# Revision of the F-gas Regulation

Eurelectric, E.DSO & Geode position paper

May 2021

Eurelectric represents the interests of the electricity industry in Europe. Our work covers all major issues affecting our sector. Our members represent the electricity industry in over 30 European countries.

We cover the entire industry from electricity generation and markets to distribution networks and customer issues. We also have affiliates active on several other continents and business associates from a wide variety of sectors with a direct interest in the electricity industry.

## We stand for

The vision of the European power sector is to enable and sustain:
- A vibrant competitive European economy, reliably powered by clean, carbon-neutral energy
- A smart, energy efficient and truly sustainable society for all citizens of Europe

We are committed to lead a cost-effective energy transition by:

**investing** in clean power generation and transition-enabling solutions, to reduce emissions and actively pursue efforts to become carbon-neutral well before mid-century, taking into account different starting points and commercial availability of key transition technologies;

**transforming** the energy system to make it more responsive, resilient and efficient. This includes increased use of renewable energy, digitalisation, demand side response and reinforcement of grids so they can function as platforms and enablers for customers, cities and communities;

**accelerating** the energy transition in other economic sectors by offering competitive electricity as a transformation tool for transport, heating and industry;

**embedding** sustainability in all parts of our value chain and take measures to support the transformation of existing assets towards a zero carbon society;

**innovating** to discover the cutting-edge business models and develop the breakthrough technologies that are indispensable to allow our industry to lead this transition.

Dépôt légal: D/2021/12.105/24

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# Position paper on the revision of the F-gas Regulation

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## KEY MESSAGES

- Eurelectric and the co-signing DSO associations E.DSO and Geode are supportive of the EU commitment to reduce global greenhouse gas emissions towards the achievement of climate neutrality in 2050, as part of the European Green Deal objectives. Distribution system operators (DSOs) and generators are willing to commit further efforts to reduce emissions of fluorinated greenhouse gases (F-gases), and in particular $SF_6$, as far as possible through the adoption of $SF_6$-free switchgear equipment. In this context, we welcome the review of the Regulation (EU) No 517/2014 (hereinafter referred to as the F-gas Regulation).

- End-users, such as DSOs and generators have already voluntarily committed to using $SF_6$-free alternatives provided they meet the criteria laid out in Article 21.4 of the F-gas Regulation[1] and strict safety requirements from toxicological and environmental perspectives.[2]

- In the following position paper, Eurelectric, E.DSO and Geode urge the European Commission to take the following considerations into account when revising the F-gas Regulation:

  - $SF_6$-free alternatives have already been deployed both in standard applications (particularly at 12kV, and more recently in smaller quantities up to 24kV), as well as in pilot projects at higher voltages (predominantly up to 36kV).

  - Thus, reflecting the will of DSOs and generators to voluntarily move to more sustainable solutions when technically feasible. However, **commercial availability of $SF_6$-free products for voltage levels above and including 24 kV,** with the same or at least comparable operational suitability and reliability requirements of $SF_6$ solutions, **is still limited and predominantly installed in pilot projects.** Furthermore, the definition of MV used by the European Commission in its preliminary findings of the evaluation and impact assessment extending up to 52kV, is too broad and should be clearly aligned with classifications of commercially available switchgears (as in other EU legislation such as the EcoDesign Directive for Transformers).

  - DSOs and generators must guarantee the security of electricity supply at all times. To achieve this, **all technical grid equipment**, including switchgears and circuit breakers, **must meet strong**

[1] Article 21.4 requires that alternatives to SF6 Switchgear would be '*available, cost effective, technically feasible, energy efficient and reliable'*. Eurelectric's joint paper with E.DSO, GEODE and CEDEC assessed these factors in further detail.

[2] Compliance with the REACH Directive (EC 1907/2006) is a necessary condition, but not necessarily sufficient in itself to address the risks of using substances which may have toxicological effects if released. An evaluation of the REACH registered, $SF_6$-free substance in different operational environments must also be carried out to ensure that in the intended use any associated hazards and failures can be mitigated to an acceptable level. Any substitute $SF_6$ gas must be sufficiently acceptable on an environmental basis to not require replacement in its lifetime (i.e. 40+ years) and considering the operational environments of switchgears (especially at MV) are often situated on customer premises or on public streets, the impact of any escape of non-SF6 gas shall have no worse impact than a similar escape of $SF_6$ gas.

**reliability criteria** throughout their entire life cycle. Thus, any future $SF_6$-free solution must be proven to be as reliable, cost-effective, and safe as currently deployed $SF_6$ technology.

- Considering the long-expected lifetime (in excess of 40 years) of electrical switchgears, alternative products must fulfil the same or at least **comparable operational suitability requirements** as current $SF_6$ solutions. $SF_6$-free products must be qualified in their proposed usage, both toxicologically and environmentally, to avoid any supply disruptions, replacement programmes before lifetime expiration, or severe environmental damage.

- End-users, such as DSOs and generators, are ready to support the introduction and deployment of $SF_6$-free technologies. Nevertheless, **significant market availability of reliable and suitable $SF_6$ alternatives remains a condition to be developed before integrating these into industrial practices.** In this context, the revision of the F-gas regulation should aim at supporting, by clear policy measures, alternatives to $SF_6$ for new switchgear which have a low global warming potential. This would support a stepwise phasedown of $SF_6$ use in electrical switchgear and related equipment, with a corresponding substitution with $SF_6$-free alternative solutions.[3]

- Considering the above, Eurelectric, E.DSO and Geode have elaborated a set of short-term implementable recommendations to achieve significant $SF_6$ emission reductions within the framework of a revised F-gas Regulation:

  - **Foster R&D and experimentation between transmission and distribution (T&D) equipment manufacturers and end-users:** pilot projects and medium scale adoption schemes enable both parties to gain further experience, to identify common needs and requirements, and promote the exchange of best practices crucial for the integration of newly developed technologies. In this context, experimentation activities will also strive to produce new switchgears with additional benefits compared to $SF_6$ technologies (for instance more compact dimensions [4], and featuring smart connectivity), thus enabling adaptation to defray any extra costs and accelerate deployment of $SF_6$ alternatives.

  - **Monitoring leakage rates and end-of-life management practices**: further progress can be achieved in deep leakage detection by focusing efforts on non-sealed $SF_6$ equipment. Ensuring normative and effective compliance with end-of-life management processes when decommissioning $SF_6$-materials would significantly reduce greenhouse gas emissions and the manufacturing of new $SF_6$.

  - **Allow adequate transition timelines differentiated by voltage levels, local technical constraints, and special applications:** the revision of the F-gas Regulation should acknowledge that further experience needs to be gained concerning the integration of newly developed technologies into the electrical grid. Given the current limited availability of suitable and reliable alternatives to $SF_6$ switchgear, the European Commission shall also take into consideration particular requirements arising from applications on different voltage levels, environments, and conditions.

  - **Continue to promote the use of reclaimed $SF_6$**: when $SF_6$-free alternative solutions are not available, the use of reclaimed $SF_6$ is already a feature of most manufacturing processes and should continue to be promoted. As described in Article 2 of the F-Gas Regulation, reclaimed $SF_6$ should exhibit equivalent performance, while effectively reducing greenhouse gas emissions and the

[3] While recognising the variety of existing technical and associated requirements

[4] As a practical example, the use of resin insulated switchgear with vacuum interrupters for 6.6kV Substations in Tokyo (Japan) has allowed the development of very small 200kVA MV/LV substations which are small enough to be installed on sidewalks. Such developments have their own commercial advantages which would drive their use, with the use of such non-$SF_6$ switchgear being justified by the economic benefits from smaller size, with the use of non-$SF_6$ then simply being a free by-product of the decision.

manufacturing of new $SF_6$. Where there is any lack of clarity on what an 'overall acceptable composition' may require, Eurelectric and individual utilities are open to clarifying discussions with manufacturers.

- Eurelectric believes that such measures, which either replace $SF_6$, increase its reuse or reduce the quantities used, will be key to facilitating a successful development and large-scale deployment of $SF_6$-free solutions. They will support DSOs and generators in achieving the decarbonisation of the European power sector by 2045, while ensuring a safe, reliable, and secure supply of electricity to communities and businesses throughout Europe.

# Position paper on the revision of the F-gas Regulation

## Introduction

Eurelectric, E.DSO and Geode are supportive of the EU commitment to reduce global greenhouse gas emissions in line with the achievement of climate neutrality by 2050, as part of the European Green Deal objectives. DSOs and generators are willing to commit further efforts to reduce emissions of fluorinated greenhouse gases (F-gases), and in particular $SF_6$, as far as possible. In this context, **we welcome the review of (EU) Regulation 517/2014** (hereafter F-gas regulation). The F-gas regulation has had a very positive impact with respect to its objectives, clearly demonstrating the need to have a strong regulation in this field.

**The revision of the F-gas regulation should aim at supporting, by clear policy measures, alternatives to $SF_6$ which have a low global warming potential (GWP)** to induce a stepwise phasedown of $SF_6$–use in electrical switchgear and related equipment, with a corresponding substitution of non-$SF_6$ equipment. In this position paper, Eurelectric highlights the underlying conditions and enabling factors required by the European power industry to operate **suitable and reliable** $SF_6$-free technical grid equipment and to further develop their market maturity. The following will be key to enabling the successful development and large-scale deployment of $SF_6$-free alternative solutions by end-users such as DSOs and generators. Furthermore, these considerations would ensure a safe, reliable, and secure power supply to citizens and communities throughout Europe, while enabling the achievement of a decarbonised the power sector by 2045.

This position paper builds upon the following previous publications:

- Common feedback by CEDEC, E.DSO, Eurelectric and GEODE on the report from the European Commission assessing the availability of alternatives to fluorinated greenhouse gases in switchgear and related equipment, including medium-voltage secondary switchgear

- Eurelectric's response to the European Commission's Open Public Consultation on the revision of the F-gas regulation

- Eurelectric's feedback to the European Commission's Fluorinated greenhouse gases – review of EU rules (2015-20) Initiative

## Current situation and availability of alternative solutions

### The present importance of $SF_6$ switchgear in the daily operation of the European electricity system

Because of its excellent dielectric, arc quenching, heat transfer and chemical recombination properties, $SF_6$ is essential for transmission and distribution (T&D) equipment such as switchgears and circuit breakers. In the power industry, $SF_6$ is utilised in sealed Medium-Voltage (MV) and closed High-Voltage (HV) pressure systems banked in switchgears and circuit breakers. Since the deployment of $SF_6$ technologies, the size of switchgears has been significantly reduced, enabling safe and reliable power supply at HV levels closer to consumers and large metropolitan areas. Overall, technical grid equipment containing $SF_6$ provides the following technical advantages:

- High chemical stability and non-flammable properties
- High reliability and long lifetime of the equipment
  The high compactness and reduced equipment size results in significant land and material savings through the reduced dimensions of switchgear rooms
- Sealed designs of MV switchgears minimise leakage rates while ensuring high personnel safety
- Closed design of HV switchgears includes sophisticated leakage detections systems monitored by utilities so that any leakages can be detected, reported and fixed
- No maintenance requirements for MV switchgears (i.e. no periodical $SF_6$ replacement) and low maintenance requirements for HV switchgears
- Special switching capabilities available for generator breakers

For all these reasons, $SF_6$ products are widely used by DSOs and generators throughout Europe in the daily operation of the electricity system. To provide some perspective, as an example of a typical EU based utility, the French DSO Enedis alone owns and operates more than 300.000 gas insulated MV secondary switchgears and 57.000 primary MV circuit breakers.

### DSOs and generators operate the SF6 equipment in a very responsible way

In the last decades, awareness about the environmental impact of F-gases has grown substantially. Accordingly, DSOs and generators have been fully committed to ensuring that equipment containing F-gases (including $SF_6$) is correctly maintained and repaired through preventive maintenance programs. Furthermore, DSOs and generators are determined to gain further experience in responsibly operating $SF_6$ equipment through the adoption of end-of-life recycling and strict leakage monitoring schemes. In this regard, the implementation of the F-gas Regulation has proven to be very effective.

As a matter of fact, the level of $SF_6$ emission of the electric sector is very low. For instance: in France Enedis' yearly $SF_6$ leakage rate is well below 1 tonne, representing less than 0,005% of the whole country's $CO_2$ equivalent emissions. Similarly, in Portugal, E-REDES' yearly $SF_6$ leakage rate is well below 0,2 tonne, representing less than 0,008% of the whole country's $CO_2$ equivalent emissions.

Nevertheless, further progress can and should be achieved by DSOs and generators which are ready to step forward and support the introduction and deployment of climate-neutral alternative technologies to $SF_6$.

**Network operators are already voluntarily moving to more sustainable solutions**

Piloting and testing of alternative $SF_6$-free equipment in electricity grids and installations are already performed today by DSOs and generators in close cooperation with T&D equipment manufacturers. These testing and piloting phases are very important for all stakeholders as they allow further experience to be gained with alternative technologies and to continuously improve products, thus expanding the development of $SF_6$-free technologies in other (i.e. higher) voltage levels.

Cooperation is beneficial to both, DSOs and manufacturers, as illustrated by the following examples provided by Eurelectric members, it speeds up the development and deployment of alternative solutions paving the way towards decarbonization as committed in the EU Green Deal.

- Enedis, which operates in approximately 95% of French territory, is committed to carrying out experimentation works on $SF_6$-free alternative solutions. These works allow the qualification of alternative solutions to $SF_6$, such as air insulated switchgears (AIS) for higher voltage[5] primary substations with vacuum interruption. Starting in 2021, Enedis will no longer install new electrical 24 kV switchboards with $SF_6$ in its primary substations.

- E-REDES, the main Portuguese DSO, seeks to give priority to a selection of equipment that does not contain F-gases or any other substance dangerous to the environment wherever possible. In the coming months, a new type of $SF_6$-free MV switchgears with vacuum switching and solid insulation media (up to 24kV) will be tested in the framework of the NextStep (Next Distribution SubsTation ImprovEd Platform) project. This product type-test received grants from the COMPETE program, within the national 'Portugal 2020 framework' supported by the European Union and will serve as the test bed for E-REDES' first $SF_6$-free MV Secondary Substation Switchgear integrated with IoT (Diagnosis of Insulation Condition and Medium Voltage Condition). Since 2009, E-REDES implemented, an Environmental Management System (EMS) certified by the ortuguese Standard NP EN ISO 14001, which since 2015 has been extended to all activities and processes.

- ENEL is the world's leading privately owned international operator of electricity distribution grids. With more than 2.2 million kilometres of power grids in 8 different countries between Europe and Latam, and over 44 million smart meters installed on its networks, it provides accessible, efficient and reliable grid connection for the benefit of more than 74 million end users worldwide. The company is currently trialling, mainly in Spain and Italy, SF6-free equipment on both MV (up to 24KV) and HV levels (up to 145KV). In this sense, several initiatives are conducted aimed to engage the switchgear market and manufacturers to take off properly according to needs and manufacturers to take off properly according to needs and requirements. Since 2021, within the purchasing and procurement process for MV switchboards and HV circuit breakers, Enel is reserving "lots" of SF6 free equipment. Therefore, thousands of $SF_6$ free units supplied by four different EU manufacturers are expected to be put in service and trialled in Italy in the next 3 coming years, as a result of a dedicated lot of 17 M€ in a MV RMU tender. Furthermore, during 2019/2020, thanks to an open innovation approach, Enel has already involved two of the main suppliers of MV and HV equipment in developing SF6-free projects in compliance with current Enel's technical requirements. Conducting the installation in Italy and Spain of **20** MV RMU at 24 kV with alternative gas insulation, and **5** HV

[5] Use of vacuum circuit breakers up to 12kV is well established for many years, although such units may also use a surround of $SF_6$ gas to achieve required BIL levels. However, at higher voltage levels (typically used in primary MV substations, e.g. 33kV) the use of vacuum circuit breakers is less common, and at even MV higher levels (such as 52 kV, inaccurately defined as MV by the European Commission in its preliminary findings of the evaluation and impact assessment), the effects are virtually unknown.

circuit breakers at 145kV with dry air insulation in Spain. Moreover, existing SF6 free technologies have been assessed in relation to functionality, reliability, safety, sustainability and integration such has HV and MV vacuum interruption, dry air and alternative gas dielectric insulation and arc quenching. The main goal of this open approach is to promote the field experimentation, upgrades and development, and best practice sharing related to switchgear equipment according to the Group needs. This will ensure to keep moving forward towards the scalability and widespread deployment into the grids. On the other hand, Enel is introducing mandatory requirements to foster the reuse of recycled SF6 in new equipment, following circular economy principles. Furthermore, strict requirements within the procurement tenders are established for gas reclaiming during the end-of-life disposal process.

- E.ON grid operators are currently running different pilot projects at MV and HV levels using dry air and vacuum for insulation and breaking respectively. For instance, at MV level, a complete primary substation has been installed with 'AirPlus' technology and an existing primary substation has been enlarged with two dry air insulated switch panels (both operating at 24 kV). Whereas, on higher voltage levels (i.e. at 110 kV), **two** SF6-free switch panels have been installed with a 145 kV dry insulation with a vacuum circuit breaker respectively, complemented by dry air instrument transformer sets enabling remote online performance monitoring.

- I-DE (the network business company of the Iberdrola Group in Spain) is currently testing SF6-free equipment at MV (on secondary substations at 24 kV) and HV (on primary substations at 132 kV) in collaboration with different manufacturers with the purpose of developing and reaching market maturity for these products. MV trials use dry air requiring vacuum for breaking, while HV trials use an alternative fluorine gas. Available SF6-free technologies are currently being analysed, but up to now none of them have been found ready for a successful implementation on the network. On the other hand, I-DE has been committed to the verified end-of-life management of SF6 switchgear since the mid-90s, providing recycled SF6 that is used for maintenance. Recycled SF6 is a useful tool to manage the transition to future technologies as they are being developed.

**Requirements for the introduction and deployment of SF6-free alternatives**

Despite the rapid development and recent progress, $SF_6$ alternative technologies are still limited with regard to the following aspects:

- **Reliability**: DSOs and generators must guarantee the security of electricity supply at all times. Achieving this, requires all technical grid equipment including switchgears to meet strong reliability criteria throughout their entire life cycle. Thus, any future $SF_6$-free technical solution must be proven to be as reliable as $SF_6$ technology which has been deployed and continuously improved over the last six decades. To this regard, the lack of internationally recognised standards for $SF_6$-free switchgears hinders the comparability between equipment, compelling end-users to rely on strict requirements (for instance, a minimum 10 year product maturity with a provision of the $SF_6$-free equipment to at least 3 European utilities and/or countries in the previous 5 years).

  In practice some types of switchgears based on $SF_6$ alternatives, particularly at lower MV levels (i.e. at 12kV), have been installed in sufficient volumes in standardised designs allowing performances to be evaluated. However, for $SF_6$ higher MV levels, there is much less experience and unsuitable $SF_6$ alternative trials may lead to much more severe consequences. Additionally, limited trials with small numbers of installations will unlikely exhibit long-term failures, which can accurately be identified when large volumes are employed for extended periods. Especially

in the case of a vastly interconnected power networks, significantly dependent now more than ever on switchgears to connect distributed generation sources at MV level, like for like replacements and reliability have significant implications. In this regard, the revision of the F-gas Regulation should enable DSOs, generators and T&D manufacturers to broaden the scale and scope of product type tests to not only review predictable defects, but also to detect unexpected defects that may arise from different mechanism failures. Previous experiences from dry type transformers deployed in windfarms, where a significant number of failures occurred after some years in service, should be avoided by all means necessary.

- **Suitability**: SF6-free alternatives must fulfil the same or at least comparable operational suitability requirements as current $SF_6$ solutions. Currently, the operational suitability of $SF_6$-free alternative products is still limited regarding the following aspects:

    - **Spatial constraints**: $SF_6$ offers the most compact technological switchgear solution at the present time. Especially in urban environments, installing alternative technologies in certain cases may be challenging because of limited space availability. This means that $SF_6$-alternatives are most commonly suitable in areas that are not constrained by space requirements. In this context, where spatial constraints can not be timely addressed (for instance, package substations notably designed with specific dimensions) switchgears containing reclaimed $SF_6$ should be supported in the short to medium-term. In this regard, an adequate transition time will facilitate the shift in urban space management and the technical development required to address spatial constraints of specific $SF_6$-free equipment.
      In the development of new switchgear to use instead of SF6 based switchgear, it would be generally beneficial if such new switchgear also had other technical advantages which would encourage its adaptation on its own merits, rather than require adaptation simply because it is non-SF6 (i.e. smaller dimensions, easier maintenance, higher reliability etc.)

    - **Extreme temperatures**: Especially in the case of outdoor HV and MV switchgear installations, $SF_6$-free alternatives must be suited to be deployed in very cold environments, or where temperatures cannot be readily controlled. Thus, the deployment of $SF_6$ alternatives is currently limited to certain areas with specific operating conditions and restricted by the limited market availability of $SF_6$-free alternatives suitable for outdoor use.[6]

    - **Global Warming Potential (GWP)**: $SF_6$-free switchgears shall have comparable lifetimes of approximately 40 years or longer. It should also be noted that most of the currently available $SF_6$ gas substitutes have a GWP impact. In this context, $SF_6$ gas substitutes shall not be required to be replaced before the end of their lifetime because of legislative change which would impact any replacement $SF_6$ gas substitutes which had a GWP that was currently acceptable, but which later be deemed unacceptable.

    - **Toxicological assessment**: DSOs and generators need to have absolute confidence that any alternative to $SF_6$ will not carry toxicological risk. Whilst a necessary condition for the safe deployment of $SF_6$ alternative gases, conformity with the REACH Regulation[7] is not necessarily a sufficient condition. On the Safety Data Sheet of the REACH Regulation, properties of substances and the associated hazards are identified. Nevertheless, the end-user must assess hazards in the context of specific applications and whether these can be mitigated to an acceptable level. In other words, REACH registration and CIGRE/CIRED references provide valuable information on $SF_6$-free alternative product but further assessments are still required to assess the risks of using alternative products in specific

[6] For further information, see Annex on currently available $SF_6$ alternatives

[7] required for all chemical products used in the EU

volumes, applications, and environments. Past experiences have shown that previously deployed products, such as PCB, which were initially thought to be safe, had carcinogenic properties. However, by the time the carcinogenic properties were discovered, trace amounts polluted large volumes of transformers which then needed to be replaced. These replacements incurred significant costs for utilities. Accordingly, in any assessment on the requirements for the use of $SF_6$ alternative gases by end-users, the European Commission should consider conducting risk assessments on their introduction, as well as the possible limitations that may arise from such assessments. For end-users, such as DSOs and generators, these risk assessments shall cover:

**a) The acceptability of new $SF_6$ alternative gases on safety grounds in their intended use**

Introducing any new product to replace an existing one with a known track record, may imply additional risks which have not been anticipated and hence not assessed by testing. The risk assessments, should account for the likelihood and subsequent consequences of hazards and failures for end-users, ensuring that overall benefits outweigh the outcome of similar risks.

The case of PCB is particularly apposite as when introduced no significant risks were foreseen. Subsequently it was found to be carcinogenic and required to be removed, which was costly but done in a controlled manner toward end of life, but which was recently required to be removed in total by 2025 at a much more significant cost.

**b) The technical reliability of $SF_6$ alternative solutions on a system level**

If a product containing a $SF_6$ alternative solution was found unsuitable, then it would not be able to operate on electrical safety grounds, having a significant impact on continuity. To mitigate such risk, $SF_6$ alternative solutions are only introduced where on the same circuit other switchgears can be used as substitutes, limiting the impact of the disruption.

In certain applications, such as in the case of many HV applications, the absence of multiple $SF_6$ alternative solutions with adequate track records may lead to significant risks with regards to the correction of hazards and failures. This would be a particular problem for HV substations that feed large critical loads and where security of supply is normally provided by standby equipment in the same station, which if compromised are unable to provide said service.

**c) The financial risks to utility customers of introducing immature $SF_6$ alternative solutions**

Due to the early replacement requirements for PCB, the expected cost for utilities in a medium-sized European country (between now and 2025) is close to € 1 Billion[8]. Consequently, it needs to be recognized by the European Commission that the introduction of such alternatives carries risk, and that any requirement to introduce non-$SF_6$ alternatives provides the ability to the utility to manage this risk through the selection of appropriate equipment, derogations on the use of such equipment where unsuitable, and the discretion to make an assessment on safety grounds of the applicability of such requirements.

[8] Cost estimates of replacing PCB contaminated transformers in distribution grids throughout the UK by the Energy Network Association (ENA).

- **Market availability**: the availability of reliable and suitable alternatives for use in the electricity system is a condition to be achieved through joint development initiatives to gradually shift away from $SF_6$ use. As previously highlighted, $SF_6$-free alternative solutions do not currently meet the conditions laid out in Article 21.4 of the F-gas Regulation[9]. Only when these are fulfilled will demand for $SF_6$-free switchgears fully develop and manufacturers be willing to build up the needed production capacity to serve the full market. In this regard, Eurelectric stresses that all $SF_6$-free applications at MV level should not be treated the same, as these are much more common at MV below 24kV than at 33kV, and very few installations are currently available for voltage levels above and including 52kV (see Chart 1 on p.8). Furthermore, the definition of MV extending to 52kV is too broad and problematic: what may be technically feasible at a MV voltage of 12kV will not be necessarily feasible at a MV voltage of 52kV. More precise voltage bands, as specified in other EU legislation such as the EcoDesign Directive for Transformers, would be welcomed.

**The need for an adequate transition time**

Within the scope of the review of the F-gas Regulation, it is ever so important to adopt an adequate transition time to address these considerations. As a matter of fact, an adequate transition time would enable DSOs and generators to exhaustively assess the following conditions before replacing significant sections of their industrial estate:

1. **Investigation testing**: functionalities and behaviour of new alternative equipment need to match with features and operational modes of the network. In this regard, investigation testing and/or experimentations on the grid constitute a fundamental prerequisite to assess the technical maturity of alternative solutions.
2. **Selection of potential solutions**: based on the conclusiveness of first trials, a screening of potential solutions is carried out. Based on its technology, each alternative solution will be risk assessed, determining control points to be checked during qualification tests of the equipment.
3. **Qualification phase**: in this phase, each selected equipment will undergo a conformity assessment with DSO's specific requirements and standards, requiring several tests (for instance, on functionality, security and endurance) by EN 17025-accredited laboratories. Furthermore, if chemicals are used (i.e. gases), their toxicology will be assessed according to REACH regulation. Ultimately, many DSOs shall perform audits of the manufacturer's production site to assess its ability to ensure product compliance and quality over time. At the end of this phase, a formal approval of the DSO will allow a progressive roll out of $SF_6$ alternative solution across the network.

The whole process implies a close partnership between end-users (i.e. DSOs and generators) and T&D equipment manufacturers, especially considering the different development and testing time needs. These different timeframes must be considered when determining and adequate transition time. Nevertheless, DSOs and generators are willing to work together with T&D equipment manufacturers to speed up the process to the fullest extent.

**Market availability of $SF_6$-free alternatives**

DSOs and generators are willing to follow manufacturers' $SF_6$-free equipment roadmap, ensuring that any future technology standardisation is aligned with equipment supply availability and incorporates best practices, as well as market tendencies. In this regard, an adequate timeline is

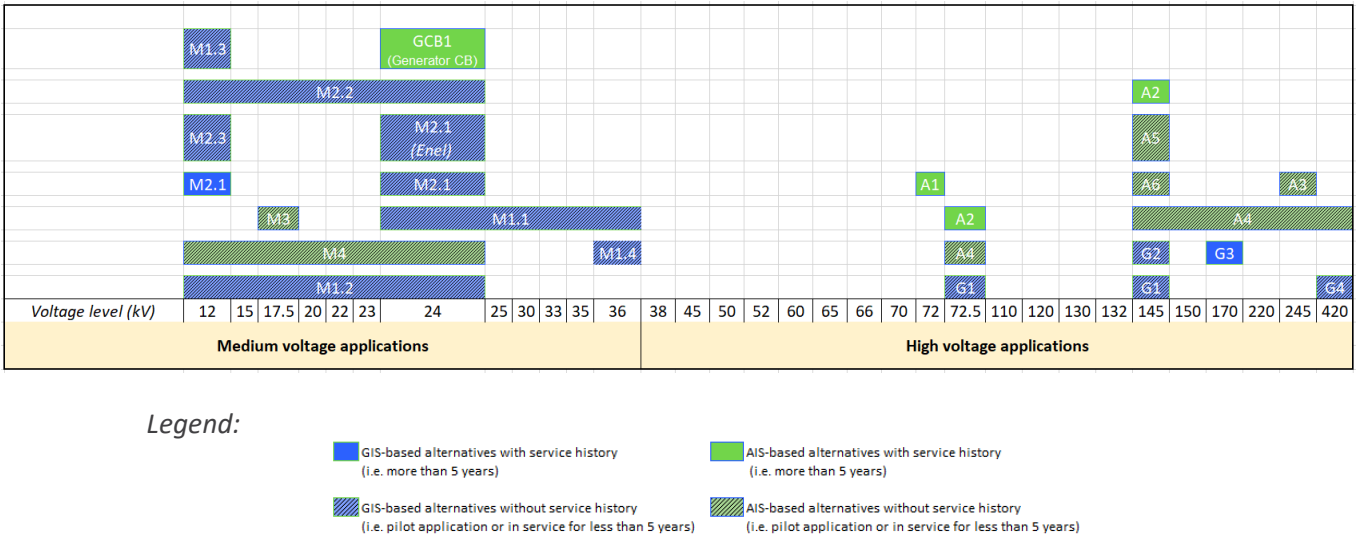
[9] Article 21.4 requires that alternatives to SF6 Switchgear would be 'available, cost effective, technically feasible, energy *efficient and reliable'.* Eurelectric's joint paper with E.DSO, GEODE and CEDEC assessed these factors in further detail.

necessary for manufacturers to develop and manufacture a suitable range of $SF_6$-free alternative solutions, and for DSOs and generators to conduct thorough tests and assessments before implementing them on a large scale. Only when the alternative products will fulfil the reliability, suitability and health requirements, manufactures will be eager to build up the needed production capacity to serve the full market.

In the view of end-users, sufficient market availability is guaranteed if type-tested $SF_6$-free alternatives are available on a large production scale from multiple manufacturers and subject to free market dynamics. To enable large scale deployments of $SF_6$-free alternative solutions, these must meet the conditions laid out in Article 21.4 of the F-gas Regulation and achieve the power industry's requirements, especially concerning the technical, environmental, health and safety criteria. $SF_6$-free switchgears that have been deployed in lower MV levels for years (particularly at 12kV) have achieved high levels of suitability and reliability (for instance, in greenfield applications). More recently, 24 kV $SF_6$-free switchgears have started to be operated in smaller quantities, mainly in pilot projects. Nevertheless, the volume of $SF_6$-free equipment installed at higher MV levels is still significantly lower and has not been in place in sufficient volume for enough time to properly assess its performance.

As depicted in Chart 1 below, **beyond announcements and company presentations, very few $SF_6$-free alternative products are commercially available in voltage levels above (and including) 24 kV.** The chart below represents currently available $SF_6$-free solutions for MV and HV applications according to equipment manufacturers organised in T&D Europe (see Annex for further technical descriptions). The chart outlines a considerable service history deficiency for most $SF_6$-free solutions currently available, as only 6 out of 25 applications have a 5-year or longer service history, and **a considerable gap for alternative solutions between 24kV and 70kV, as well as above 220kV.** Furthermore, other important findings (also provided in the Annex) include the scarce information on indoor and outdoor applications (particularly relevant for non-protected switchgears exposed to extreme temperatures) and the absence of $SF_6$-free alternatives for some niche applications (for instance, circuit breakers for power generators of 600 MW and above).

*Chart 1: Currently available $SF_6$-free equipment for MV and HV applications*




*Legend:*




*Source: Table in the Annex, based on updated information from T&D Europe's Technical report on alternative to SF6 gas in medium voltage & high voltage electrical equipment (April 2021)*

Considering the current market availability and development stage of $SF_6$ alternative products across the whole voltage range, a minimum of a five-year service history with extensive deployments would better enable all relevant stakeholders to meet the conditions laid out in Article 21.4 of the F-gas Regulation and achieve power industry's requirements especially concerning technical, environmental, health and safety criteria.

## Eurelectric recommendations for a revised F-gas Regulation

The European power sector is supportive of the EU commitment to reduce global greenhouse gas emissions towards the achievement of climate neutrality by 2050, as part of the European Green Deal objectives. Against this background, DSOs and generators are willing to commit further efforts to reduce emissions of F-gases, in particular $SF_6$, as far as possible.

Considering the various remarks above, Eurelectric has elaborated the following recommendations for a revised F-gas regulation:

**Monitoring leakage rates and end-of-life management practices**

Eurelectric believes that further progress can be achieved in deep leakage detection by focusing efforts on non-sealed equipment. As far as non-sealed equipment is concerned, $SF_6$ leakages are a critical issue that can be tackled through a stricter monitoring of leakage assessment. In this regard, developing a common assessment methodology would effectively support DSOs and generators in their efforts to monitor such leakages. Monitoring for sealed-for-life equipment (for instance, ring main units) is not necessary since the leakage rate of this equipment is already considered negligible and incapable of being reduced further. Additionally, as most emissions are related to the production and disposal of $SF_6$ materials, ensuring a proper end-of-life and decommissioning management of $SF_6$-switchgear (for both sealed and non-sealed equipment) would enable effective reductions of greenhouse gas emissions while boosting new life-cycle applications. The use of alternative $SF_6$ gases in existing switchgears has been determined by and utilities as unsuitable for a variety of reasons, but especially because the existing switchgear was not designed with the use of alternative gases in mind, so that the impact of such gases on switchgear components such as gaskets, and on electrical operation (gas breakdown, dielectric behaviour, partial discharge etc over the remaining lifetime of the equipment would be impractical to assess over the variety of equipment installed. Hence it would be uneconomic to attempt to replace existing gas prior to end of life (as only very small leakages would be saved) and any early replacement would result in greater $SF_6$ emissions being created with the disposal of existing $SF_6$ switchgear. In this context, Eurelectric recommends a strengthening of the leakage assessment and end-of-life management measures already established in the F-gas regulation.

**Foster R&D and experimentation between T&D manufacturers and end-users**

DSOs and generators are ready to assume their responsibility to support the introduction and deployment of climate-neutral $SF_6$-free technologies. Nevertheless, considering the current limited availability of alternative solutions and limited operational experience with $SF_6$-free solutions, the revision of the F-gas regulation should foster R&D for switchgears and circuit breakers operating at voltage levels above (and including) 24kV and support experimental applications of $SF_6$-free equipment. For this purpose, end-users (i.e. DSOs and generators) are willing to gain further experience by continuing and extending R&D activities with T&D equipment manufacturers and by integrating newly developed technologies into their grids and installations.

Today, a sufficient market availability of alternative products is not yet guaranteed. Furthermore, it must be acknowledged that it will take time for manufacturers to develop a full range of products and for DSOs and generators to test these thoroughly before adopting them on a large scale. In this regard, manufacturers and end-users will closely work together in order to reduce these timeframes. Only when products fulfil the reliability, suitability, sustainability and health requirements mentioned above, will manufacturers be willing to build up the needed production capacities to serve the full market. The revision of the F-gas regulation should encourage collaborations between manufacturers, DSOs and generators through forums, research programs or joint ventures. Thus, enabling the exchange of best-practice knowledge, the improvement of products and more transparency on the market maturity of alternative solutions.

**Allow for adequate transition timelines differentiated by voltage level**

Considering the current limited market availability of $SF_6$-free solutions, the revision of the F-gas regulation should acknowledge that additional time is needed to complete the development of suitable $SF_6$-free alternatives, to carry out pilot projects, as well as end-user homologation and industrialisation processes. Furthermore, an adequate transition timeline will enable most manufacturers to integrate added value operational and maintenance functionalities (for instance: automation, integrated metering, protection asset and network observability (IoT), and auxiliary power supply) to fully enable the transition from traditional electromechanical equipment to mechatronic equipment.

As previously highlighted, it will take time for T&D manufacturers to develop the full product range and for DSOs and generators to gain further experience concerning integrating newly developed technologies in the electricity grid and properly assessing their reliability during operation. While Eurelectric members already committed to using $SF_6$-free alternatives where they meet the EU criteria laid out in Article 21.4 of the F-gas Regulation[10] and offer the same or at least comparable operational suitability and reliability requirements as current $SF_6$ solutions (in compliance with provisions from the REACH Regulation[11]), the revision of the F-gas regulation should distinguish by voltage and current level and propose an adequate transition timeline. Additionally, this would allow end-users to indicate requirements, and hence give certainty to manufacturers, allowing them to build up the needed production capacity to serve the full market.

**Allow for a system of adaptations taking into account technical constraints in special applications**

In the context of restricting the usage of $SF_6$ in new switchgear, Eurelectric emphasises that a system of adaptation taking into account special applications and specific technical constraints would be necessary. As previously highlighted, $SF_6$ offers the most compact and reliable technological switchgear solution especially in certain cases where available space is limited (i.e. urban areas) and where temperature cannot be controlled (i.e. very cold/hot environments). Thus, $SF_6$-free switchgear solutions may be limited to specific areas with certain operational conditions. In some instances, certain applications such as redesigns of lower MV $SF_6$-free applications for secondary substations (for instance, resin-based vacuum interrupted switchgears) have demonstrated technical and economic benefits beyond the non-usage of $SF_6$, such as reduced sizes enabling the placement of substations on public streets reinforcing electric vehicle charging infrastructure. Nevertheless, particularly in the case of external HV installations serving as primary substations, an adequate transition time would be greatly needed, as it would enable the required

[10] i.e. cost-effectiveness, technical feasibility, energy-efficiency and reliability
[11] Regulation (EC) No 1907/2006

shift in urban space management and enable further market maturity assessments of $SF_6$-free alternative solutions. Furthermore, Eurelectric would like to highlight that the consequences of failures of less experienced equipment may be tolerable in certain areas where there are low volumes of customers and load is non-critical (for instance, secondary MV substations connected to non-critical infrastructures). On the contrary, the consequences of failures of less experienced equipment would be considerably higher for primary MV substations connected to city centres and industrial sites, as the volume of customers affected and the criticality of loads would be substantially greater. In this context, Eurelectric advocates for a system of adaptations taking into account technical constraints in special applications.

**Promote the recovery and use of reclaimed $SF_6$**

Continuing support for the existing usage of reclaimed $SF_6$ is the most effective option where $SF_6$-free alternative solutions are not available, while effectively reducing greenhouse gas emissions and preventing the manufacturing of new $SF_6$. Reclaimed $SF_6$ could be further developed by ensuring that the $SF_6$ performance requirements for switchgear did not unnecessarily preclude the use of recycled $SF_6$, making recycling of dismissed equipment gas mandatory and closely engaging with the supply chain in the decommissioning process of $SF_6$ products. In this context, permitting the usage of reclaimed $SF_6$ for switchgears operating at voltage levels above (and including) 24kV would enable the power sector to maintain and repair critical network infrastructure guaranteeing the security of electricity supply at all times. Potentially helpful in this regard could be the establishment of a certification system for reclaimed $SF_6$.[12]

## Conclusion

DSOs and generators are willing to commit further efforts to reduce emissions of F-gases as far as possible through the adoption of $SF_6$-free switchgear equipment. DSOs and generators have already voluntarily committed to using $SF_6$-free alternatives, provided they meet the criteria laid out in Article 21.4 of the F-gas Regulation[13], and strict safety requirements from a toxicological and environmental perspective[14].

Nevertheless, with current technologies and at the best of our knowledge, the deployment of $SF_6$-free solutions is not technically feasible in significant segments of the electricity system and most installations. Hence, the revision of the F-gas regulation should acknowledge that further experience needs to be gained with regard to integrating newly developed technologies into the electricity grid. Against this backdrop, an adequate timeline is necessary for manufacturers to develop, manufacture and test a suitable and reliable range of $SF_6$-free alternative solutions, and for DSOs and generators to conduct field tests and assessments before implementing them on a large scale.

In the interim, the recovery and usage of reclaimed $SF_6$ from dismissed equipment represents the most cost-effective, suitable and reliable solution for DSOs and generators to guarantee the security of electricity supply at all times. Furthermore, because leakage volumes of operational

[12] As described in Article 2 of the F-Gas Regulation

[13] Article 21.4 requires that alternatives to SF6 Switchgear would be '*available, cost effective, technically feasible, energy efficient and reliable'.* Eurelectric's joint paper with E.DSO, GEODE and CEDEC assessed these factors in further detail.

[14] Compliance with the REACH Directive (EC 1907/2006) is a necessary condition, but not necessarily sufficient in itself to address the risks of using substances which may have toxicological effects if released. Switchgear especially at MV is often situated on customer premises or on public streets, so that the impact of any escape of non-SF6 gas must have no worse impact than a similar escape of SF6 gas. Additionally, any substitute SF6 gas must be sufficiently acceptable on an environmental basis that it will not require replacement in its lifetime (i.e. 40+ years)

equipment are negligible and most $SF_6$ emissions occur during manufacturing and disposal at end of life, Eurelectric calls for the European Commission to recognise this impact in the framework of the revision of the F-gas Regulation.

Finally, we would like to highlight the importance of a holistic approach to revising F-Gas Regulation in line with the Green Deal and harmonisation with other EU legislation revisions contributing to climate action, such as the Eco-design Directive, EU waste legislation and circular economy-related measures. In this context, the revision of the F-gas Regulation, should support collaboration between T&D manufacturers and end-users through forums, research programs and joint ventures to effectively reduce global greenhouse gas emissions towards the achievement of climate neutrality by 2050.

## *Annex: Table on currently available $SF_6$ alternatives*

Source: *Based on updated information from T&D Europe's Technical report on alternative to SF6 gas in medium voltage & high voltage electrical equipment (April 2021)*

| T&DE Reference | voltage type | type technology (AIS, | Alternative technology | Function type | Rated performance | | | | Suitable for outdoor use (i.e. capable of withstanding wind, rain, snow, dirt deposits, condensation, ice and frost) | Footprint versus SF6 version from same manufacturer | Weigth *(vs SF6 version from same manufacturer)* | Year of delivery / service | Reference | Connectivity compatibility (vs SF6 version from same manufacturer) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Ur (kV) | Ir (feeder) A | Isc (kA) | min op Temp (°C) | | | | | | |
| M1.1 | MV | *GIS primary* | *Insulation C5-Fluoroketone gas mixed with synthetic air at 1.3 bar abs., Vacuum breaking* | *Circuit-Breaker ; disconnector/earthing-switch ; disconnector ;* | 24 / 36 (40,5) | 2000 | 25 / 31,5 | -15 | No information available | same | similar | *Commercially available (1)* | 2 pilots, in Switzerland (2015) and Germany (2016). Product launch 2016. In total >200 panels in EU in operation. | Same footprint and primary connections as SF6-Version. Fully exchangable. Extention panels to SF6-Version possible. |
| M1.2 | MV | *GIS primary* | *Filtered air, for both 12 kV, 24 kV and 36 kV, Vacuum breaking* | *Circuit-Breaker ; disconnector/earthing-switch ; disconnector ;* | 12-24-36 | 2500 | 40 | -25 | indoor uncontrolled | same | same | *On-going R&D, 24 kV pilot since 2020* | CIRED Q2/2019 | yes |
| | MV | *AIS primary* | *Air ambiant, Vacuum breaking* | *Circuit-Breaker ; ; ;* | 24 | 1250 | 16,5 | -25 | indoor controlled | same | same | Commercially available | 24 kV AIS, feeder substations since 2021, ENEDIS France (pilot project) | yes |
| M1.3 | MV | *GIS primary* | *Natural origin gases, Vacuum breaking* | *Circuit-Breaker ; disconnector/earthing-switch ; disconnector ;* | 12 | 2750 | 40 | -25 | No information available | same | similar | *Commercially available* | Shown at Hanover Fair 2018 In service since beginning of 2018 | yes |
| M1.3 | MV | *GIS primary* | *Natural origin gases, Vacuum breaking* | *Circuit-Breaker ; disconnector/earthing-switch ; disconnector ;* | 12-24 | 1250 | 25 | -25 | No information available | same | similar | *On-going R&D (further ratings and Typicals), commercially available, user piloting of selected Typicals* | Shown at Hanover Fair 2020 | full compatible, busbar at same location (mixing between SF6 and SF6-free posible) |
| M1.4 | MV | *GIS primary* | *HFO1234zeE, Vacuum breaking* | *Circuit-Breaker ; disconnector ; ;* | 36 | 2000 | 31,5 | -15 | indoor uncontrolled | same | same | pilot in 2020 | CIRED Q2/2019 | yes |
| M2.1 | MV | *GIS secondary* | *Synthetic air 1.4 bar abs, Vacuum breaking* | *Circuit-Breaker ; disconnector/earthing-switch ; switch ;* | 12 | 630 | 20 | -25 | No information available | same | slightly higher | Commercially available | About 2000 RMU installed all over the world | Same footprint. Full replacement possible. RMU is in general not extendable. |
| M2.1 | MV | *GIS secondary* | *Synthetic air 1.4 bar abs, puffer loadbreak switch* | *Circuit-Breaker ; disconnector/earthing-switch ; switch ;* | 12 | 630 | 20 | -25 | No information available | same | slightly higher | Commercially available | market introduction 01/2021 | Same footprint. Full replacement possible. RMU is in general not extendable. |
| M2.1 | MV | *GIS secondary* | *C5-Fluoroketone gas plus synthetic air, 1.4 bar abs, Vacuum breaking* | *Circuit-Breaker ; disconnector/earthing-switch ; switch ;* | 24 | 630 | 16 | -25 | No information available | same | slightly higher | Commercially available | Deliveries started end 2016 | |
| M2.1 | MV | *GIS secondary* | *C5-Fluoroketone gas plus synthetic air, 1.4 bar abs, puffer loadbreak switch* | *Circuit-Breaker ; disconnector/earthing-switch ; switch ;* | 24 | 630 | 16 | -25 | No information available | same | slightly higher | Commercially available | market introduction 01/2021 | |
| M2.1 | MV | *GIS secondary* | *C5-Fluoroketone gas plus synthetic air, 1.4 bar abs, puffed gas breaking* | *Circuit-Breaker ; disconnector/earthing-switch ; switch ;* | 25 | 630 | 16 | -25 | No information available | same | similar | Under field trial | 20 units to be installed in Italy and Spain by Enel in 2Q 2021 | |
| M2.2 | MV | *GIS secondary* | *Filtered air, for both 12 kV and 24 kV , Vacuum breaking* | *Circuit-Breaker ; disconnector/earthing-switch ; switch ; switch-fuse* | 24 | 630 | 25 | -25 | indoor uncontrolled | same | slightly higher for 24 kV | On-going R&D, 24 kV pilot in 2021 | Cired Q2/2019, pilot announced CIGRE 2020 | no |
| M2.2 | MV | *GIS secondary* | *Natural origin gases, Vacuum breaking* | *Circuit-Breaker ; disconnector/earthing-switch ; switch ; switch-fuse* | 24 | 630 | 20 | -25 | No information available | same | similar | On-going R&D, First user piloting of a specific RMU configuration | Press release 2021, Hannover Fair 2021 | Same footprint. Full replacement possible. Block variants (RMU) and individual panels. Both extendable and non-extendable. |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M2.3 | MV | *GIS secondary* | *Natural origin gases, Vacuum breaking* | *Circuit-Breaker ; disconnector/earthing-switch ; switch ;* | 12 | 630 | 20 | -25 | No information available | same | similar | On-going R&D, User piloting of selected Typicals (small quantities) | Hannover Fair 2019, Press release 2020 | Same footprint. Full replacement possible. Block variants (RMU) and individual panels. Both extendable and non-extendable. |
| M3 | MV | SSIS | *Dry air & Shielded Solid epoxy or EPDM, Vacuum breaking* | *Circuit-Breaker ; disconnector ; switch ;* | 17,5 | 1250 | 25 | -25 | indoor uncontrolled | similar | higher | Commercially available | No specific pilots. First commercial equipment in Sweden and Netherlands in service since end of 2012, | N/A |
| M4 | MV | AIS secondary | *Filtered air, for both 12 kV and 24 kV , Vacuum breaking* | *Circuit-Breaker ; disconnector/earthing-switch ; switch ; switch-fuse* | 12 - 24 | 630 | 25 | -25 | indoor controlled | same | same | Commercially available | market introduction 04/2021 | yes |
| Chapter 5.1.1.2.1 Table 2 | MV | GIS secondary | Dry natural air at atmospheric pressure with Electric-Field control.. Vacuum Switching | Circuit-Breaker ; disconnector ; switch ; switch-fuse | 12 | 630 | 20 | -25 | indoor uncontrolled | same | slightly higher | Commercially available since 2003 | >85000 functional units delivered all over the world | Yes, to be connected with standard C and A connectors acc EN50181 |
| Chapter 5.1.1.2.1 Table 2 | MV | GIS secondary | Dry natural air at atmospheric pressure with Electric-Field control.. Vacuum Switching | Circuit-Breaker ; disconnector ; switch ; switch-fuse | 12 | 630 | 20 | -25 | indoor uncontrolled | same | slightly higher | Commercially available since 2003 | >40000 functional units delivered all over the world | Yes, to be connected with standard C and A connectors acc EN50181 |
| | MV | Overhead lines switchgear | *Not fixed yet* | *disconnector ; switch ; ;* | 12-36 | 630 | 25 | -50 | outdoor | To be confirmed | To be confirmed | On-going R&D | | |
| GCB1 | MV | GCB | Air, Vacuum breaking | ; ; ; | 24 | 12500 | 100 | -25 | No information available | similar | | Commercially available | Launched in 2015 | yes |
| A1 | HV | live tank | synthetic Air or N2, Vacuum breaking | ; ; ; | up to 145 | 3150 | 40 | -55 | outdoor | same | similar | Commercially available | France (several sites); another European Australia / First operation since 2010 | |
| A2 | HV | live tank | CO2 and O2 for insulation and breaking | Circuit-Breaker ; ; ; | 72.5 | 2750 | 31,5 | -50 | outdoor | similar | | Commercially available | More than 100 installations | |
| A2 | HV | live tank | CO2 and O2 for insulation and breaking | Circuit-Breaker ; ; ; | 145 | 3150 | 40 | -50 | outdoor | similar | | Commercially available | In operation since 2020 | |
| A5 | HV | live tank | CO2 and C4-Fluoronitrile and O2 for insulation and breaking | ; ; ; | 145 | 3150 | 40 | -30 | No information available | same | same | Commercially available | 3 substations energized in Denmark, Germany and Switzerland. 20 bays ordered | yes |
| A6 | HV | live tank | synthetic Air, Vacuum breaking | ; ; ; | 145 | 3150 | 40 | -60 | No information available | same | | Commercially available | First pilot delivery in 2017 and operation started in 2018 (Germany), meanwhile more than 50 breaker in operation | |
| G1 | HV | GIS | synthetic Air, Vacuum breaking | ; ; ; | Up to 145 | Up to 3150 A | Up to 40 kA | Up to -50 | outdoor | | | Commercially available | First 4 pilot bays delivered in 2016, operation start 2017, meanwhile more than 20 bays 145 kV and more 200 bays 72.5 kV in operation and more than 1000 bays ordered, latest news see Blue white paper Hannover fair | |
| G2 | HV | GIS | CO2 and C4-Fluoronitrile and O2 for insulation and breaking | ; ; ; | 145 | 3150 | 40 | -25 | No information available | same | same | Commercially available | 10 substations with 58 bays are in operation in Switzerland, France, Netherlands, Germany & Denmark. More than 100 bays ordered. | yes |
| G3 | HV | GIS | CO2 and C5-Fluoroketone and O2 for insulation and breaking | GIS including circuit-breaker | 170 | 1250 | 40 | 5 | No information available | larger | | | S/S in operation in Zurich for EWZ (Switzerland) since 2015 | |
| | HV | GIS | CO2 and C4-Fluoronitrile and O2 for insulation and breaking | ; ; ; | 420 | 5000 | 63 | -25 | No information available | same | same | On-going R&D | Development supported by EU LIFE program. First project delivery will be in UK (9 bays). | yes |
| G4 | HV | GIL_GIB | CO2 and C4-Fluoronitrile | ; ; ; | 420 | 5000 | 63 | -30 | No information available | same | same | Commercially available | 2 substations energized in UK. More than 5000m ordered for 8 substations. | yes |
| G4 | HV | GIL_GIB | synthetic Air | ; ; ; | 420 | 4000 | 63 | -50 | outdoor | same | higher | On-going R&D | Order, Press release Nov. 2019 | |
| A4 | HV | instrument transformer | synthetic Air | ; ; ; | 72,5 to 420 | 1200 | 31,5 | -35 | outdoor | similar | similar | Commercially available | Prototypes shown at Cigre session 2016, meanwhile dozen in operation and in order, see separate tab | |

Eurelectric pursues in all its activities the application of the following sustainable development values:

Economic Development

- Growth, added-value, efficiency

Environmental Leadership

- Commitment, innovation, pro-activeness

Social Responsibility

- Transparency, ethics, accountability

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