

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

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**1** Energy transition / decarbonisation

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**2** Replacing SF<sub>6</sub> in Switchgears

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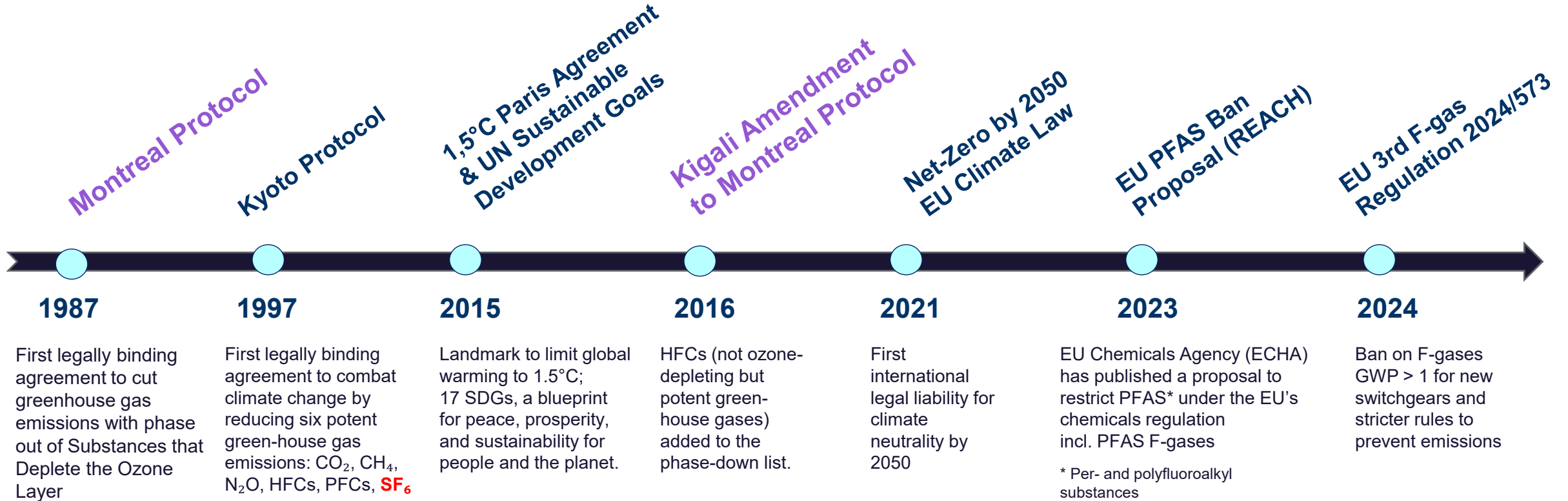
**3** Insights to R&D Activities

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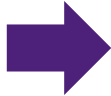
**4** Summary



# Main International Agreements on Sustainable Development

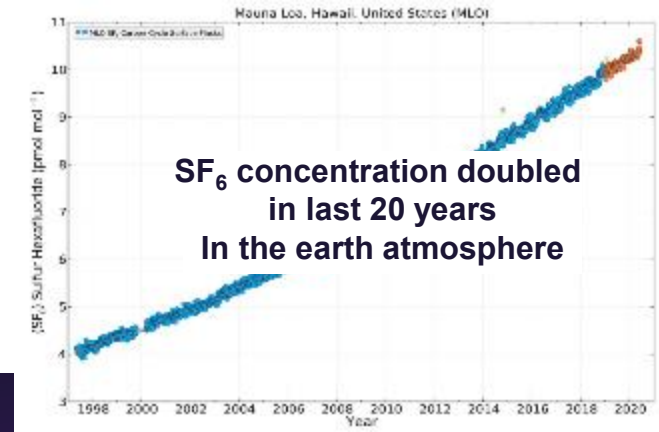


**From Research to Reality:  
F-Gas-Free Switchgears Since 2000s**



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

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



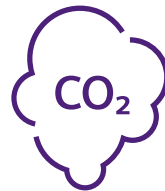
**Today's power grid**  
still relies on the most  
potent greenhouse gas:



Typical SF<sub>6</sub> amount per GIS unit of latest design:  
→ 145 kV ~80 kg      → 420 kV ~800 kg



**1 kg**  
of SF<sub>6</sub> is  
equivalent to ...



**24,300 kg**  
of CO<sub>2</sub>

or



**One car-life**  
petrol consumption

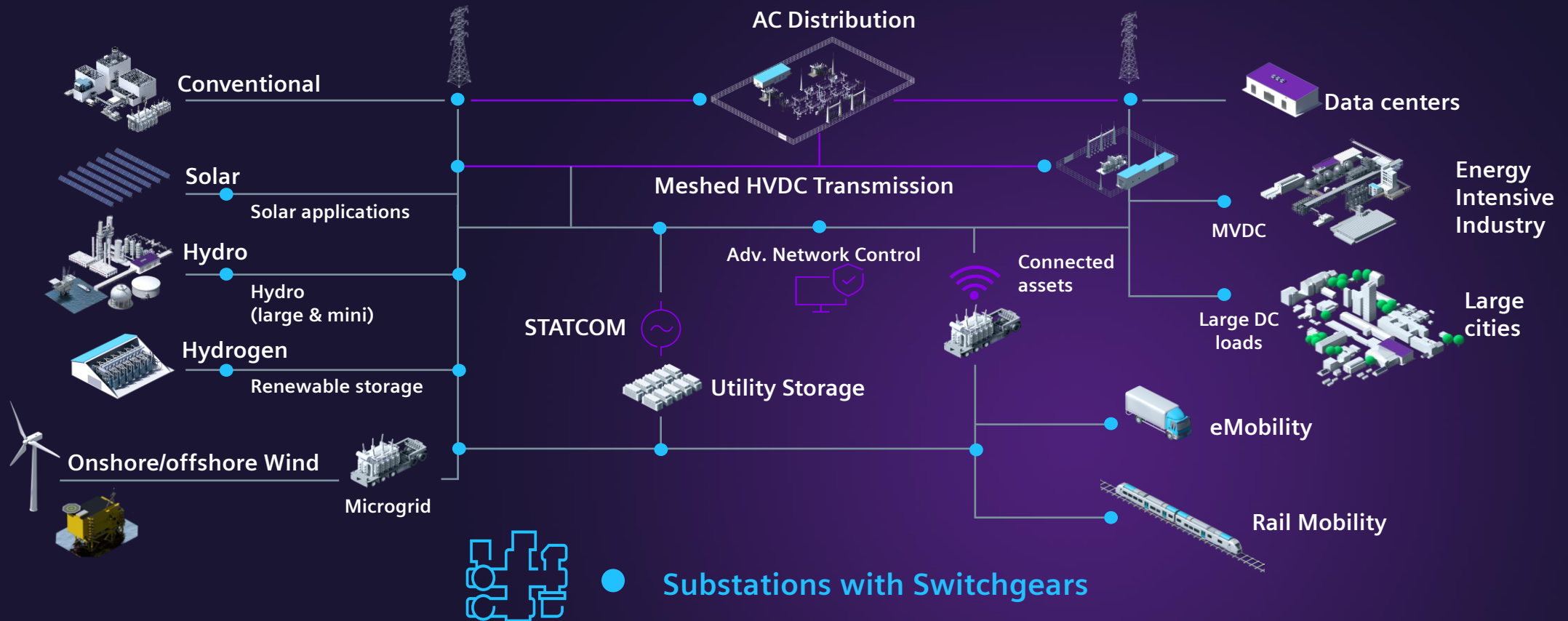
# 5 Drivers of Electricity Demand / Substations: Electrification, Digitalization, Decarbonization, Growth & Energy Transition

Distributed

Ageing + Unpredictable

Multi-directional

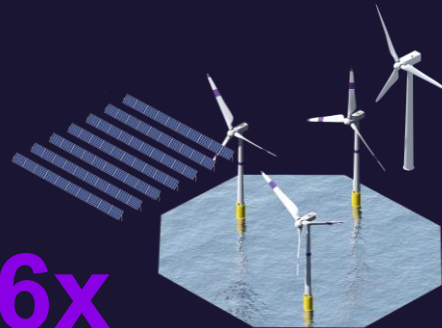
Horizontally networked



# 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**



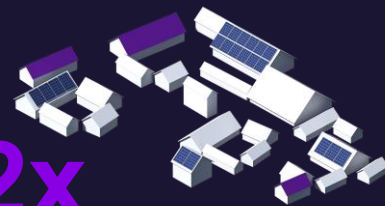
**6x**

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



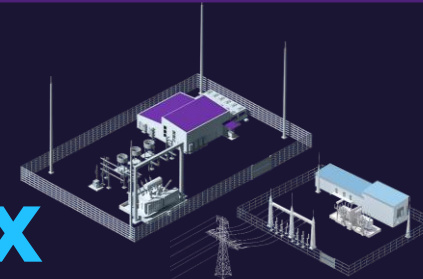
**~€650bn p.a.**

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

# Replacing SF<sub>6</sub> 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 equip-  
ment the lowest carbon  
footprint across its life cycle



## Suitably sized

Our clean air units fit within  
the footprint of the SF<sub>6</sub> 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<sub>6</sub> and other PFAS-F-gases ongoing, products already available up to including 550 kV

## F-Gas-Free Technologies (CO<sub>2</sub>/O<sub>2</sub> & N<sub>2</sub>/O<sub>2</sub>, 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

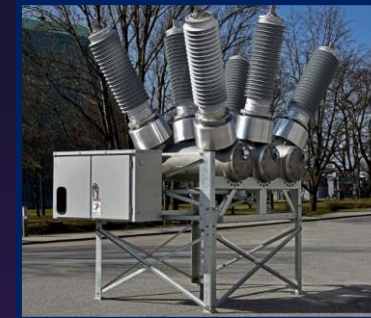
\*Very few OEMs use PFAS-F-Gases like C4-FN-gas-mixture with GWP ~ 500 as SF6 alternatives for GIS equipment



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

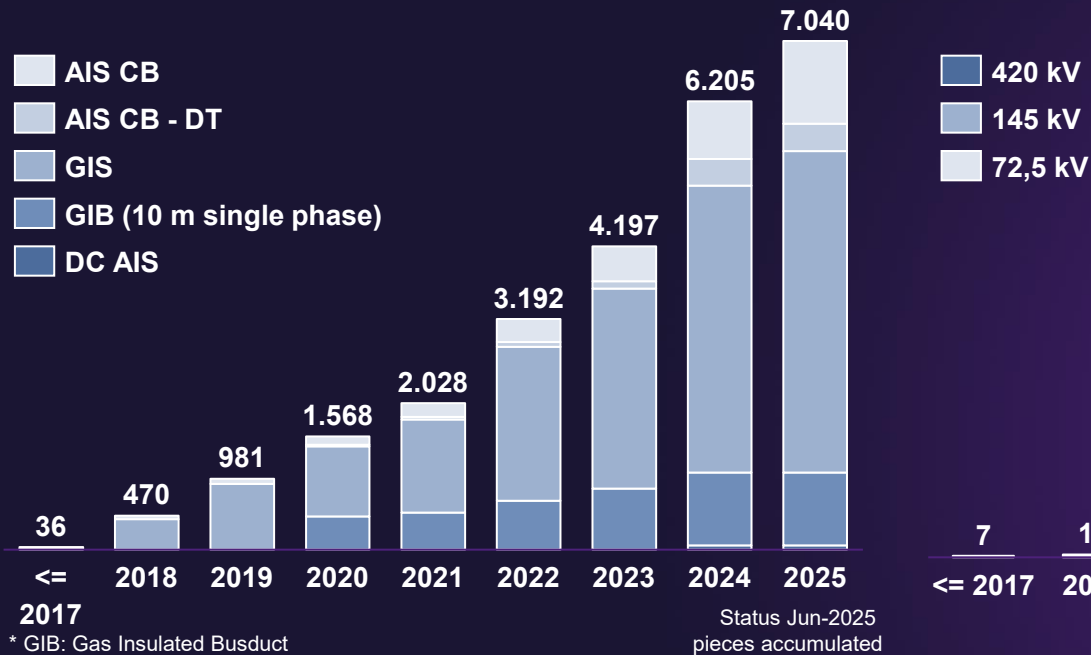
# F-Gas-Free Orders: A Major Success

- More than 4150 units delivered
- More than 2550 units in service
- 45 Mio hours service experience
- 8,7 Mio t CO<sub>2</sub>e emissions saved through avoidance of installed SF<sub>6</sub>
- 0,35 Mio t CO<sub>2</sub>e emissions saved through avoidance of leakages from not installed SF<sub>6</sub>



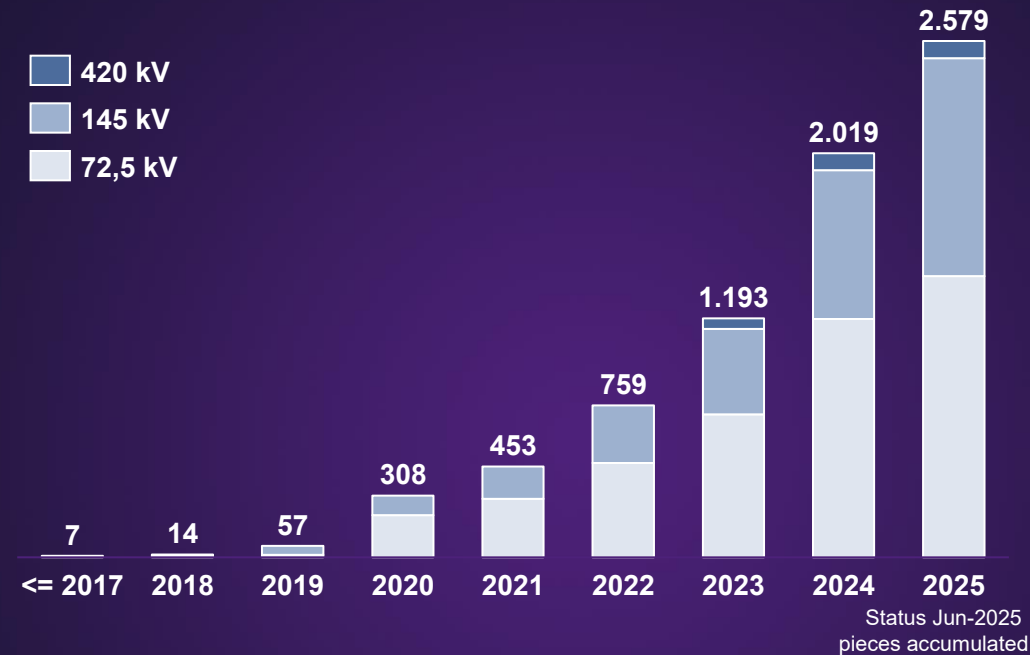
## Blue Order Intake

Circuit Breaker, GIS, GIB, DC AIS



## Blue Service Experience

Circuit Breaker, GIS, GIB



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

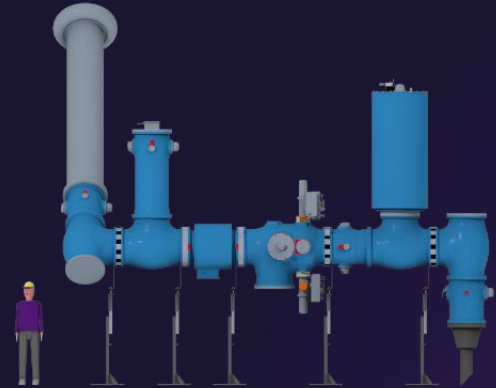
**SIEMENS ENERGY**



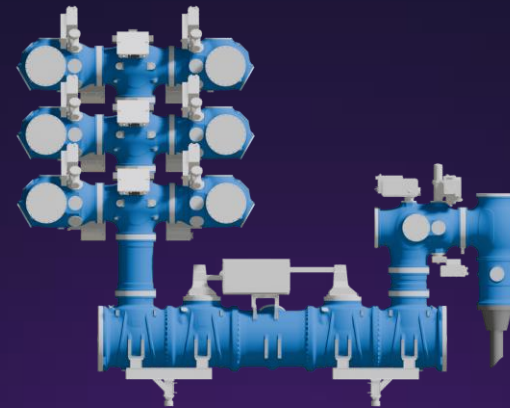
Pilots 2026

Rte

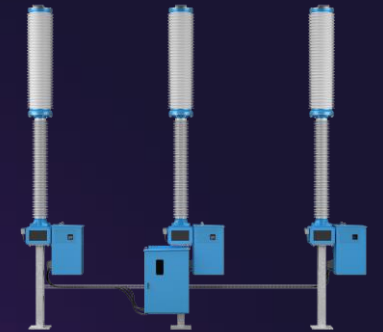
Statnett



Lab-Pilot 2026



Pilot 2027



Pilot 2029

red eléctrica

Clean Air LT  
420 kV, 4000 A, 63 kA

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

Clean Air GIS  
420 kV, 4000 A, 63 kA

Clean Air LT  
245 kV, 4000 A, 63 kA



EU Project Mission



EU LIFE Blue 420 kV GIS



EU LIFE Blue 245 kV LT

**1**

**Energy transition requires  
Decarbonisation  
measures in switchgears**

**2**

**Replacement of SF<sub>6</sub> 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!



## European Union



## United States



## Rest of World

**F-gas regulation (2024/573): Ban of GWP  $\geq 1$  F-gases from 2028 > 52 kV & 2032 > 145 kV**

Law effective in **California** (CARB<sup>2</sup>) and in **New York** state for **SF<sub>6</sub>** for ban from 2025 respectively 2027 in MV and HV

CN, JP, KR transition for SF<sub>6</sub> / F-gas-free started w/o regulations, in other countries first pilots  
G7 commit in 2024 to phase out the use of SF<sub>6</sub> in new switchgear applications by 2035

**Restriction proposal for PFAS<sup>1</sup> incl. Ban of PFAS F-gases like C4-FN in switchgears from 2029<sup>4</sup>  $\leq$  145 kV & 2034 > 145 kV<sup>4</sup>**

**PFAS<sup>1</sup> 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!**

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