

## Study Committee C3 Power System Environmental Performance Paper ID\_11102

### Transition to Climate Neutral, Safe and Sustainable Power Grids – Benefits for Society, Grid Operators and Manufacturers

Dirk HELBIG, Shibani BOSE, Peter GRONBACH, Karsten JUHRE, Mark KUSCHEL

Siemens Energy, Germany

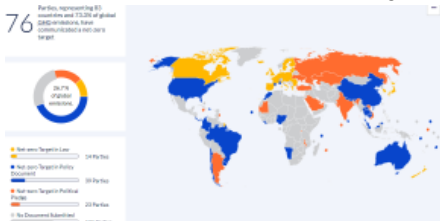
#### Motivation – A Sustainable World

- United Nations Sustainable Development Goals are our framework for a sustainable world
- Climate actions and health are two action fields
- Countries all over the world take actions to become carbon neutral and toxic-free



#### Method – Achieving Net-Zero

- The Paris Agreement is a legally binding international treaty to limit global warming to well below 2, preferably to 1.5 degrees Celsius. It was adopted by 196 Parties in Paris, on 12 December 2015
- Climate watch Net-Zero Tracker, August 2022: 76 parties, representing 83 countries and 73% of Global GHG emissions have communicated net-zero targets



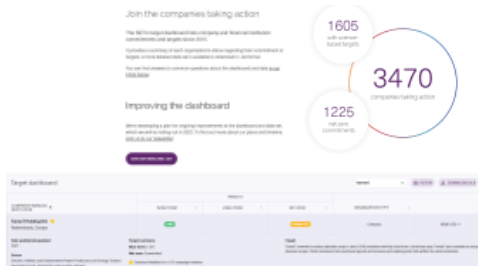
#### Power Grid operators are key

- Renewable GHG-free electricity generation and resilient electrical grids are key for a GHG-free world
- Electrical power grid operators globally are committed to become CO<sub>2</sub> neutral. Direct emissions (Scope 1) are key. SF<sub>6</sub> is the main direct emission of grid operators.

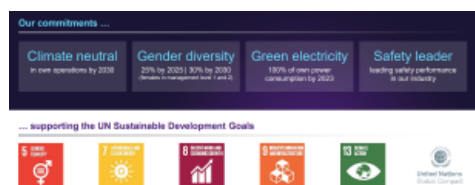


#### Grid operators' goals and actions

- Science based target initiative (Sbti) is driving ambitious corporate climate actions. August 2022: 3470 companies taking actions, thereof 104 Electric utilities. One example: TenneT commits to reduce absolute scope 1 and 2 GHG emissions 95% by 2030 from a 2019 base year.



#### Siemens Energy climate neutral in 2030



#### Target system for sustainable grids



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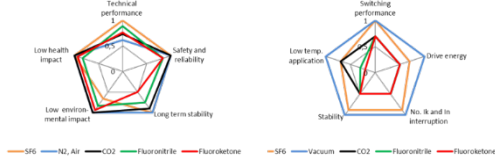
#### Properties of SF<sub>6</sub> gas and alternatives

- Intensive research for decades on over 200 gases to identify the most sustainable insulating technology.
- Conclusion: There is no perfect gas. Clean air is the most sustainable gas: Zero GHG and GWP, No decomposition products, No toxicity

	SF <sub>6</sub>	Clean Air	F-Gases based on Fluoronitrile
Chemical formula	SF <sub>6</sub>	N <sub>2</sub> + O <sub>2</sub> (79.5%/20.5%)	C4F7N
CO <sub>2</sub> -equivalent / GWP <sub>100</sub> (reversibly)	22,800 (IPCC AR4) 23,500 (IPCC AR6 2022)	0	2,100 (Manufacturer data) 2,750 (www-ipc-ar6-2022)
Boiling point [°Celsius]	-64°	< -188°	-43°
Life time (years)	3,200	-	30
Carrier gas	Pur or mixed with N <sub>2</sub>	-	CO <sub>2</sub> + C4F7N and in some cases + O <sub>2</sub>
CO <sub>2</sub> -equivalent / GWP <sub>100</sub>	25,200	0	> 500 based on applications
Boiling point [°Celsius]	< -64° (variable)	< -188°	-30° – -25°C dependant on C4F7N amount
Dielectric strength	1 (normalized)	~ 0.4	~ 0.7
<b>Arctic impact</b>			
Dissociation/decomposition	~ 2000 K (reversib.)	~ 7000 K (N <sub>2</sub> reversib.)	~ 820 K (reversib.)
Decomposition products	H <sub>2</sub> , SO <sub>2</sub> , sulphur compounds	None under normal operating conditions (N/O) If failure: Chlorine, NOx	F-Nitrile (H <sub>2</sub> , HF, CO, COF <sub>2</sub> , CF <sub>2</sub> , CF <sub>3</sub> , CF <sub>4</sub> , C <sub>2</sub> F <sub>4</sub> , C <sub>2</sub> F <sub>6</sub> , C <sub>2</sub> F <sub>8</sub> , C <sub>2</sub> F <sub>10</sub> , C <sub>3</sub> F <sub>8</sub> , C <sub>3</sub> F <sub>10</sub> , C <sub>4</sub> F <sub>10</sub> in MV GIS with air) <i>Preferred property</i> <i>Compromised property</i>

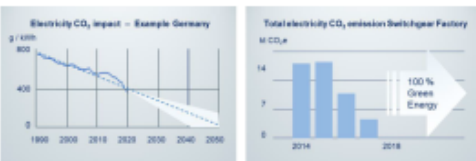
#### Comparison of insulating and switching technologies

- Insulation: All gases with strengths and weaknesses
- Switching: Vacuum technologies with stronger switching overall performance than gas circuit breakers



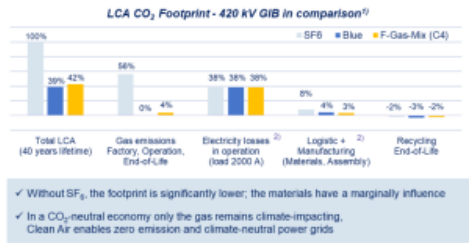
#### Life Cycle Assessment (LCA) consideration

- CO<sub>2</sub> emission caused by electrical losses assumed to be Zero in 2020
- Total electricity CO<sub>2</sub> emissions of Switchgear Factory is Zero since 2018



#### LCA comparison of SF<sub>6</sub> and alternatives

- Clean Air technology with lowest LCA – Carbon Footprint



- Without SF<sub>6</sub> the footprint is significantly lower; the materials have a marginally influence
- In a CO<sub>2</sub>-neutral economy only the gas remains climate-impacting, Clean Air enables zero emission and climate-neutral power grids

1) own evaluation for 100 m GIS length 2) depends significantly on the electricity mix

#### References for GHG-free power grid products

- Power grid operators globally take actions installing GHG-free, so-called Blue, power products
- >1900 units contracted; >700 units in operation
- 2,700,000 tons of CO<sub>2</sub>e not produced and installed description/figure



#### Outlook and Conclusion - Power grids will become GHG-free

- Power grids are the key to a CO<sub>2</sub> neutral world
- Power grids operators now have the choice to build and operate the grid completely GHG-free, F-gas-free and PFAS-gas free
- Up to 145 kV all products are available, up to 420 kV partially available, up to 550 kV in development



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## EU legislation on sustainability

- In October 2020, the EU Commission published the “Chemicals Strategy for Sustainability – Towards a Toxic-Free Environment” with major changes for the users of chemicals.
- The European Commission is scaling up measures to protect people’s health and nature, lessen the impact on climate change (GHG) and radically reduce consumption of natural resource
- Siemens Energy ambition is not only complying to existing regulations but to drive pro-actively the realization of a sustainable and toxic-free environment beyond existing regulations, such as EU REACH, EU Persistent Organic Pollutants (POP)

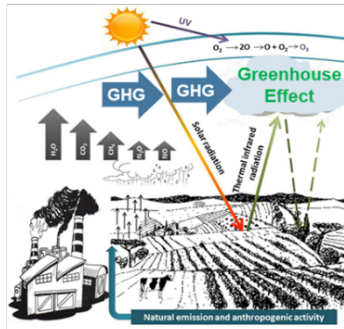
## Sustainable approach

- Siemens Energy drives sustainable technologies with lowest operational risks. They are not any more subject of existing or upcoming international regulations and restrictions, such as the F-GHG regulation or PFAS-F-gas restriction. Grid operators with GHG-free and PFAS-gas free products will be a role model for society.
- The proven Clean Air insulation technology of Siemens Energy not only adhered to the regulation on PFAS F-gas, but it also enables the replacement of the PFAS nozzle material (PTFE) for all F-gas and PFAS-gas free portfolio HV switchgear due to innovative design.
- A substance declaration data and analysis tool enables Siemens Energy to digitally process all material information. Substances of very high concern (SHVC) are identified, and research and development of alternative materials is initiated. Target is not to use any SHVC in future

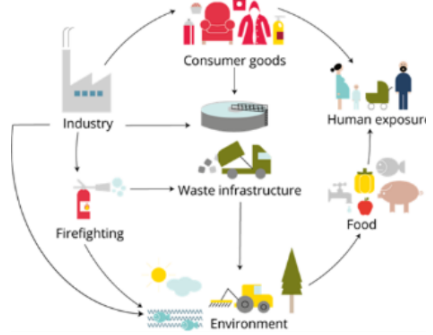
## Conclusion

- F-gas-free, clean air & vacuum switching technology sets the new sustainability standard for GHG-free global power grids of the future.
- Main values: zero GHG-emission, zero pollution: non-toxic, non-hazardous, F-gas and PFAS-gas (forever chemicals)-free
- F-gas-free, clean air & vacuum switching technology enable grid operators to become GHG-free and achieve their sustainability goals, thus being a role model for a sustainable society

## Simplified scheme of GHG effects



## Typical PFAS exposure pathways



## Global activities on PFAS regulations

**EU and global activities on PFAS regulations**

The **Stockholm Convention on Persistent Organic Pollutants** is a United Nations treaty signed in 2001 aimed at reducing or eliminating the production, use, and release of key POPs. PFAS substances already banned: PFOS, PFOA, PFHxS

Beginning of 2020, five EU states (Denmark, Sweden, Norway, Germany, the Netherlands) started activities [20], starting on the **broad restriction of the manufacture and use of all per- and polyfluorinated substances (PFAS)**. End of 2020, the **Chemical Strategy for sustainability towards a toxic-free environment of the European Union**, was published, which is the first step towards the zero-emissions target for a pollution-free environment announced in the **European Green Deal**.

In the beginning of 2020, Environment Protection Agency (EPA) of the United States issued an upgrade of the existing **PFAS Action plan** for drinking water regulation. Additionally, a product that contains certain PFAS chemicals cannot be imported into the United States unless EPA reviews and approves. PFOA & PFOS banned, following the Stockholm convention. (EPA, United States Environmental Protection Agency) [21]

Australia started a PFAS Task Force to develop the **PFAS National Environmental Management Plan (PFAS NEMMP)** giving a guidance to address PFAS concentrations [22]

“...product including „Substances of Very High Concern“ (SVHC) can't be considered as health & environmental friendly and sustainable”

