

# Transition to Climate Neutral, Safe and Sustainable Power Grids

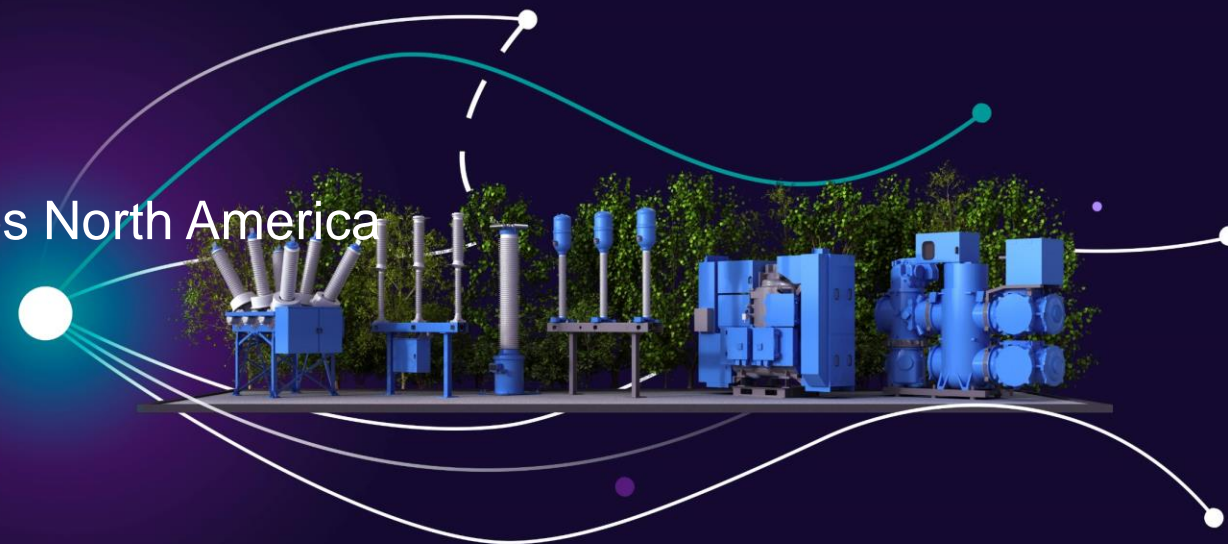
## SF<sub>6</sub> free, F-gas free and GHG free High Voltage Switchgear

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Director Sales and Innovation, Grid Technologies North America

October 31, 2022

Workshop 3, 11:00-12:00

Cigre Canada Conference and Expo, Calgary



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Greenhouse gas free & F-gas free grids, Regulations**

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# There is an increasingly urgent need to achieve decarbonization in all sectors worldwide – actions to reduce GHG emissions must be taken fast

- In the UNFCCC (United Nations Framework Convention on Climate Change) Paris Agreement signed by 189 countries in 2015, it was agreed to limit anthropogenic global warming to well under 2° centigrade
- Each country must determine and report regularly on how it intends to mitigate its greenhouse gas emissions and thus reduce global warming

## CAN

2035: Net zero electricity  
2050: Net zero GHG pollution

## US

2035: 100% clean electricity  
2050: Net zero GHG pollution

## EU

2050: First climate-neutral continent

## China


> 2030: CO<sub>2</sub> emission peak  
> 2060: Carbon neutrality






# Take Action for the Sustainable Development Goals

The Sustainable Development Goals are the blueprint to achieve a better and more sustainable future for all. They address the global challenges we face, including poverty, inequality, climate change, environmental degradation, peace and justice. Learn more and take action.







# Siemens Energy is committed to realize UN Sustainable Development Goals

## We want to enable our transmission industry to achieve its sustainability goals



### Core sustainable development goals for electrical grids

- **Health and Well-being**

Goals are **highest occupational safety** for production, operation and service and **highest public health and safety**:

ZERO toxicity and

ZERO pollution: no PFAS (forever chemicals) F-gases

- **Affordable and Clean Energy**

Clean generation: ZERO GHG emission by renewable generation

Clean grids: ZERO GHG use in electrical grids

- **Climate Action**

ZERO SF<sub>6</sub>

ZERO GHG: Global Warming Potential (GWP) = 0

# The world is jointly working on a safe and sustainable future

## Goals, Agreements and Regulations



UN Sustainable Development Goals

UN Paris Climate Agreement



CAN:

Net-zero Emissions Accountability Act

2035 net-zero electricity

2050 net-zero GHG emissions

US

2035 100% Clean electricity

2050 Net-Zero GHG pollution

Recommitting the US to the Paris Climate Agreement

Executive Order on Protecting Public Health and Environment

Executive Order on Tackling the Climate Crisis

CLEAN Future Act     CARB regulation for SF<sub>6</sub> & GHG emissions

EU

2050 First climate neutral continent

EU F-GHG regulation

EU Chemical Strategy for Sustainability and a toxic-free environment

EU Safe and Sustainable by design

EU PFAS restrictions

China

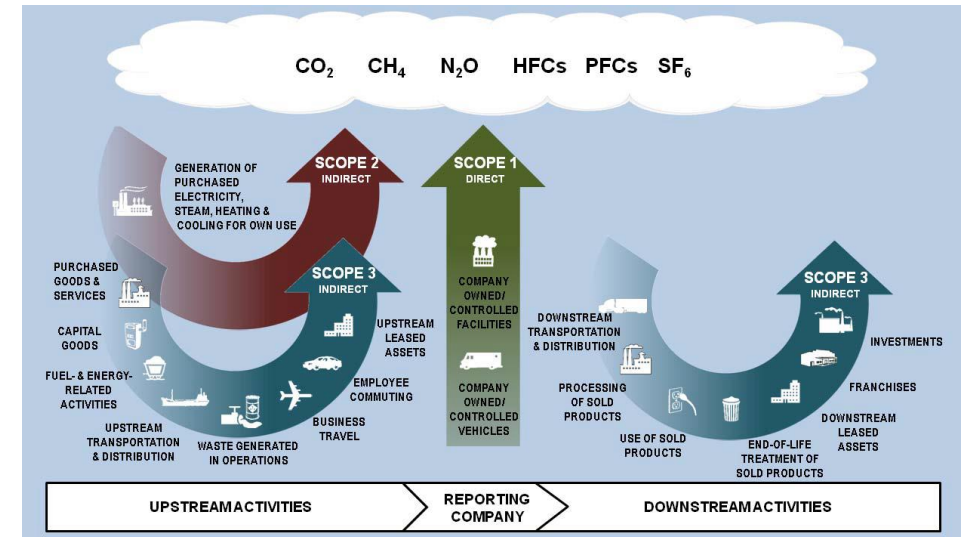
Before 2030 CO<sub>2</sub> Emission peak  
2060 Carbon neutrality

# Major TSO's have committed to the UN global sustainability goals and report according GHG protocol

## UN Global Sustainability Goals



## Reporting acc. to Greenhouse Gas (GHG) Protocol



**Scope 1:**  
Direct Emissions from own sources

**Scope 2:**  
Indirect emissions from purchased energy

**Scope 3:**  
All other indirect emissions in value chain



# The pressure on power companies to phase out SF<sub>6</sub> and other F-gases is especially high

- With global carbon emissions hitting an all-time high of 36.8 billion metric tons in 2019, there is growing pressure on power companies to step up their decarbonization efforts
- SF<sub>6</sub> is classified as a strong greenhouse gas (GHG) with a CO<sub>2</sub> equivalent of 25,200, but is still commonly used as an isolation gas in switchgear products
- An increasing number of companies have already committed to switching to SF<sub>6</sub>-free alternatives



# California SF<sub>6</sub> & GHG Regulation

Electricity grids: GHG emissions

Final regulation order

## Phase out of SF<sub>6</sub> in GIE (Gas-insulated equipment)

### 1) Stepwise phase-out of SF<sub>6</sub> for GIE in electrical grids

*Table 1. Phase-Out Dates for SF<sub>6</sub> GIE with Voltage Capacity ≤ 38 kV*

Configuration	Voltage Capacity (kV)	Short-Circuit Current Rating (kA)	Phase-Out Date
Aboveground	< 38	All	January 1, 2025
	38	All	January 1, 2028
Belowground	≤ 38	< 25	January 1, 2025
		≥ 25	January 1, 2031

*Table 2. Phase-Out Dates for SF<sub>6</sub> GIE with Voltage Capacity > 38 kV*

Voltage Capacity (kV)	Short-Circuit Current Rating (kA)	Phase-Out Date
38 < kV ≤ 145	< 63	January 1, 2025
	≥ 63	January 1, 2028
145 < kV ≤ 245	< 63	January 1, 2027
	≥ 63	January 1, 2031
> 245	All	January 1, 2033

### 2) Reporting of all gases with a GWP > 1

... Siemens Energy Blue F-gas-free portfolio with GWP = 0 fully complies with the Californian regulation and is not regulated (not covered gas because of GWP=0: no ban, no reporting duties)



A photograph of a middle-aged man with grey hair, wearing a light blue button-down shirt, sitting on a boat. He is looking towards the right of the frame. Behind him is a large green sail. The background shows a body of water and a distant shoreline under a clear sky. The text 'Challenging the energy industry on SF6' is overlaid on the left side of the image.

# Challenging the energy industry on SF6

Source: <https://assets.siemens-energy.com/siemens/assets/api/uuid:ce31f501-4351-4511-8c60-2715119fab88/sustainability-report-2020-siemens-energy.pdf>

October 31, 2022, Cigre Canada Workshop – Transition to Climate Neutral, Safe and Sustainable Power Grids

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# EU F-Gas Regulation

Proposal for legislation from  
05.04.2022

COM(2022) 150 final

DG Climate lead

(23) Installation and replacement of the following electrical switchgear:	(a)	medium voltage switchgear for primary and secondary distribution up to 24 kV, with insulating or breaking medium using, or whose functioning relies upon, gases with GWP of 10 or more, or with GWP of 2000 or more, unless evidence is provided that no suitable alternative is available based on technical grounds within the lower GWP ranges referred to above;	1 January 2026
	(b)	medium voltage switchgear for primary and secondary distribution from more than 24 kV and up to 52 kV, with insulating or breaking medium using, or whose functioning relies upon gases with GWP of 10 or more, or with GWP of more than 2000, unless evidence is provided that no suitable alternative is available based on technical grounds within the lower GWP ranges referred to above;	1 January 2030
	(c)	high voltage switchgear from 52 and up to 145 kV and up to 50 kA short circuit current with insulating or breaking medium using, or whose functioning relies upon gases with GWP of 10 or more, or with GWP of more than 2000, unless evidence is provided that no suitable alternative is available based on technical grounds within the lower GWP ranges referred to above;	1 January 2028
	(d)	high voltage switchgear of more than 145 kV or more than 50 kA short circuit current with insulating or breaking medium using, or whose functioning relies upon gases with GWP of 10 or more, or with GWP of more than 2000 unless evidence is provided that no suitable alternative is available based on technical grounds within the lower GWP ranges referred to above.	1 January 2031

## Prohibition of Switchgear with F-gases starting 2026

- 1) Reporting obligations for F-Gases as SF<sub>6</sub> (ANNEX II and III)
- 2) Prohibition of switchgear with F-Gases with GWP > 10 (ANNEX IV)
  - Up to 24 kV: From January 1<sup>st</sup>, 2026
  - 24 to 52 kV: From January 1<sup>st</sup>, 2030
  - 52 to 145 kV: From January 1<sup>st</sup>, 2028
  - Above 145 kV: From January 1<sup>st</sup>, 2031

### Exceptions:

Option a) If GWP below 10 is not available:

- F-gases between GWP 10 and 2000 may be used

Option b) If GWP below 2000 is not available:

- F-Gases above GWP 2000 may be used

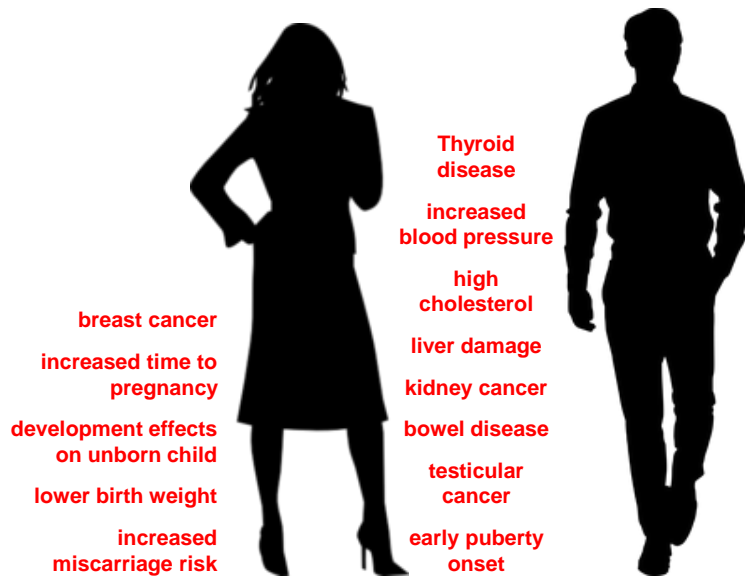
**... Siemens Energy Blue portfolio without F-gases and GWP = 0 fully complies with the EU Proposal and is not regulated**

# Restrictions on Chemicals

## SF<sub>6</sub> and PFAS\* F-Gases are in restriction process globally



### Risks of F-gases for health & safety



- Toxic decomposition products arise in SF<sub>6</sub> due to electric arcs and in F-gas-mixes additionally during operation
- PFAS\*: > 4,700 chemicals that accumulate in humans and environment and are highly persistent and toxic (health impact; contamination of water and soil).



### Cost risks of F-gas regulations

- F-gas regulation (EU) | SF<sub>6</sub> reporting (US) | CARB (California)
- REACH (EU) to improve the protection of human health and the environment from the risks that can be posed by chemicals.
- Beginning of 2020, five EU states (DK, SE, NO, DE, NL) started activities with the target to ban all PFAS within EU, unless it is considered as 'essential' for society
- Worldwide organizations will follow, e.g. Stockholm Convention - UN; Environment Protection Agency (EPA) – US
- July 2021: EU Registry of restriction for PFAS
- July 2021: US Senate and House enacted PFAS Action Act

\*per- and polyfluoroalkyl substances

- SF<sub>6</sub> is already restricted and phase-out is only a matter of time
- PFAS F-gases restriction has started

# Government of Canada: SF<sub>6</sub> a variety of preventive control actions PFAS, e.g. Flouornitrile: review policy developments in other jurisdictions

## Toxic substances list: sulphur hexafluoride

Sulphur hexafluoride (SF<sub>6</sub>) is a synthetic (i.e., human-made) gas that is colourless, odorless, non-toxic (except when exposed to extreme temperatures), and non-flammable. It is heavier than air and hence stays close to the ground upon release which can cause death by suffocation if large quantities are involved. SF<sub>6</sub> is primarily used in the electricity industry as insulating gas for high voltage equipment. It is also used as cover gas in the magnesium industry to prevent oxidation (combustion) of molten magnesium. In lesser amounts, SF<sub>6</sub> is used in the electronic industry in manufacturing of semiconductors, and also as tracer gas for gas dispersion studies in the industrial and laboratory settings. Sulphur hexafluoride acts as a greenhouse gas due to its very high heat trapping capacity.

Sulphur hexafluoride was added to Schedule 1 of CEPA in November 2005. Under subsection 90(1) of CEPA, a substance can be added to Schedule 1 of CEPA by the Governor in Council on the recommendation of the ministers of the environment and health if it is determined that a substance is entering or may enter the environment in a quantity or concentration or under conditions that:

- (a) have or may have an immediate or long-term harmful effect on the environment or its biological diversity;
- (b) constitute or may constitute a danger to the environment on which life depends; or
- (c) constitute or may constitute a danger in Canada to human life or health.

Based on an analysis of the existing science, most notably documented in the Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC) and in subsequent reports including the Fifth Assessment Report (2014), there is sufficient evidence to conclude that the principal greenhouse gases namely carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF<sub>6</sub>)

constitute or may constitute a danger to the environment on which life depends. The addition of sulfur hexafluoride to schedule 1 of CEPA gives the Government the power to put in place a variety of preventative or control actions to control SF<sub>6</sub> under that same Act. The reporting on releases of SF<sub>6</sub> to the atmosphere is regulated under section 46 of CEPA and is required from large industrial and commercial facilities that meet a certain threshold for their combined emissions in CO<sub>2</sub> equivalent of the six principal greenhouse gases.

CAS (Chemical Abstract Service) registry number: 2551-62-4

## Risk Assessment

- [Order Adding Toxic Substances to Schedule 1 to the Canadian Environmental Protection Act, 1999](#)

Source: <https://www.canada.ca/en/environment-climate-change/services/management-toxic-substances/list-canadian-environmental-protection-act/sulphur-hexafluoride.html>

## Per- and polyfluoroalkyl substances (PFAS)

Per- and polyfluoroalkyl substances (PFAS) are a group of over 4,700 human-made substances that are used as surfactants, lubricants, repellents (for dirt, water, and grease). They can be found in certain firefighting foams, textiles (including carpets, furniture, and clothing), cosmetics, and in food packaging materials.

Adverse environmental and health effects have been observed for well-studied PFAS (PFOS, PFOA, and LC-PFCAs and their salts and precursors) and they have been shown to pose a risk to the Canadian environment. In Canada, PFOS, PFOA, and LC-PFCAs (and their salts and precursors) are prohibited through regulations; however, scientific evidence to date indicates the PFAS used to replace regulated PFOS, PFOA, and LC-PFCAs may also be associated with environmental and/or human health effects.

Therefore, the Government of Canada is considering activities that would address PFAS as a class. A [notice of intent to address the broad class of PFAS was published in the Canada Gazette, Part I, Vol. 155 No. 17 – April 24, 2021](#).

In 2021, the Government of Canada will:

- continue to invest in research and monitoring on PFAS
- collect and examine information on PFAS to inform a class-based approach
- review policy developments in other jurisdictions

In addition, within the next 2 years, the Government of Canada will publish a state of PFAS report, which will summarize relevant information on the class of PFAS.

Stakeholders and interested parties will have opportunities to provide input to help inform Government of Canada activities related to addressing PFAS as a class. As a first step, stakeholders are invited to provide initial feedback on the intent to address PFAS as a class, including challenges or opportunities they foresee, or indicate their interest in being engaged in future discussions by emailing [substances@ec.gc.ca](mailto:substances@ec.gc.ca).

### Related information

- [Long-chain \(C9-C20\) Perfluorocarboxylic Acids \(LC-PFCAs\), their salts and precursors](#)
- [Perfluorooctanoic Acid \(PFOA\), its salts and precursors](#)
- [Perfluorooctane sulfonate \(PFOS\)](#)

Source: <https://www.canada.ca/en/health-canada/services/chemical-substances/other-chemical-substances-interest/per-polyfluoroalkyl-substances.html>



# Restrictions on Chemicals SF<sub>6</sub> and PFAS\* F-Gases are in restriction process globally

## EU – Restriction for PFAS - 2025

Restriction of per- and polyfluoroalkyl substances (PFAS) under REACH

Webinar date

29 Oktober 2020 13:30 - 15:30 CET, GMT +1

Summary

Germany, the Netherlands, Norway, Sweden and Denmark are working on a REACH restriction proposal to limit the risks to the environment and human health from the manufacture and use of all per- and polyfluoroalkyl substances (PFAS). A call for evidence was held during the summer of 2020.

Join the webinar to learn about the REACH restriction process and status of the proposed PFAS restriction.

The webinar will be published on our home page on 29 October at 13:30 CET, GMT +1 together with instructions for joining a live Q&A session where experts from the 5 Member States will be answering your questions until 15:30. Join the [Slido Q&A session](#) or by going to [slido.com](#) and entering the event code: **pfas2020**

Five European states call for evidence on broad PFAS restriction - [ECHA news release, 11 May 2020](#)

More on PFAS



\*per- and polyfluoroalkyl substances

## US – EPA action to address PFAS

A screenshot of the EPA website. The header includes the EPA logo and "United States Environmental Protection Agency". A search bar contains "Search EPA.gov". The navigation menu has "Environmental Topics", "Laws &amp; Regulations", "Report a Violation", and "About EPA". The main content area is titled "PFOA, PFOS and Other PFAS" and "EPA Actions to Address PFAS". It includes a "PFAS News Releases" box with a link to "Read the latest news from EPA about PFAS".

### EPA Actions to Address PFAS

Under the Biden-Harris Administration, EPA has restored scientific integrity and accelerated the pace of research and actions needed to tackle the PFAS crisis and protect American communities.

- [Learn more about PFAS.](#)
- [Learn more about EPA's PFAS Strategic Roadmap.](#)

Since January 2021, EPA has taken bold actions, including:

### Clean Water PFAS Actions

In April 2022, EPA announced three clean water actions that advance progress under EPA's PFAS Strategic Roadmap:

### Draft Aquatic Life Criteria for PFOA and PFOS

- EPA proposed the first Clean Water Act aquatic life criteria for PFAS, focusing on two of the most well-studied chemicals in this group: PFOA and PFOS. These draft recommendations reflect the latest peer-reviewed scientific knowledge regarding the toxicological effects of PFOA and PFOS on freshwater aquatic organisms.
  - [Review the 2022 Draft Recommended Aquatic Life Criteria for PFOA](#)
  - [Review the 2022 Draft Recommended Aquatic Life Criteria for PFOS](#)

## US – Main stops PFAS pollution 2023-30

LAW WITHOUT  
GOVERNOR'S  
SIGNATURE  
JULY 15, 2021

CHAPTER  
477  
PUBLIC LAW

STATE OF MAINE

IN THE YEAR OF OUR LORD  
TWO THOUSAND TWENTY-ONE

H.P. 1113 - L.D. 1503

### An Act To Stop Perfluoroalkyl and Polyfluoroalkyl Substances Pollution

**Emergency preamble.** Whereas, acts and resolves of the Legislature do not become effective until 90 days after adjournment unless enacted as emergencies; and

**Whereas,** contamination of soil and water in the State from perfluoroalkyl and polyfluoroalkyl substances, or PFAS, poses a significant threat to the environment of the State and to the health of its citizens; and

**Whereas,** the full extent of PFAS contamination in the State is not presently known but is anticipated to be widespread and to require a significant expenditure of resources to identify and remediate; and

**Whereas,** PFAS continue to be used across a variety of industries for a variety of purposes and are ultimately contained in a variety of products sold in the State; and

**Whereas,** to address the imminent threat of further contamination of soil and water in the State, it is imperative to collect information regarding the use of PFAS in and to phase out the sale of certain nonessential products containing PFAS, as proposed in this legislation; and

**Whereas,** in the judgment of the Legislature, these facts create an emergency within the meaning of the Constitution of Maine and require the following legislation as immediately necessary for the preservation of the public peace, health and safety; now, therefore,

Be it enacted by the People of the State of Maine as follows:

Sec. 1. 38 MRSA §1612 is enacted to read:

**§1612. Products containing PFAS**

# Regulations and legislations

## -> Globally decarbonization started to become climate-neutral

IPCC  
08/2021 ✓ AR6 report: Reduction of greenhouse gases to zero needed to mitigate climate change  
-> Replacement needed: SF<sub>6</sub> GWP<sub>100</sub> = 25.200, Fluoronitril C4 GWP<sub>100</sub> = 2750, GWP<sub>20</sub> = 4580  
AR 6 report: 6<sup>th</sup> Assessment Report by the Intergovernmental Panel on Climate Change from the United Nations.

GHG /  
F-Gases ✓ EU Revision of F-gas regulation in response to the urgency for climate action in progress, for switchgears gradual **bans of F-gases with GWP > 10** from 2026, see proposal from 05.04.2022 COM(2022) 150 final  
✓ California: Gradual ban on SF<sub>6</sub> from 2025, F-gases with GWP > 1 are subject to reporting analogously SF<sub>6</sub>

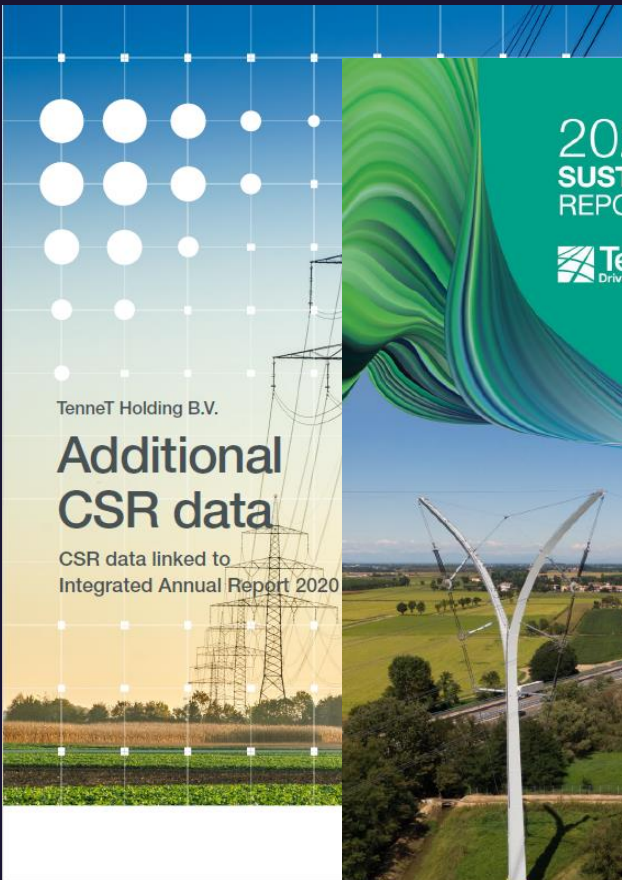
Chemicals /  
PFAS ✓ EU REACH: In order to improve the protection of human health and the environment, a ban on PFAS\* has been initiated, unless there is an 'essential use', Registry of restriction  
✓ The Environmental Protection Agency (EPA) in US established a PFAS\* Council, US state Maine placed a first PFAS ban from 01.01.2030

\*Per- und polyfluoroalkyl Substances including F-Gases as Fluoronitril C4FN and Fluoroketone C5FK used as alternative to SF<sub>6</sub> in switchgears  
REACH: Registration, Evaluation, Authorization and Restriction of Chemicals is a European Union regulation.

Users ✓ Globally, grid operators own commitments to net zero and specifications for equipment with GWP < 1, NG in UK wants to buy no SF<sub>6</sub> from 2026 and replace all equipment with SF<sub>6</sub> by 2050



# Many TSO's provide detailed sustainability reports that address SF6 emissions





# Hydro One Sustainability Report 2020

## SF<sub>6</sub> is highest Scope 1 direct emission and is directly influenceable



### Climate Change: Mitigation and Adaptation

#### Approach

We are creating a better and brighter future for all Ontarians by focusing on reducing our carbon footprint and creating a resilient grid for the future. At the management level, climate change is governed by a cross-functional leadership level committee and guided by our environmental policy and climate change management strategy.

#### Low-Carbon Energy Mix

Ontario has one of the lowest carbon-emitting electricity grids in North America.

Ontario's electricity sources are largely carbon-free – Hydro One transmits and distributes electricity that is approximately 96%<sup>20</sup> carbon emission-free<sup>21</sup> and our GHG emissions are estimated to account for only 0.2% of Ontario's total GHG emissions.<sup>22</sup>

#### ESG Corner

Key ESG policies, programs and management systems guiding our actions include:

- Environmental policy
- Climate change policy
- Climate change management strategy
- Grid resiliency strategy
- Climate change committee

#### 2020 Performance

For 2020, Hydro One is reporting Scope 1 and Scope 2 GHG emissions. These emissions have been verified by a third party.<sup>23</sup> We have calculated these emissions using the most recent Canadian emission factors published by Environment and Climate Change Canada in April 2021.

Hydro One's total reported GHG emissions<sup>24</sup> in 2020 are estimated to be 344,722 metric tonnes of carbon dioxide equivalents (tCO<sub>2</sub>e).

Our Scope 1 emissions are predominantly from our vehicle fleet, fuel consumption,<sup>25</sup> fossil fuel-based electricity generation in Hydro One Remote Communities operations<sup>26</sup> and sulfur hexafluoride (SF<sub>6</sub>)<sup>27</sup> releases. Scope 1 emissions increased by approximately 9% in 2020 as compared to the 2018 baseline year, due to an increase in SF<sub>6</sub> releases and a slight increase in emissions from Hydro One Remote Communities fossil fuel generation. It is anticipated that these emissions will be reduced in the future through an enhanced SF<sub>6</sub> management program and as northern communities are connected to the electricity grid.

#### GHG Emission Classification

**Scope 1** – Direct emissions from sources owned or controlled by Hydro One (e.g., use of fossil fuels in our owned and operated fleet vehicles).

**Scope 2** – Indirect emissions from the generation of acquired and consumed electricity, steam, heat, or cooling from sources owned or controlled by an external organization (e.g., from energy purchased for use in our facilities and GHG emissions related to transmission and distribution).

The primary source of Scope 2 emissions<sup>28</sup> is related to line losses which are determined by the energy lost as heat when we move power and the energy mix in the province. Scope 2 emissions were approximately 3% lower than our baseline emissions from 2018 primarily due to reduced line losses attributable to changing energy demands.

<sup>20</sup> As determined by the Canadian Energy Regulator.

<sup>21</sup> The average Ontario system grid emissions five-year average is 32 gCO<sub>2</sub>e/kWh (2015–2019). Source of data: Canada's National Inventory Report, 1990–2019, Part 3, Annex 13, Table A13-7. Electricity Generation and GHG Emission Details for Ontario.

<sup>22</sup> All data is from the Environment and Climate Change Canada's National Inventory Report 1990–2019: Greenhouse Gas Sources and Sinks in Canada, Part 3. Hydro One's emissions are those that directly relate to the electricity sector.

<sup>23</sup> GHD Limited verified Hydro One's GHG Emissions report for the compliance period of January 1 to December 31, 2020. The [letter of assurance](#) can be found in the appendix.

<sup>24</sup> Hydro One's GHG Inventory is aligned with the GHG Protocol Corporate Accounting and Reporting Standard; ISO 14064-1:2018; Greenhouse Gas Emissions: Quantification, Reporting and Verification Regulation (O.Reg. 390/18). Emission Factors are from Canada's National Inventory Report 1990–2019 and Global Warming Potential (GWP) from the IPCC Fourth Assessment Report (AR4).

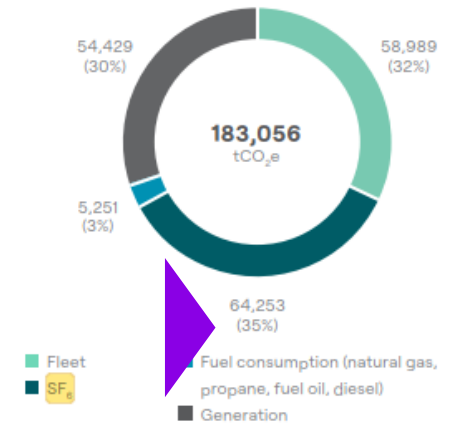
<sup>25</sup> Fuel consumption includes natural gas, propane, fuel oil and diesel.

<sup>26</sup> Hydro One Remote Communities Inc. serves 22 communities in Ontario's north. Due to the lack of grid connection to the majority of these communities we serve (all but one), they generate electricity to meet their obligation under Section 26 of the Electricity Act, 1998.

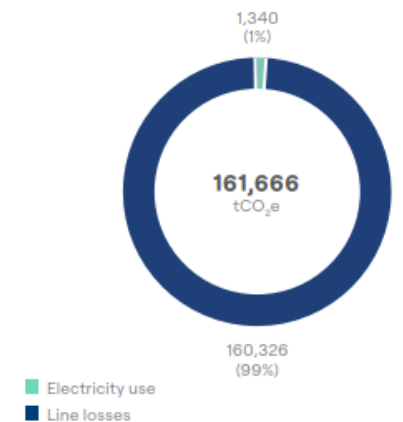
<sup>27</sup> SF<sub>6</sub> is used to insulate high-voltage circuit breakers and gas-insulated switchgear.

<sup>28</sup> Scope 2 emissions are not directly controlled by Hydro One and are subject to the [composition of energy generated and dispatched](#) through the Ontario grid for consumption.

#### Scope 1 Emissions<sup>29</sup>



#### Scope 2 Emissions



<sup>29</sup> R22 is not represented on the graph as it's less than 1% of Scope 1 emissions, at 134 tCO<sub>2</sub>e.

# Hydro One Sustainability Report 2020

## GHG reduction targets for SF<sub>6</sub> : Replace and Eliminate SF<sub>6</sub>

### 1. Replace leaking equipment

“Reduce SF<sub>6</sub> gas releases and leaks by identifying and replacing equipment that contribute to leaks”

### 2. Eliminate SF<sub>6</sub> usage

“Eliminate, whenever possible, the usage of SF<sub>6</sub> in our equipment”

## Setting GHG reduction targets



At Hydro One we recognize the vital role we play in helping Ontario communities grow and thrive – now and in the future. We emit a small amount of GHG emissions but we believe that we have a responsibility to lower our footprint even further.

We are excited to announce our commitment to reduce our GHG emissions by 30% by 2030 and to achieve net zero emissions by 2050.

These are ambitious targets that will require us to substantially reduce our emissions and work with government and industry to advocate for a cleaner energy mix in Ontario.

Our current plan will see us making reductions from fleet vehicles, SF<sub>6</sub> gas releases and facility energy efficiency and include programs to:

- Decrease the amount of fossil fuels Hydro One’s vehicle fleet consumes. We plan to convert 50% of our fleet of sedans and SUVs to electric vehicles or hybrids by 2025 and 100% by 2030.
- Reduce SF<sub>6</sub> gas releases and leaks by identifying and replacing equipment that contribute to leaks, improve gas handling through training and eliminate, whenever possible, the usage of SF<sub>6</sub> in our equipment.

- Continue to install building automation and energy efficiency technologies at our facilities to help reduce overall energy consumption, including enhanced web-enabled thermostats, sensors and controllers.
- Pursue renewable generation opportunities to reduce Hydro One Remote Communities’ dependency on diesel fuel to generate power.
- As required, we will also investigate future opportunities to reduce emissions including carbon capture initiatives – such as tree planting and biodiversity initiatives and consider carbon avoidance or offsets.



# Carbon Tax Price today up to US\$ 140 / tCO<sub>2</sub>e

Example: 1 HV-GIS bay: 100kg banked SF<sub>6</sub>. Tax 2.520t CO<sub>2</sub>e x 130 US = US\$ 327.600

Prices in implemented carbon pricing initiatives selected



THE WORLD BANK  
What we Do / Data / Carbon Pricing Dashboard

Carbon Pricing Dashboard

Map & Data

Displaying Map for the YEAR 2019, for multiple STATUSES, for multiple INSTRUMENTS, for multiple JURISDICTIONS

MAP GHG EMISSION COVERAGE PRICE VALUE

1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019

Source: World Bank, 28. October 2021 [https://carbonpricingdashboard.worldbank.org/map\\_data](https://carbonpricingdashboard.worldbank.org/map_data)

[Siemens decarbonization position paper](#): Siemens joined the Carbon Pricing Leadership Coalition of the World Bank (CPLC) in 2016 to advocate the introduction of carbon pricing globally.

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  - 5 **Questions and Discussion**

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# SF<sub>6</sub> is the most harmful greenhouse gas with a GWP 25,200 times higher than CO<sub>2</sub>

## What is global warming potential (GWP)?

It represents the heat absorption effect of any GHG relative to CO<sub>2</sub>, which has a GWP of 1

## SF<sub>6</sub> installations

10,000 tons of SF<sub>6</sub> are installed globally every year. This gas has a GWP of 25,200



It takes **3,200 years** for nature to absorb SF<sub>6</sub>

**18,800,000 trees** are needed to absorb the impact of the yearly installations



~ 28 million soccer fields

## SF<sub>6</sub> leakage

An estimated leakage rate of 0.46%<sup>1</sup> results in an annual amount of 46 tons



Again, it takes **3,200 years** for this gas to be absorbed

**86,480,000 trees** are needed to absorb the impact of the yearly leakage of SF<sub>6</sub>



~ 128,000 soccer fields

# Less harmful F-gas mixes are not a sustainable alternative since carbon neutrality can only be achieved with a GWP of Zero

## Fluoronitrile-mix<sup>1</sup>

10,000 tons of Fluoronitrile-mix are installed annually, with leakage<sup>2</sup> of 50 tons and a GWP of around 500



It takes **30 years** for nature to absorb Fluoronitrile-mix



**321,600,000 trees** are needed to absorb the impact of the yearly installation and leakage



~ 476,000 soccer fields

## Vacuum and clean air

This is the most environmentally friendly switching technology in the world with a GWP of 0



The leakage rate of clean air is **0.1%** and it is naturally absorbed by the surrounding air



**0 trees needed**  
No greenhouse gases  
No impact on health or environment



**0 soccer fields**

At the moment, a GWP of Zero can only be achieved by clean air and vacuum technology



<sup>1</sup> Besides vacuum and clean air, Fluoronitrile-mix (GE&ABB) is the most common SF<sub>6</sub> alternative

<sup>2</sup> Leakage rate of Fluoronitrile-mix is typically 0.5%

# Phasing out SF<sub>6</sub> and other F-gas mixes is inevitable – clean air is the only future-proof option



## Health and safety risks of F-gases

- SF<sub>6</sub> and fluoronitrile F-gas mixes produce toxic decomposition products during electric arcs and operation
- Fluoronitrile belongs to the PFAS<sup>1</sup> group: more than 4,700 chemicals which accumulate in both humans and the environment, and which are highly persistent and toxic (negative health impact; contamination of water and soil).



## Cost risks of SF<sub>6</sub> / F-gas regulations

- F-gas regulation (EU)<sup>2</sup>
- SF<sub>6</sub> ban CARB (California) / PFAS ban DEP (Maine)
- REACH (EU) helps protect human health and the environment from risks associated with hazardous chemicals, such as PFAS. In 2020, five EU states<sup>3</sup> started working on a proposal with the goal of banning all 'non-essential' PFAS within the EU
- Worldwide institutions will follow, e.g. Stockholm Convention (UN) and Environment Protection Agency (EPA) (US)

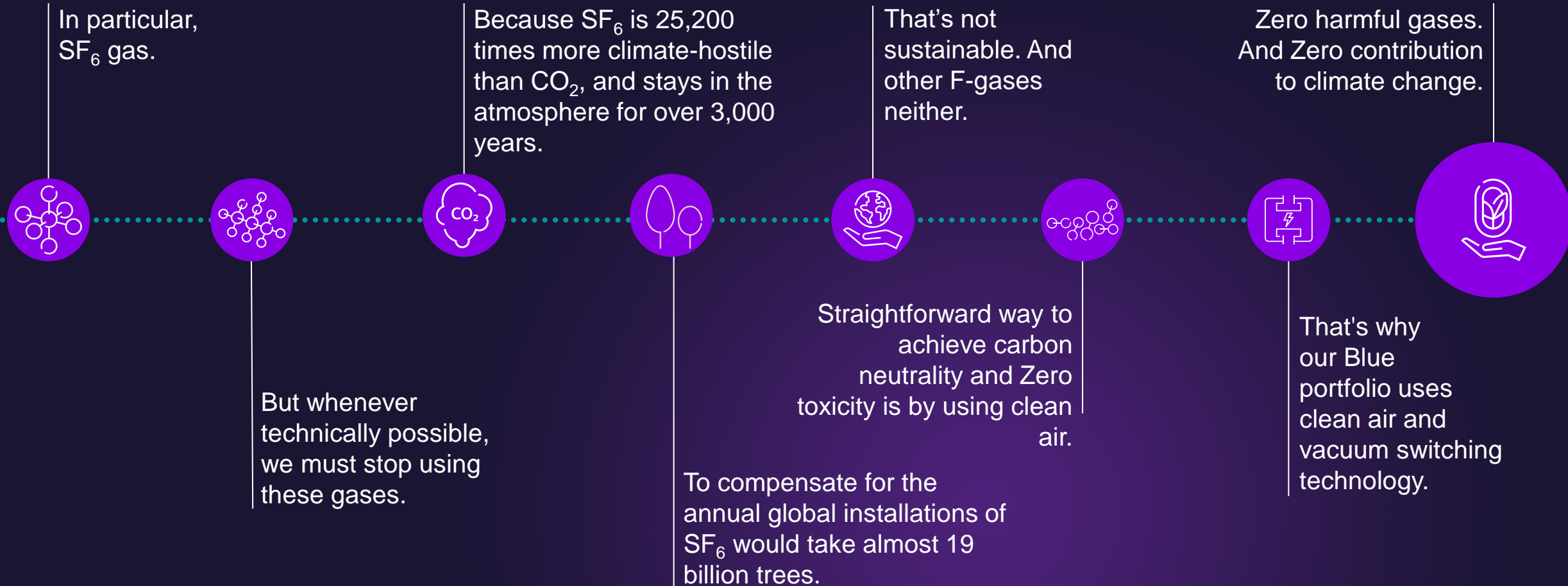
- SF<sub>6</sub> is already restricted and complete phase-out is more than probable
- F-gases are under investigation and restriction as well as a ban is possible
- Clean air does not need any regulation now or in the future

<sup>1</sup> Per- and polyfluoroalkyl substances

<sup>2</sup> The European Commission bans using F-gases with a GWP >10 in switchgear

<sup>3</sup> DK, SE, NO, DE, NL

# Until now, switchgear technology has typically used F-gases...





# The Blue portfolio is based on game-changing technology: vacuum switching and clean air insulation

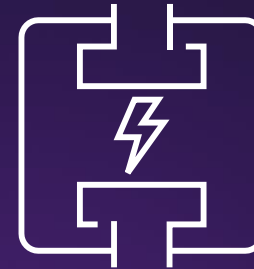
## Clean air



$N_2 + O_2 =$  pure air  
Zero CO<sub>2</sub> emissions  
Zero toxicity  
Zero hazard  
Zero liquefaction  
at low temperatures



## Vacuum technology

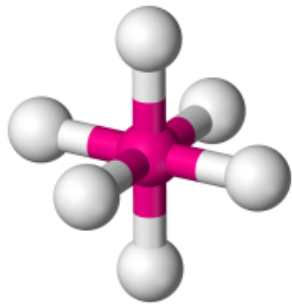


Zero CO<sub>2</sub> emissions  
Hermetical tightness to protect  
from decomposition products  
High switching performance  
without degradation  
Zero maintenance (sealed for life)

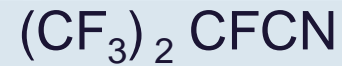
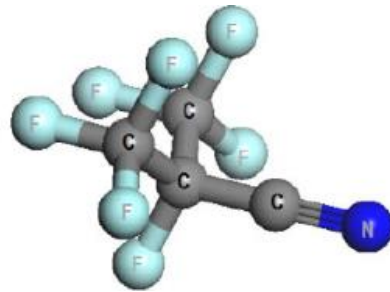
# Non-SF<sub>6</sub> Solutions

## Alternate Gases – What's in Market

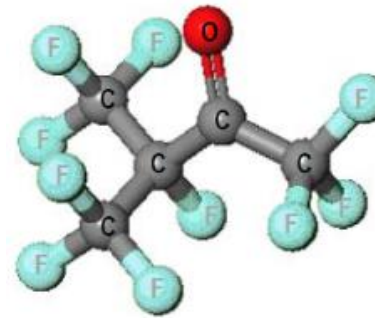
### Sulfur Hexafluoride



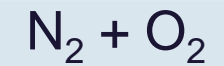
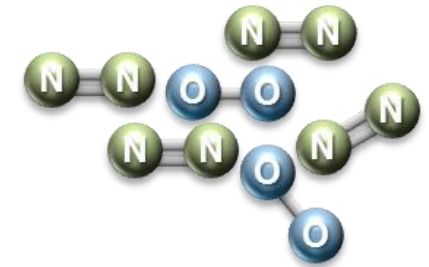
### Fluoronitrile



### C5 - Fluoroketone



### Clean Air



Carrier gas:

Pure or mixed with  
N<sub>2</sub>, CF<sub>4</sub>

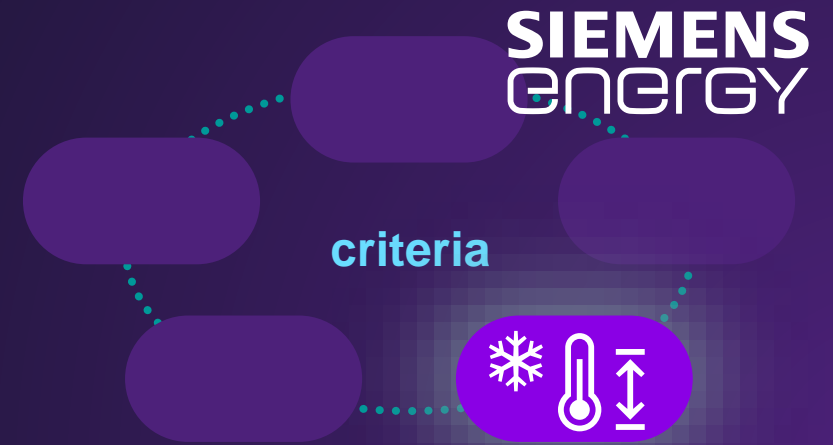
CO<sub>2</sub> and  
sometimes O<sub>2</sub>

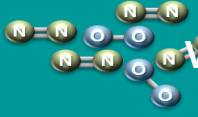
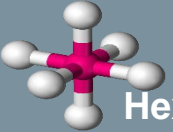
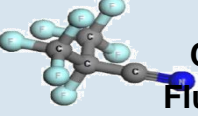
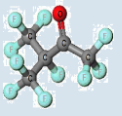
CO<sub>2</sub>, O<sub>2</sub>

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# Product-evaluation criteria: Operating temperature range

Vacuum / clean air technology can be operated in a wide temperature range and is especially suitable for **very low temperature applications**

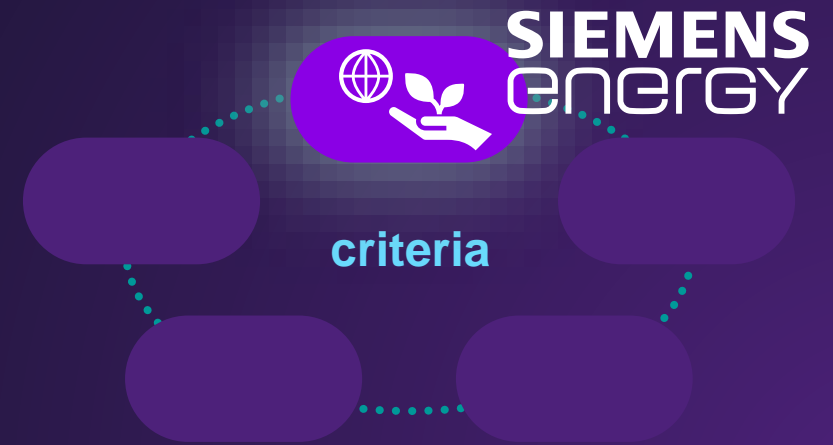


 Vacuum / clean air	From -60 °C to + 55 °C
 SF <sub>6</sub> Sulfur- Hexafluoride	From -40 °C to + 55 °C
 CO <sub>2</sub> -F-Mix Fluoronitrile	From -30 °C .. -25 °C to + 55 °C
 CO <sub>2</sub> -F-Mix C5 Fluoroketone	From +0 °C to + 55 °C



# Product-evaluation criteria: Environmental impact

GWP (Global Warming Potential) in CO<sub>2</sub>-equivalent



Vacuum / clean air – due to its zero GWP – is the **most environment-friendly** switching technology of the world

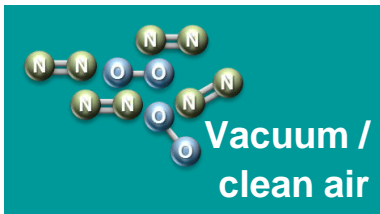
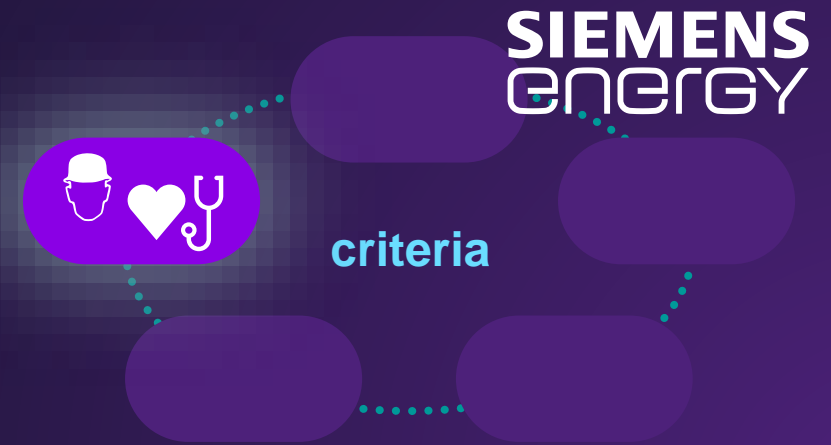
<p>Vacuum / clean air</p>	GWP = 0
<p>SF<sub>6</sub> Sulfur- Hexafluoride</p>	GWP ~ 25,200
<p>CO<sub>2</sub>-F-Mix Fluoronitrile</p>	GWP ~ 500

Note: Fluor-Ketone gas mixture not considered due to its inability to withstand temperatures below +5°C

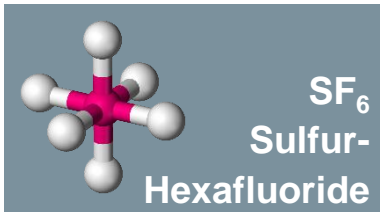
# Product-evaluation criteria: Health & safety

Gas decomposition products, gas leakage, long-term gas behavior

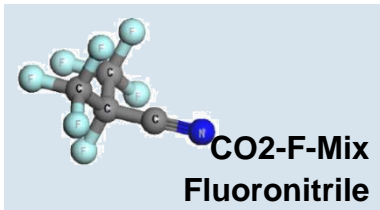
Vacuum / clean air is **non-toxic, non-hazardous** and does not require special safety systems like ventilation or CO-monitoring



- Vacuum: no decomposition products ; sealed for life
- Clean air: no arc-quenching in air; no decomposition products  
gas leakage < 0.1% p.a./compartment



- Toxic decomposition products
- Hazardous when inhaled, causes skin & eye irritation
- Gas leakage < 0.1% p.a./compartment



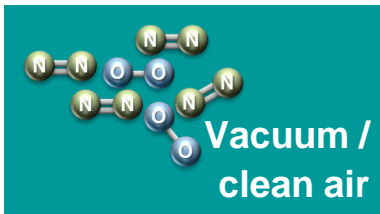
- PFAS - Toxic decomposition products (details unknown)
- Hazardous (details unknown)
- Gas leakage < 0.5% p.a./compartment (details unknown)

Note: Fluor-Ketone gas mixture not considered due to its inability to withstand temperatures below +5°C

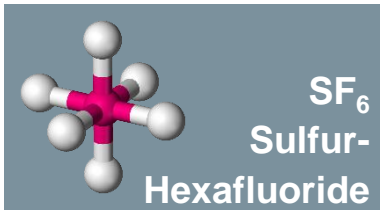
# Product-evaluation criteria: Switching performance



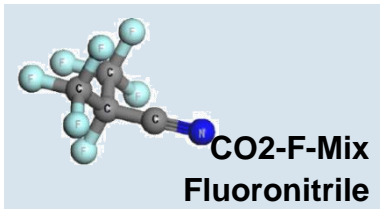
Vacuum circuit-breaker offers **highest short-circuit switching capability** without degradation and is maintenance-free



- Vacuum CB can switch up to 30 times 40 kA currents
- No degradation of short-circuit switching performance
- Vacuum interrupter: sealed for life; maintenance-free



- SF<sub>6</sub> CB can switch up to 10 times 40 kA currents
- Long term stability (SF<sub>6</sub> gas recombines)
- Known additional gas-maintenance efforts



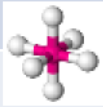

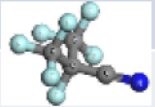
- CO<sub>2</sub>-F-mix switching performance decreasing
- Does not recombine completely after arcing
- Additional maintenance efforts required

Note: Fluor-Ketone gas mixture not considered due to its inability to withstand temperatures below +5°C



# Properties of SF<sub>6</sub> and alternative gases

## Clean Air is most sustainable & safe

	SF <sub>6</sub>	Clean Air	F-Gas-mix based on Fluoronitrile
<b>Chemical formular</b>	SF <sub>6</sub> 	N <sub>2</sub> + O <sub>2</sub> (79,5%/20,5%) 	C4F7N 
<b>CO<sub>2</sub>-equivalent / GWP<sub>100</sub></b> (100 years horizon)	22.800 (IPCC AR4) 23.500 (IPCC AR5) 25.200 (IPCC AR6 2022)	0	2.100 (Manufacturer data) 2.750 (New in IPCC AR6 2022)
<b>Boiling point (°Celsius)</b>	-64°	< -183°	-4,7°
<b>Life time (years)</b>	3.200	-	30
<b>Carrier gas</b>	Pur or mixed with N <sub>2</sub> , CF <sub>4</sub>	-	CO <sub>2</sub> + C4F7N and in some cases + O <sub>2</sub>
<b>CO<sub>2</sub>-equivalent / GWP<sub>100</sub></b>	25.200	0	> 500 based on applications
<b>Boiling point (°Celsius)</b>	-40° (with CF <sub>4</sub> ) ... -25°	<-100°	-30°...-25°C dependant on C4F7N amount
<b>Dielectric strength</b>	1 (normalized)	~ 0,4	~ 0,7
<b>Arcing impact</b>			
<b>Dissociation/decomposition</b>	~ 2000 K (reversib.)	~ 7000 K (N <sub>2</sub> reversib.)	> 920 K (irreversib.)
<b>Decomposition products</b>	HF, SO <sub>2</sub> , sulphur compounds	<b>None</b> under normal operating conditions (VIU) If failure: Ozone, NOx	F-Nitrile [4]: HF, CO, COF <sub>2</sub> , CF <sub>3</sub> CN, C <sub>2</sub> F <sub>5</sub> CN, C <sub>2</sub> F <sub>6</sub> C5-K. [6]: HF, CF <sub>4</sub> , C <sub>2</sub> F <sub>6</sub> , C <sub>5</sub> F <sub>10</sub> O, C <sub>3</sub> F <sub>8</sub> , C <sub>4</sub> F <sub>10</sub> , C <sub>3</sub> HF <sub>7</sub> C <sub>4</sub> F <sub>8</sub> , C <sub>4</sub> F <sub>6</sub> , C <sub>3</sub> F <sub>6</sub> , C <sub>2</sub> F <sub>3</sub> N, C <sub>2</sub> N <sub>2</sub> in MV GIS with air

Preferred property      Compromised property

# Clean air insulation technology

## Values for operators and society

Clean air is a composition of 80% N<sub>2</sub> and 20% O<sub>2</sub>, cleaned and free from humidity (synthetic air)

- + Global Warming Potential (GWP) = 0
- + Low boiling point and low-temperature application
- + Non-toxic
- + High stability
- + Not inflammable
- + Ozone Depletion Potential (ODP) = 0
- + F-gas free insulation with lowest requirements on transport, installation, operation, reporting and recycling
- + C-gas free with no risk of C-decomposition in insulation and switching compartments
- + Clean air insulation with well-known and proven material compatibilities
- + No special gas-mixture gas cart
- + No special gas training
- + No EHS investment cost
- + Easy availability of insulating gas
- + No gas recycling cost
- + No F-gas reporting cost
- + Secure invest with no unknown follow-up cost from F-gas regulation

# GIS Clean Air gas handling

## Evacuating:

Evacuation of a Clean Air vessels to lower the pressure in a controlled manner down to 1bar abs. Then the gas compartment can be opened.

We do not store or re-use Clean Air. Evacuation of ambient air before filling with Clean Air is done with a vacuum pump.



## Leakage detection:

Leakage detection after installation is done with Helium, like we do it during routine testing of enclosures in the factory.

Leakage detection after installation at a specific module can be done with commercially available leakage spray (quick method).

Leakage detection by measuring CO<sub>2</sub> absence (cumulative and quantitative measurement).



## Filling:

Filling will be done directly from the Clean Air bottles with the filling device which is (as always) part of delivery of a new project.

## Measuring:

After final filling, the moisture content is to be measured (dew point -10°C).



## Gas handling after internal arc:

The main decomposition products are Ozone and NOx. Ozone (O<sub>3</sub>) is recombining to O<sub>2</sub> within 1-2h. NOx are slowly disappearing.

Partly it will be neutralized by the filter GIS material. Switchgear room needs to be vented.

If the short-circuit-current was so small that the bursting disc did not operate, the gas room shall be evacuated through a filter.

Behind the filter there are no more decomposition products. Filters are the same as for SF<sub>6</sub>.



# Quantum leaps in history of high-voltage circuit breakers

from

## arc interruption in oil



**1897:** This CB was designed in the US, consisting of two barrels, originally filled with cucumbers, now filled with oil, each with a fixed and a moving contact with ropes forming the breaker

1897

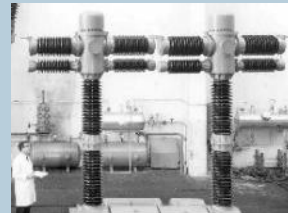
1910

**1910:** 3-pole oil breaker R40, up to 40 kV, manual drive. Start of CB manufacturing in Berlin, Germany



to...

## arc interruption in SF<sub>6</sub>

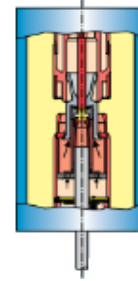


**1964:** Delivery of the first SF<sub>6</sub> dual pressure breaker for 220 kV (H 904, 1 pole)

1964

1972

**1973:** Development of the patented self-compression principle



1973



**1972:** LT breaker 3AS2, 220 kV, hydraulic drive

to...

## arc interruption in vacuum!



**2017:** Start of series production of 3AV1FG 145 kV blue circuit breaker with vacuum interruption and spring drive

2010

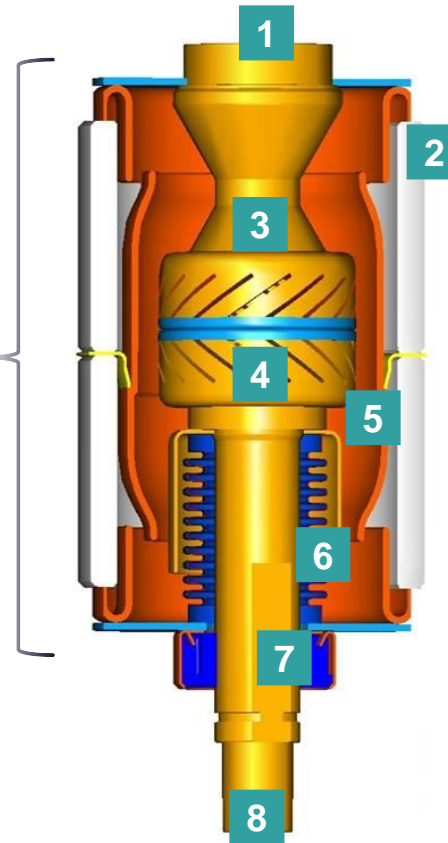
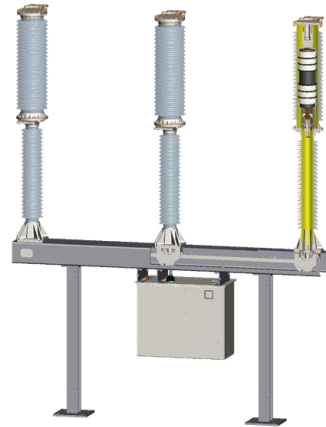
2017



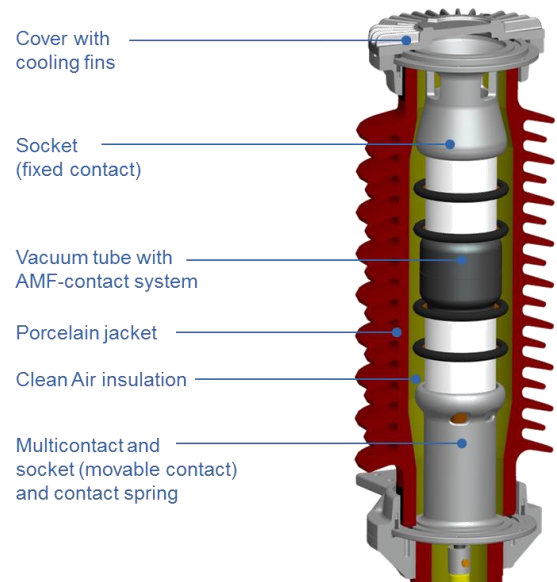
**2010:** Pilot installation of first vacuum breaker prototypes 3AV 72.5 kV with spring drive

LET'S MAKE TOMORROW DIFFERENT TODAY!

# Blue Circuit Switcher 72.5 / 145 kV , 40 kA , 3150A



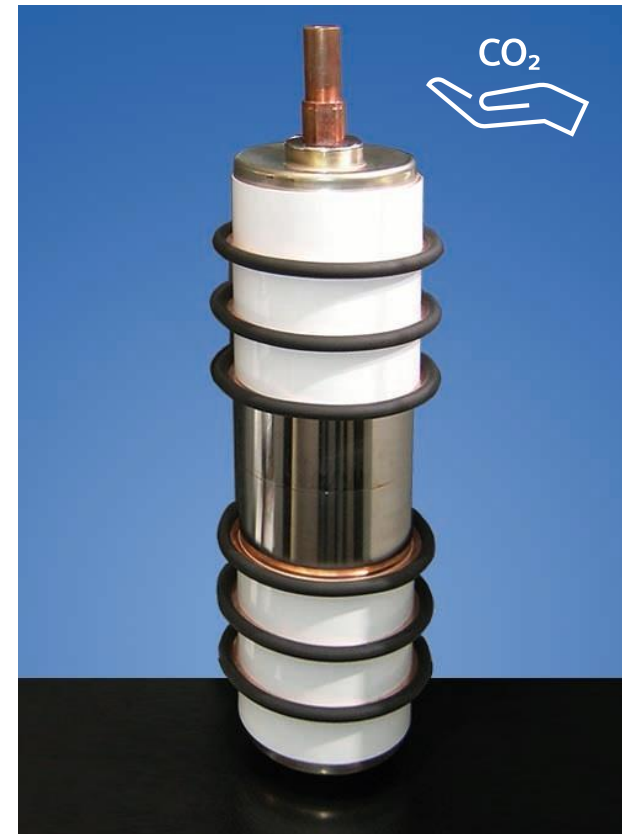
- 1 Feststehende Anschlussbolzen
- 2 Isolations-Keramik
- 3 Feststehender Kontakt
- 4 Beweglicher Kontakt
- 5 Dampf- und Steuerschirm
- 6 Metallfaltenbalg
- 7 Führung (Lager)
- 8 Beweglicher Anschlussbolzen



# Vacuum interrupter technology - customer value

For more than 40 years successful operational experience in medium-voltage, since 2010 in high-voltage

- **High reliability**  
due to the hermetically tight vacuum interrupter, eliminating any influence of decomposition products
- **High performance**  
Perfect for frequent switching applications: high number of short-circuit interruptions with excellent interrupting performance at rated nominal current and rated short-circuit currents throughout life-time of the vacuum circuit-breaker
- **Perfect for low temperature**  
No liquefaction of switching medium
- **No maintenance**  
Maintenance-free due to sealed for life technology; no spare part costs
- **No CO<sub>2</sub>e emissions**  
Switching media (vacuum) with GWP=0; no CO<sub>2</sub>e emissions during operation, maintenance or recycling



# Vacuum Switching Technology

## Vacuum Interrupters for 145 kV and 100 kA in operation

### Highlights

- Extreme high reliability
- High manufacturing experience with more than 5 million units installed in different applications throughout the world
- Specific developments for OEM customers
- Large VI range for a variety of applications
- More than 1 Mio Vacuum Circuit-Breakers installed worldwide



#### Application in:

- Medium- and low-voltage switching devices
- Medium-voltage circuit breakers and contactors
- HV GIS and circuit breakers



100 kA



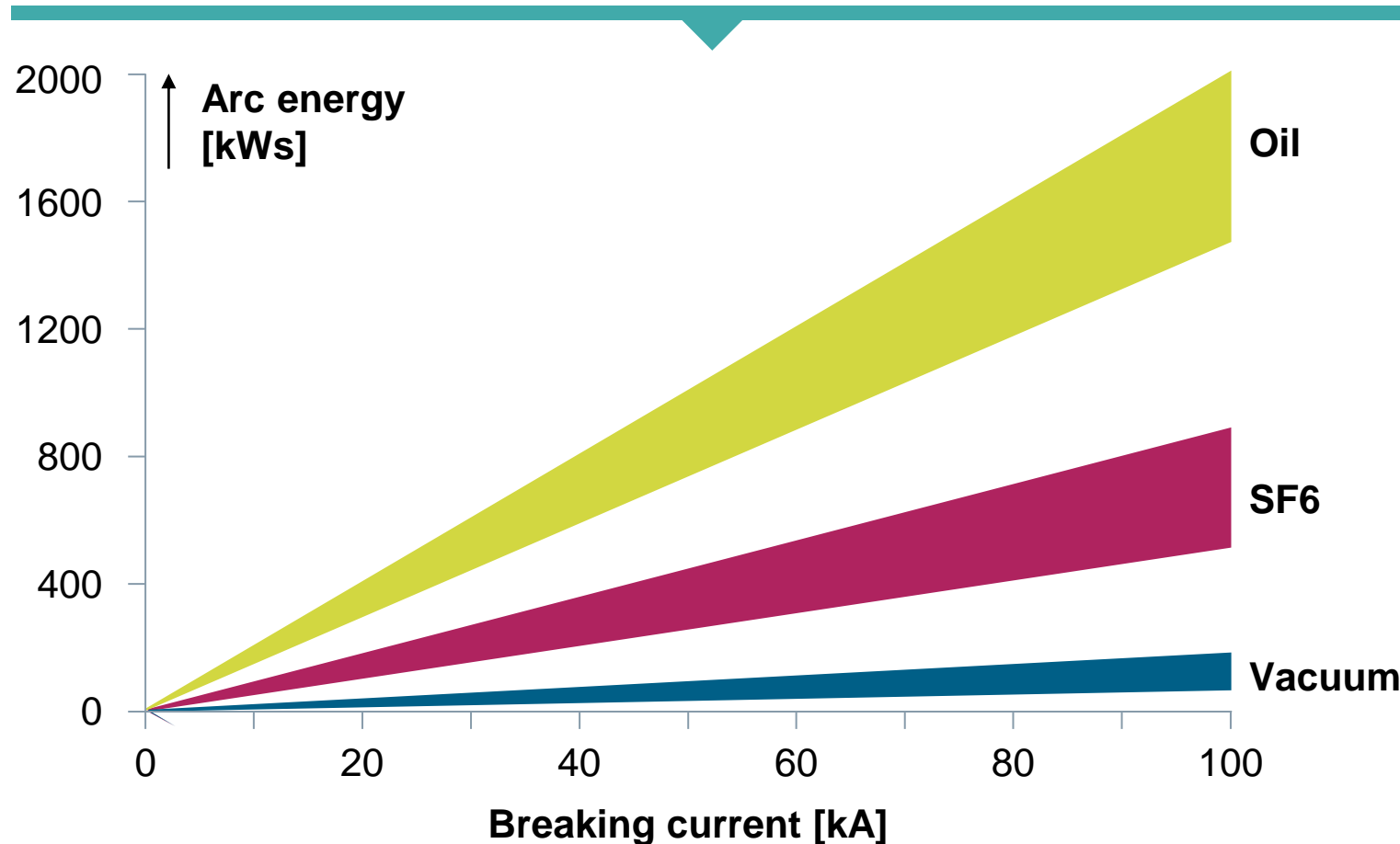
145 kV



# Siemens vacuum interrupters

## Advantages of vacuum switching for high breaking currents [kA]

### Endurance - Arc energy



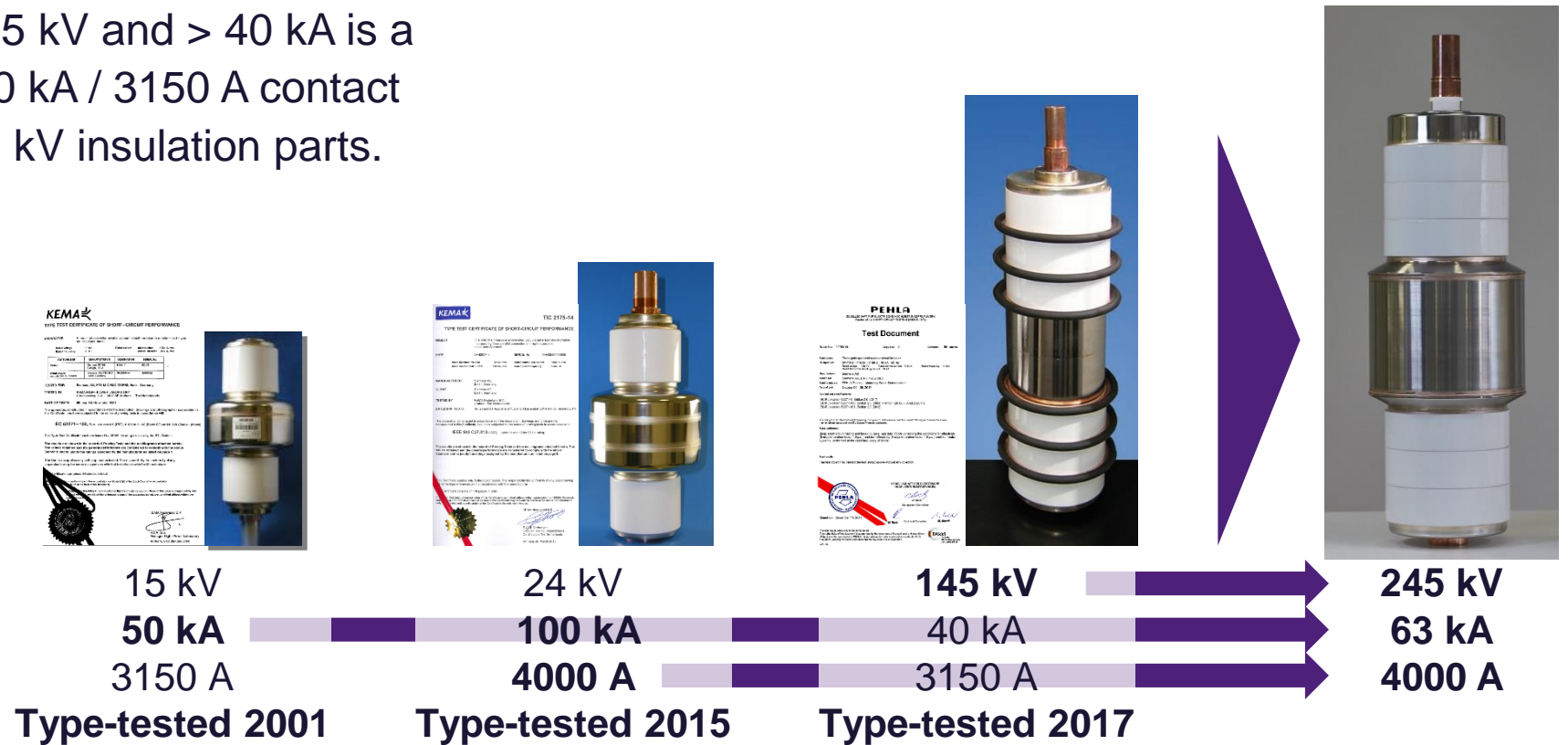
$$W = \int_0^T u \cdot i \cdot dt$$

### Vacuum circuit breakers

- Low arc voltage
- Low arc length
- Short arc time
- Low arc energy

# Vacuum Interrupters for 145 kV & 100 kA type-tested & in operation 170 kV and 245 kV up to 63 kA based on proven design elements

The Vacuum-Interrupter > 145 kV and > 40 kA is a combination of type-tested 50 kA / 3150 A contact systems and type-tested 145 kV insulation parts.



# Production of vacuum interrupters



## One-shot brazing technology under clean room conditions

The brazing furnace ensures that its complete volume is evacuated and the vacuum interrupters are exposed to a pre-defined temperature profile. Depending on loading, one cycle can require up to 20 hours.

**The fully automatic system guarantees the vacuum interrupters to be “sealed for life”.**

# Production of vacuum interrupters



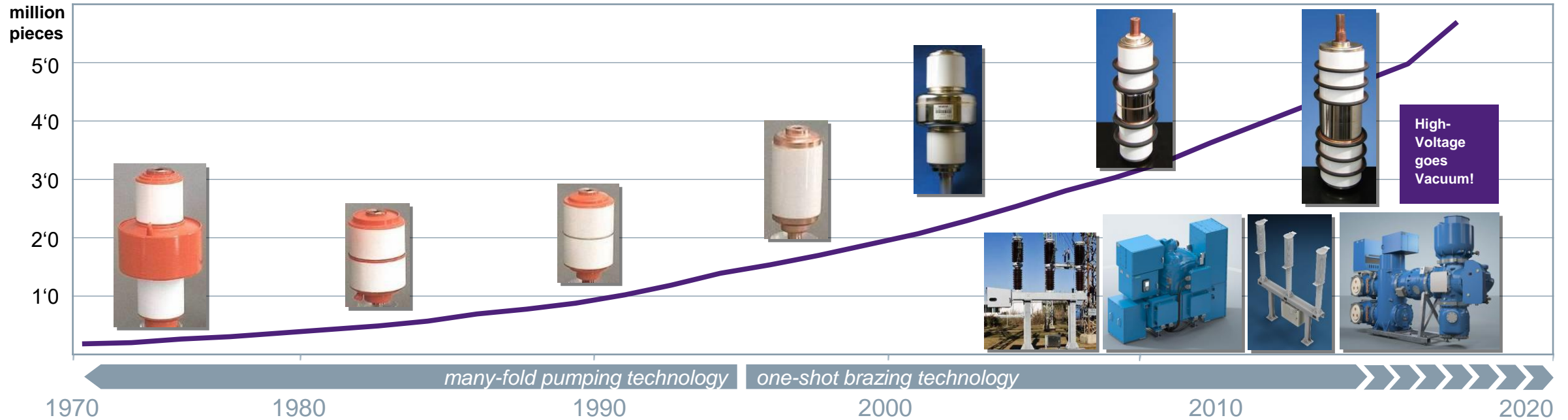
## X-ray based quality inspection

With help of x-ray based testing, positions and completeness of internal parts as well as brazed joints can be exactly ascertained.

This intermediate inspection **grants for continuously high quality and longevity.**



# Vacuum interrupter - development of product/production technology



**1971**

First serial manufacturing of vacuum interrupters for contactors.

- More than 40 years of operational experience in the field of medium voltage applications
- More than 5.5 million vacuum interrupters delivered

**2010**

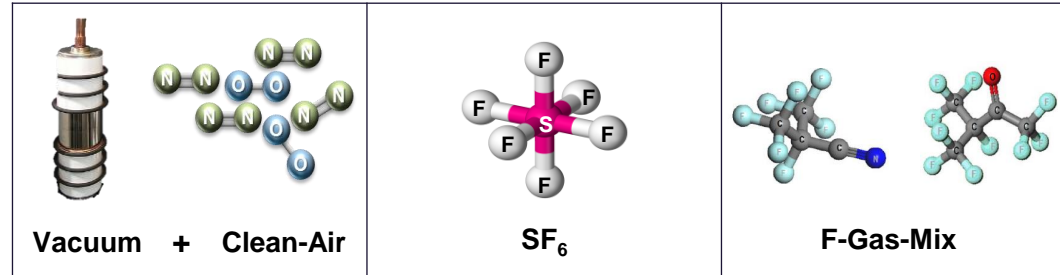
Introduction of prototypes for 72.5 kV

**2016**

Introduction of 145 kV portfolio with vacuum interrupter for up to 72.5 kV and up to 145 kV

# Summary Comparison of switching and insulation technology

## -> Blue products set the HSE and operational performance standard



Health, Safety & Environment	Gas handling	+	○	-
	Decomposition products	+	-	-
	Toxicity	++	○	-*
	GWP	++	-	○
Operational performance	Switching rated current	++	+	○
	Degradation of switching media	++	○	-
	Long term stability	++	++	uncertain
	Gas tightness	+	+	-
Maintenance	Maintenance of interrupter unit	++	○	-
Reporting / Regulation	Current and future proof	++	-	-

\* Per- und polyfluoroalkyl substances as e.g. Fluoronitrile C4-FK & Fluoroketone C5-FN with potential health risks if dissolved in water: EU registry of restriction and first ban in Maine, US beginning 2030

++ Outstanding performance    + Good performance    ○ Average performance    - Performance below average

# T&D equipment manufacturers committed to ZERO F-gases

Toward T&D equipment free of fluorinated gases for sustainable, climate-neutral power grids

## A joint statement of T&D equipment manufacturers

2021/11/02

The recently published 6th Intergovernmental Panel on Climate Change (IPCC) report shows the seriousness of the climate crisis. Human activity is changing the climate in unprecedented and sometimes irreversible ways. The electrical transmission and distribution (T&D) industry has an opportunity to lead society's response to deliver infrastructures that are targeting climate-neutral objective to underpin the transition to net zero emission economies.

The clean transport of low-carbon electricity is an essential element of national decarbonization plans, which will underpin the sustainable economies of the future. In conjunction with decarbonized power generation using renewable energy sources, it is vital to do the same for T&D power grids upon which the system relies.

For over 50 years, the recognized insulation and switching performance as well as proven and stable characteristics of SF<sub>6</sub> have contributed to the reliability, efficiency, and resilience of power network facilities, enabling compact equipment for all voltage classes. However, because SF<sub>6</sub> has a global warming potential over 25,000 times greater than CO<sub>2</sub>, action is now required to achieve truly sustainable power grids. To enable this change, we need to limit the SF<sub>6</sub> emissions and install new electrical equipment using clean reliable and non-toxic alternatives.

As equipment manufacturers, we embrace our responsibility to society and are fully committed to the net zero goal. Each of the undersigned has already developed or is in the process of developing T&D equipment completely free of fluorinated gases. The phase-out of fluorinated and PFAS-gases (per- and polyfluoroalkyl substances) in electrical T&D equipment, where alternatives are available, would accelerate progress toward a more sustainable future.

Each of the undersigned is committed to delivering T&D equipment free of fluorinated-gas and PFAS-gas needed to enable this transition. The first F-gas free products are successfully in operation, and each of the signing companies is committed to close the remaining portfolio gaps in the upcoming years in order to deliver on science-based net zero targets (SBTi) that companies are setting. These products will help deliver our own company health and climate commitments while enabling environmental improvements.

You are welcome to join in delivering this ambition and building truly sustainable clean power grids for a climate-neutral future.

The undersigned will continue to develop, manufacture, sell, and service independently. This statement shall in no way create any joint responsibility or liability or any form of cooperation or joint venture.



## A joint statement of Pfiffner and Trench as AIS Instrument Transformer manufacturers

Environmental aspects are drastically gaining importance and becoming an essential part of today's society. Recent natural disasters, floods and drought followed by wildfires send a clear signal that the status quo needs to change.

The decarbonization of the power generation sector is ongoing with renewable energy making an essential contribution. The T&D sector needs to follow and foster the decarbonization process.

With its outstanding insulation and safety properties, SF6 is traditionally used in AIS High Voltage Instrument Transformers. SF6 is, however, considered to be a gas contributing to global warming when it is released into the atmosphere.

Trench and Pfiffner, both leading manufacturers of AIS High Voltage Instrument Transformers with SF6 insulation, with the aim to support decarbonization efforts, commit to focus their development activities in this product application on entirely F-gas free solutions. Both companies consider pure Air as a suitable solution in AIS applications to reduce the environmental impact to the maximum extent possible and contribute significantly to the decarbonization required to safeguard our planet.

The "Clean Air or SynAir Technology" is based on field proven SF6 designs offering the same operational benefits such as explosion safety, > 95% recyclability, maintenance freedom, and reliability.

While both companies will continue to develop their Air-based technology independently, they will work on standardizing aspects relevant to customers (e.g., diameter of filling devices) to reduce complexity for the Transmission Operators and their service teams.



## Press release

Berlin, November 22, 2021

### New production facility in Berlin: Siemens Energy wants to eliminate the world's most potent greenhouse gas from power transmission

- Siemens Energy invests over €60 million in Berlin site
- New vacuum interrupter production is a clear commitment to climate-neutral power transmission and the Berlin location

Siemens Energy is investing over €60 million in a new production facility in Berlin. In the future, vacuum interrupters will be manufactured in the company's switchgear plant in 6,200 m<sup>2</sup> of space. The vacuum interrupters are the technological core of the Blue Portfolio, which comprises climate-neutral power transmission products in the high-voltage range and uses industrially purified air for insulation and vacuum as the switching medium instead of climate-damaging fluorinated gases. The new manufacturing facility is scheduled to go into operation in 2023.

"The consequences of rapidly advancing global warming require a fundamental change in the way we deal with energy, including power transmission," said Ulf Katschinski, Senior Vice President Switching Products and Systems at Siemens Energy. "Siemens Energy aims to sell only F-gas-free high-voltage switching technology starting in 2030 at the latest. With our new vacuum interrupter production, we're laying the groundwork to achieve this goal and meet the growing demand for climate-neutral switchgear."

# Siemens Energy Blue high-voltage products

Innovation roadmap



# The Blue portfolio comprises individual products & solutions, supporting our clients on their way to Zero

## Up to 145 kV

### Wind Tower Blue GIS™

- 72.5 kV
- switchgear for application in wind turbines, with vacuum CB and clean air Insulation
- Optimized for its special application



### Blue Circuit Breaker™ Live Tank

- 72.5 kV and 145 kV
- World's first LT CB with vacuum interrupter and clean air insulation



## Higher voltages (available)

### Blue Clean Air GIB™

- 420 kV
- 245 – 400 kV = combined solution GIS + Blue GIB (30 – 65% less SF<sub>6</sub>)



### Blue Instrument Transformer™

- up to 420 kV
- World's first 420 kV transformer with clean air insulation
- Same footprint as SF<sub>6</sub> product



### Blue GIS™

- 145 kV
- World's first 145 kV GIS switchgear with vacuum CB and clean air insulation
- Optimized footprint by using LPIT<sup>1</sup>



### Blue Circuit Breaker™ Dead Tank

- 145 kV
- World's first 145 kV DT vacuum CB with clean air insulation
- Same footprint as SF<sub>6</sub> product



<sup>1</sup> Low Power Instrument Transformer

# Siemens Energy Blue has a clear Zero-compromise philosophy



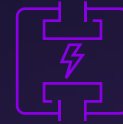
## Zero F-gases

Blue products contain Zero SF<sub>6</sub> or other F-gases and are thus out of scope of any kind of F-gas regulation



## Zero global warming potential

Blue products contain only clean air, and thus produce Zero greenhouse gases



## Vacuum technology

Vacuum interrupters offer the highest short-circuit switching capability without degradation (up to 30 times 40kA currents) and freedom from maintenance (they are “sealed for life”)



## Virtually Zero maintenance

With only air to deal with during servicing, maintenance is made much easier and more cost-efficient. Moreover, Zero accounting and reporting is necessary and end of life disposal is simple



## Sustainability leader

Blue products gain high public and market acceptance due to green-house gas-free operation, low maintenance and simple end of life treatment



## Zero-harm materials

All materials and substances used are environmentally-friendly and meet all health and safety standards (i.e. REACH, RoHS in Europe). A material impact analysis is an integral part of the design thinking approach



## Zero waste

Recycling capability and defined return schemes make Blue products perfect examples of the circular economy



## Long-lasting design

The operational lifetime of Blue products is expected to be more than 40 years - saving natural resources

# LPIT

Advantages of Low Power Instrument Transformers compared to conventional Instrument Transformers:

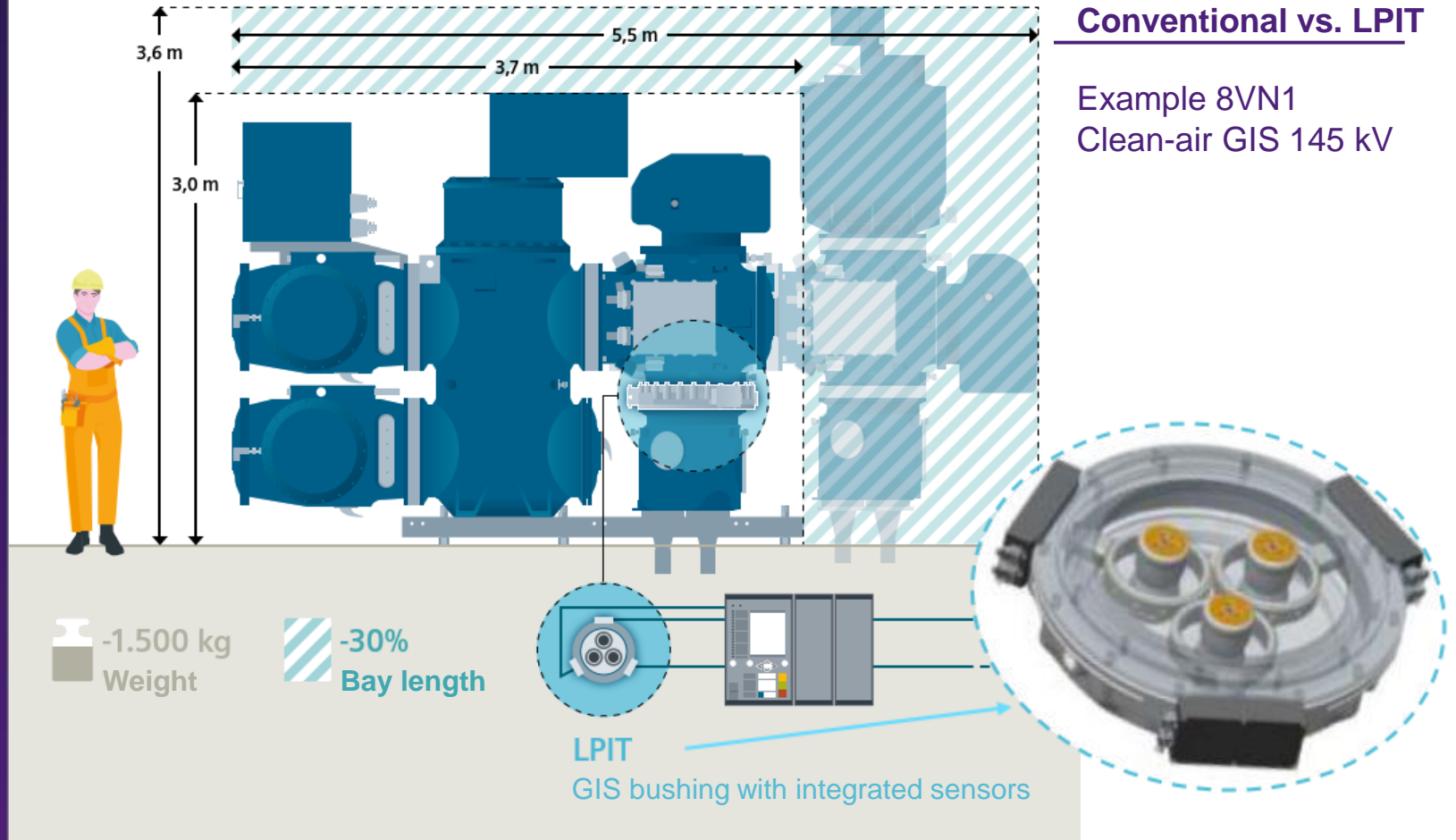
- Enabler for digitalization of current and voltage signals
- One standardized multi-purpose device covering all current ratings
- Improved measurement performance
- Conversion of voltage and current signals into sample measure values according to IEC 61850

Savings:

- GIS dimensions, weight and gas quantity

# Low Power Instrument Transformer

The new Instrument Transformer Technology reduces the Blue GIS footprint



1. **Combined** electronic voltage and current sensor according to IEC
2. **Redundant:** two current sensors and one voltage sensor in each bay

# The world's first SF<sub>6</sub>-free gas-insulated switchgear with clean air and vacuum technology

## Key facts

- Customer: BKK Nett, Norway
- Modernization of a 145 kV Koengen substation in Bergen – Norway's largest cruise port
- Operation requires no SF<sub>6</sub> or any other greenhouse gas
- Year of order: 2018
- Energization: 2020



## Gas-insulated switchgear

- Installation of 3 bays of the 8VN1 Blue GIS™ for 145 kV
- Vacuum interrupter technology
- Clean air insulation technology



## Low-power instrument transformers

- GIS includes low-power instrument transformers (LPIT) to ensure a compact design



# It's Day Zero for Bergen Port

Cruise ships used to power up in the harbour using their diesel engines. Now, thanks to BKK Nett and Blue switchgear technology from Siemens Energy, they use only clean power. Zero greenhouse gas emissions, zero F-gases and zero health impact. It's their Day Zero. Let's plan yours.



# Siemens Energy has more than 40 years experience in vacuum & air-insulation technology

1970

## First HV GIS with air-insulation

Type: BISEP GIS  
170 kV/ 50 kA with air-puffer CB & air-insulation  
References: 88 bays



1976

## First MV vacuum CB

References:  
> 6 million units



2010

## First HV vacuum CB

Type: 3AV1FG 72.5 kV/  
31.5 kA with vacuum interrupter  
References: 6 units



2017

## First HV vacuum GIS with clean air 72.5 kV

Type: 8VM1 72.5 kV/  
31.5 kA with vacuum CB & clean air-insulation  
References: >1000 bays



2017

## First HV vacuum CB with clean air 145 kV

Type: 3AV1FG 145 kV/  
40 kA with vacuum interrupter & clean air-insulation  
References: >150 units



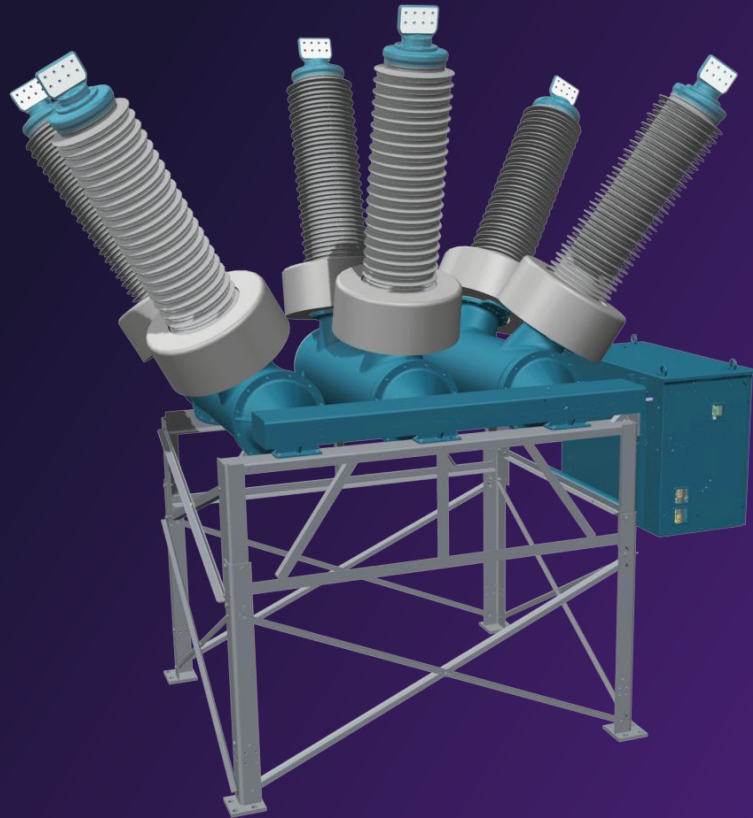
2018

## First vacuum GIS with clean air 145 kV

Type: 8VN1 145 kV / 40  
kA with vacuum CB and clean air-insulation  
References: >350 bays



# 3AV1 Blue Dead Tank CB up to 145 kV



## Product characteristics

- Vacuum interrupter technology | Clean air insulation technology
- Weight of SF<sub>6</sub> or other fluorinated greenhouse gases = 0 kg
- GWP Global Warming Potential = 0
- Expected product life-time > 50 years, first major inspection > 25 years
- No reporting or emission costs during operation and recycling, e.g. taxes or CO<sub>2</sub>e emission compensation (no SF<sub>6</sub>- or F-gases)

## Technical features

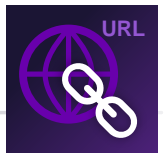
- Proven reliable energy spring drive mechanism
- Rated voltages up to 145 kV, rated frequency 50 / 60 Hz
- Rated continuous current up to 3150 A, rated short-circuit breaking current 40 kA
- Chopped wave (2 μs) voltage 838 kV
- Capacitive switching class (overhead lines & cables) C2
- Perfect for frequent breaking operations and extreme temperatures from -60 °C up to +55°C
- Leakage rate < 0.1% p.a.

## Types / variants

- Three-pole operation (FG)
- Composite insulators

## Type tests

- Planned for 2021 (IEEE / IEC 62271-100)





# JXN USA News!

## Manufacturing of World's 1st Clean Air Vacuum Breaker 3AV1DT 123 kV, 40 kA, 3150A



### Product Showcased @ JXN Factory

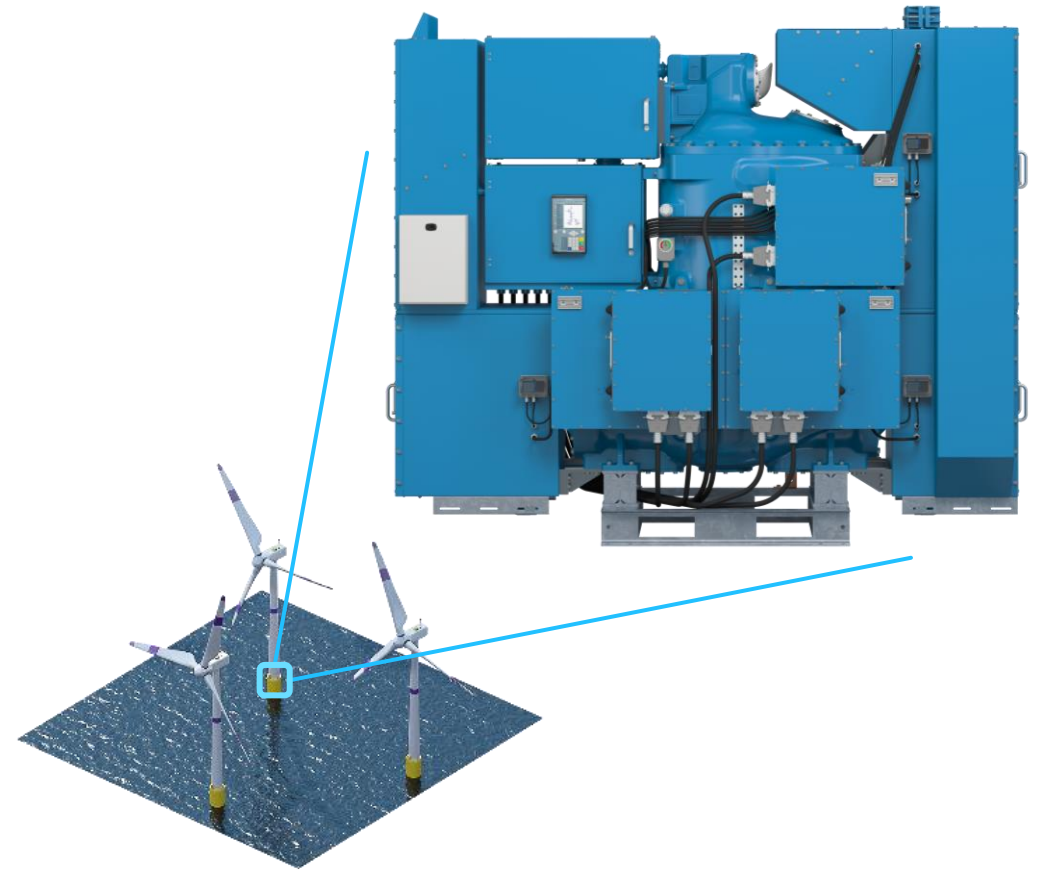




# Siemens Energy's 8VM1 Blue 72.5 kV GIS<sup>®</sup>

Compact GIS solution designed for on- & offshore wind turbine installations based on proven component technology. 8VM1 Blue GIS<sup>®</sup> is designed using a well-proven modular platform concept based on decades of manufacturing and operating experience. This successful concept has been implemented in our new generation of HV GIS.

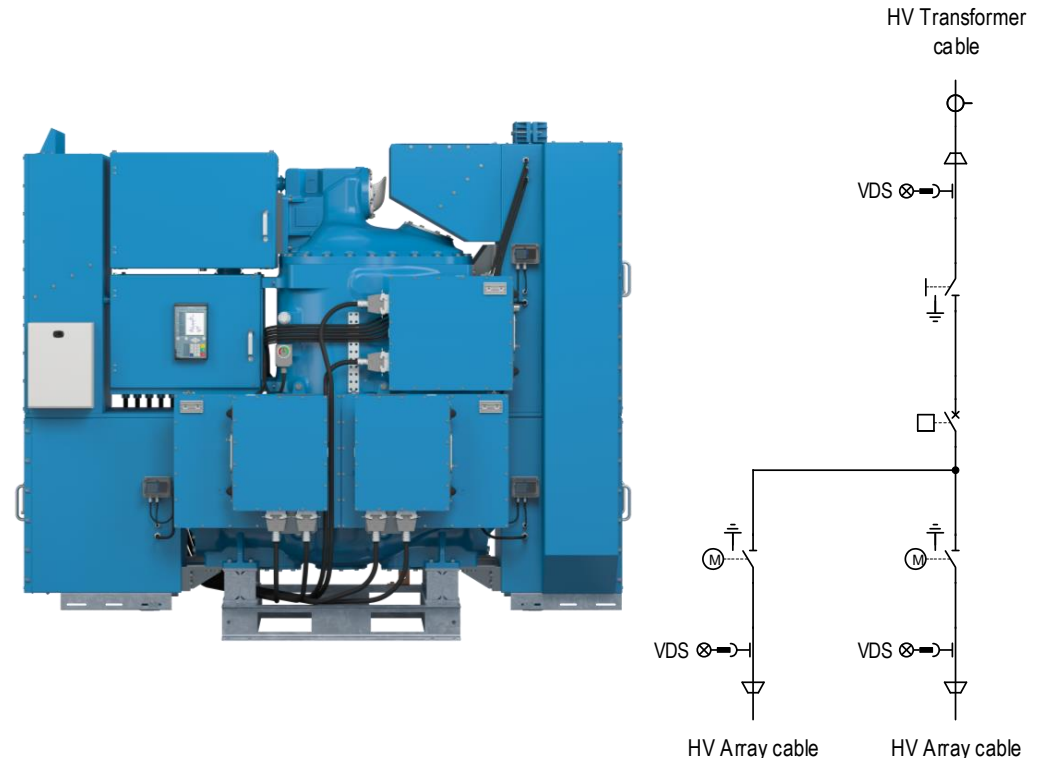
Siemens Energy's vacuum interrupter and clean air technology realizes the F-gas-free insulation and supports the demand for fully environmentally compatible wind power generation.



# Siemens Energy's 8VM1 Blue GIS<sup>®</sup>

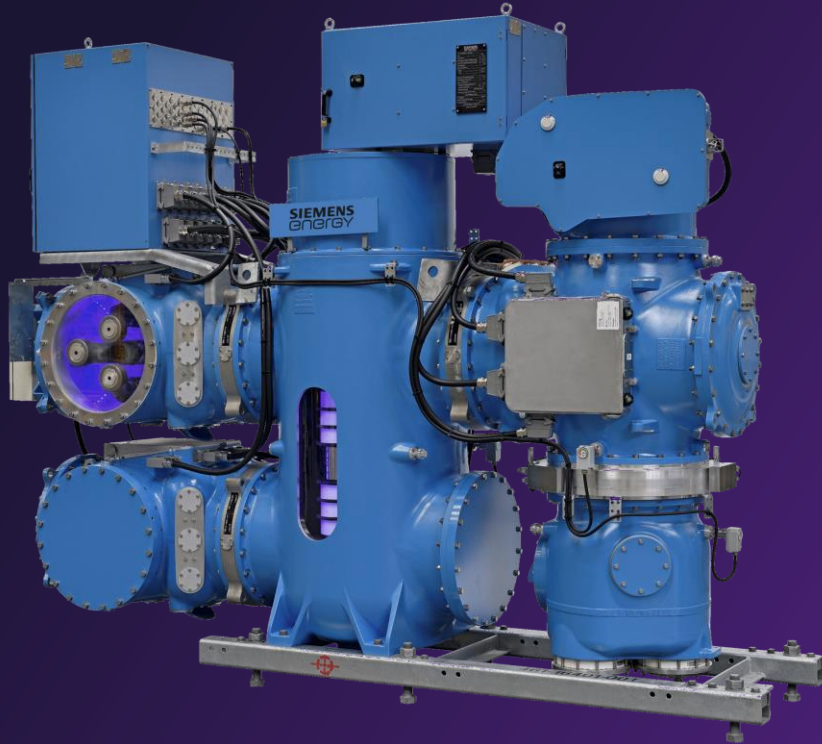
## Main features

- World's leading environment-friendly and future-proof technology free of F-gases
- Innovative clean air insulation medium significantly reduces carbon footprint
- Proven vacuum interrupter technology
- Compact GIS solution designed for wind turbine installations
- Completely factory assembled, tested and shipped in single transport unit
- Safe and easy handling
- High operational safety
- Low operational costs throughout the entire life cycle



*Typical switchgear configuration in offshore wind turbine installations*

# 8VN1 Blue GIS<sup>®</sup> up to 145 kV



## Product characteristics

- Vacuum interrupter technology | Clean air insulation technology
- Weight of SF<sub>6</sub> or other fluorinated greenhouse gases = 0 kg
- GWP Global Warming Potential = 0
- Expected product life-time > 50 years | first major inspection > 25 years
- No reporting or emission costs during operation and recycling, e.g. taxes or CO<sub>2</sub>e emission compensation (no SF<sub>6</sub>- or F-gases)

## Technical features

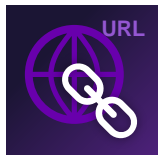
- Rated voltage up to 145 kV, rated frequency 50/60 Hz
- Rated short-circuit breaking current up to 40 kA
- Ambient temperature range -50 °C up to +55 °C
- Stored-energy spring type driving mechanism of circuit-breaker
- Seismic withstand capability 1.0 g
- Leakage rate per year and gas compartment (type-tested) < 0.1%
- Equipped with new [Sensgear<sup>®</sup> technology](#) →

## Types / variants

- Indoor & outdoor installation
- Optional with Low Power Instrument Transformer (LPIT) for reduced bay size / weight

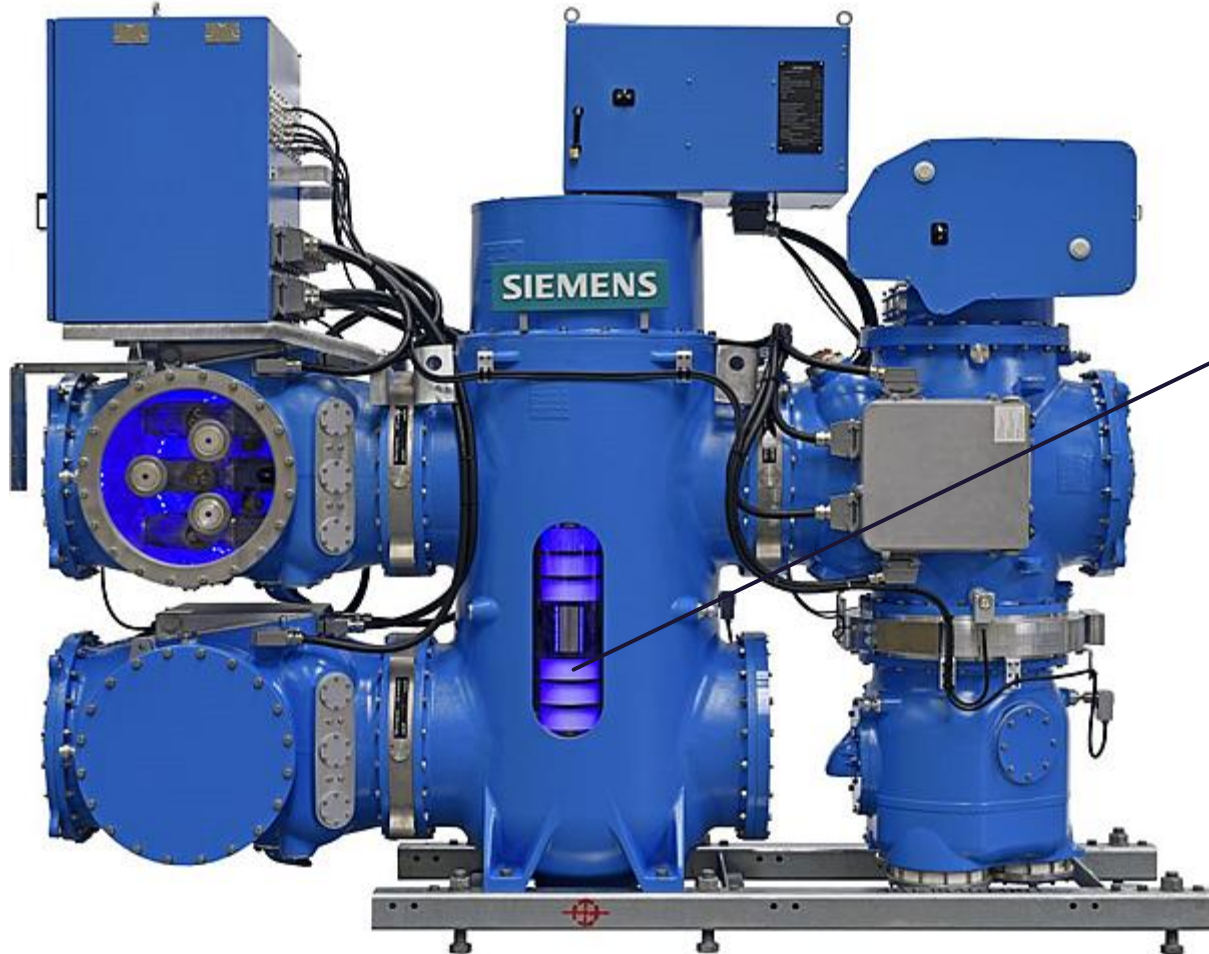
## Type tested

- Acc. to IEC / IEEE



# 145 kV Blue GIS™ solution

Clean Air insulation instead of SF<sub>6</sub>  
Power switching with single break vacuum CB



## Technical features

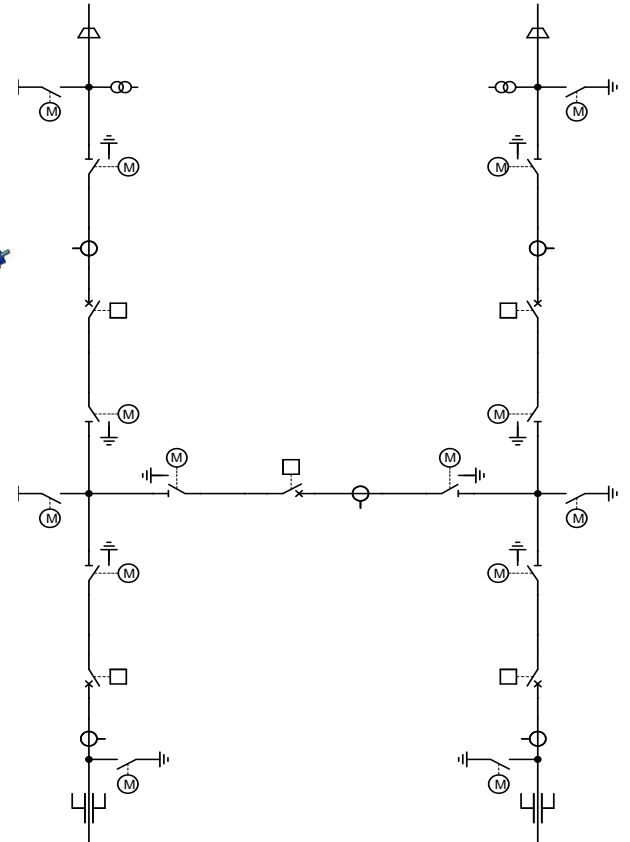
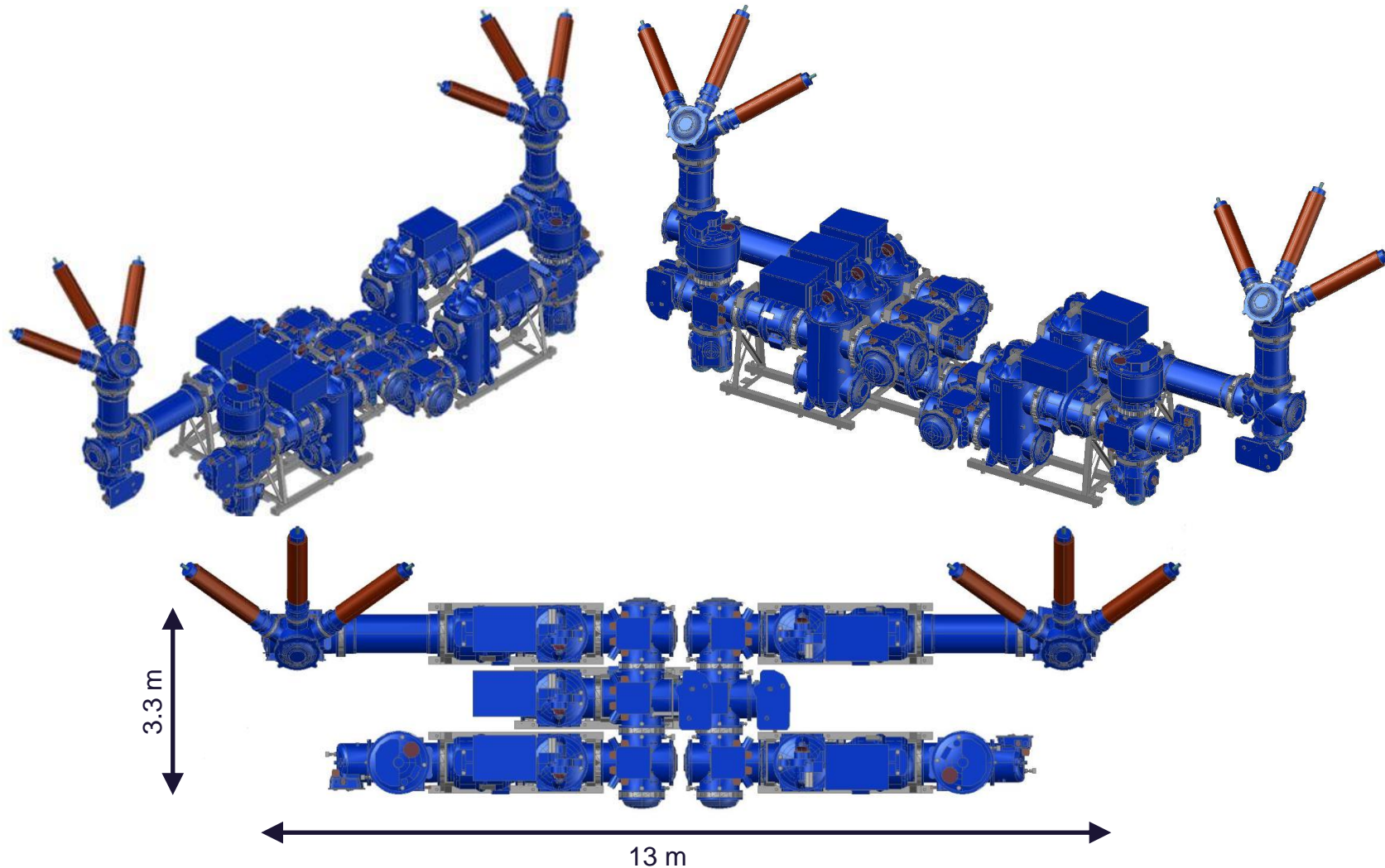
- Rated short-circuit breaking current up to 40 kA
- Ambient temperature range -50 °C up to +55 °C
- Type tested seismic withstand capability 1.0 g
- Leakage rate per year and gas compartment (type-tested) < 0.1%
- Indoor & outdoor installation
- Equipped with new **Sensgear™ technology**

## Types / variants

- Optional with Low Power Instrument Transformer (LPIT) for reduced bay size / weight



# Gas-insulated switchgear 8VN1 Blue GIS™ up to 145 kV / 40 kA H-arrangement



# LPIT

Advantages of Low Power Instrument Transformers compared to conventional Instrument Transformers:

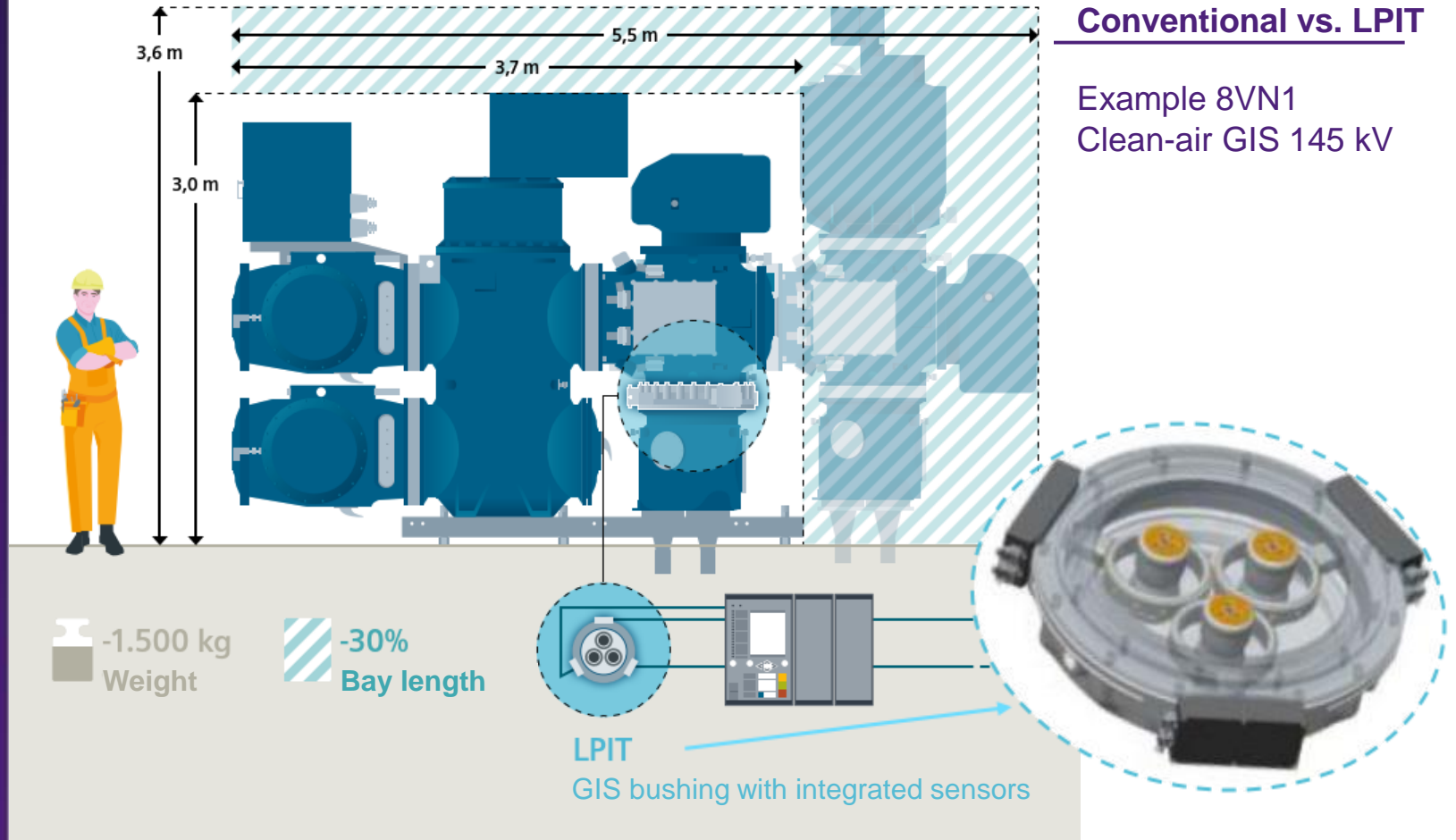
- Enabler for digitalization of current and voltage signals
- One standardized multi-purpose device covering all current ratings
- Improved measurement performance
- Conversion of voltage and current signals into sample measure values according to IEC 61850

Savings:

- GIS dimensions, weight and gas quantity

# Low Power Instrument Transformer

The new Instrument Transformer Technology reduces the Blue GIS footprint



1. **Combined** electronic voltage and current sensor according to IEC
2. **Redundant:** two current sensors and one voltage sensor in each bay

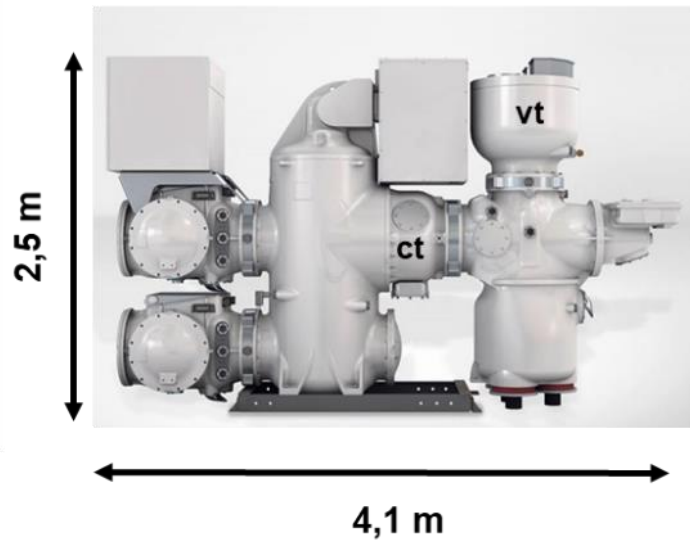
# Footprint Blue GIS

## 8DN8 SF<sub>6</sub> GIS 145 kV

Inductive Current & Voltage Transformer  
(ct, vt conventional)

Bay width 0,8 m // Weight ~ 4,5 t

SF<sub>6</sub> ~ 85 kg (banked GWP = 2.000 t CO<sub>2</sub>-eq.)

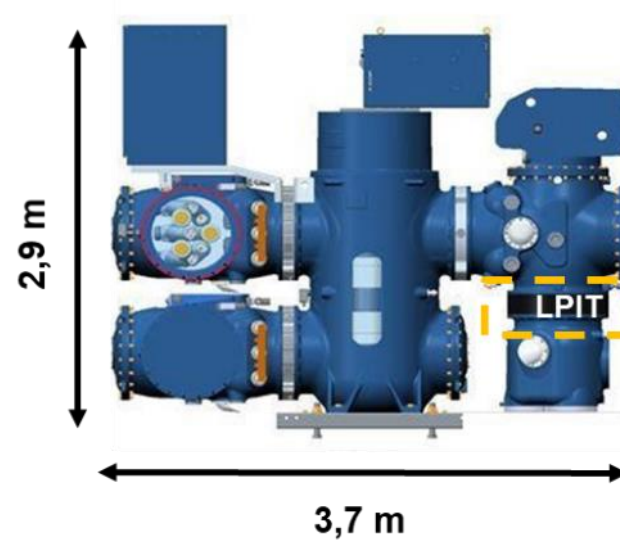


## 8VN1 blue GIS 145 kV

Low-Power Instrument Transformer  
(non-conventional)

Bay width 1 m / Weight ~ 4.7 t

Clean air ~ 33 kg (GWP = 0)

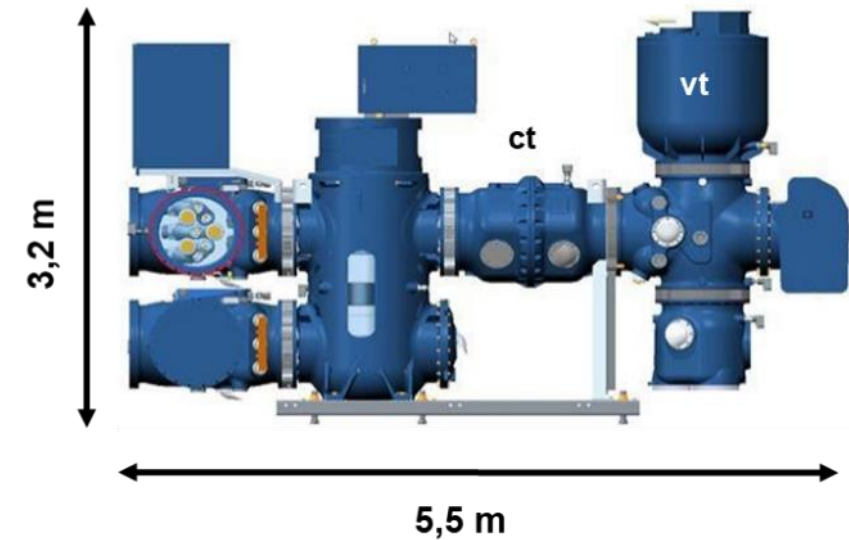


## 8VN1 blue GIS 145 kV

Inductive Current & Voltage Transformer  
(ct, vt conventional)

Bay width 1 m / Weight ~ 6 t

Clean air ~ 38 kg (GWP = 0)





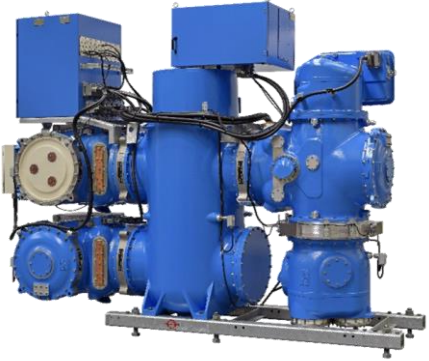
# Blue Footprint 145 kV GIS

Clean Air is prerequisite for emission-free (GWP = 0) and pollution-free (non-toxic, F-Gas-Free) power grids.

To ensure dielectric performance, the size and pressure needs to be increased slightly.

LPIT (Low-Power Instrument Transformer) in GIS is a counter-measure to reduce the footprint, enabling digitalization of current and voltage signals.

- Blue GIS footprint < 120% of the current SF<sub>6</sub> GIS
- Existing 145kV GIS (up to year 1999) can be replaced by Blue GIS within the given footprint

	1st SF <sub>6</sub> GIS	Current SF <sub>6</sub> GIS	1st Blue GIS
			
		<b>Reduction:</b> SF <sub>6</sub> -Vol - 60 % Weight - 60 % Footprint: - 80 %	
Leakage rate per year in %	1	0.1	0.1
Bay W x H x D in m	2.4 x 3.7 x 5.0	0.8 x 2.5 x 4.1	1.0 + 2.9 x 3.7
Bay weight in t	12	4.5	4.7
Gas amount in kg	230	85	32
Banked GWP in t CO <sub>2</sub> -eq.	5,405	2,000	0



# 8VQ3 Blue Clean Air GIB™ 420 kV



## Product characteristics

- Clean air insulation technology
- Weight of SF<sub>6</sub> or other fluorinated greenhouse gases = 0 kg
- Global warming potential = 0
- Expected product lifetime > 50 years | first major inspection > 25 years
- No reporting or emission costs during operation and recycling, e.g. taxes or CO<sub>2</sub> emission compensation (no SF<sub>6</sub> or F-gases)

## Technical features

- Rated voltage up to 420 kV
- Rated frequency 50/60 Hz
- Rated short-circuit breaking current up to 63 kA
- Rated continuous current up 5000 A
- Ambient temperature range -50°C to + 55°C
- Leakage rate per year and gas compartment (type-tested) < 0.1%

## Types / variants

- Indoor and outdoor installation

## Type tested

- Acc. to IEC / IEEE

420 kV  
SF<sub>6</sub>-free switchgear  
becomes reality



# Blue Instrument Transformer<sup>®</sup> up to 420 kV

## Product characteristics

- Clean air insulation technology: Climate neutral, safe, reliable
- 50 years of experience with > 40.000 gas-insulated instrument transformers delivered
- Utilizing the proven SF<sub>6</sub> instrument transformer designs (current and voltage measurement characteristics identical with SF<sub>6</sub> insulated design)

## Technical features

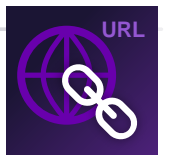
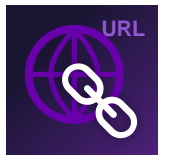
- Perfect for low temperature application -50 °C and below
- No special gas handling equipment needed; no gas handling during lifetime required
- No reporting or emission costs during operation and recycling, e.g. taxes or CO<sub>2</sub>e emission compensation (no SF<sub>6</sub>- or F-gases)
- Equipped with new [Sensgear<sup>®</sup> technology](#) →

## Types / variants

- Available for air-insulated substations (current transformer, voltage transformer, combined instrument transformer) and gas-insulated substations (current transformer, voltage transformer)

## Type tested

- Completely type-tested according to latest international standards



# Blue Station Service Voltage Transformer® up to 420 kV and 167 kVA



## Product characteristics

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- 50 years of experience with > 40.000 gas-insulated instrument transformers delivered
- Utilizing the proven SF<sub>6</sub> power voltage transformer designs (voltage and power ratings identical with SF<sub>6</sub> insulated design)

## Technical features

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- Continuous output power up to 167 kVA
- Available secondary voltage from 100 V – 1000 V
- Perfect for low temperature applications of -50 °C and below
- No special gas handling equipment needed; no gas handling during lifetime required
- No reporting or emission costs during operation and recycling, e.g. taxes or CO<sub>2</sub>e emission compensation (no SF<sub>6</sub> - or F-gases)

## Types / variants

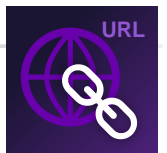
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- Available for air insulated substations
- Voltage levels in accordance with international standards
- Output power classes 25 kVA, 50 kVA, 100 kVA, 125 kVA and 167 kVA

## Type tested

---

- Completely type-tested according to latest international standards



# Global project references for more than 2500 units More than 700 units in operation



**72.5 kV  
Blue Circuit Breakers, LT**  
6 in operation in EU **since 2010**  
2 in operation in USA **since 2020**



**72.5 kV  
Blue GIS Wind**  
>1000 ordered for GBR, USA,  
NDL, TAI, DEN, CHN, FRA  
>200 in operation



**72.5 & 123 kV  
Blue Circuit Breakers, DT**  
>20 ordered for USA, Delivery in 2021-  
2023



**145 kV Blue  
Circuit Breakers, LT**  
>150 ordered for GER, POL,  
NOR, SWE, DEN, KAZ, USA,  
CHE, GBR, ROU...  
Thereof >100 in operation,



**145 & 245 & 420 kV Blue  
Instrument Transformers**  
>400 ordered in US, NOR, SWE,  
GER  
> 250 in operation



**145 kV Blue GIS**  
>350 ordered in NOR, USA,  
GER, SPA, DEN, NDL  
> 25 in operation



**420 kV Blue GIB, extensions, bushings**  
>5000 m single-phase ordered in GER,  
600 m delivered GBR

2,500,000 tons of  
CO<sub>2</sub> equivalent  
Blue projects prevent the  
installation of 2,500,000 tons of  
additional greenhouse gas on  
electrical grids



- 
- 1 **Short Introduction**

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  - 2 **UN Sustainable Development Goals, grid operator's actions  
Greenhouse gas free & F-gas free grids, Regulations**

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  - 3 **Greenhouse gas free (SF<sub>6</sub>- free, F-gas-free) Technology,  
Blue Portfolio, References**

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  - 4 **Way forward:  
Roadmap - Products and Regulations  
Specification and Evaluation Criteria**

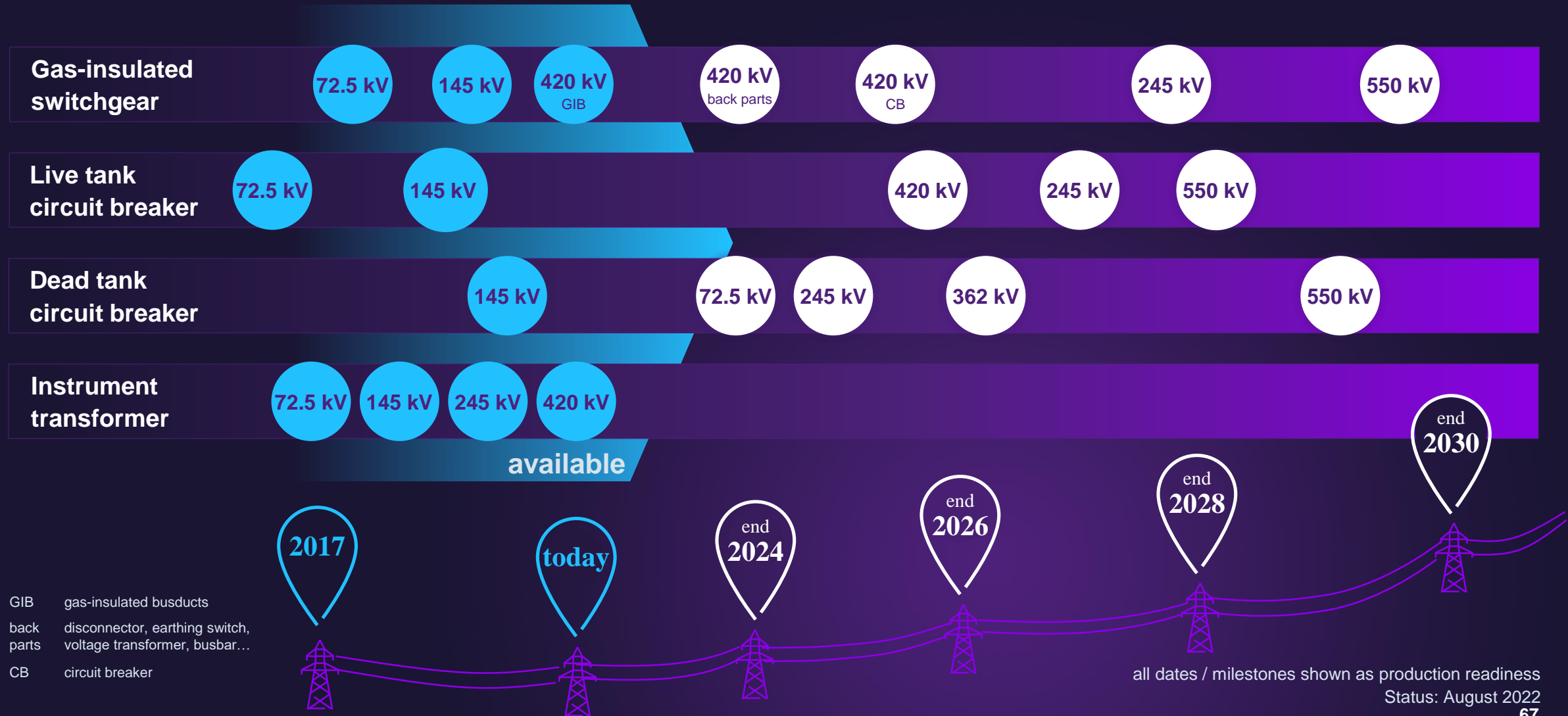
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  - 5 **Questions and Discussion**

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# Roadmap from Zero to Zero: Offering a fully F-gas-free, climate-neutral Blue portfolio by 2030



GIB gas-insulated busducts  
back parts disconnecter, earthing switch, voltage transformer, busbar...  
CB circuit breaker

# Blue product evaluation

# Customer product evaluation criteria for switchgear products



**Environmental  
impact**



**Health & safety**



**Performance**



**Gas handling  
& costs**



**Manufacturer  
competence**



# Three isolation mediums: a comparison



**Vacuum / clean air**

$N_2$  and  $O_2$  (80% / 20%)



**CO<sub>2</sub>-F mix fluoronitrile<sup>1</sup>**

$(CF_3)_2CFCN$

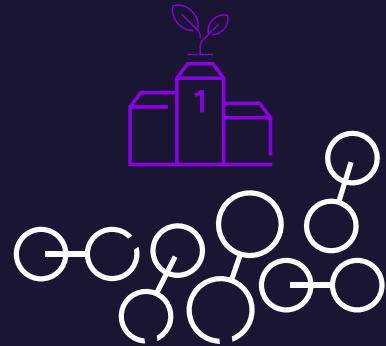


**SF<sub>6</sub> sulfur hexafluoride**

SF<sub>6</sub>

<sup>1</sup> Fluor-ketone gas mix is not considered due to its inability to withstand temperatures below 5°C

# Criteria 1: Environmental impact



**Vacuum / clean air**

Zero greenhouse gas

GWP = 0

(Immediately absorbed)



**CO<sub>2</sub>-F mix fluoronitrile**

Greenhouse gases

GWP ~ 500

(Lifetime 30 years)



**SF<sub>6</sub> sulfur hexafluoride**

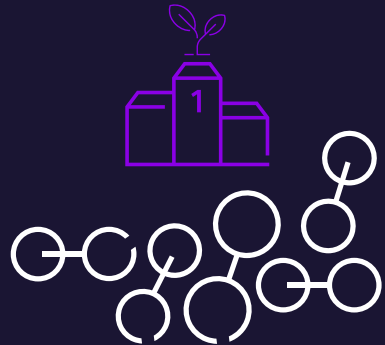
Greenhouse gas

GWP ~ 25,200

(Lifetime 3,200 years)

Vacuum / clean air is the **most environmentally friendly** switching technology in the world

## Criteria 2: Health & safety



**Vacuum / clean air**

Vacuum: Zero decomposition products;  
sealed for life

Clean air: non-toxic decomposition  
products, non-hazardous

Gas leakage < 0.1% p.a./compartment



**CO<sub>2</sub>-F mix fluoronitrile**

Toxic decomposition products  
(details unknown)

Hazardous (details unknown)

Gas leakage < 0.5% p.a./compartment  
(details unknown)



**SF<sub>6</sub> sulfur hexafluoride**

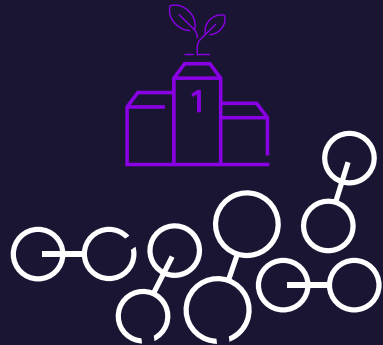
Toxic decomposition products

Hazardous when inhaled, causes skin  
and eye irritation

Gas leakage < 0.1% p.a./compartment

Vacuum / clean air is **non-toxic, non-hazardous** and does not require special safety systems  
such as ventilation or CO<sub>2</sub>-monitoring

# Criteria 3: Performance



**Vacuum / clean air**

Vacuum circuit breaker can switch up to 30 times 40 kA currents

Zero degradation of short-circuit switching performance

From -60 °C to +55 °C



**CO<sub>2</sub>-F mix fluoronitrile**

CO<sub>2</sub>-F mix shows decreasing switching performance

Does not recombine completely after arcing

From -25 °C to +55 °C



**SF<sub>6</sub> sulfur hexafluoride**

SF<sub>6</sub> CB can switch up to 10 times 40 kA currents

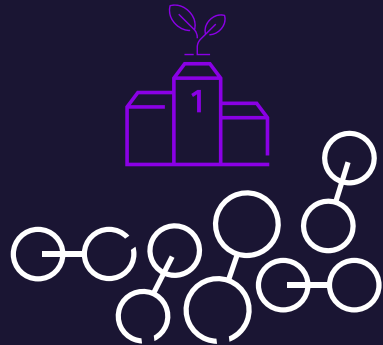
Long term stability (SF<sub>6</sub> gas recombines)

From -40 °C to +55 °C

Vacuum / clean air offers the **highest short-circuit switching capability** without degradation and can be operated in a wide temperature range, being especially suitable for **very low temperature applications**



# Criteria 4: Gas handling & costs



## Vacuum / clean air

- Vacuum interrupter is sealed for life > Zero maintenance
- No special tools, training, ventilation or reporting
- No recycling or special EOL treatment necessary
- Lowest lifecycle costs



## CO<sub>2</sub>-F mix fluoronitrile

- unknown
- Special tools, training, ventilation and reporting
- No recycling option, disposal can cause extra CO<sub>2</sub>
- Higher lifecycle costs

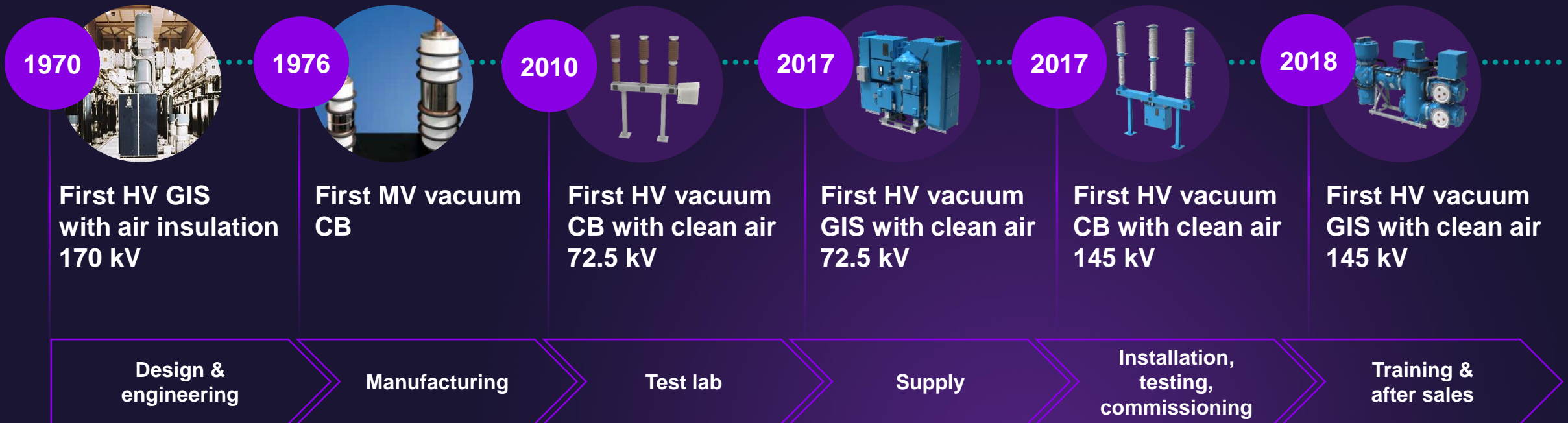


## SF<sub>6</sub> sulfur hexafluoride

- Additional gas maintenance
- Special tools, training, ventilation and reporting
- Can be cleaned and re-used (extra effort)
- Higher lifecycle costs

Vacuum / clean air is maintenance- and regulation-free and requires no special EOL treatment. Overall it has the lowest lifecycle costs

# Criteria 5: Manufacturer competence

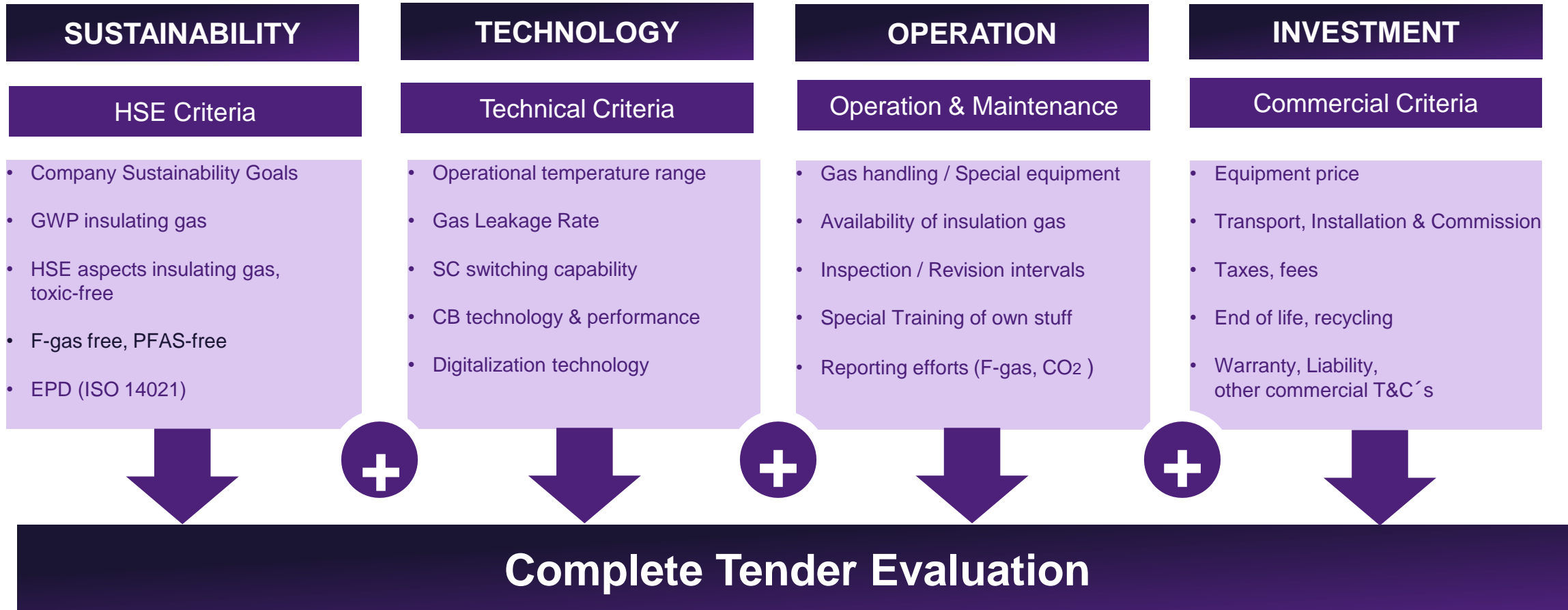


Siemens Energy has **over 50 years of experience** in switchgear with **global production** of 400,000+ GIS bays and 145,000+ CBs as well as more than **40 years of experience** in vacuum and air insulation technology

# Customer product evaluation criteria for switchgear products



# Evaluation criteria including sustainability indices are being developed by customers: Example GIS with alternative gases





# Evaluation criteria based on TCO including sustainability criteria helping customers to support UN Global Goals

## Possible Tender Evaluation Criteria:

### Equipment Price & Commercial Conditions

#### Technical Criteria

#### Sustainability Criteria

### Technical (General)

Physical footprint (dimensions)

3ph switching capability > 12 times 40kA

Leakage rate <0,1%

Building ventilation required

### Technical (Operation & Maintenance)

Special gas processing equipment required

Availability of insulating gas (no of suppliers)

Gas handling / contamination tests / precaution measures

Ease of degassing and gassing

Training and reporting efforts

### GWP Insulating Gas:

> 1 - 1000

> 0,1 - 1

< 0,1

### HSE Aspects

No F- gas used / No environmental risks (water/soil) due to PFAS

Not Harmful to health/ no toxicity classification

Non-Hazardous or non-toxic decompensation products

Finalized HSE regulation assessment /hazard analysis

### EPD, Diversity & Wages & LTIF-Rate

Environmental Product Declaration available (yes/no)

Target of diversity/inclusion goals and fulfilment

Paying wages > labour agreement

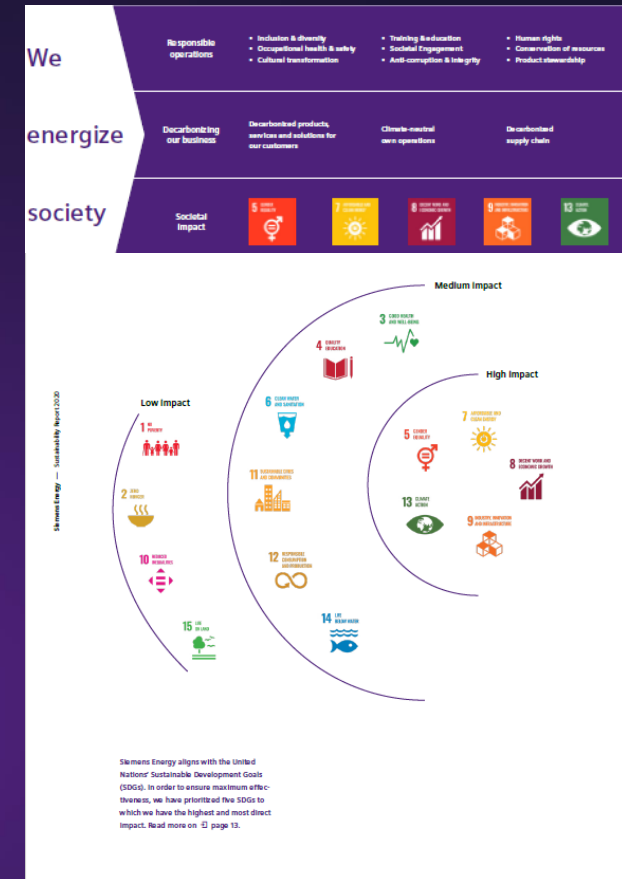
LTIF Rate < 0,3% (TRIR)



Target 12.7:  
Promote sustainable  
public procurement  
practices



## Siemens Energy Strategic CSR targets



# Examples for customer tender evaluations, in addition to TCO technical aspects and sustainability become more important

## APG / Austria



### 2 Zuschlagskriterien und Gewichtung

Der Zuschlag bzw. der Abschluss der Rahmenvereinbarung erfolgt nach dem Bestangebotsprinzip mit jenem Bieter, der das technisch wirtschaftlich günstigste Angebot unter Einhaltung aller vorgegebenen Bedingungen je Los gelegt hat. Bei der Ermittlung des technisch wirtschaftlich günstigsten Angebotes werden nur jene Angebote berücksichtigt, die nicht ausgeschlossen bzw. ausgeschieden worden sind.

Die Bewertung der einzelnen Angebote ergibt sich aus den Zuschlagskriterien:

Zuschlagskriterium	Gewichtung
Gesamtpreis je Los	70 Punkte
Qualität und Nachhaltigkeit	30 Punkte

#### Zuschlagskriterium „Preis“ (70 Punkte)

Das niedrigste Angebot, das die Ausschreibungskriterien erfüllt, wird mit 70 Punkten bewertet. Je höher ein Angebot im Vergleich zum Niedrigstangebot ist, desto niedriger ist auch die Punkteanzahl.

Berechnungsformel: 70 x Niedrigstes Angebot / Angebotspreis

#### Zuschlagskriterium „Qualität und Nachhaltigkeit“ (30 Punkte)

- Global Warming Potential (GWP-100 nach internationalen Standards, z.B. Greenhouse Gas Protocol, IPCC-ARS): max. 18 Punkte
  - Mindestanforderung Gasgemisch: GWP ≤ 500
  - Angabe des GWP des Gasgemischs (Bewertung siehe u.a. Tabelle)

GWP	Punkte
zwischen 500 und >1	4
zwischen 1 und >0,5	8
Zwischen 0,5 und >0,1	12
≤ 0,1	18

- Zusätzliche Angabe des eingesetzten Gewichts pro Gerät
- Zusätzliche Angabe GWP absolut pro Gerät
- Handhabung des eingesetzten Isolier- und Löschmediums im Betrieb: Sind Spezialgeräte zur Evakuierung des Gasraumes notwendig? – max. 5 Punkte
- Verfügbarkeit des Gasgemischs bei mehreren Lieferanten? – max. 5 Punkte
- Gewährleistungs- und Garantieverlängerung (max. 2 Jahre) – max. 2 Punkte
- Beschreibung des Bieters zum Thema Produkt-Umweltdeklaration gemäß ISO 14025 (in Planung, in Bearbeitung, bereits erhalten) – informativ, keine Punktevergabe

## TransnetBW / Germany

### 08 AUSWERTUNG DER ANGBOTE

Die Zuschlagserteilung wird an den Bieter erfolgen, der das wirtschaftlich günstigste Angebot gemäß den nachfolgend genannten Zuschlagskriterien abgegeben hat.

Die Bewertung nach Kriterien wird in vier Kategorien aufgeteilt:

TCO	40% Gewichtung
Vertrag	5% Gewichtung
Technik	40% Gewichtung
Projektmanagement/Fachexpertise	15% Gewichtung

Der Bieter hat ein vollständiges Angebot zu übergeben, welches die vollständige Bewertung aller genannten Bewertungskriterien durch die AG erlaubt.

Hinweis: Im gesamten hier beschriebenen Bewertungsverfahren wird kaufmännisch bis auf die zweite Kommastelle gerundet. Die Rundungsregelung richtet sich nach der Norm DIN 1333. Das Bewertungsverfahren wird im nachfolgenden Abschnitt beschrieben.

## Therwil / Switzerland

Hauptkriterium	Subkriterium	Gewichtung %
Angebotspreis	---	40%
Technik	Havarie- und Schottungskonzept (10%)	35%
	Gastyp / GWP / Gasmenge (10%)	
	Anlagendisposition (7%)	
	Gasdruck / Gashandling (2%)	
	Garantierte max. Leckrate (2%)	
	Konzept TE-Sensoren (2%)	
	Konzept Gegen Wiedereinschalten sichern (2%)	
Referenzen	gemäss Eignungskriterien	15%
	Qualität der gelieferten Schaltanlagen gemäss Auskünften der Referenzpersonen	
Serviceorganisation	Interventionszeit von einem werkseigenen Spezialmonteur zum Standort der Schaltanlage. Interventionszeit von einem werkseigenen Schaltanlagen-Experten zum Standort der Schaltanlage.	10%

## Elia / Belgium

Elia Asset NW/SA  
Tender Assessment

FA 018 06-220-330KV Onshore-Offshore Elia-50Hertz  
2021-2025

Contract No: Elie  
2020/8 081-218200

### 2 Tender Evaluation Overview

The Bid shall be evaluated against pre-determined Evaluation Criteria.

For Lot 1 and Lot 2, the Contract will be awarded to the Tenderer who achieves the highest total score on the Key subject areas and the back-up contract will be awarded to the Tenderer who achieves the second highest total score.

For Lot 3, the Contract will be awarded in the order described above following the total score on the Key subject areas.

The evaluation of the submitted Bids for this Request For Quotation will be performed using the following four Key subject areas and their Score repartition for each lot:

Key subject area	Chapter	Score repartition	Min score
Total Cost of Ownership	Ch. 4	55%	No min score
Acceptance draft of FA, maintenance contract and GPC	Ch. 5	16%	No min score
Technical aspects of solution(s)	Ch. 6	25%	No min score
Project Management & Safety	Ch. 7	4%	No min score
<b>Total</b>		<b>100%</b>	No min score

#### 2.1.1 Environmental aspects

These costs will be considered as a price added to the TCO to take into account the impact of the GIS installation proposed by the Tenderer on the Environment.

Lot 1 and Lot 2: This cost will be calculated for the forecasted quantities (= the quantities considered in part B of the **price book**) during the whole framework agreement period.

Lot 3: This cost will be calculated for the project concerned by the mini-competition and so, in Tender Phase, only the quantities of gas in **Coupeles** and Mercator (GIB) will be taken into account.

The environmental aspect E will be considered as follows:

$$E_F = (0,1 \cdot M_{SF6} [kg_{SF6}] \cdot C_{R_{SF6}} \left[ \frac{€}{kg_{SF6}} \right])$$

$$E_{V,year} = \left( \left( L_r \left[ \frac{m^3}{y} \right] \cdot \frac{M_{gas} [kg_{gas}] + GWP}{1000} \right) [T_{eq,CO2}] + C_{T_{CO2}} \left[ \frac{€}{T_{CO2}} \right] \right)$$

$$E = E_F + NPV_{50y}(E_{V,50years})$$

With

**E<sub>F</sub>**: the fixed part penalizing the installed SF6 quantity  
**E<sub>V</sub>**: the variable part penalizing the leakage rate of gas (net present value applied)

**M<sub>SF6</sub>**: the total mass of SF6 in the GIS (= 0 if gas is not SF6)

**M<sub>gas</sub>**: the total mass of gas in the GIS

**L<sub>r</sub>**: the leakage rate



3

# Grid operators started to specify T&D equipment with GWP < 1

## Tennet / Germany & Netherland

<b>SRS_06222 - Global warming potential</b>		Parent: SRS_02808
The GIS Encapsulation System shall be filled only with gases or gas mixture with a global warming potential smaller than one.		
<b>Verification plan</b>	<b>Verification phase</b>	
Proposal by Contractor	E2 - Design	

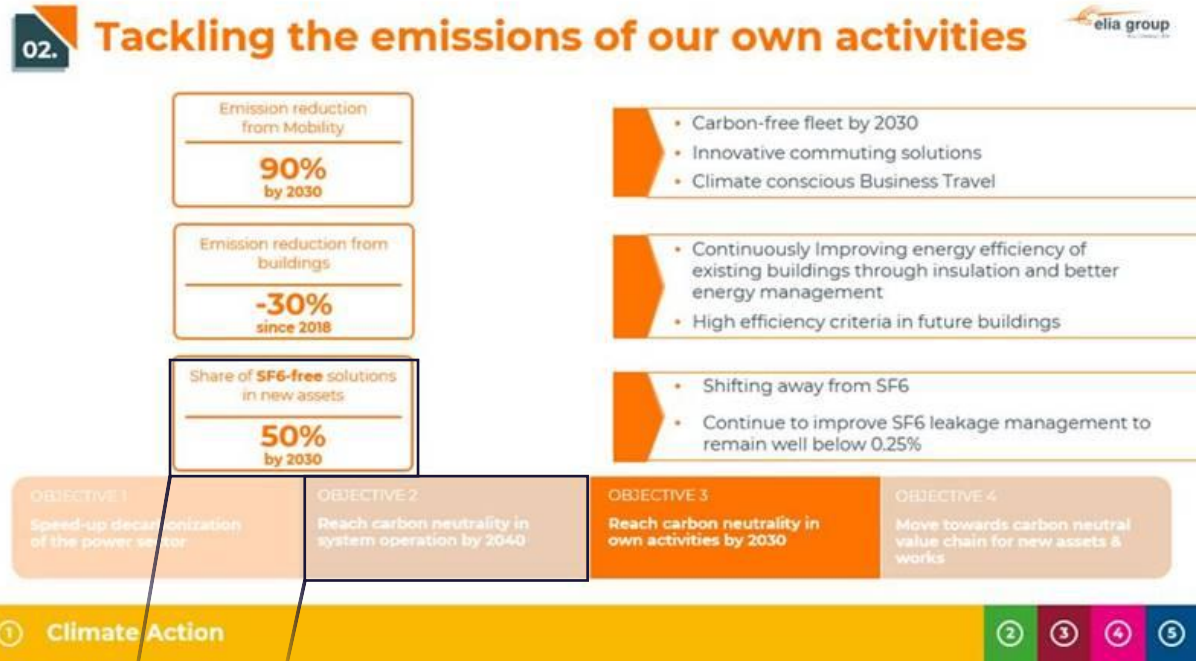
## TransnetBW / Germany

### 3.0 MINDESTANFORDERUNGEN

Um einen möglichst großen Beitrag zum Erreichen der Klimaziele zu leisten, muss die Schaltanlage mit Alternativgas betrieben werden. Das **GWP** (Global Warming Potential) des Gases muss einen Wert  $\leq 1$  aufweisen. Der Bieter muss bestätigen, dass die gesamte Anlage bis spätestens 2026 komplett mit alternativem Gas betrieben werden kann.

## Railway DE / CH / AT: GWP $\leq 1$

## Elia / Belgium



Reach carbon neutrality in system operation by 2040  
Share of SF6-free solutions in new assets 50% by 2030

# Summary and Conclusion

## How to specify for a sustainable power grid

1. Specification: Usual technical specification, plus sustainability goals, e.g. GHG free or with a GWP of Zero or <1
2. Evaluation criteria according your criteria, e.g. reliability, installations, technical performance, sustainability, total cost of ownership
3. Financial evaluation: Total cost of ownership: Investment of products and buildings, installation, operation, maintenance, end of life, risk of stranded assets due to regulation



# Zero-harm energy transmission is already becoming a reality around the world



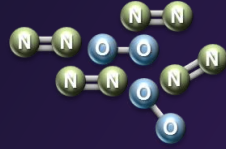
**> 6,5 million hours**  
of commercial operation

**~ 2,500,000 tons**  
of CO<sub>2</sub>-equivalent saved

**> 2,500 units**  
sold

**> 700 units**  
already in operation

Status: June 2022

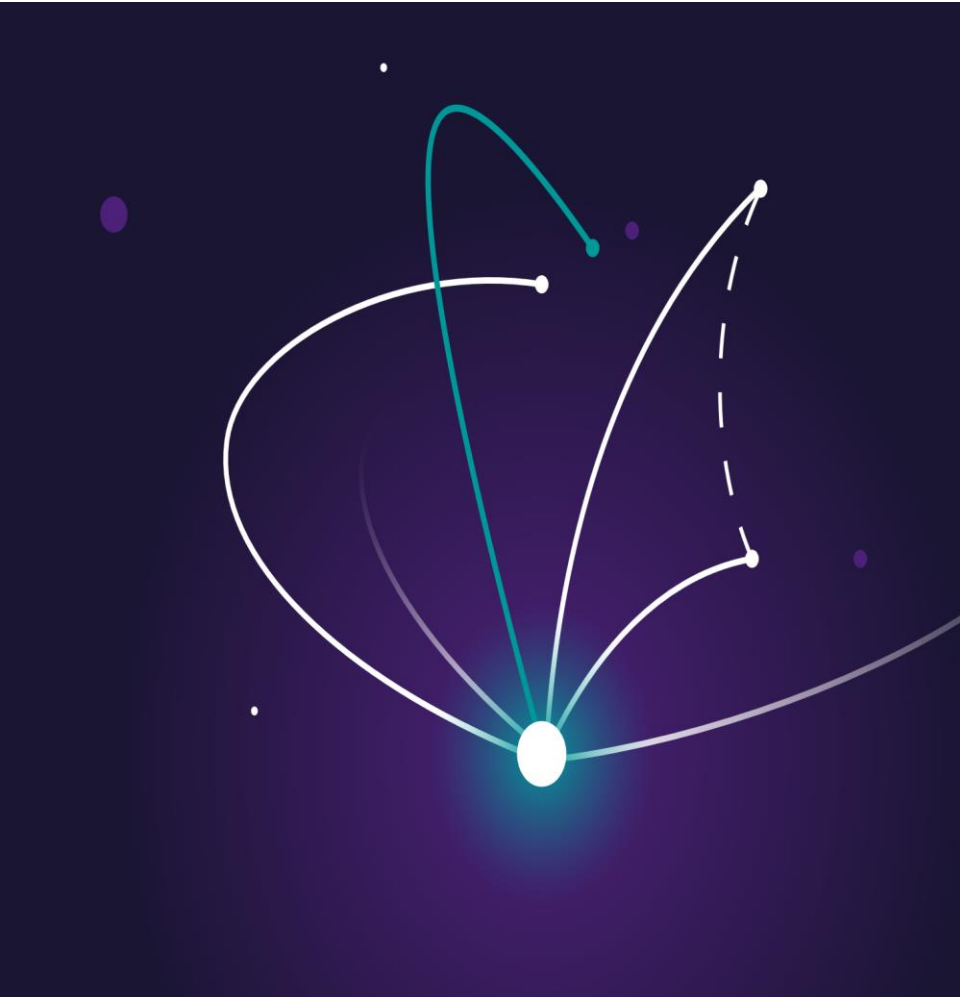


**F-gas-free clean air  
& vacuum switching  
technology set  
sustainable  
standards and is  
the future of global  
power grids!**

## Summary and Q&A

- 1** Most environment-friendly technology,  
**Zero emission: GWP = 0**
- 2** No special health and safety requirements,  
**Zero pollution:** non-toxic, non-hazardous,  
F-gas-/ PFAS-gas-free
- 3** **Out of any F-gas & chemical regulations now & in future!**
- 4** No degrading effects during operation, long-term stable &  
**reliable at improved technical performance!**
- 5** Lowest lifetime costs, Simple gas handling,  
No recovery & recycling needed! Multiple gas supplier!

# Thank you!



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### **Further reading:**

- [Siemens Energy Blue Products](#)
- [Siemens Energy Gas-insulated substations](#)
- [Siemens Energy Transmission Products](#)

# Disclaimer

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