

Panel Discussion

Designing Tomorrow's Grid : F-Gas-Free MV Switchgear and the Path to EU Compliance

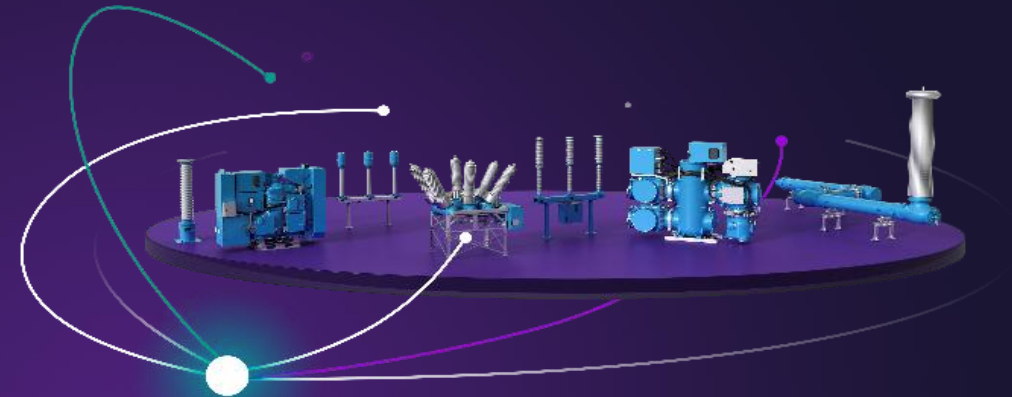
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20.05.2026

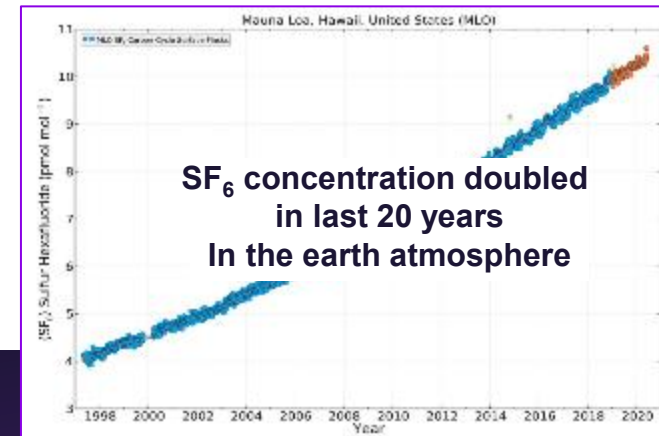
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Time for action: F-gases in switchgears and grids require attention



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



Typical SF_6 amount per GIS unit of latest design:

→ 6-24KV ~ 3kg

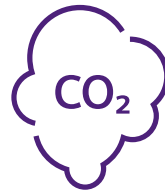
→ 36KV ~ 6kg

→ 145 kV ~80 kg

→ 420 kV ~800 kg



1 kg
of SF_6 is
equivalent to ...



24,300 kg
of CO_2

or

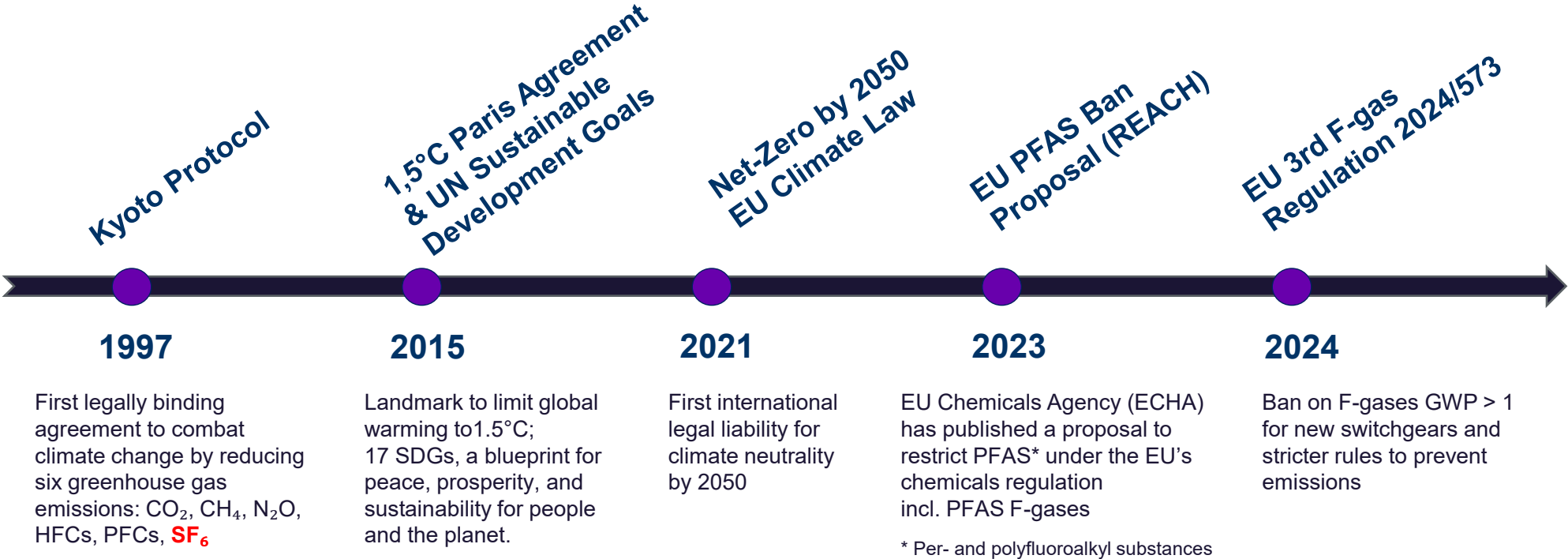


One car-life
petrol consumption

Source: [Final IPCC AR6 Report, 2023](#)

Car-life: $\sim 135 \text{ g CO}_2/\text{km} \times 12,000 \text{ km/a} \times 15 \text{ a}$

Key International Agreements on Sustainable Development



Research of SF₆ Alternatives Begins; First F-gas-free MV/HV Vacuum-Interrupter Products Enter Operation in the 2000

Sustainable development drive globally regulations

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European Union

F-gas regulation ([2024/573](#)): ban of GWP ≥ 1 F-gases from 2028 > 52 kV & 2032 > 145 kV

EU [Taxonomy](#) (GWP < 10 compliant)

Restriction proposal for PFAS¹ incl. ban of PFAS F-gases like C4-FN in switchgears from 2029⁴ $\leq$ 145 kV & 2034 > 145 kV⁴



United States

Law effective in **California** (CARB²) and in **New York** state for **SF₆** for ban from 2025 respectively 2027 in MV and HV

PFAS¹ restrictions: First laws effective incl. PFAS F-gas (e.g. C4-FN-Gas) in Maine and Minnesota – further adoptions expected in next years



Rest of World

CN, JP, KR transition for SF₆ / F-gas-free started w/o regulations, in other countries first pilots

[G7 commit](#) in 2024 to phase out the use of SF₆ in new switchgear applications by 2035

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

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)

Legislations and regulations

Details EU F-gas regulation 2024/573 (1)



Switchgear restrictions

For more information
see also our Factsheet:
[Link](#)



1 Prohibition of F-gases when putting into operation of new switchgear:

Medium voltage	≤ 24 kV	all F-gases	01.01.2026
	> 24 kV ... ≤ 52 kV	all F-gases	01.01.2030
High voltage	> 52 kV ... ≤ 145 kV, ≤ 50 kA	F-gases GWP ≥ 1	01.01.2028
	> 145 kV or > 50 kA	F-gases GWP ≥ 1	01.01.2032

2 New (*virgin*) SF₆ prohibited from 2035 for servicing & maintenance use, reclaimed & recycled SF₆ is possible.

3 SF₆ and C₄FN as part of Annex I are subject to **specific obligations**, e.g., reporting, certification of personnel, labelling, regular checks of leakage detection systems, prohibition of gas release into the atmosphere.

European Union, Brussels, 20. Feb 2024 – [Link](#)

European Union, Commission FAQ – [Link](#)

European Union, F-gas Consultation 21.10.2025 – [Link](#)

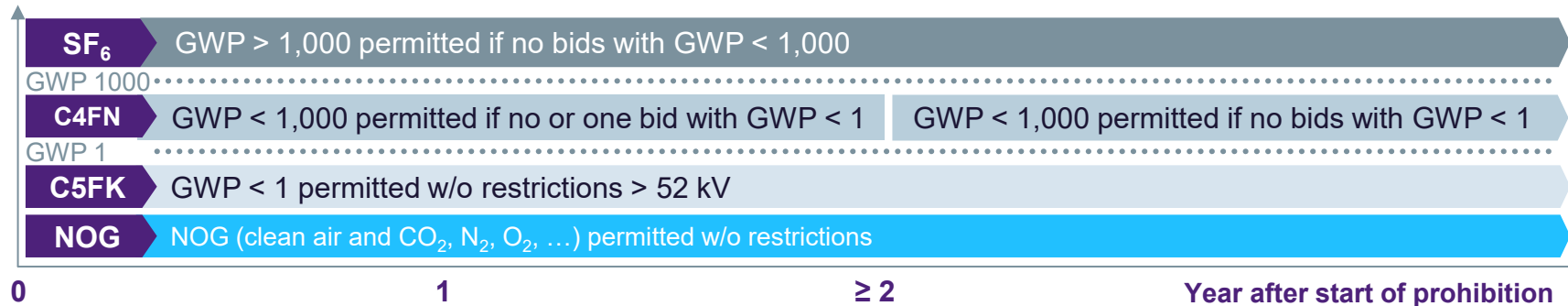
Legislations and regulations

Details EU F-gas regulation (2)

Derogations

1 No prohibition for equipment **contracted/ordered ahead** the regulation **entry into force** (11.03.2024)

2 **Cascading principle** for F-gas prohibition:



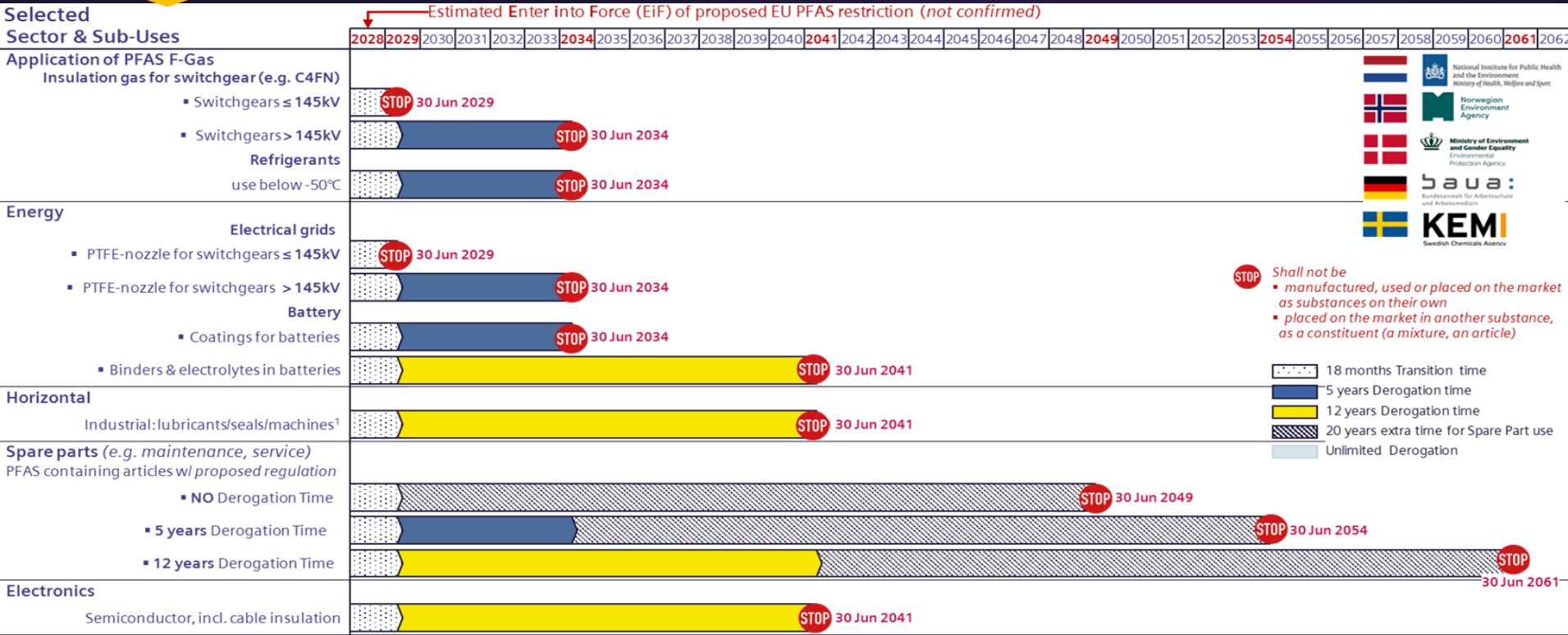
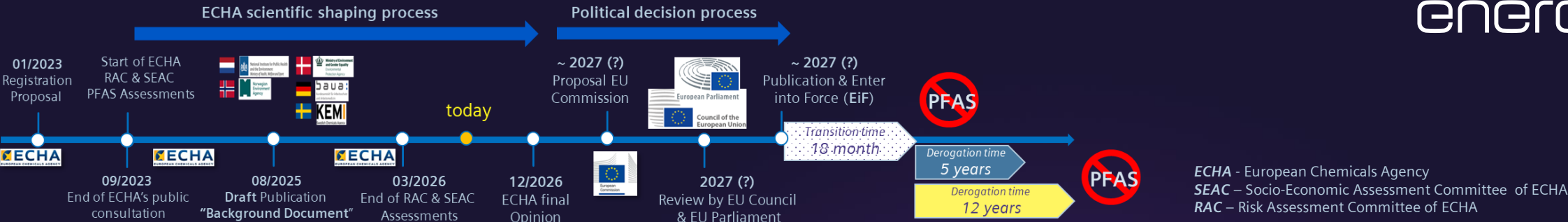
In general,
Natural Origin Gases (NOG)
and gases with GWP < 1
in high voltage have to be
applied if bids are available!

3 **Repair** is generally **allowed**. **Extension** of existing switchgear with SF₆ is possible **if the** equipment with **lower GWP is not compatible and would require the replacement** of the existing entire electrical switchgear.

4 **Mobile substations** (taking out of service and putting into service at different site) **are allowed**.

5 **Life-cycle-assessment** (LCA) and eco-design requirements **do not apply to switchgear products** as they are not part of the Eco-design Directive 2009/125/EC and Eco-design for Sustainable Products Regulation (ESPR). It is **currently not foreseen**, if and if at all, eco-design requirements will be adopted for switchgears, see also EU Commission answer [P-000922/24](#). Switchgears are also NOT included in the recently published [ESPR & labelling 2025-2030](#) workplan COM(2025) 187 final of 16 April 2025.

Status of EU PFAS Restrictions



Engineering Challenge ?

MV 6–24 kV - - 2026 & HV ≤ 145 kV, ≤ 50 kA - 2032 deadline, mature technology

- 1 **Same footprint, no civil rework.** New SF₆ Free switchgears are designed with identical footprint, operations, and backward compatibility to its SF₆ predecessor - panel-for-panel brownfield replacement without room modifications.
- 2 **Arc safety proven.** Clean Air produces no toxic decomposition byproducts during switching, a material safety improvement in occupied indoor environments.
- 3 **Long service life.** Hermetically sealed, welded stainless-steel vessels provide environmental independence from humidity, dust, and wildlife. Stated service life: ≥ 35 –40 years across leading platforms.

MV 24–52 kV - 2030 & HV > 145 kV or > 50 kA - 2032 deadline, solvable with discipline

- 1 **Insulation gap is bridged** through optimised field control, solid insulation interfaces, and sealed vessel design - compensating for clean air's lower dielectric strength vs. SF₆.
- 2 **Harsh environment resilience.** Hermetically sealed vessels eliminate ingress from coastal salt air, desert dust, and wildlife, failure accelerators in open equipment at remote sites.
- 3 **High switching endurance.** Vacuum interruption separates arc-extinction from insulation, handling multi-feeder collector switching duty without degrading dielectric performance.
- 4 **Avoid the eco-mix trap.** Fluoroketone and fluoronitrile remain regulated F-gases. Specifying fluorine-free now removes mid-life requalification risk as regulation tightens.

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Replacing SF₆ in high voltage with Clean Air



Proven technology

Already > 7,500 units sold,
> 2,800 units with > 50 million
hours successfully in operation



GWP = 0

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



Peak performance & safety

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



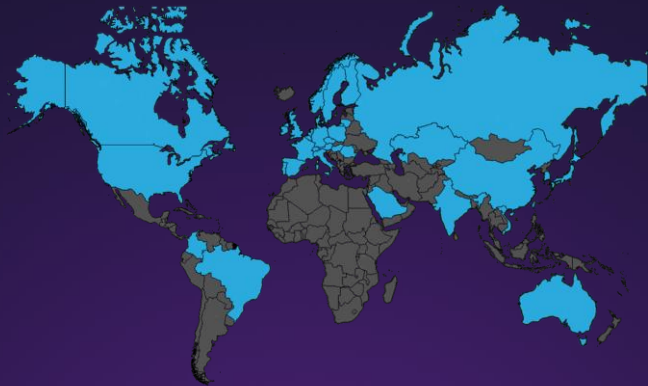
Suitably sized

Our clean air units fit within
the footprint of the SF₆ 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



What This Means for TSOs and DSOs



- 1 **Managing a transition across large, heterogeneous networks** in the context of lack of standardization
- 2 **Lack of Standardisation is a procurement risk**
- 3 **Brownfield replacement requires more planning than a product swap.**

What This means for OEMs?

- 1 In Europe, SF₆ is effectively a sunset technology for new MV equipment.**
- 2 Outside Europe, the picture is different, and OEMs need both portfolios.**
- 3 The eco-mix position requires careful re-evaluation.**



Deployments across EU confirm fluorine-free MV & HV switchgear works. But the transition is uneven, and clarity about where it stands matters.



In Europe, it is no longer optional. The 2026 deadline is live. Utilities still procuring SF₆ are not just accumulating regulatory risk; they are commissioning assets whose serviceability deteriorates progressively through the 2030s.



Outside Europe, SF₆ is not disappearing soon. Few states in US are implementing SF₆ free regulations. Rest of world is doing pilot studies but eventually the whole world is likely to switch to SF₆ free.



Two challenges will define the next decade.

- Lack of Standardisation: IEC, CIGRE, and IEEE frameworks are still maturing.
- Lack of Operational validation : SF₆ has sixty years of field data across every climate. Fluorine-free does not. First deployments must be treated as instrumented learning assets, not just compliance checkboxes.

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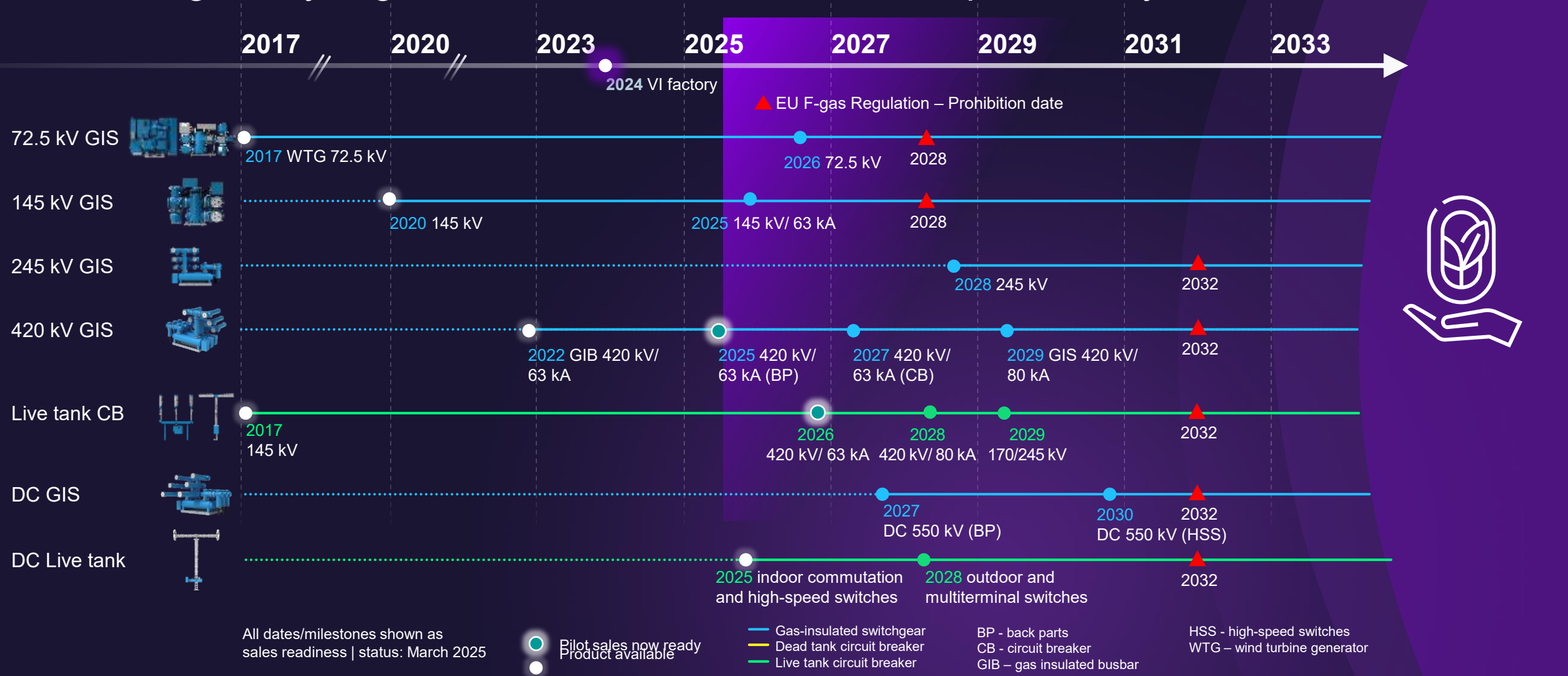
Thank you for your attention

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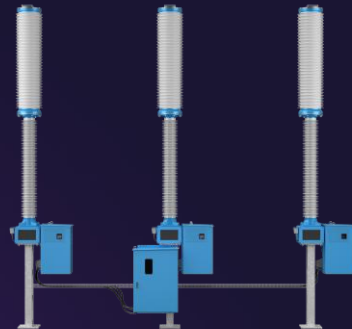
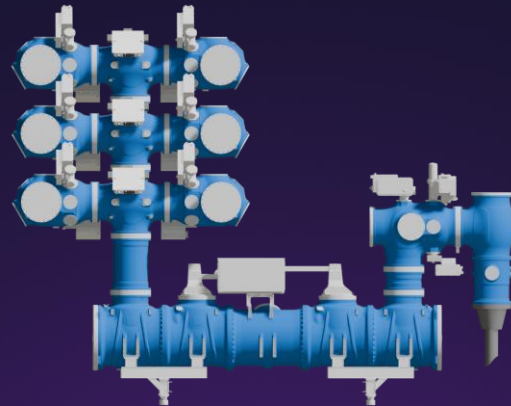
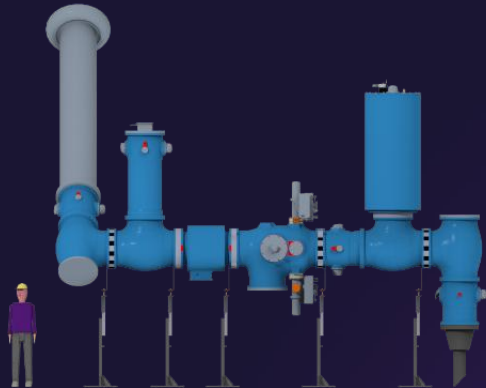
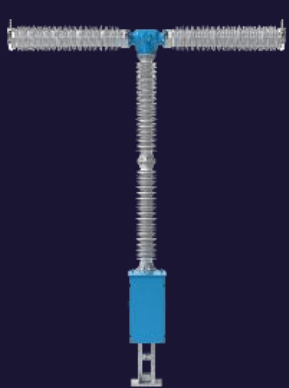
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Roadmap from Zero to Zero (EU related products)

Offering a fully F-gas-free GWP = 0 AC & DC Blue portfolio by 2030



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



Pilots 2026



Lab-Pilot 2026

Pilot 2027



Pilot 2029



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

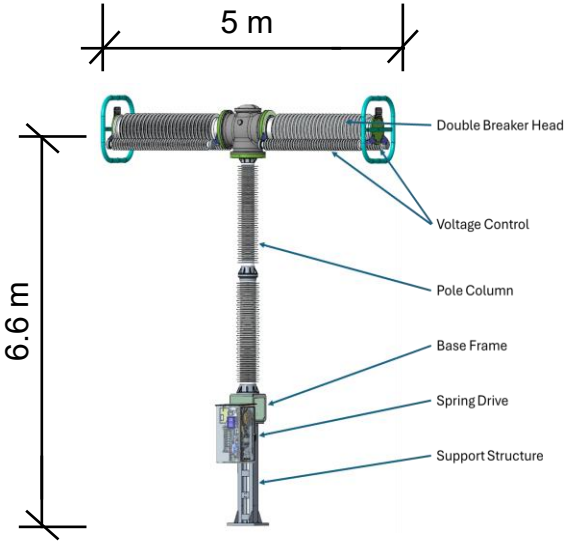


EU LIFE Blue 420 kV GIS



EU LIFE Blue 245 kV LT

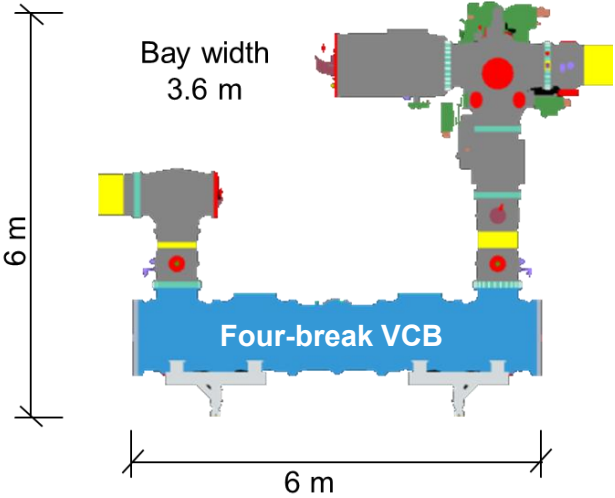
Status of Blue 420 kV LT and GIS Development



Development tests on LT VCB prototype successfully completed, type testing in 2026



First installation in Norway & France in 2026



Back parts and GIB all type tests successfully completed



Development tests on GIS VCB prototype successfully completed, type testing in 2026



First installation including LPIT in Belgium in 2027