Technology and regulations drive decarbonization – Clean air our path towards net zero

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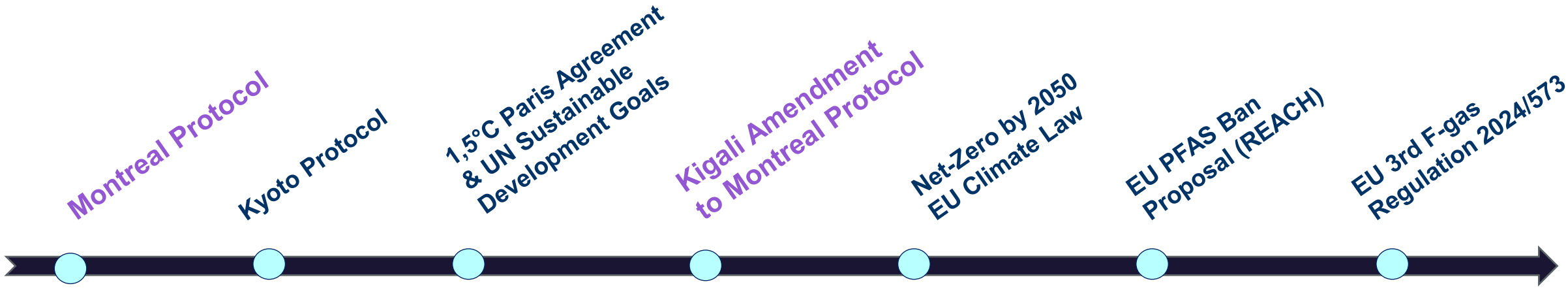
Content

Main International Agreements on Sustainable Development



1987

First legally binding agreement to cut greenhouse gas emissions with phase out of Substances that Deplete the Ozone Layer

1997

First legally binding agreement to combat climate change by reducing six potent green-house gas emissions: CO_2, CH_4, N_2O, HFCs, PFCs, **SF_6**

2015

Landmark to limit global warming to 1.5°C; 17 SDGs, a blueprint for peace, prosperity, and sustainability for people and the planet.

2016

HFCs (not ozone-depleting but potent green-house gases) added to the phase-down list.

2021

First international legal liability for climate neutrality by 2050

2023

EU Chemicals Agency (ECHA) has published a proposal to restrict PFAS* under the EU's chemicals regulation incl. PFAS F-gases

* Per- and polyfluoroalkyl substances

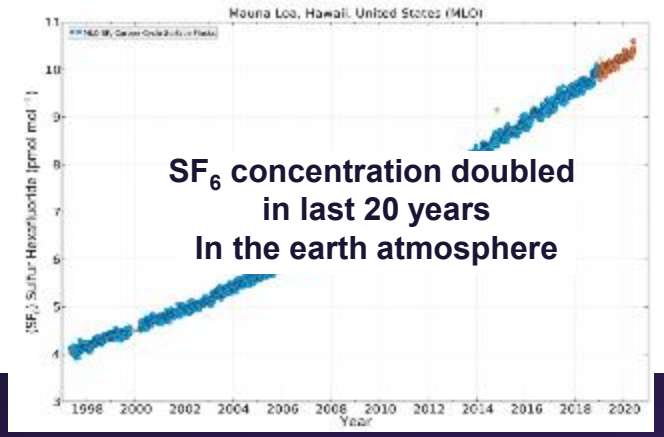
2024

Ban on F-gases GWP > 1 for new switchgears and stricter rules to prevent emissions

From Research to Reality:
F-Gas-Free Switchgears Since 2000s

Time for Action:
Global Phase-Down to Cut F-Gas Emissions!

Time for Action:
F-gases in switchgears and grids require attention



SF_6 concentration doubled in last 20 years In the earth atmosphere

Today's power grid
still relies on the most potent greenhouse gas:

SF_6

Typical SF_6 amount per GIS unit of latest design:
→ 145 kV ~80 kg → 420 kV ~800 kg

kg

1 kg
of SF_6 is equivalent to …

CO_2

24,300 kg
of CO_2

or

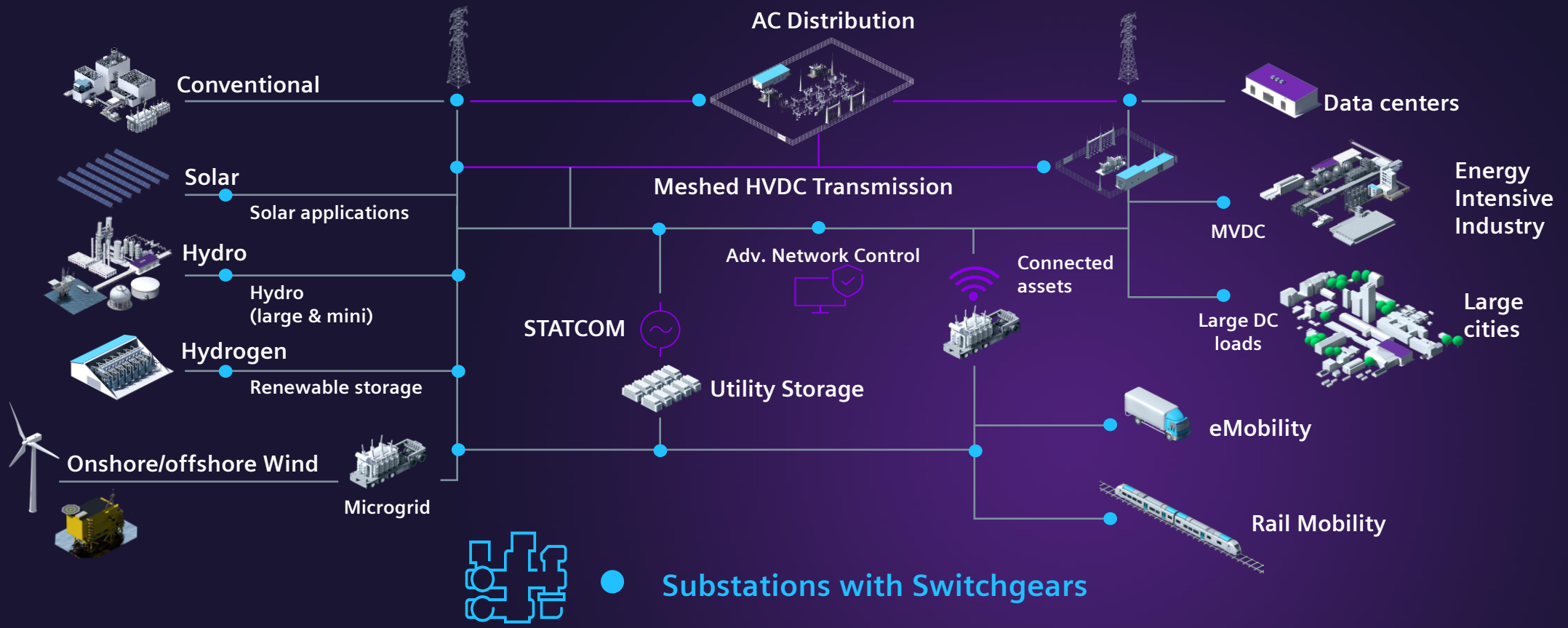
One car-life
petrol consumption

Source: Final IPCC AR6 Report, 2023

Car-life: ~135 g CO_2/km * 12,000 km/a * 15 a

5 Drivers of Electricity Demand / Substations: Electrification, Digitalization, Decarbonization, Growth & Energy Transition

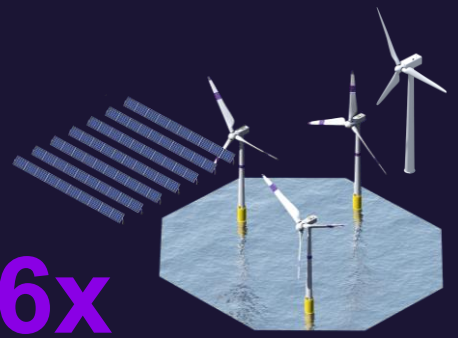
Distributed | Ageing + Unpredictable | Multi-directional | Horizontally networked



Market growth led by renewables additions and electricity demand presents challenges in grid infrastructure

Energy transition challenges

- **Connect** renewable energy sources
- Improve **grid resilience**
- Drive **decarbonization**
- Manage **grid complexity**

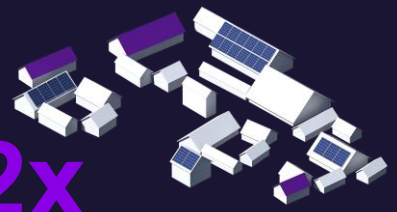


6x

more installed capacity from grid-connected RES (2024 vs. 2050)

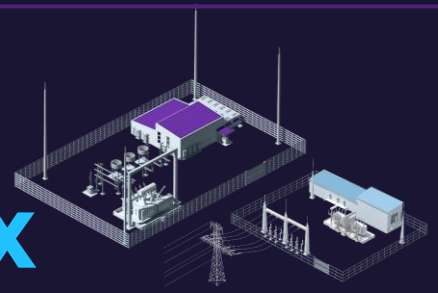
~€650bn p.a.

grid investment required by 2030 to reach national climate goals



2x

more electricity demand (2050 vs. 2022) **Consumers are becoming prosumers**



2.5x

more capacity in the grid needed to connect planned renewables additions and secure stability of power systems

Sources: DNV Energy Transition Outlook 2024, IEA World Energy Outlook 2024, IEA Renewables 2024, IEA Electricity Grids and Secure

Replacing SF_6 in high voltage

We are doing it with clean air

Proven technology

Already > 7,000 units sold, > 2,600 units with > 40 million hours successfully in operation

Peak performance & safety

Highest switching performance, zero toxic by-products, fully compliant with IEC and ANSI/IEEE

GWP = 0

Clean air gives the equipment the lowest carbon footprint across its life cycle

Suitably sized

Our clean air units fit within the footprint of the SF_6 units they replace

Future-proof

Answer to the EU F-gas regulation GWP < 1 and PFAS-F-Gas ban proposals

2010
72.5 kV

2017
145 kV

2017
72.5 kV

2019
145 kV

2022
145 kV

2023
420 kV

2026
420 kV

Phase-down of F-gases including SF_6 and other PFAS-F-gases ongoing, products already available up to including 550 kV

F-Gas-Free Technologies (CO_2/O_2 & N_2/O_2, Air, GWP < 1) *

1. F-gas-free alternative technology & **products already available**
2. The manufacturers committed to **close the portfolio gaps**
3. The **timeframe** of the F-gas regulation* for bans is **sufficient** to develop an F-gas-free portfolio

Medium Voltage

High Voltage

Source: Publications & web sites

*Very few OEMs use PFAS-F-Gases like C4-FN-gas-mixture with GWP ~ 500 as SF6 alternatives for GIS equipment

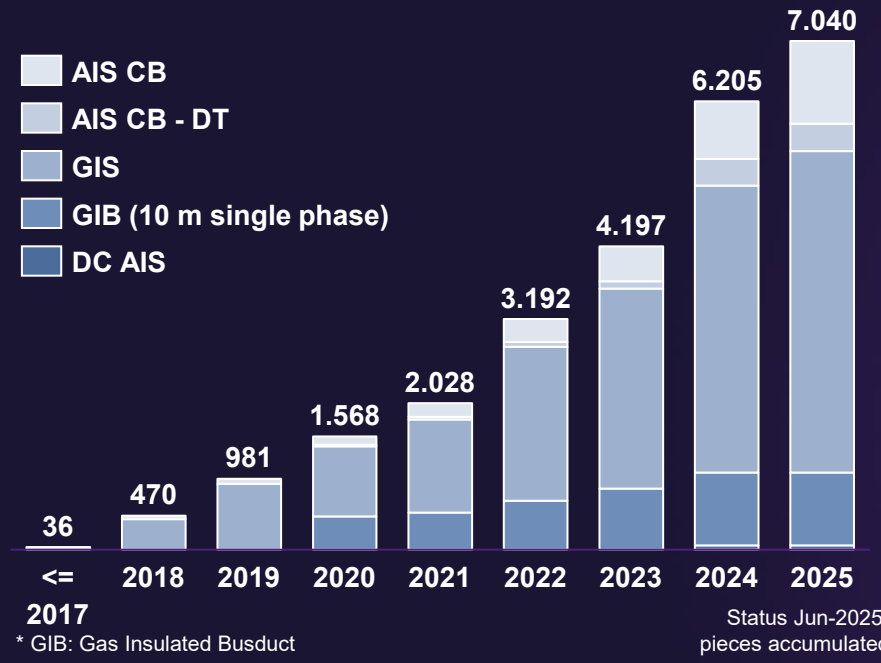
EU F-Gas GWP > 1 Ban: Import to Secure Industry Path to Net-Zero Power Grids

F-Gas-Free Orders: A Major Success

- More than 4150 units delivered
- More than 2550 units in service
- 45 Mio hours service experience
- 8,7 Mio t CO_2e emissions saved through avoidance of installed SF_6
- 0,35 Mio t CO_2e emissions saved through avoidance of leakages from not installed SF_6

Blue Order Intake

Circuit Breaker, GIS, GIB, DC AIS

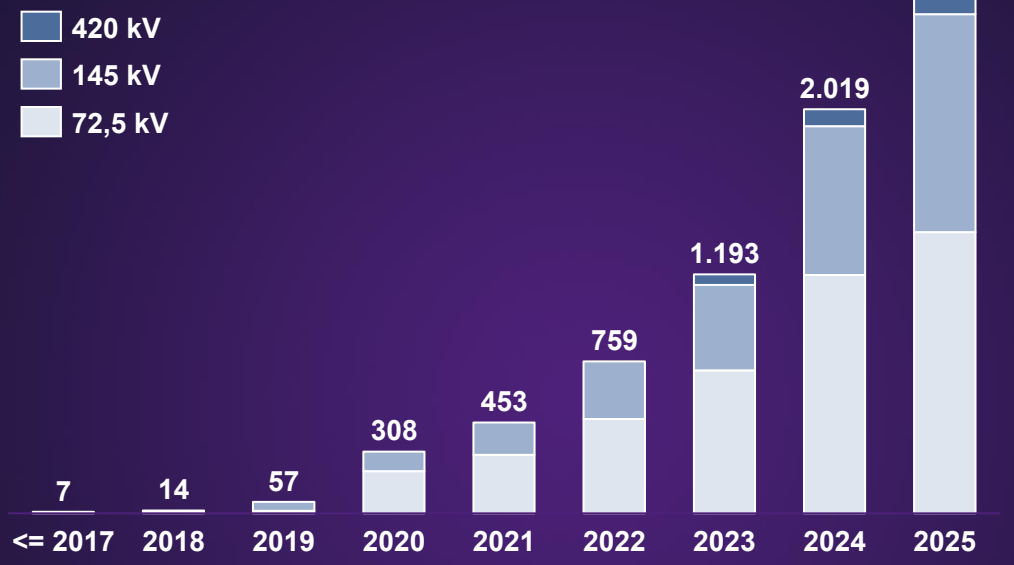


Status Jun-2025
pieces accumulated

* GIB: Gas Insulated Busduct

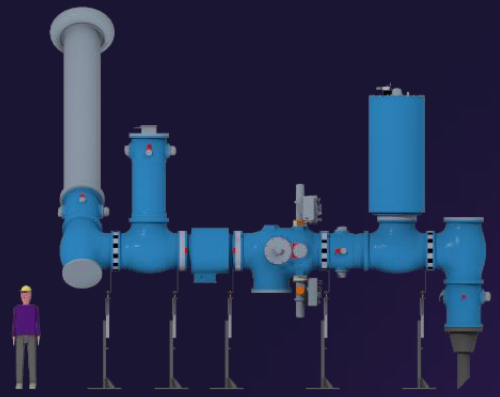
Blue Service Experience

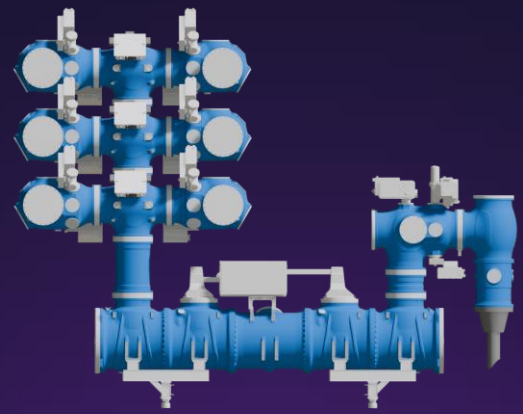
Circuit Breaker, GIS, GIB

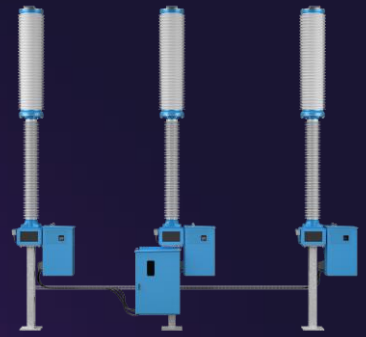


Status Jun-2025
pieces accumulated

EU supports GWP < 1 and PFAS-free developments & pilots, promoting sustainability & the latest EU switchgear regulations







Pilots 2026

Clean Air LT
420 kV, 4000 A, 63 kA

Lab-Pilot 2026

Clean Air DC GIS
550 kV, 5000 A, 63 kA

Pilot 2027

Clean Air GIS
420 kV, 4000 A, 63 kA

Pilot 2029

Clean Air LT
245 kV, 4000 A, 63 kA

MISSION Co-funded by the European Union

EU Project Mission

LIFE Blue Project GIS 420 kV Co-funded by the European Union

EU LIFE Blue 420 kV GIS

LIFE Blue Project LT 245 kV Co-funded by the European Union

EU LIFE Blue 245 kV LT

Summary

1

Energy transition requires Decarbonisation measures in switchgears

2

Replacement of SF_6 by non-toxic Clean air with GWP = 0

is a proven decarbonization measure for electrical grids

3

Regulations are driving sustainability by phasing out F-gases with GWP > 1

Time for Action Globally

4

Siemens Energy supports sustainability and decarbonisation by clean air switchgears

Thank you for your attention

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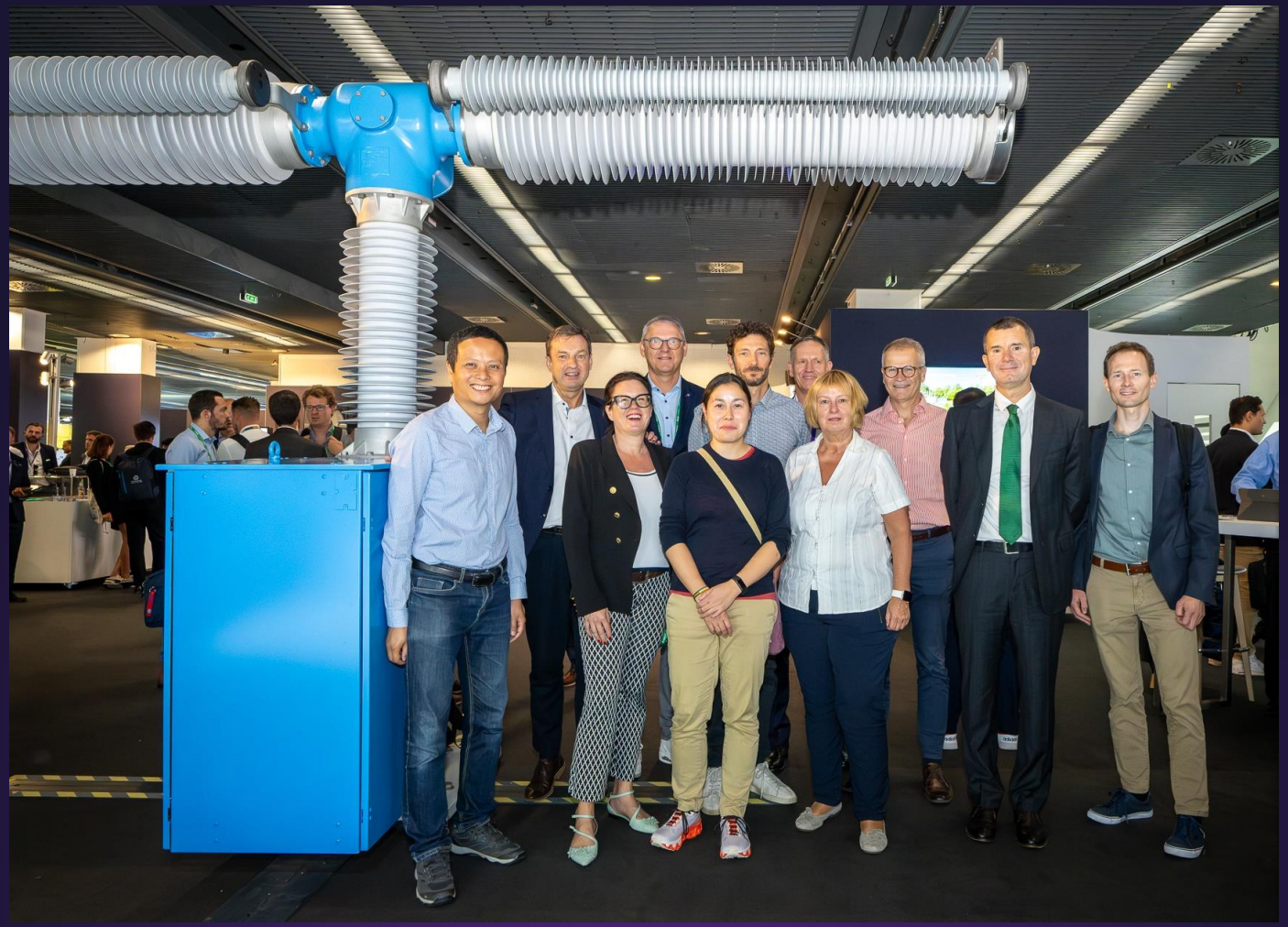

Mission LT Blue 420kV @ CIGRE Paris 2024

Backup

Based on internal and external assessments: very low probability of a change to the F-Gas Regulation, global F-gas restrictions expected in the mid-term!

SIEMENS energy

European Union

United States

Rest of World

F-gas regulation (2024/573): B**an of GWP ≥ 1 F-gases** from **2028** > 52 kV & **2032** > 145 kV

Law effective in **California** (CARB[2]) and in **New York** state for **SF_6** for ban from 2025 respectively 2027 in MV and HV

CN, JP, KR transition for SF_6 / F-gas-free started w/o regulations, in other countries first pilots

G7 commit in 2024 to phase out the use of SF_6 in new switchgear applications by 2035

Restriction proposal for **PFAS[1] incl. Ban of PFAS F-gases like C4-FN in switchgears** from **2029**[4] ≤ 145 kV & **2034** > 145 kV[4]

PFAS[1] restrictions: First laws effective incl. PFAS F-gas (e.g. C4-FN-Gas) in Maine and Minnesota – further adoptions expected in next years

Most countries follow UN Stockholm Convention (including the PFAS restriction for PFHxS, PFOA, PFOS & PSOSF (recommendation in 2025: PFCA)

Time for Action: Global Phase-Down to Cut F-Gas Emissions!

1 Per-and polyfluoroalkyl substances including PFAS F-Gas C4-FN | **2** CARB: California air resources board | **3** Persistent Organic Pollutants | **4** Expected Publication and Entry into Force (EiF)