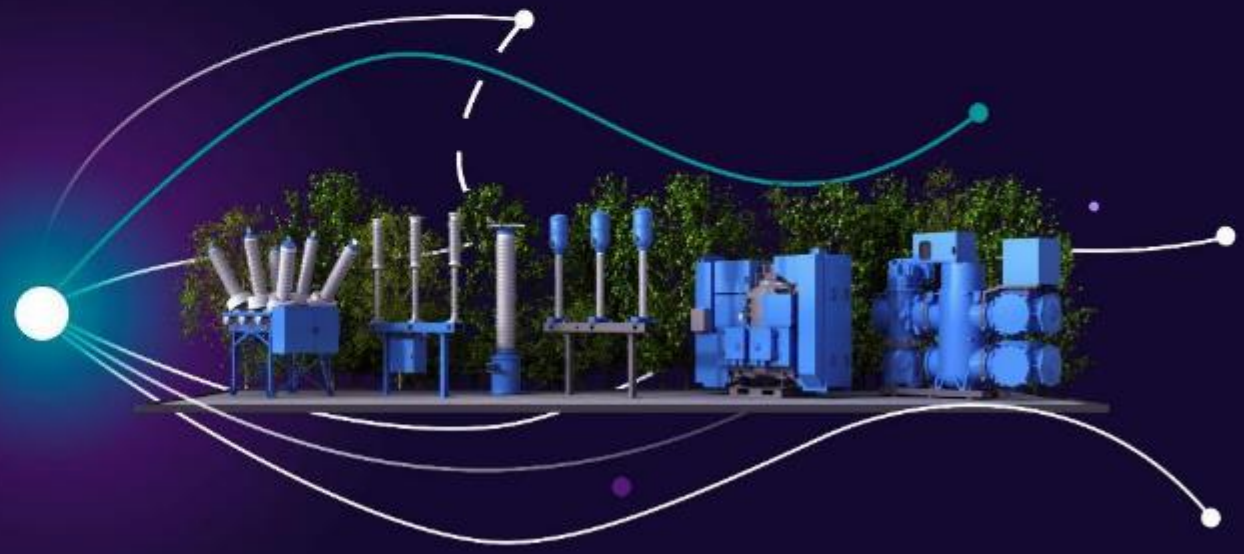
Blue –
Our path to Zero with Clean Air



Dr. Mark Kuschel
Siemens Energy - Grid Technologies

July 2023

Agenda

1. Siemens Energy at glance
2. Background phase-out of F-gases
3. Clean air – Our path to zero in transmission
4. Clean air – Status and Roadmap
5. Conclusion

Siemens Energy is a

global leader in the energy business

~ 1/6

of global electricity generation is based on our technology.

91,000

employees work as a team to energize society.[1]

We are present in

> 90 countries.

We invest around

€1bn annually in research and development.

1 Number of employees as of September 30, 2021

As an integrated energy technology company

we support our customers along the energy value chain

Low- or zero-emission power generation

- Gas Services
- Siemens Gamesa Renewable Energy

Transport and storage of energy

- Grid Technologies

Reducing GHG emissions & energy consumption in industrial processes

- Transformation of Industry

4

Agenda

1. Siemens Energy at glance
2. Background phase-out of F-gases
3. Clean air – Our path to zero in transmission
4. Clean air – Status and Roadmap
5. Conclusion

F-gases in our switchgears and power grids require attention

Today’s power grid still relies on the most potent greenhouse gas: **SF_6**

1 kg of SF_6

is equivalent to **24.300 kg** of CO_2.

Source: Final IPCC AR6 Report, 2023

UN Sustainable Development Goals, that encourage Sustainable Products enabling Energy Transition

Regulatory frameworks

CLIMATE ACTION

- Regulations
- Climate protection laws (e.g. EU Net-Zero 2050)
- Green deal

Enterprises

- Sustainability part of the corporate strategy

Society

- Climate change
- Sustainability
- Environmental protection

- ✓ **F-Gas ban / restrictions**
- ✓ **PFAS ban / restrictions**

- ✓ **Emission-free products**
- ✓ **Decarbonised operations and supply chains**

- ✓ **Purchasing decisions**
- ✓ **Investment decisions**

Natural-origin gases are the only way to achieve a CO_2 neutral and non-toxic environment in all aspects

Clean Air (**GWP = 0**, natural-origin gas)

if used by everyone it is the most environment-friendly switchgear technology of the world.

No harm

on health & environment

0 trees

No greenhouse or F-gases

F-gas: Fluoronitrile-mix (**GWP ~ 500**)

10,000 tons F-gases are needed annually for SF_6 replacement in new installations, which means around 50 tons of leakage (= 20 million kg CO_2).

It takes 30 years until the nature absorbs it.

Health risks

Fluoronitrile belongs to PFAS*,

its decomposition is toxic

321,600,000 trees

Latest News

https://California Sues 3M and DuPont Over PFAS Chemicals - WSJ

https://news.3m.com/2022-12-20-3M-to-Exit-PFAS-Manufacturing-by-the-End-of-2025

*PFAS: Per- and polyfluoroalkyl substances including PFAS-F-Gas C4-FN Fluoronitrile

It is time for action!

EU F-Gas Regulation to reduce harmful F-gases in switchgear

EU F-Gas Regulation - Draft published 5th April

- **EU Commission**: proposal to ban all F-gases with GWP > 10 in switchgear
- **EU Parliament**: proposal to ban all F-gases in switchgear
- **EU Member States**: proposal to ban all F-gases with GWP > 10 in switchgear with exemptions


EUROPEAN COMMISSION

Strasbourg, 5.4.2022
COM(2022) 150 final

2022/0099 (COD)

Proposal for a

REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

on fluorinated greenhouse gases, amending Directive (EU) 2019/1937 and repealing Regulation (EU) No 517/2014

(Text with EEA relevance)

{SEC(2022) 156 final} - {SWD(2022) 95 final} - {SWD(2022) 96 final} - {SWD(2022) 97 final}

EN EN

Siemens Energy welcomes the proposals to phase out F-gas in switchgear as it:

- **Is Consistent** with net zero climate targets and a toxic-free environment ambition
- **Is Affordable** to individual households and society
- Provides **Choice** without creating new dependencies in critical infrastructure

Siemens Energy is part of an **alliance** of six HV and MV voltage power equipment manufacturers who are committed to phase out F-gases in switchgear and who have joined forces to introduce a **switch from F-gas insulation to natural-origin gases** with GWP < 1 in the **EU F-Gas Regulation**.

MITSUBISHI ELECTRIC *Changes for the Better* | nuventura | Schneider Electric | SIEMENS energy | SIEMENS | TOSHIBA

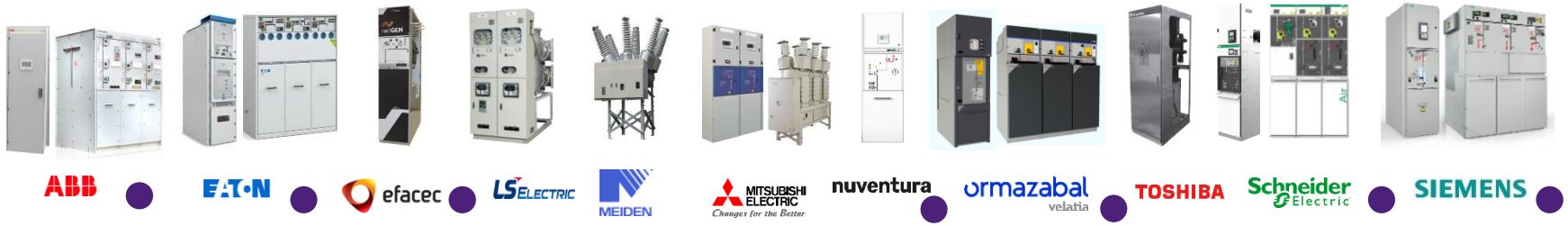
Learn more about our mission on: **www.switchinggearsfornetzero.com**

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

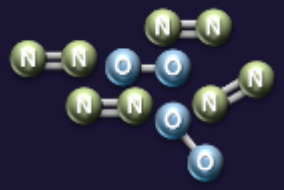
Agenda

1. Siemens Energy at glance
2. Background phase-out of F-gases
3. Clean air – Our path to zero in transmission
4. Clean air – Status and Roadmap
5. Conclusion

12

Clean air - Benefits for grid operators and society

Clean air (N_2 + O_2) insulation



- Zero CO_2emissions, lowest CO_2 footprint, GWP = 0
- Zero toxicity, highest stability, easiest gas handling
- Zero liquefaction at low temperatures -60 °C
- Zero patent dependencies, multiple suppliers

+

Vacuum interruption

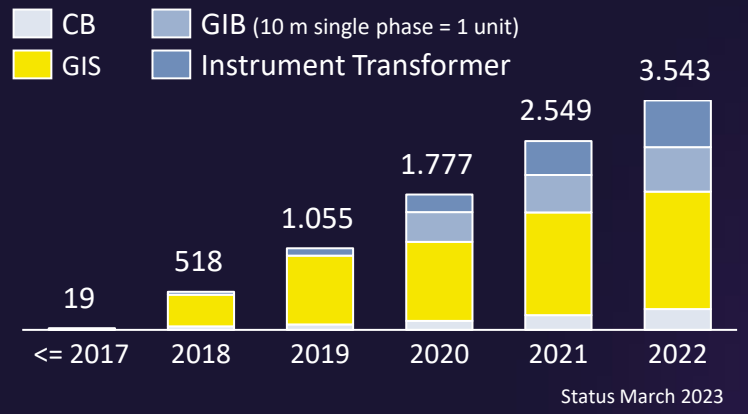
- Zero toxic decomposition products, hermetically tight
- Highest switching performance w/o degradation, scalable short-circuit current capabilities
- Zero maintenance (sealed for life)

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

Clean air - Proven technology

Order intake of clean air units

Circuit breaker (LT, DT), Instrument Transformer, GIS, GIB



- ✓ more than **3000 units contracted** worldwide in al climate zones
- ✓ nearly **1500 units** & over **20 Mio** hours **successfully in operation**

2,6 Mio t CO_2 emissions saved through banked and leakages from SF_6 over the lifetime

AIS & GIS clean air installation examples

Agenda

1. Siemens Energy at glance
2. Background phase-out of F-gases
3. Clean air – Our path to zero in transmission
4. Clean air – Status and Roadmap
5. Conclusion

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

SIEMENS energy

GIB gas-insulated busducts

back parts disconnector, earthing switch, voltage transformer, busbar…

CB circuit breaker

all dates / milestones shown as production readiness

Status: August 2022

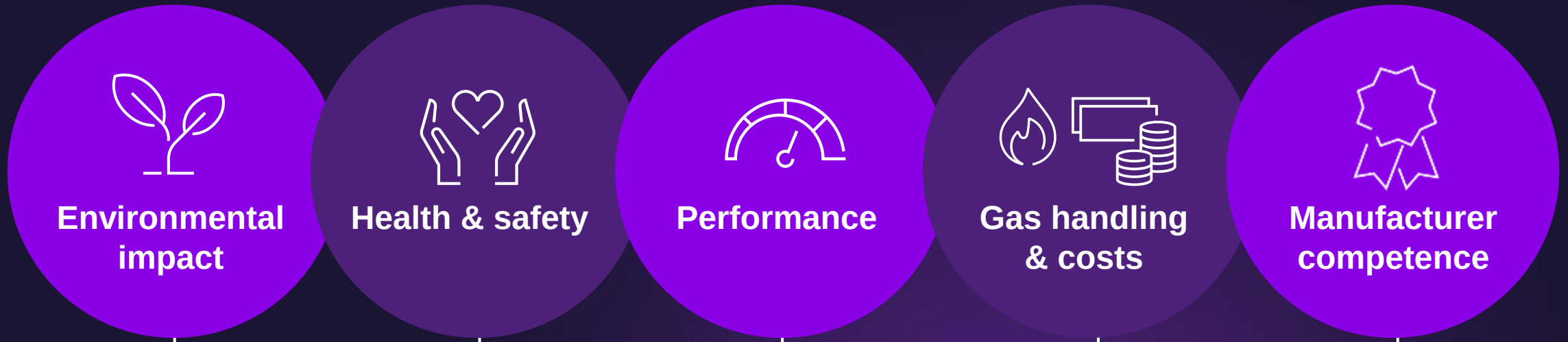
July 2023

Agenda

1. Siemens Energy at glance
2. Background phase-out of F-gases
3. Clean air – Our path to zero in transmission
4. Clean air – Status and Roadmap
5. Conclusion

17

Conclusion –
Clean air fits perfectly for customer switchgear requirements



Grid technologies for clean energy:

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

Thank you for your attention!

Contact

Mark Kuschel | LinkedIn

mark.kuschel@siemens-energy.com

Head of International Standardization for Grid Technologies

Personal involvement

1) Secretary IEC SC17C & Cenelec TC17AC
2) Vice Chair IEC TC99
3) Area Advisor Cigre SC B3 AA2 GIS Substations
4) Associations T&D Europe, VDE FNN, ZVEI

Backup

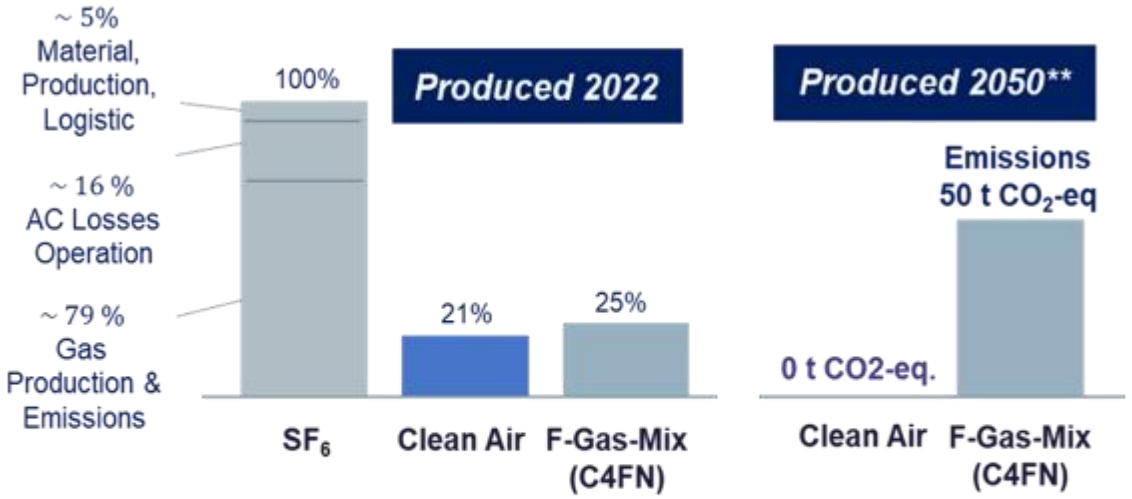
F-gas free products enable zero emission in all aspects

Space Footprint, Example 145 kV GIS*

Reduction:
SF_6-Vol - 60 %
Weight - 60 %
Footprint: - 80 %

	1st SF_6 GIS	Current SF_6 GIS	1st Blue GIS
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_2-eq.	5,405	2,000	0

Total LCA (40 years) CO_2 Emission Footprint, Example 145 kV GIS*



Grid operators do not require infrastructure changes, replacement is easily possible within the given footprint

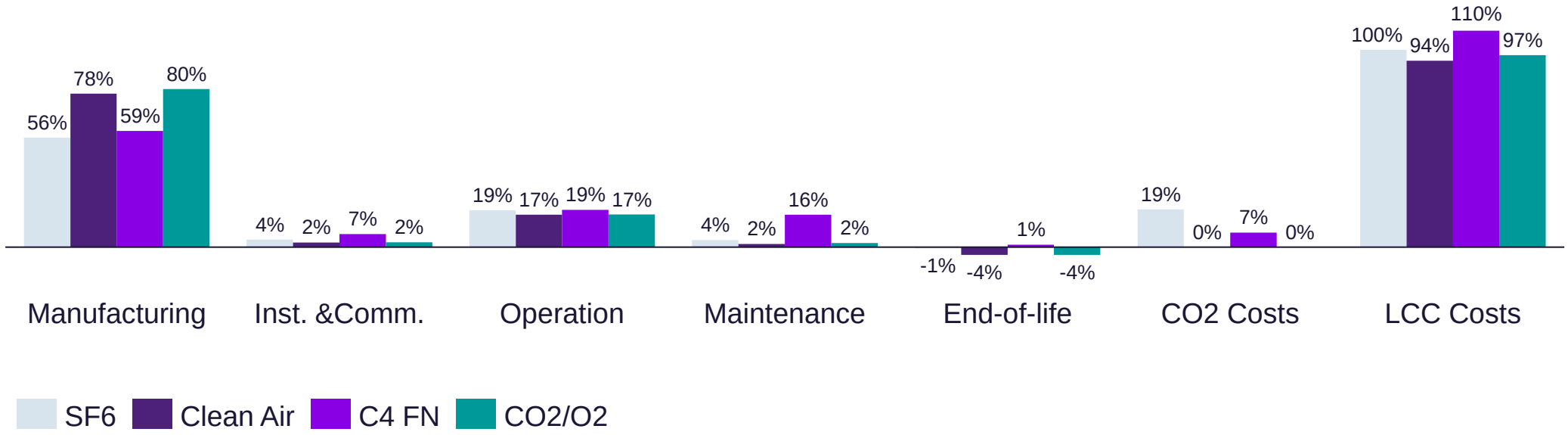
F-gas free enables net zero without any CO_2 compensation

* LPIT (Low-Power Instrument Transformer is an excellent countermeasure to optimize footprint and enable digitalisation

* own evaluation, Produced 2022 European power-mix, around 400 g CO2/kWh & 2050 0 CO2 emission from power generation
** Typical substation with 7 Bays

Life Cycle Cost Analysis for 145 kV GIS (40 years life assumption)

Gas and Gas-Handlings costs of F-gases are considerable

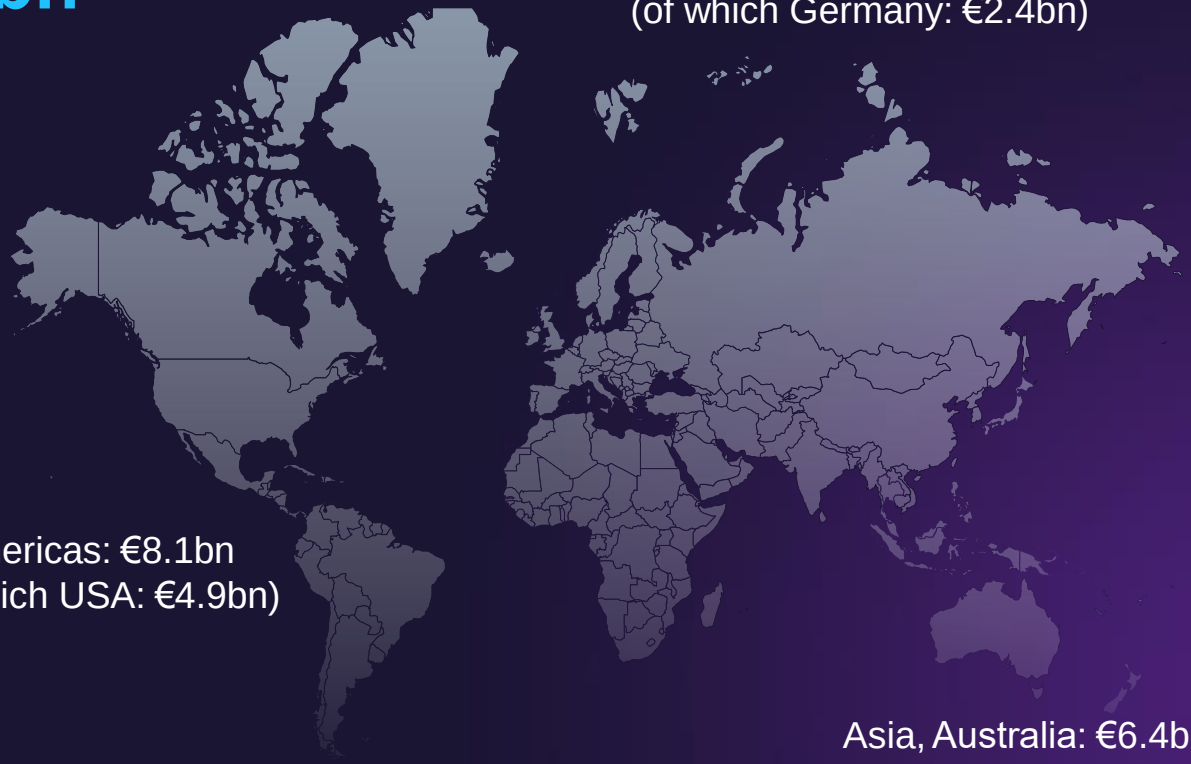


1) Grid operator & end consumer perspective: Lowest life cycle costs with Clean Air
2) Society perspective: No costs for climate and environment with Clean Air

Our financial performance in Fiscal Year 2021

Revenue
€28.5bn

EMEA (Europe, Middle East, Africa): €14.1bn
(of which Germany: €2.4bn)



Americas: €8.1bn
(of which USA: €4.9bn)

Asia, Australia: €6.4bn
(of which China: €1.6bn)

Our Annual Report 2021

Orders
€33.0bn

Order backlog
€84bn

Basic earnings per share
€(0.63)

Adjusted EBITA
before Special Items
€661m

Adjusted EBITA margin
before Special Items
2.3%

24

We enable a reliable, sustainable and digital grid
through a leading portfolio

Our grid technology portfolio

- Grid Consulting
- IoT and Edge
- Grid Automation

- High-Voltage Direct Current (HVDC) – onshore & offshore
- Flexible AC Transmission System (FACTS)
- Substations – onshore & offshore
- Medium-Voltage Direct Current (MVDC)

- Power and Distribution Transformers
- Bushings, Instrument Transformers & Coils
- Renewables & Traction
- Switchgears
- Product bundles and systems

- Turnkey battery energy storage solutions (grid connected and off-grid)

- Product services
- Modernization and upgrades
- Long-term service concepts and grid integration

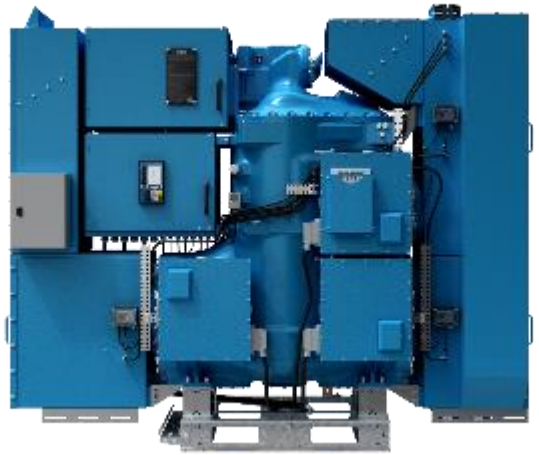
East Anglia ONE: the world’s largest order for an offshore wind power plant

Key facts

- Customer: Siemens Gamesa Renewable Energy for Scottish Power Renewables
- Offshore wind farm located off the east coast of England
- Operation of GIS requires no SF_6 or any other greenhouse gas
- Year of order: 2018
- Energization: 2020

Gas-insulated switchgear

- Installation of 102 bays of SF_6-free 8VM1 Blue GIS™ for 72.5 kV with a total capacity of 714 MV to power around 500,000 British households with clean energy
- Vacuum interrupter technology
- Clean air insulation technology



Customer benefits

- Zero direct CO2 emissions
- Easiest gas handling process
- Reduced quantities of cable
- Reduced cable installation times
- Improved efficiencies in power transmission

The world's first SF_6-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_6 or any other greenhouse gas
- Year of order: 2017
- Energization: 2018

Circuit breakers

- Installation of two SF_6-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

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_6 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 SF6 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_6 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

Detailed story: https://www.siemens-energy.com/global/en/news/magazine/2021/eliminating-sulfur-hexaflurides.html

Stakeholders, legislation and regulations – Details Europe

Natural-origin gases with GWP < 1 are 100 % future-proof with no risk for regulatory exposure!

F-gas regulation - Trialogue negation started
Decision and Adoption expected July 2023

(a) kV ≤ 24 (b) 24 < kV ≤ 52 (c) 52 < kV ≤ 145 (d) kV > 145	European Commission	European Parliament	Council of the European Union
Decision / Publication	Commission 05.04.2022	Parliament 30.03.2023	Council 05.04.2023
Preferred alternative	**GWP < 10**	**F-gas-free**	**GWP < 10**
Further alternatives in case no bidders	GWP < 2000 / SF_6 (a), (b), (c), (d)	GWP < 1000 (c), (d)	GWP < 2000 / SF_6 (a), (b), (c), (d)
Ban date (a), (b), (c), (d)	2026 2030 2028 2031	2026 2028 2028 2031	2026 2030 2028 2032
Obligations F-Gases* C4-FN, C5-FK	Reporting	Same as SF_6	Reporting & Certification
Ban of Export	No	Yes	No
Service exemptions	No	Repair	Repair, Expansion

PFAS* Restrictions started
Decision and Adoption expected 2025

ECHA EUROPEAN CHEMICALS AGENCY

EUROPEAN COMMISSION
Brussels, 14.10.2020
COM(2020) 667 final
Chemicals Strategy for Sustainability
Towards a Toxic-Free Environment

Report from 07.02.2023 includes a restriction proposal for PFAS-F*-Gaes in switchgears starting

2026 / 2027 ≤ 145 kV, > 145 kV in 2033

* Per- and polyfluoroalkyl substances (forever chemicals) including C4-FN and C5-FK

Stakeholders, legislation and regulations – Details USA

Natural-origin gases with GWP < 1 are 100 % future-proof with no risk for regulatory exposure!

SF6-gas regulation – In place in CA and being implemented by other states

January 2022 CARB SF6 regulation becomes effective No reporting of Clean Air as GWP is zero

Table 2. Phase-Out Dates for SF_6 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

New York state working on regulation to ban SF6

Maryland commits to Net Zero GWP by 2045

PFAS* Restrictions started and manufacturing being stopped by 3M in 2025

July 2021 state of Maine 'Effective January 1, 2030, any product containing intentionally added PFAS may not be sold in Maine unless the use of PFAS in the product is specifically designated as a currently unavoidable use by the Department'.

3M to stop production of PFAS from end 2025 (letter Dec 20, 2022) Including F gases used in switchgear

The Environmental Protection Agency (EPA) has established a PFAS* Council

Many states restricting us of PFAS in fire fighting and food packaging

*Per-und polyfluoroalkyl Substances including F-Gases C4-FN

75 % of today‘s SF_6-free High Voltage portfolio > 52 kV manufactured in Europe uses gases with GWP < 1

Global OEMs manufacturing in Europe*	AIS CB	AIS IT	GIS / GIL***	Bushings
Siemens Energy	NOG	-	NOG	-
Trench	-	NOG	-	NOG
HSP	-	-	-	NOG
Hitachi Energy	NOG (CO2/O2)	-	C5-FK, C4-FN	-
General Electric	C4-FN**	-	C4-FN	-
Piffner	NOG	NOG	-	-
Arteche	-	Open	-	-
Yearly new unit installations in Europe	> 10.000	> 20.000	> 4.000	> 25.000

*Global sales with complete portfolio, not limited to local country markets as e.g. Koncar and ELBUD;
AIS Air-insulated switchgear, GIS Gas-insulated switchgear, GIL Gas-insulated line; CB Circuit-breaker, IT Instrument transformer;
NOG Natural-origin gases (N_2/O_2 or CO_2/O_2) GWP < 1, **C4-FN Fluoronitrile (PFAS)-CO_2-O_2-Mixture GWP ~ 500, IP protected by 3M
C5-FK Fluoroketone (PFAS)-CO_2-O_2-Mixture GWP < 1; **C4-FN can easily be moved to NOG (CO_2/O_2) -> *slide 6*

***Additional global OEMs manufacturing worldwide (Production outside Europe)

- All Japanese OEMs incl. Meiden, Toshiba, Mitsubishi & Hitachi use NOG; South Korea use partly NOG and C4-FN; China – 4 x NOG, 1 x C4-FN, most of OEMs in China are still open regarding alternative SF_6 technology
- **Asian manufacturers** successfully **supply High Voltage CB & GIS with NOG to Europe with GWP < 1**

Clear regulatory framework in EU with F-gas bans and sufficient transition time enables globally electric zero emission grids.