processes, including sustainable specifications together with technical and economical parameters already in place", added Francesco Amadei, Head of Engineering & Construction, Enel Global Infrastructure and Networks for Enel. "The collaboration with innovative partners such as ABB is key to accelerate the delivery of sustainable grids worldwide, a challenging path that must include all components and assets of the value chain. Innovative solutions like ABB's SF₆-free technology will help us to minimize our global warming impact and support our commitment to the 13th SDG goal – Climate Action. They will also help to make our networks more and more safe and reliable, ensuring continuity and quality of the electricity supply to our customers."





Begin your migration

ABB has been at the forefront of the migration towards a more certain future, since the innovation of AirPlus in 2015. We continue to invest in our products and services so that we are best placed to support organizations with their migration towards SF₆-free switchgear, in a way that is compliant with EU guidelines and similar legislation from around the world.

To read more about AirPlus technology, [visit our website](#), and to start your migration, contact our team of specialists today.

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1 https://ec.europa.eu/clima/eu-action/fluorinated-greenhouse-gases/eu-legislation-control-f-gases_en

2 <https://www.epa.gov/eps-partnership/sulfur-hexafluoride-sf6-basics>

3 <https://www.statista.com/statistics/280704/world-power-consumption/>