Thomas A. Paul, ABB Corporate Research, Switzerland

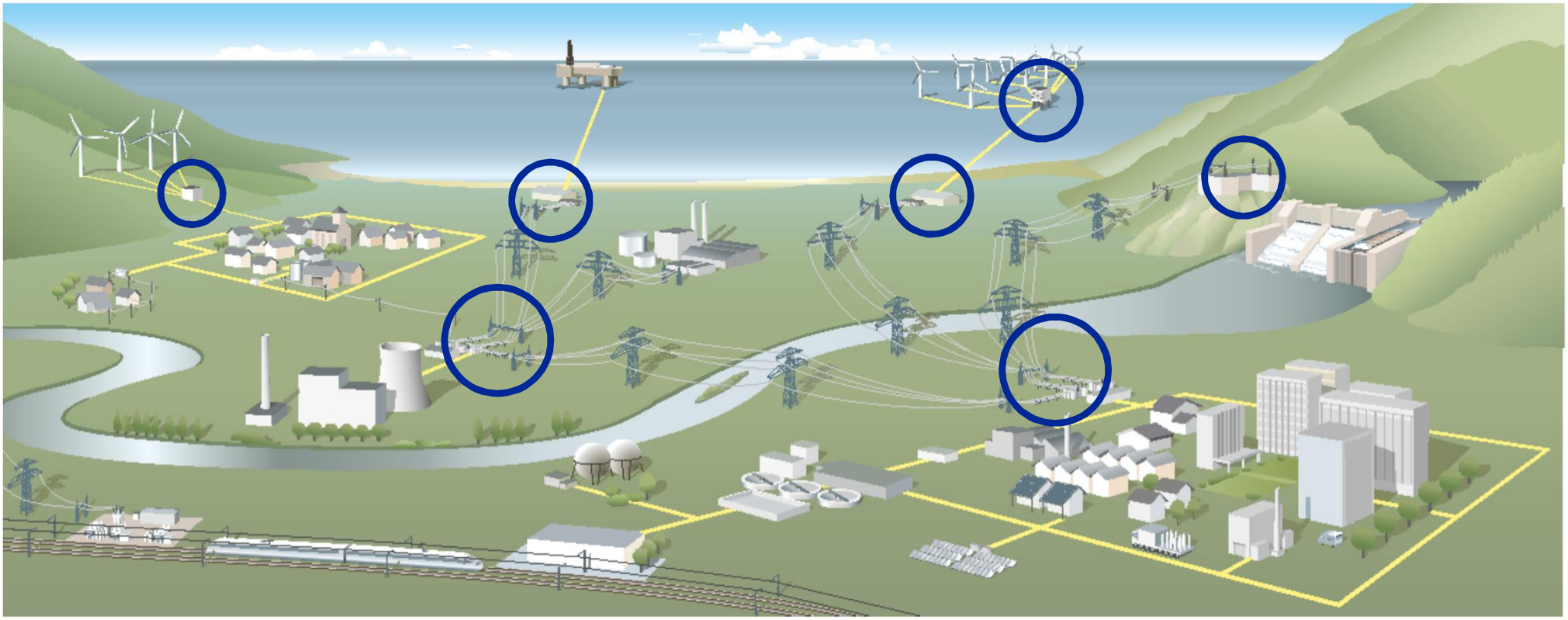
Optical technologies in the power industry: Monitoring and diagnosis of gas-insulated electrical switchgear

Outline

- Electrical switchgear and gas insulation
- Insulation gas diagnostics for SF_6
- Insulation gas diagnostics for SF_6-alternatives

Electrical Switchgear

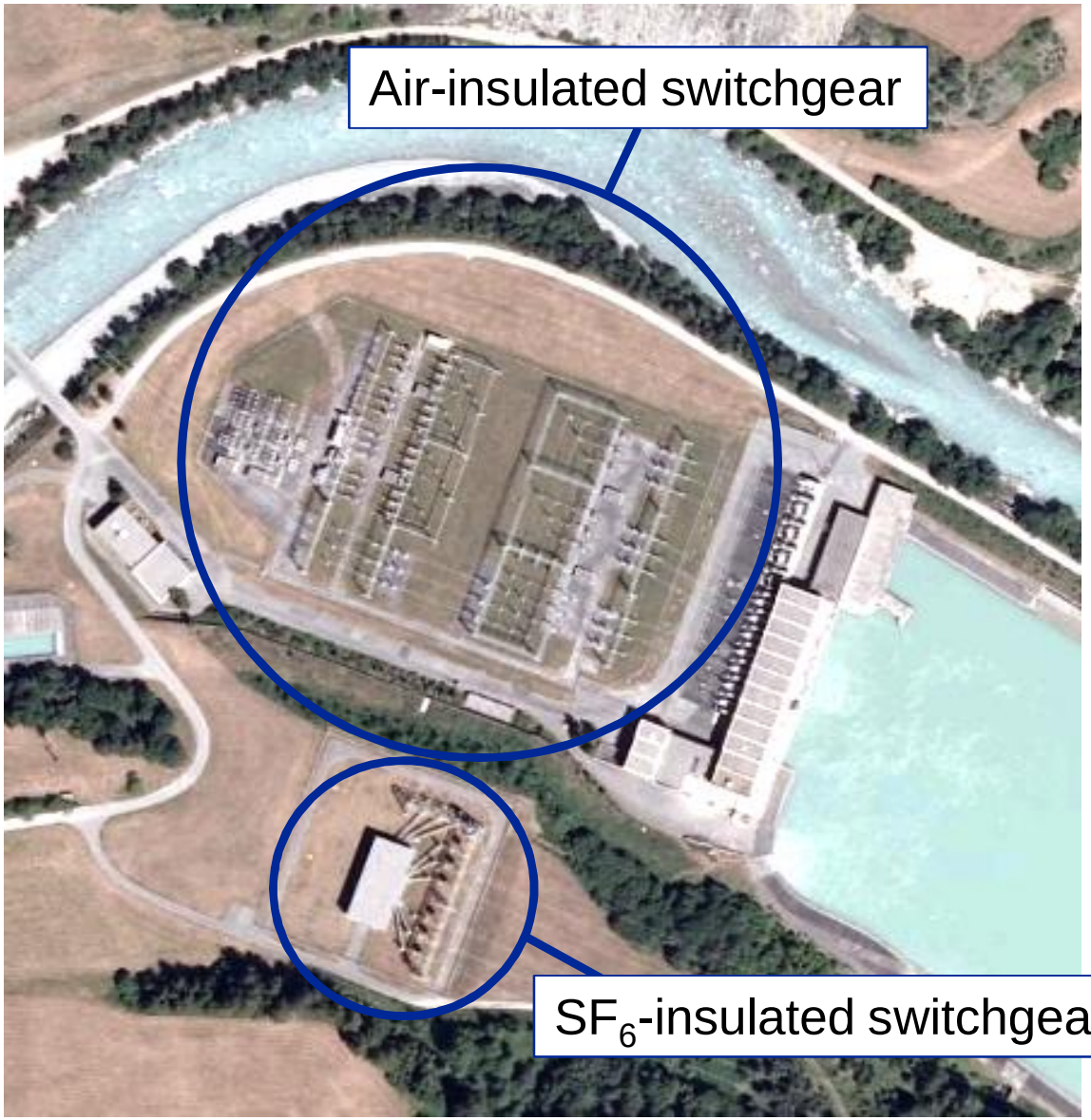
- Essential components for energy transmission and distribution.
- Necessary at every switching point in the electrical power grid.
- Switching devices are associated with control, protection and metering of power systems.



Electrical Switchgear

- Air-insulated substations have large space requirement
- Significant reduction in footprint through use of potent insulation gases – the best is SF_6.

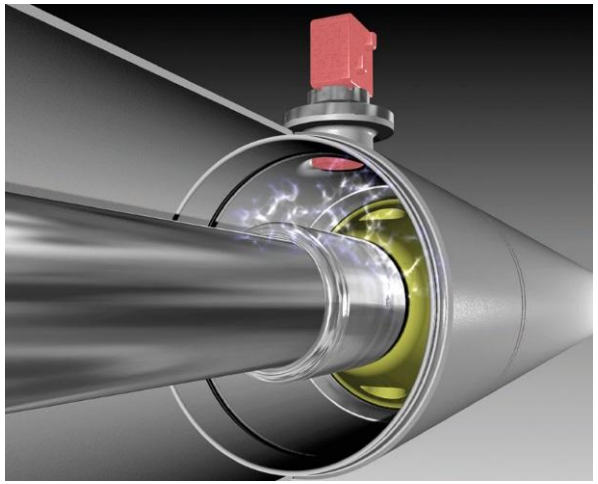
ABB's ELK-3 GIS



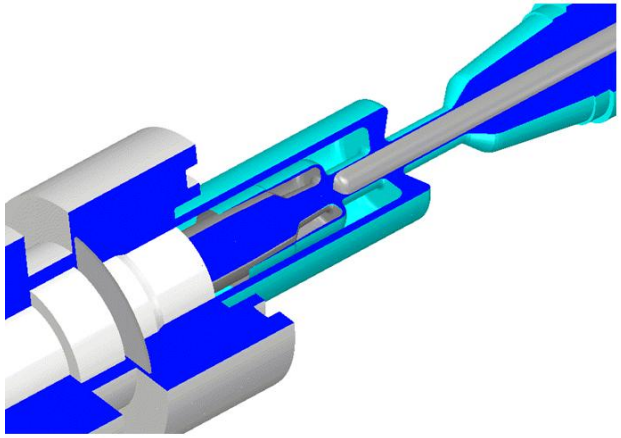
380kV GIS and AIS, Pradella CH

SF_6 as insulation gas

- During operation, the gas composition can change
  - Humidity ingress through seals and from outgassing
  - Arc-induced decomposition during switching
  - Partial discharge induced decomposition
- Decomposition products can be toxic and corrosive, and impede operability and safety of switchgear.



Partial discharge [image from www.think-grid.org]



SF_6 HV circuit breaker, M. Abrahamsson, ABB

Insulation gas diagnostics

- Permanent monitoring devices
  - Density and *T*-compensated pressure
  - Humidity
- Off-line, extractive devices
  - Humidity
  - Complete gas composition
- Leakage detection

Humidity sensor on a GIS, Vaisala

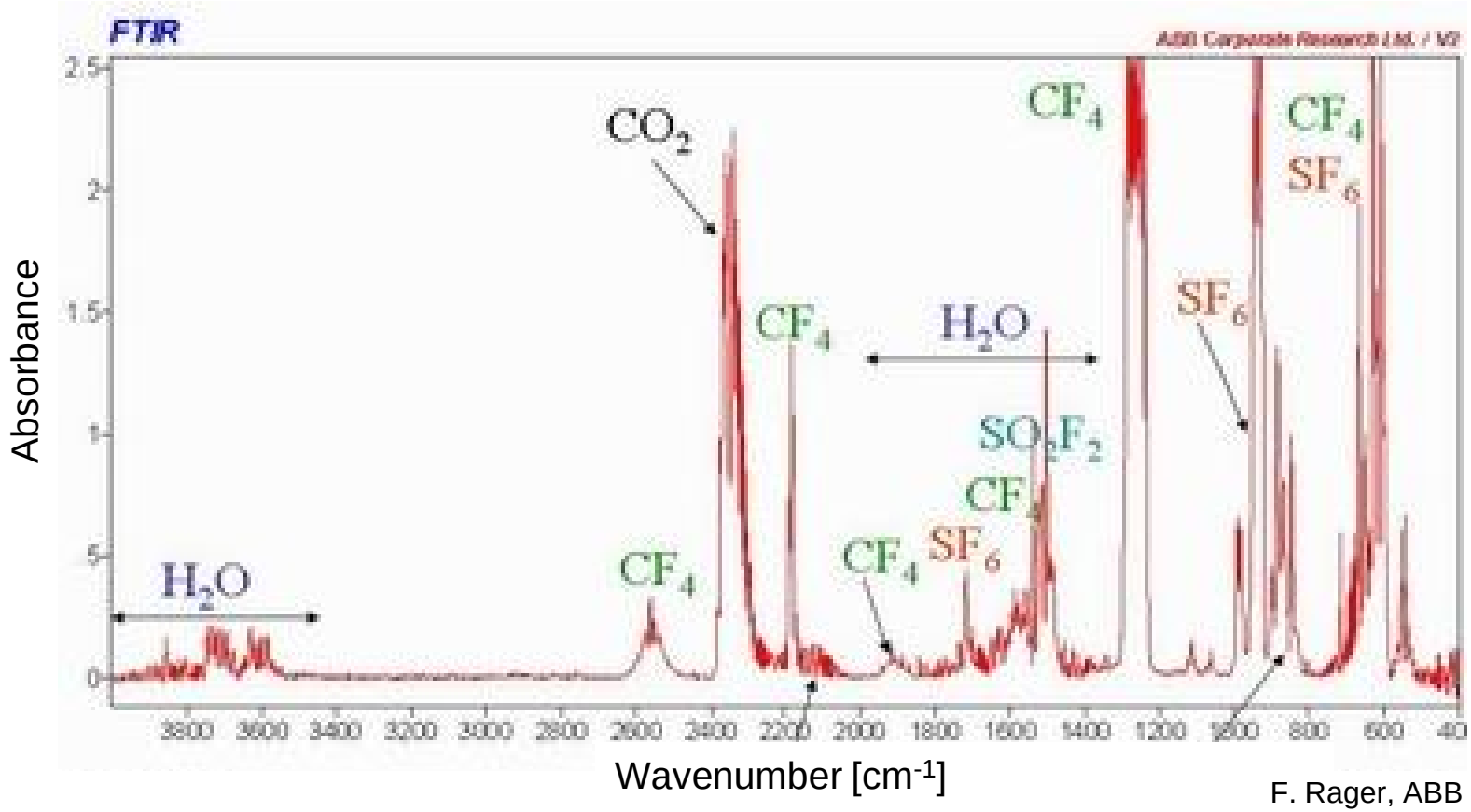
Gas analysis on a DTB, V. Williams, Company EMT

Optical chilled mirror dewpoint meter, MBW

SF_6 sniffer, CPS

Optical instruments for switchgear diagnosis

- SF_6 and many decomposition products offer IR signatures
- These are conveniently used for gas diagnostics



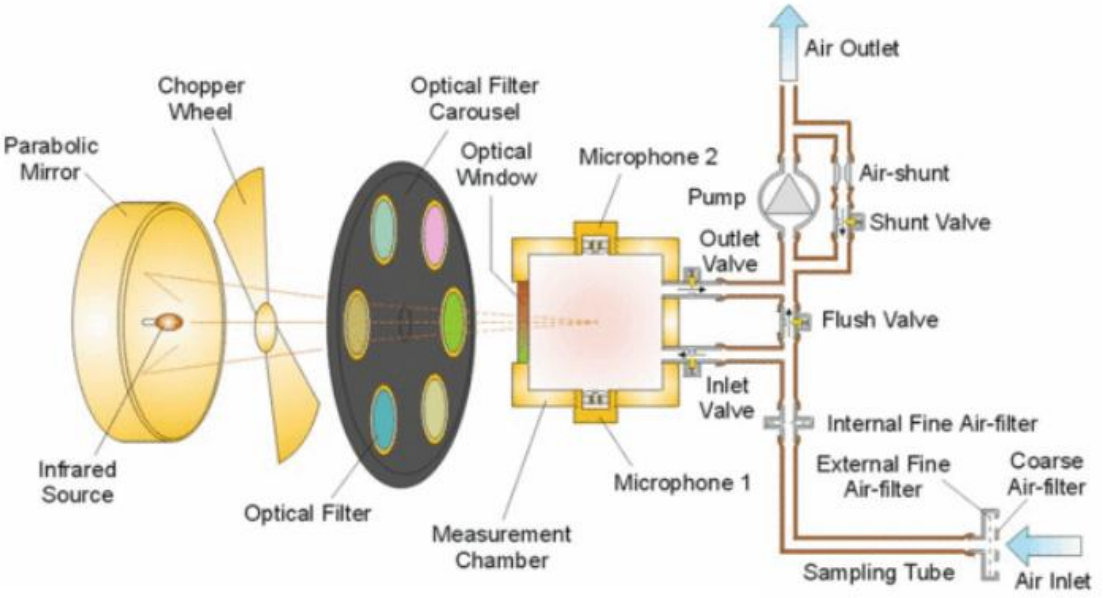
F. Rager, ABB

Commercial optical instruments for switchgear diagnosis

- Multi-component analysis
  - Gas composition analysis
  - Sampling & pump-back
- Integral leakage detection
  - Photoacoustic sensors
  - IR imaging

Innova-Lumasense

IR SF_6 analyzers, EMT



IR photoacoustic SF_6 analyzers, Innova-Lumasense

SF_6-alternatives: insulation gas *mixtures*

- Alternatives to SF_6 are based on gas *mixtures*
- Fluorinated organics (FOs) have high break-down strength
- Performance of SF_6-alternatives strongly depends on composition
- Composition is prone to change
  - Consumption in arc
  - Condensation
  - Other undesired processes,

Press Release

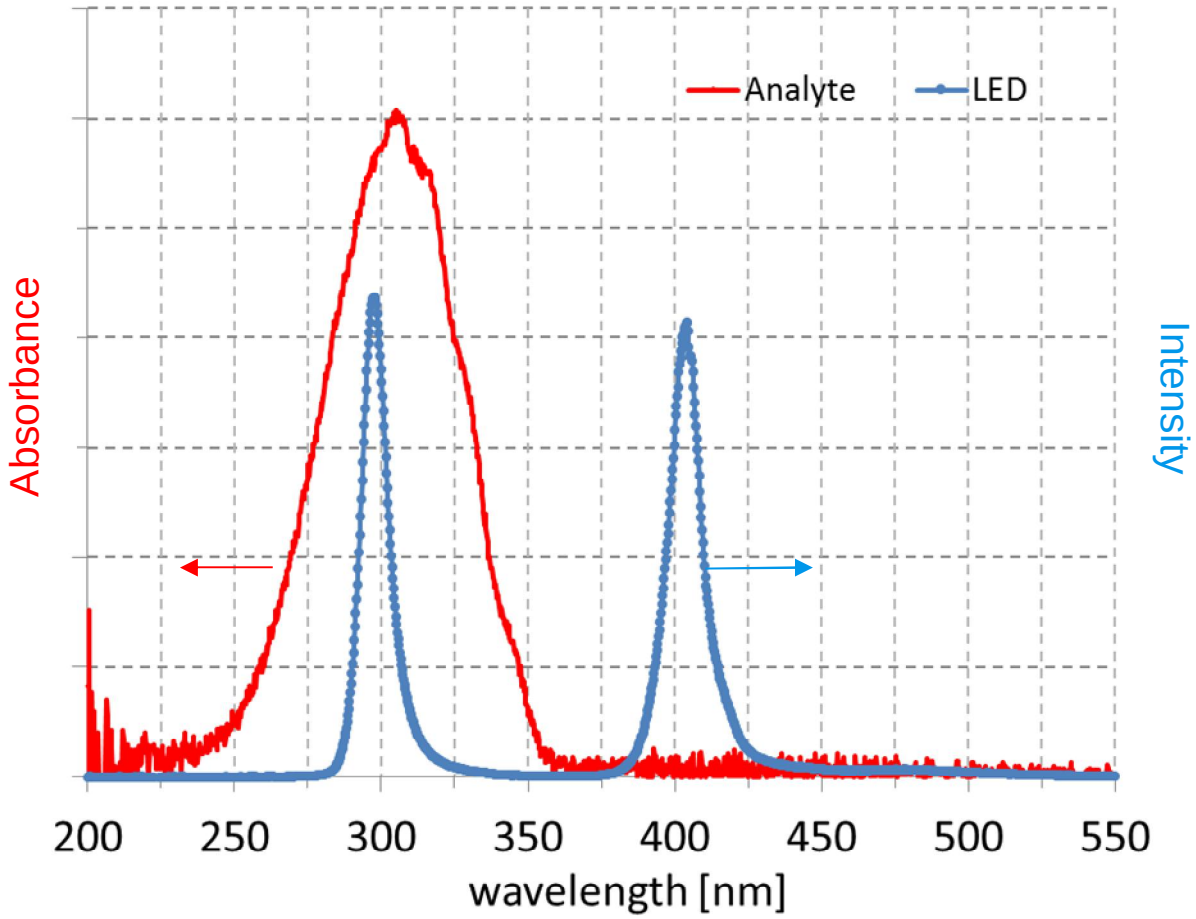
ABB achieves breakthrough in switchgear technology with eco-efficient insulation gas

New gas mixture offers alternative to SF6 and has potential to reduce carbon footprint of GIS by up to 50 percent – technology to be deployed in a Swiss pilot project.

New measurement instumentation needed

Optical monitoring of SF_6-alternatives in switchgear

- Characteristic UV bands available for FOs
- UV LEDs available down to 200 nm with small bandwidth
- Can use straight-forward absorption measurement

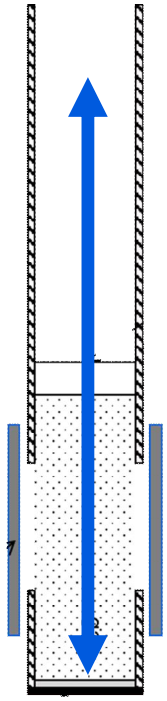


A. Kramer, ABB

Optical monitoring of SF_6-alternatives in switchgear

- Challenging measurement environment
  - Dust
  - Vibration
  - Corrosive gases
- Optical absorption measurement nevertheless viable
- Accuracy better than 1% of measured concentration

A. Kramer and
M. Porus, ABB



Optical probe

Summary

- Optical technologies are used widely for insulation gas diagnosis
- Diagnosis instrumentation is established for most aspects related to the use of SF_6
- SF_6-alternatives require new solutions

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