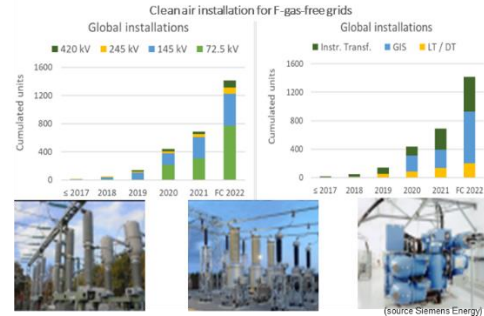


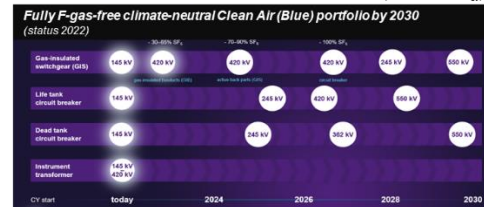
Development pathways to adopt SF₆-free equipment

Looking at current developments on the electrical equipment market, the following development in terms of reducing CO₂ emissions, can be recognized.

- The number of SF₆ free installations worldwide is growing rapidly.
- Today, a full SF₆-free and F-gas-free (*Clean Air*) portfolio up to 145 kV and Instrument Transformers up to 420 kV is available and in operation.



- According to the Clean Air roadmap, the full F-gas free portfolio (GWP=0) will be available
 - up to 420 kV in 2027
 - up to 550 kV in 2030
 which is in line with GHG-regulations in California and proposed EU F-gas regulation with GWP < 10.

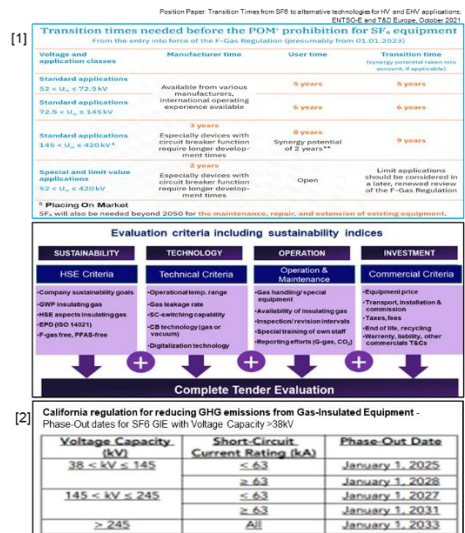


With this outlook, manufacturer of electrical equipment but also grid operators, will be able to achieve the worldwide CO₂ and sustainability targets.

Important R&D and pre-normative activities

To establish R&D and pre-normative activities to develop and use SF₆-free electrical equipment, an interlocking concept of involved stakeholders is considered as essential.

- **Manufacturers:**
 Focus on SF₆-free product development to realize all voltage levels in the transition time jointly developed with grid operators
- **Grid operators:**
 - Sustainable specifications beyond technology and price including HSE, Operation, Maintenance and Total cost of ownership.
 - Early installation of SF₆ free substations to gain experience for a smooth transition to GWP = 0.
- **Society, Countries and Regulators:**
 Innovative regulations, like the Californian GHG-regulations or the European F-gas regulation to phase out SF₆, will accelerate the transition for SF₆ to GHG- and F-gas-free grids to achieve climate neutral economies.



Bibliography:

[1] Position Paper: Transition Times from SF₆ to alternative technologies for HV and EHV applications; ENTSO-E and T&D Europe, October 2021

[2] Regulation for reducing sulfur hexafluoride emission from gas insulated switchgear, Sulfur Hexafluoride Phase-Out, California Code of Regulations 17CA ADC §95352, 2021