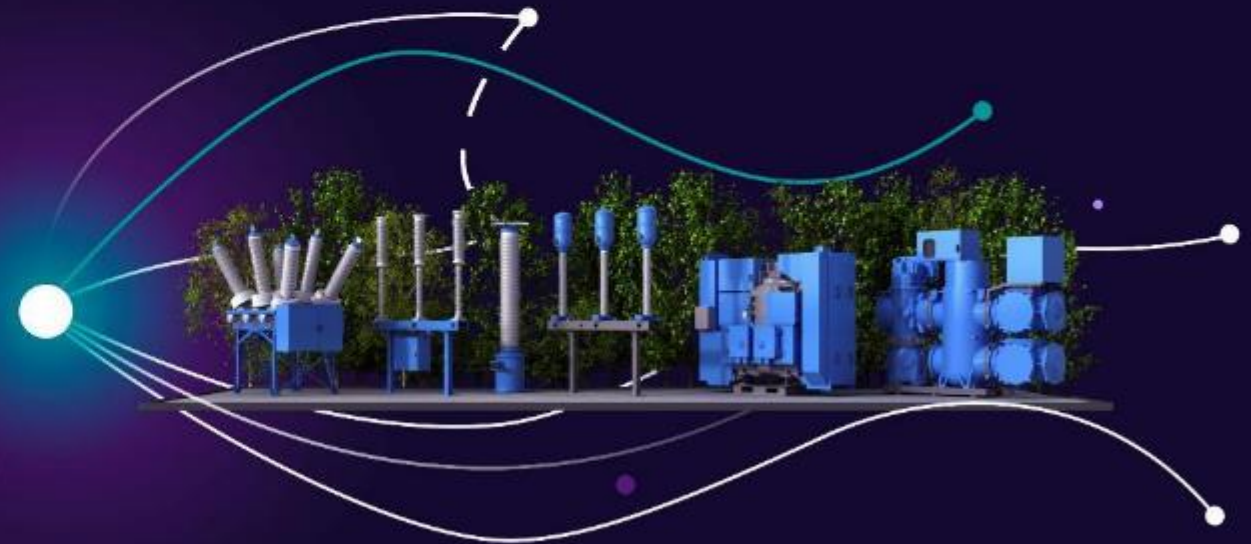


# Blue – Our path to Zero with Clean Air

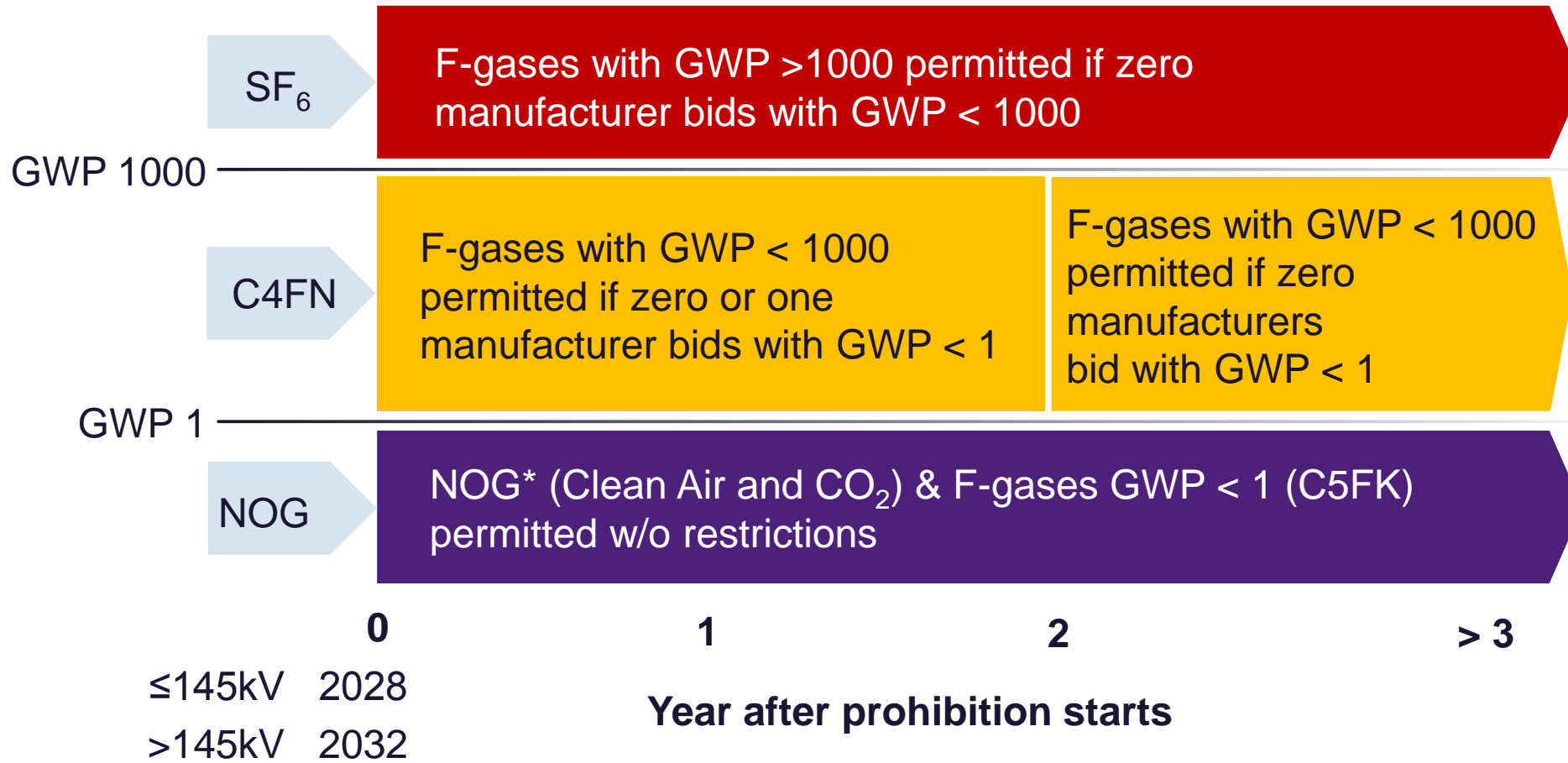
Thomas Rank  
Siemens Energy - Grid Technologies

November 2023



# Legislations and regulations – Summary main EU decision

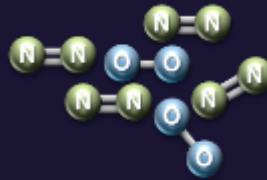
## HV T&D Switchgear- Derogation Schedule



\* NOG: Natural Origin Gases

# Blue HV products - Benefits for grid operators and society

## Clean air (N<sub>2</sub> + O<sub>2</sub>) insulation



- Zero CO<sub>2</sub> emissions, lowest CO<sub>2</sub> footprint, GWP = 0
- Zero toxicity, highest stability, easiest gas handling
- Zero liquefaction at low temperatures -60 °C
- Zero patent dependencies, multiple suppliers

+

## Vacuum interruption



- Zero toxic decomposition products, hermetically tight
- Highest switching performance w/o degradation, scalable short-circuit current capabilities
- Zero maintenance (sealed for life)

**= Clean, Safe and Future-proof regarding F-gas and PFAS regulation!**

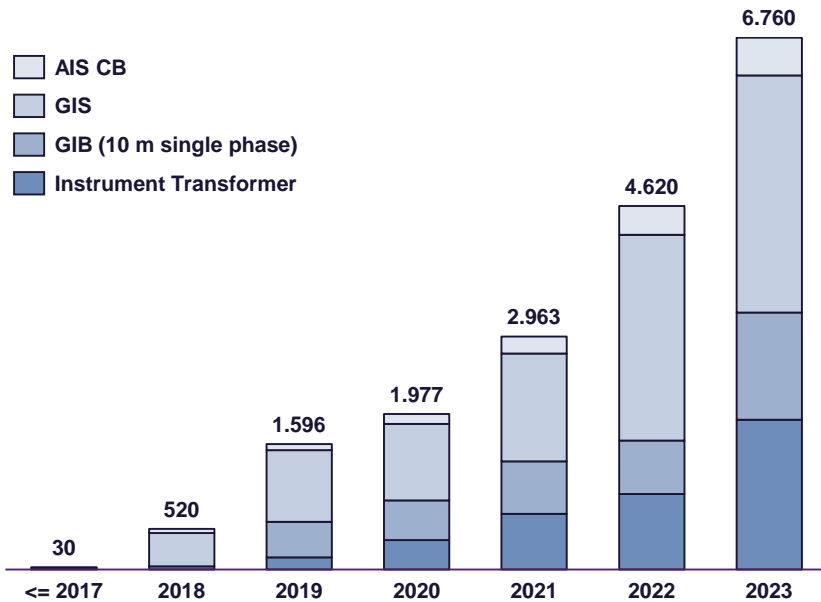
# Blue Orders and Installations

- More than 2800 units delivered
- More than 1600 units in service
- 23 Mio hours service experience
- 4,6 Mio t CO<sub>2</sub>e emissions saved through avoidance of installed SF<sub>6</sub>
- 0,18 Mio t CO<sub>2</sub>e emissions saved through avoidance of leakages from not installed SF<sub>6</sub>



## Blue Order Intake

Circuit Breaker, Instrument Transformer, GIS, GIB

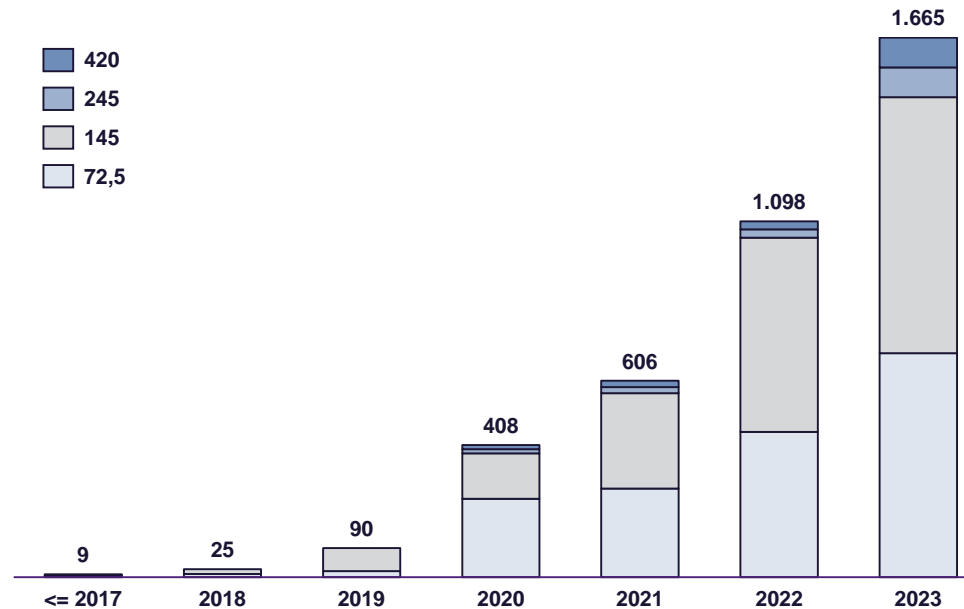


GIB: Gas Insulated Busduct

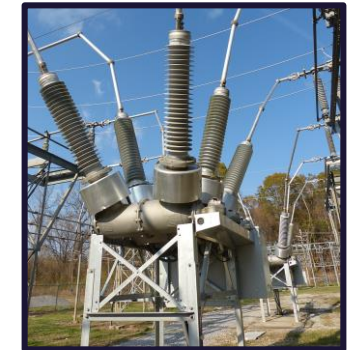
Status September 2023  
pieces accumulated

## Blue Service Experience

Circuit Breaker, Instrument Transformer, GIS, GIB



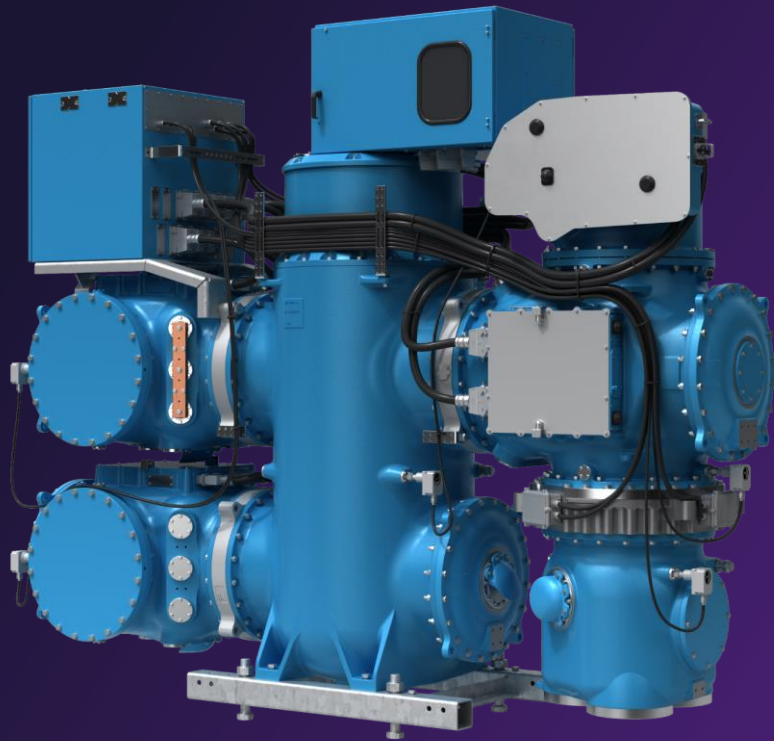
Status September 2023  
pieces accumulated



# Experiences with Blue operation

- ✓ **Delivery and installation of factory pretested units leads to quick installation and commissioning**
- ✓ **Clean air helps to reduce all gas handling processes**
- ✓ **No special difference during commissioning and assembly compared to SF<sub>6</sub> GIS noticed including high voltage and partial discharge on-site tests**
- ✓ **No operational differences compared to SF<sub>6</sub> noted**
- ✓ **With the existing factory quality measures adapted to Clean Air, the same reliability and MTBF can be expected as with SF<sub>6</sub> equipment. In fact, no major failures have been recorded so far**

# 8VN1 Blue GIS™ 145 kV



## Product characteristics

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- Vacuum interrupter technology | 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 145 kV, rated frequency 50/60 Hz
- Rated short-circuit breaking current up to 40 kA
- Ambient temperature range -50 °C 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%

## Types / variants

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



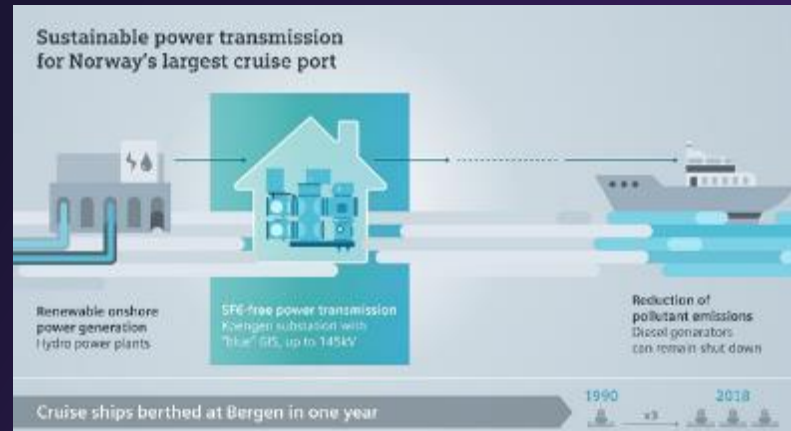
## Type tested

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- Acc. to IEC / IEEE

## Success Story

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



## The world's first F-gas-free GIS with clean air & vacuum technology

SIEMENS  
ENERGY

### 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

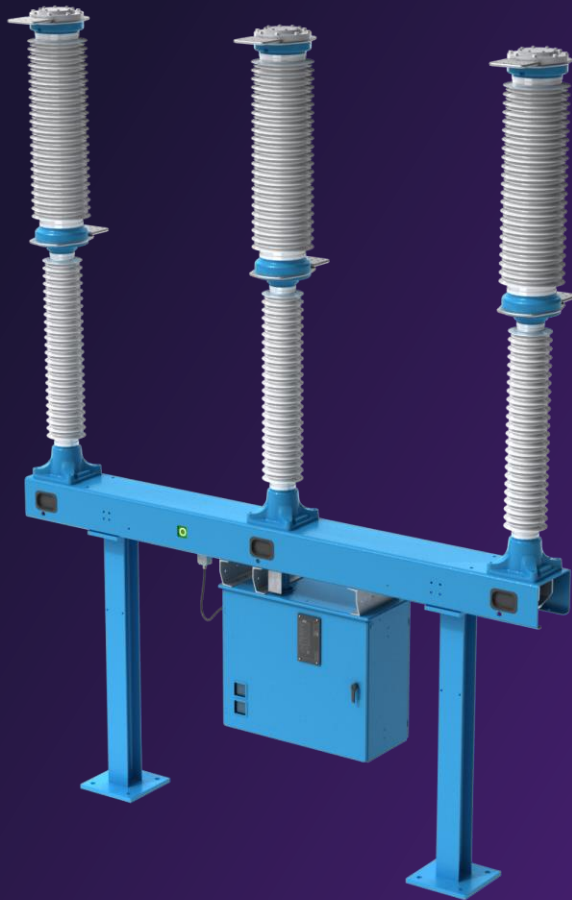
- GIS includes low power instrument transformers (LPIT) to ensure a compact design



*"We anticipate that SF<sub>6</sub> will eventually be banned or burdened by restrictions and penalty fees, so when making investments in capacity and substations in and around Bergen, we opted to eliminate SF<sub>6</sub> from the equation- because we want to move towards sustainability, and we didn't want to make a decision today that would embarrass us two years down the line."*

*- Jens Skår, Division Manager, BKK Nett- Norway*

# 3AV1 Blue Live Tank Circuit Breaker™ 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
- 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

- Stored-energy spring drive mechanism
- Rated voltages up to 145 kV, rated frequency for 50/60 Hz
- Rated continuous current up to 3150 A, rated short-circuit breaking current 40 kA
- Perfect for frequent breaking operations and extreme temperatures from -60 °C to +55°C
- 0.5 g seismic conditions, high terminal loads (2 kN stat. / 5 kN dyn.)
- Two-cycle current interruption
- Leakage rate < 0.1% p.a.

## Types / variants

- Three-pole operation (FG) | composite insulators
- Also available as 60 Hz circuit switcher according to IEEE Std. C37.016

## Type tested

- Acc. to IEC





# The world's first SF<sub>6</sub>-free high-voltage switchgear with clean air insulation

## Key facts

- Customer: Netze BW GmbH, Germany
- Modernization of a 110 kV substation in Noerdlingen
- Operation requires no SF<sub>6</sub> or any other greenhouse gas
- Year of order: 2017
- Energization: 2018



## Circuit breakers

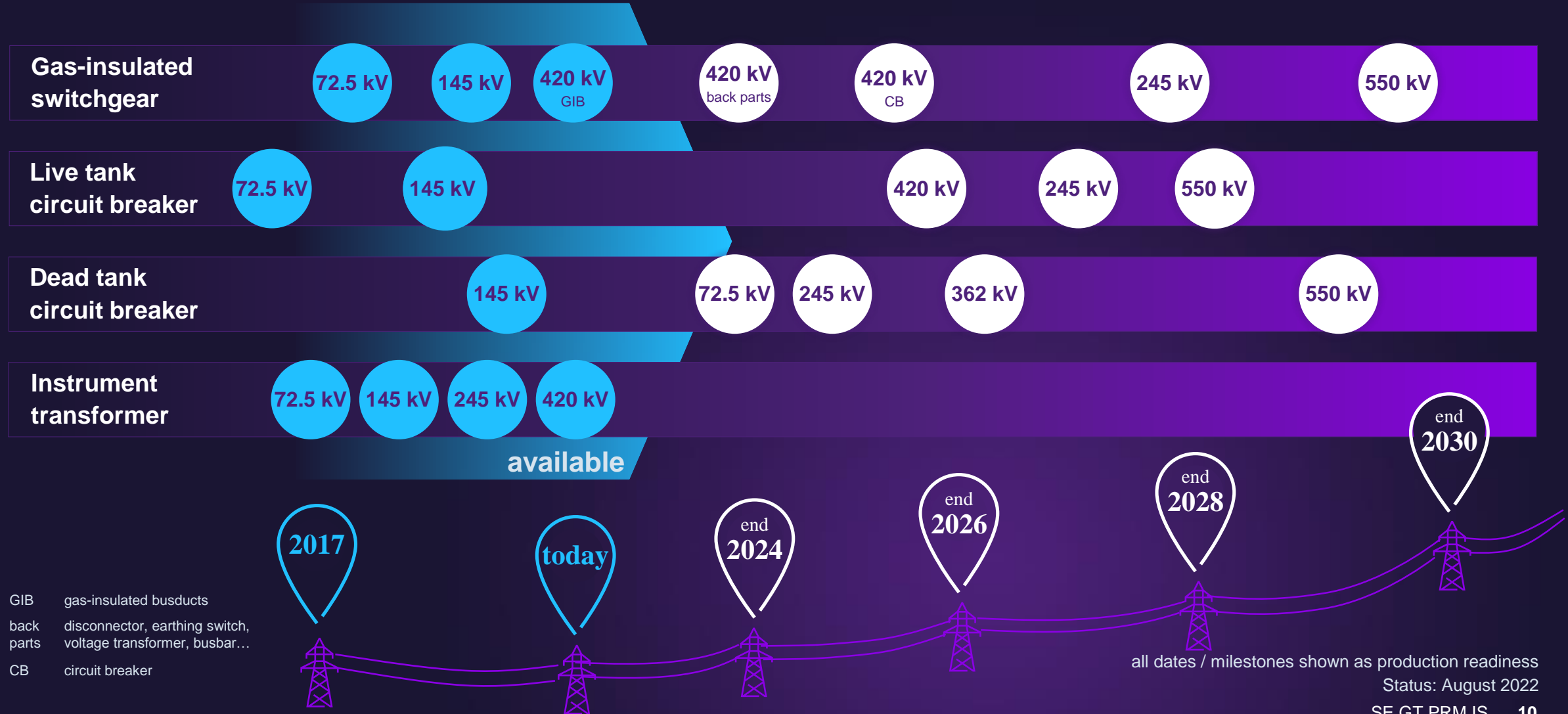
- Installation of two SF<sub>6</sub>-free 3AV1 Blue Circuit Breakers™ for 145 kV
- Vacuum interrupter technology
- Clean air insulation technology



## Instrument transformers

- Six SVAA voltage and current transformers with clean air insulation

# 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

all dates / milestones shown as production readiness  
 Status: August 2022

# F-gas free products are available and in reliable use worldwide up to 420 kV, the majority rely on natural-origin gases to ensure safe power grids!

## Natural-origin gases / F-gas-free with GWP < 1

1. F-gas free alternative technology & products **already available**
2. Manufacturers are committed to **close the portfolio gaps**
3. The proposed **transition time is sufficient to close and develop F-gas-free portfolio**

### Medium Voltage



### High Voltage



Source: Publications & web sites

● Factory in Europe

# 245 kV Blue VCB development ongoing

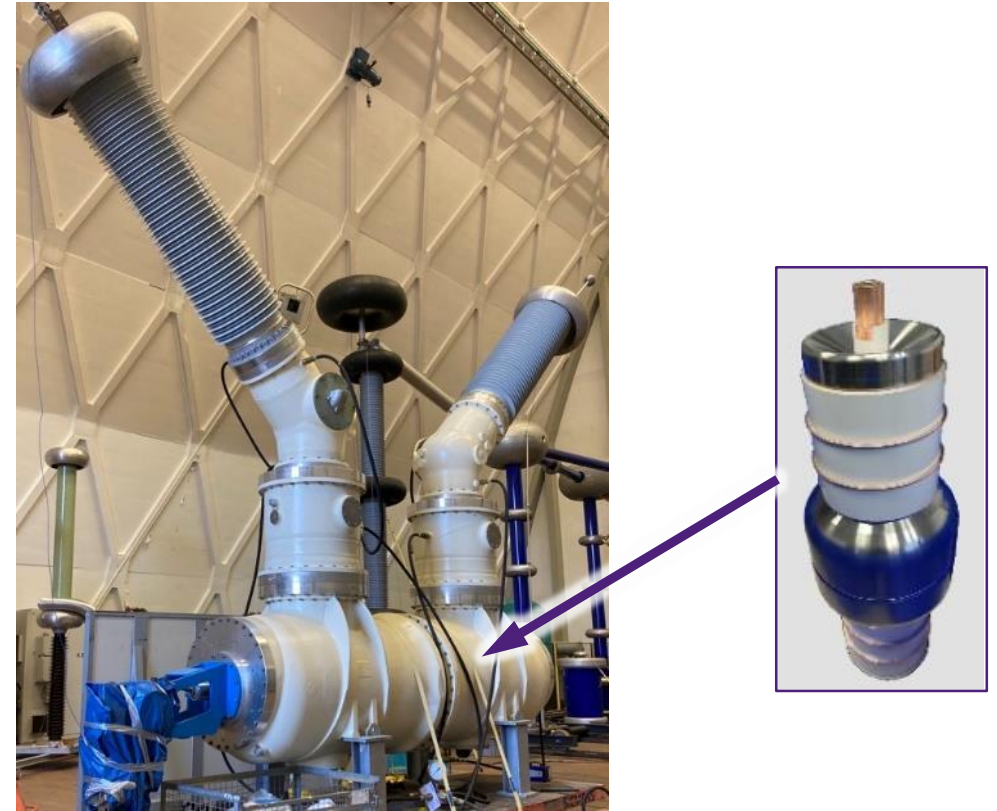
First prototypes tested in a metal-enclosed environment (single pole encapsulated with synthetic air insulation)

Development results:

High voltage from movable and fixed contact side:

- $U_{AC} = 460kV_{rms}$
  - $U_{LI} = \pm 900kV$
- AC test represents stable dielectric withstand values;
  - flashovers occurred only sporadically during LI tests with values up to  $U_{LI} = 1050kV$ ;
  - improvements ongoing to achieve IEC/IEEE requirements

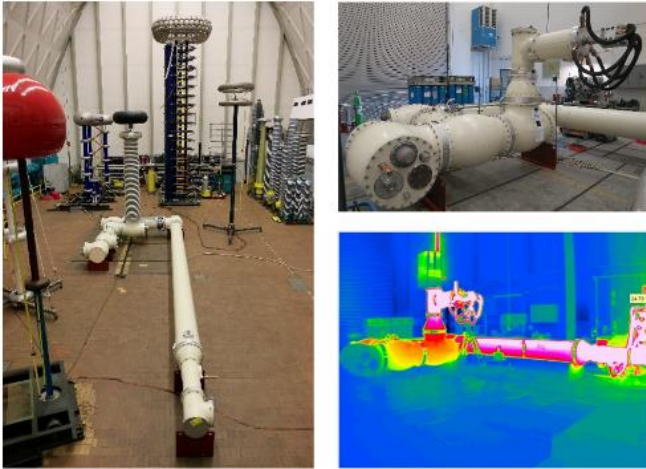
Source: Thomas Heinz; "Why is vacuum technology not a simple scaling from medium to high voltage", ISDEIV 2023, Japan



245kV VI prototype;  
**passed condition check** after 63kA T100 test duty

# 420 kV Blue GIS development ongoing

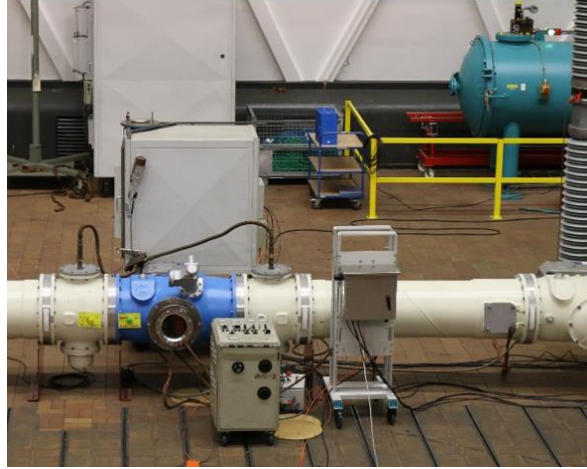
## GIB – All Type tests passed 2022



### Examples:

Dielectric type test and temperature rise type test including thermal camera observation

## Back parts – Type tests 2024



### IEC 62271-102 – successfully demonstrated

- TD1 ( $U_{\text{source}} = 267 \text{ kV}_{\text{AC}}$ ,  $U_{\text{load}} = -377 \text{ kV}_{\text{DC}}$ )
- TD3 ( $U_{\text{source}} = 242 \text{ kV}_{\text{AC}}$ ,  $I_{\text{load}} = 0.5 \text{ A}$ )
- Bus transfer current switching for  $I_r = 5000 \text{ A}$

### IEC 62271-203 – successfully demonstrated

Switching state “Open”

- $U_{\text{AC}} = 815 \text{ kV}$
- $U_{\text{SI+AC}} = 900 \text{ kV} + 345 \text{ kV}_{\text{AC,peak}}$
- $U_{\text{LI+AC}} = 1425 \text{ kV} + 240 \text{ kV}_{\text{AC,peak}}$

Switching state “Closed”

- $U_{\text{AC}} = 650 \text{ kV}$
- $U_{\text{LI}} = 1425 \text{ kV}$
- $U_{\text{SI}} = 1050 \text{ kV}$

## Vacuum Circuit Breaker – Type tests 2025



### IEC 62271-100

- Series-connection of two vacuum interrupter units
- The switching capability of 63 kA has been proven by finished type tests for 63 kA @ Dead tank breaker of 145 kV at 60 Hz

Source: P. Gronbach et al, „Zero Emission F-gas-free 420 kV GIS for a Net Zero Carbon Future“, Cigre A3&B3 Colloquium, Birmingham May 2023

# Conclusion – Clean air fits perfectly for customers switchgear requirements



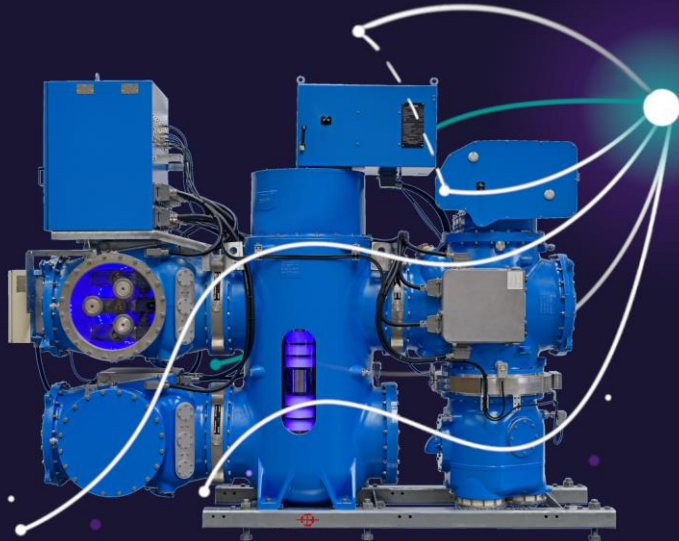
More information, see [Blue Products Webpage](#)



**Grid technologies for clean energy:**

**Environmentally friendly, safe, reliable  
and economical over the entire service life**

**Thank you for  
your attention!**



Siemens Energy Global GmbH & Co. KG  
Siemens Energy  
Gas and Power

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**Further reading:**

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

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