SIEMENS

Background

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The power supply system is going “blue.” Innovative technology for enhanced sustainability.

Green isn’t enough: blue products meet the most stringent requirements

The power supply system is going “blue.” As one of the leading providers, Siemens is defining new and exceptionally stringent criteria that far exceed the scope of current safety and environmental standards. Much more than an environmental label, blue is in fact leading the way to an environmentally friendly future for the energy industry.

The blue portfolio makes it possible to modernize and expand existing power networks with maximum safety. At the same time, it greatly reduces their environmental footprint while delivering the same performance and cost-efficiency. Vacuum switching technology and clean air in gas-insulated switchgear not only significantly reduce emissions, but also enable a higher rate of recycling and lower maintenance expenses.

Blue products exceed current standards

Products must satisfy a series of stringent criteria to qualify as “blue.” Our requirements for environmental protection and sustainability are listed below.

- No fluorinated greenhouse gases (“F-gases”): blue products contain no SF_6 or other F-gases
- A competitive edge thanks to innovative and sustainable products: detailed description of the technical solution that assures the particularly high level of sustainability of the blue product
- Documentation: lifecycle analyses (LCA) and an environmental product declaration (type II) in accordance with ISO 14021 is available. This is a systematic analysis of the environmental impacts of products throughout their entire lifecycle, and contains quantified environmental information to enable comparisons to be made between products or services with the same functions.

- Long service life: the longer the service life, the easier it is to achieve a balance between environmental protection and cost-efficiency.
- Significant reduction of greenhouse gas emissions: the savings achieved by blue products compared to comparable products, converted to kg CO_2 equivalent (CO_2e).
- The use of environmentally friendly materials: an analysis of the materials used in the product is available.
- Material declaration: a material declaration in accordance with REACh/RoHS is available. REACH is an EU regulation governing the registration, evaluation, authorization and restriction of chemicals. EU Directive 2011/65/EU, Restriction of Hazardous Substances (RoHS), serves to restrict the use of particular hazardous materials in electrical and electronic devices, to ensure they are kept out of electronic waste.
- Minimal environmental impacts in the event of an incident: blue products are constructed to ensure they pose no threat to humans or the environment even when damaged.

3AV1 blue circuit breaker up to 145 kV: SF_6-free circuit breaker from Siemens for Netze BW

Siemens has received an order from the distribution grid operator Netze BW GmbH to modernize and expand its 110-kV transformer substation in Nördlingen. Siemens will install its new 3AV1 outdoor circuit breaker with vacuum-interruption technology and a combined voltage and current converter, including clean air insulation, in a 110-kV high-voltage grid for the first time. The switchgear thus requires no SF_6 insulating gas. The order also includes retrofitting and expanding the existing air-insulated switchgear, including protection and control systems and work on cables and overhead lines. The new equipment is expected to be commissioned by the middle of 2018.

Distribution grid operator Netze BW GmbH is a member of the EnBW Group. It operates the power distribution grid in large parts of Baden-Württemberg, Germany, as well as in outlying areas of adjacent federal states.

The high-voltage circuit breakers from Siemens – with vacuum-interruption and clean air technology in the high-voltage range – are upgrades to the circuit breakers

and switchgear that work with sulfur hexafluoride (SF_6) as the insulating, switching, and extinguishing gas and those will remain in the product line. A vacuum-interrupter unit switches and extinguishes the arc, while technically prepared and purified air in a mixing ratio of 80 percent nitrogen to 20 percent oxygen provides the insulation for the current-carrying conductors inside the housing. Siemens has further developed its existing insulation and extinguishing technology according to climate-neutrality requirements by combining vacuum-interruption systems for switching and for arc extinguishing with clean air as the high-voltage insulating medium.

Siemens has been using its vacuum-interruption technology in its medium-voltage switchgear and in high-voltage circuit breakers up to 72.5 kV for more than 40 years. With its new circuit breakers, the company is expanding the application of vacuum-interruption technology for a rated voltage of up to 145 kV, a rated short circuit-breaking current of up to 40 kiloamperes (kA), a rated current up to 3,150 A, and operating temperatures between -60° Celsius and +55° Celsius. This broad range of applications makes the new circuit breakers and encapsulated switchgear suitable for many purposes in both outdoor and indoor installations. Despite of the lower insulating capacity of natural gases, the vacuum-clean air- circuit breakers have the same dimensions than the SF_6 circuit breakers. Its energy transmission efficiency is equally high in practice. The vacuum-interruption technology combined with clean air technology provides operators with many advantages, including easier handling during shipping, installation, and operation as well as during maintenance and recycling. In addition, reporting the quantity of gas used in the devices isn’t required.

Blue instrument transformers

Backed by 50 years of experience in developing, manufacturing, operating and servicing SF_6-insulated instrument transformers, with more than 40,000 devices delivered, Siemens developed the innovative and environmentally friendly system of insulation using clean air instead of oil or SF_6, which greatly reduces the environmental footprint of the devices. Clean air insulation is used both in outdoor instrument transformers and in instrument transformers for GIS applications. Since the beginning of 2018, 123 kV current and voltage transformers have been in operation, and 245 kV voltage transformers will be delivered during the year. The measurement characteristic of current and voltage transformers is identical to that of

the proven SF_6 instrument transformers. They are also suitable for use at temperatures of -50°C and lower; the use of clean air means there are no phase transition effects between the gas and liquid stages. There is no need for special gas handling or gas handling devices at any point in their service life. Moreover, there are no CO_2 emissions during either operation or recycling. The absence of F-gases means there is no requirement for F-gas documentation or the costs associated with drawing up such reports. All clean air instrument transformers are completely type-tested in accordance with international standards.

8VM1 blue GIS up to 72 kV

The 8VM1 blue GIS gas-insulated switchgear, developed especially for wind turbines, works with vacuum switching technology, which has proven itself in use with outdoor circuit-breakers since 2010 and uses industrially prepared clean air as the insulating medium, and is so compact that it can be used for offshore wind turbines where space is at a premium.

Siemens supplied four panels of the 8VM1 gas-insulated SF_6-free high-voltage switchgear (GIS) – which has a capacity of 72.5 kilovolts (kV) – to Siemens Gamesa Renewable Energy. The systems were deployed in the Nissum Bredning Vind wind farm in Denmark. The switchgear protect the wind turbines from overloads and short circuits and thereby ensure an uninterruptible power supply. The metal-encapsulated 8VM1 from the blue GIS portfolio was developed specifically for use in offshore wind turbines. They work with the proven vacuum circuit-breaker technology and with clean air as the insulating medium instead of sulfur hexafluoride (SF_6). The wind farm operators, Nissum Bredning Vindmøllelaug and Jysk Energ, are relying on a new cable and turbine concept at a voltage of 66 kV to connect the four seven-megawatt (MW) wind turbines from Siemens to the grid. Compared with the usual 33-kV grid connection, this new concept increases transmission capacity and lowers the cost of laying cables. The wind farm has been supplying electricity since March.

In the future, 66 kV could be the standard voltage for offshore turbines. A higher voltage means lower cable-laying costs and also fewer losses. The “cable in pipe” solution also makes it possible to simplify cabling between the turbines. A slimmed-down tower concept helps save even more material. In this case, reduced-weight prototypes that are specially suited to jacket concepts are to be installed.

The economic prospects of the offshore wind energy technology being tested in the project are expected to demonstrate a significant positive impact on power generation costs. The Danish energy agency DEA anticipates that the components being tested in Nissum Bredning will help substantially to save on investment and operating costs.

The 8VM1 blue GIS is an enhancement of the switchgear that use SF_6 as the insulating, switching, and extinguishing gas, and which will remain in the product line. “We’re proud that our new SF_6-free switchgear are being used successfully in the Nissum Bredning Vind wind farm,” said Karlheinz Kronen, CEO of the High Voltage Products Business Unit in the Siemens Energy Management Division. “We’ve constructed the 8VM1 specifically for this type of deployment and focused on an environmentally compatible design during development. Customers will therefore benefit from the advantages of our proven vacuum switching technology with no SF_6.” In vacuum switching technology, a vacuum-interrupter unit switches and extinguishes the arc, while technically prepared and purified air in a mixing ratio of 80 percent nitrogen to 20 percent oxygen provides the insulation for the current-carrying conductors inside the housing of the metal-encapsulated gas-insulated switchgear (GIS). By combining vacuum-interrupter units of up to 72.5 kV for extinguishing arcs with clean air as the high-voltage insulating medium, we’ve added another alternative to SF_6 to our existing insulating and extinguishing technology.

The new blue GIS portfolio is Siemens’ answer to the market requirements of customers who want to use both the proven properties of GIS systems asd well as a natural insulating medium in their power grids. The blue GIS portfolio represents Siemens’ work with insulating media that contain no fluorine gases and therefore meet all the strictest safety and environmental standards.

Siemens uses vacuum interrupters for the first time in gas-insulated high voltage switchgear up to 145 kV

While millions of vacuum interrupter units are used in medium voltage switchgear worldwide, until now they have come up against their limits in the high voltage sector above 72.5 kilovolts (kV). Following intensive research and development in this area, Siemens exhibited high voltage interrupters and gas-insulated switchgear

using vacuum technology and so-called clean air technology up to a voltage of 145 kV for the first time ever at Cigré 2016 in Paris. With this technology, a vacuum interrupter unit performs the switching and arc extinguishing activities. Technically processed and purified air with a mixing ratio of 80 percent nitrogen to 20 percent oxygen provides the insulation for the current-carrying conductors inside the housing of the metal-encapsulated, gas-insulated switchgear (GIS). The new switchgear 8VN1 blue GIS, with vacuum switching technology and clean air insulation is scheduled to be launched on the market in 2018. It is a further development of the switchgear that use sulfur hexafluoride (SF_6) as insulating, switching and arc extinguishing gas and which continue to be still part of the product range.

With the combination of vacuum switching technology for switching and arc extinction and clean air as high voltage insulating medium, Siemens has further developed existing insulation and arc extinction technology to meet climate neutrality requirements. “With this technology, we are expanding our high voltage portfolio and offering our customers an alternative solution without SF_6 for higher voltage levels as well. The use of technical switching and insulating gases with high global warming potential can be reduced or even avoided completely in many application areas with the help of vacuum switching technology,” said Karlheinz Kronen, CEO of the Business Unit High Voltage Products within the Siemens Energy Management Division.

With vacuum switching technology, when the contacts are opened the switching arc burns in a metal-vapor plasma between the contacts inside the vacuum extinction chamber. The metal vapor condenses back onto the contacts after the arc is extinguished. No decomposition products occur and the arc does not affect the surrounding insulation. This means that natural insulating gases such as dry air, nitrogen or carbon dioxide that only have poor arc extinction properties, if any at all, can be used for high-voltage insulation of current-carrying conductors. The use of technical insulating gases that have to be able to insulate live parts as well as extinguish arcs effectively can be reduced or even completely avoided by means of vacuum switching technology. The combination of vacuum interrupter units up to 145 kV for arc extinction and clean air as high voltage insulating medium offers an additional alternative to sulfur hexafluoride (SF_6) to supplement the existing insulating and arc extinction technology.

Siemens has used vacuum switching technology for more than 40 years in its medium voltage switchgear as well as in high-voltage circuit-breakers up to 72.5 kV. With the new circuit-breakers and switchgear, Siemens is extending the use of vacuum switching technology up to a rated voltage of 145 kV, a rated short-circuit breaking current up to 40 kiloamperes (kA), a rated current of up to 3;150 A and operating temperatures from -55°C up to +55°C. This wide service spectrum makes the new circuit-breakers and encapsulated switchgear suitable for many applications in both outdoor as well as indoor installations. The lower insulating capability of natural gases results in slightly larger dimensions compared with gas-insulated switchgear with SF_6. However, power transmission efficiency in practice remains equally as high as before. Vacuum switching technology provides advantages for the operator including, for example, easier handling during transport and installation and in operation as well as during maintenance and when recycling. There is also no obligation to report the volumes of gas used.

Siemens offers generator switchgear with vacuum circuit-breaker technology for high operating currents

Siemens is developing the world’s first air-insulated generator switchgear with vacuum circuit-breaker technology equipped with short-circuit breaking capacity of up to 100 kiloamperes (kA) at 27 kilovolts (kV). The switchgear type HB3-100 protects operating equipment such as electrical generators and transformers against overvoltage and short-circuit conditions and serves to support automated and demand-controlled operational management of power plants. These switchgear can be used in hydroelectric power plants, coal-fired units and combined cycle power plants as well as solar-thermal and geothermal power plants with electrical generating capacities of up to 400 megawatts (MW). Thanks to their low-maintenance vacuum circuit-breaker technology and resource-optimized development, the lifecycle costs of HB3-100 switchgear is up to 70 percent less than existing solutions.

"With our new type-tested HB3-100 generator switchgear we are now expanding our product range for power plant operators, municipal utility companies and EPC projects, and offering this proven vacuum circuit-breaker technology also for high operating current applications," explained Stephan May, CEO of Siemens’ Medium

Voltage and Systems Business Unit, already in October 2015. The products of Siemens HB3 series cover 80 percent of all market requirements for this type of switchgear in new power plant units and retrofit projects.

The HB3-100 consists of a generator circuit-breaker in vacuum technology, disconnectors, grounding system and integrated startup disconnect switches. Unlike gas-insulated circuit-breakers, vacuum circuit-breakers interrupt the arc in a high-vacuum interrupter tube. The single-phase encapsulated unit can handle rated currents of up to 13,900 amperes (A) without forced cooling. It is maintenance-free up to 10,000 electrical switching events and 30 short-circuit interruptions at 100 kA. The hermetically sealed vacuum interrupters require no maintenance as a general rule and are resistant to any environmental influences. A further important consideration is that no oxidation takes place in the vacuum, so that the metallic surfaces remain permanently clean and ensure a consistently low contact resistance. The lifecycle costs of the HB3-100 switchgear – costing of which covers everything from procurement to final disposal – are between 25 and 70 percent lower than for a generator switchgear with gaseous switching medium (e.g. SF_6), depending on the power plant type.

Siemens develops SF6-free gas-insulated medium-voltage switchgear

At this year's Hannover Fair, Siemens presents another medium-voltage switchgear that doesn't require sulfur hexafluoride (SF_6) as the insulating gas: the 8DAB 12. The system uses clean air consisting only of the natural constituents of ambient air as the insulating gas. The switchgear is a new addition to the 8DA and 8DB product family and also works with the proven vacuum switching technology. A vacuum-interrupter unit handles switching and arc extinguishing, while the natural gas insulates the current-carrying conductors inside the housing of the metal-encapsulated gas-insulated switchgear (GIS). This type-tested system is used to switch high currents at the primary distribution level. The single-pole encapsulated 8DAB 12 is a SF_6-free medium-voltage switchgear in the Siemens blue GIS portfolio. Switches and switchgear that use SF_6 as the insulating, switching, and extinguishing gas remain an important part of the Siemens portfolio.

"With the addition of the 8DAB 12, we're systematically expanding our portfolio of medium-voltage switchgear," says Stephan May, CEO of the Siemens Medium

Voltage and Systems Business Unit. “We’ll continue to offer our customers proven vacuum switching technology and single-pole switchgear encapsulation. They can now select the characteristics of the insulating gases used, depending on their requirements. The functionality and dimensions remain the same as the switchgear in our 8DA series.” The new blue GIS portfolio is Siemens’ answer to the market requirements of customers who want to use both the proven properties of GIS systems in their power grids as well as a non-chemical insulating medium. The blue GIS portfolio represents Siemens’ work with insulating media that contain no fluorine gases and meet all the strictest safety and environmental standards.

In recent years, the company has intensively researched alternative insulating materials and technologies that approximate the properties of SF_6-based gas mixtures and simultaneously ensure safe and economical switchgear operation. The gas contained in the 8DAB 12 medium-voltage switchgear consists exclusively of natural constituents of the ambient air with no any chemical additives. These constituents are, for example, nitrogen (N_2) and oxygen (O_2). The 8DAB 12 is a gas-insulated medium-voltage switchgear that works with the proven vacuum switching technology, so the operator benefits from the all the advantages of this technology: no maintenance, compact design, high operating and personal safety, and high availability. Clean air provides the added benefits of easier handling during installation and recycling. In addition, it’s not necessary to report the quantity of gas used.

Siemens has been using its vacuum interruption technology in its medium-voltage switchgear for more than 40 years. It’s also used in high-voltage systems and recently in switchgear up to 145 kV as well. With vacuum switching technology, when the contacts open the switching arc burns in a metal vapor plasma between the contacts inside the vacuum extinction chamber. The metal vapor condenses back onto the contacts after the arc is extinguished. No decomposition products occur, and the arc doesn’t affect the surrounding insulation. This means that natural gases that aren’t suitable for extinguishing arcs can be used to insulate the current-carrying conductors.

Summary

A number of alternatives to SF_6 high technology for use in high- and medium-voltage products are currently being discussed, with pilot systems in operation and on the market for selected applications. Siemens considers that insulating gases based on natural components of ambient air (clean air) are a good solution, especially from the perspective of sustainability. All insulating gases that contain fluorine could also be subject to assessment based on the European regulation on fluorinated greenhouse gases in the medium term.

The technical feasibility of alternatives to SF_6 high technology has been demonstrated in selected applications. The Siemens blue portfolio approach opens up additional fields of application for the future. But this will require meaningful, continuing efforts for a period of years to cover as many fields of application as possible that are currently served by technically and economically optimized SF_6 high technology. Incentivization, for example in research and development, in a replacement program for obsolete plant, and in compensation for initial investments would encourage efforts to start producing alternatives.

The Siemens blue portfolio represents a further offering parallel to the economically optimized SF_6 high technology aimed specifically at customers seeking an alternative to SF_6. Blue products require a higher investment, but this is counterbalanced by their environmental sustainability. Any consideration should also look at the costs over the entire product lifecycle, especially during plant operation (operating and maintenance costs), and the end of the product service life (disposal). When clean air is used, this also removes the requirement to produce reports on the use of F-gases.

Siemens blue products currently serve selected applications and markets, and reflect the efforts the company is making to provide F-gas-free solutions.

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Siemens AG (Berlin and Munich) is a global technology powerhouse that has stood for engineering excellence, innovation, quality, reliability and internationality for 170 years. The company is active around the globe, focusing on the areas of electrification, automation and digitalization. One of the world's largest producers of energy-efficient, resource-saving technologies, Siemens is a leading supplier of efficient power generation and power transmission solutions and a pioneer in infrastructure solutions as well as automation, drive and software solutions for industry. With its publicly listed subsidiary Siemens Healthineers AG, the company is also a leading provider of medical imaging equipment – such as computed tomography and magnetic resonance imaging systems – and a leader in laboratory diagnostics as well as clinical IT. In fiscal 2017, which ended on September 30, 2017, Siemens generated revenue of €83.0 billion and net income of €6.2 billion. At the end of September 2017, the company had around 377,000 employees worldwide. Further information is available on the Internet at www.siemens.com.