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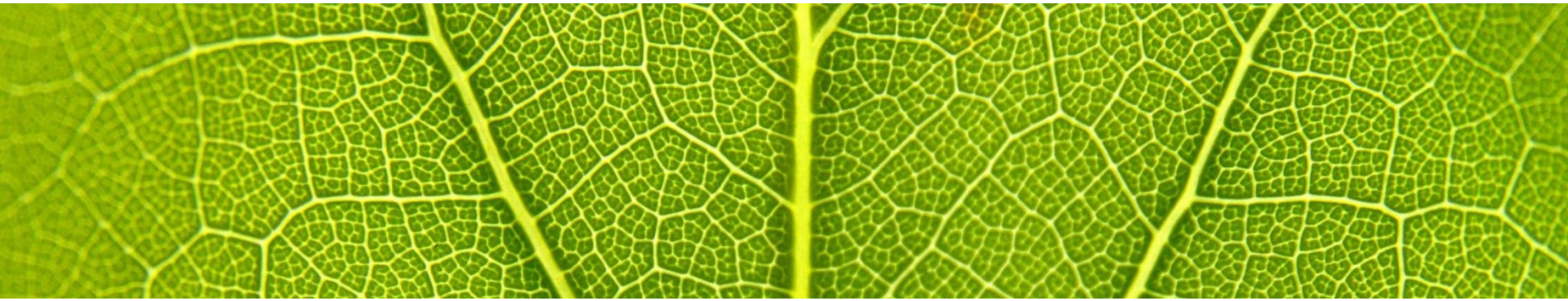
ETH zürich HVL High Voltage Laboratory



SF6 and alternatives in the electrical power supply

Overview of the current state of the investigation commissioned by the BMUB / UBA

Michael Döring, Charlotte Hussy (Ecofys)

22.02.2017

T&D working group meeting

AGENDA

- Introduction of the project and presentation of first results (20 minutes, Ecofys)
- Update: status of T&D Europe working group documents (20 minutes, T&D Europe)
- Discussion of European context (30 - 45 minutes, interactive)
  - Associations and ongoing/planned activities in other countries
  - Data collection and monitoring in other countries
  - Status and acceptance of alternative solutions for electrical equipment in other countries
  - Regulatory framework (e.g. voluntary self-commitments) in Europe
  - Asset population in Europe (age, emissions, controlled pressure,…)

Introduction of the project and presentation of first results

New developments are giving new inputs to the discussion about SF6 alternatives.

Kyoto Protocol (1997)

Voluntary commitment (2005)

F-gas Regulation (2006, 2014)

New releases of switchgear with SF6 alternatives (especially 2014 - 2016)

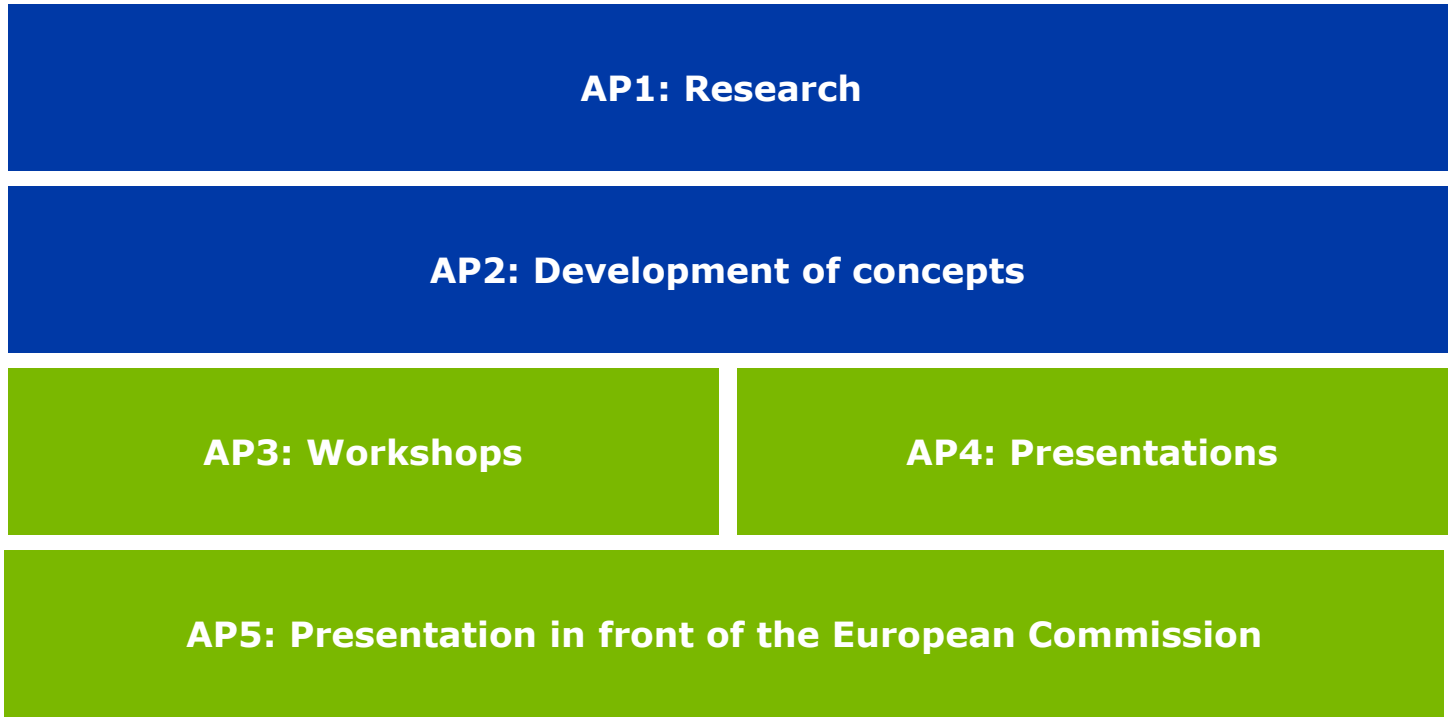
?

Review of the replacement of SF6 for specified applications (2020)

The BMUB / UBA wishes a neutral review of the current technical development in the field of SF6 alternatives.

- BMUB and UBA commissioned the study „**Concept for SF6-free transmission and distribution of electrical energy**"
- Project team: Ecofys, ETH Zürich
  - Timeframe of project: 2015 – 2018
  - Focus of project: Detailed compilation of a current overview of state of the art for equipment with and without SF6 usage
  - Object of project:
    - Switchgear in high and medium voltage
    - Further equipment with SF6 in power supply
    - Only new installations

The study consists of five work packages.



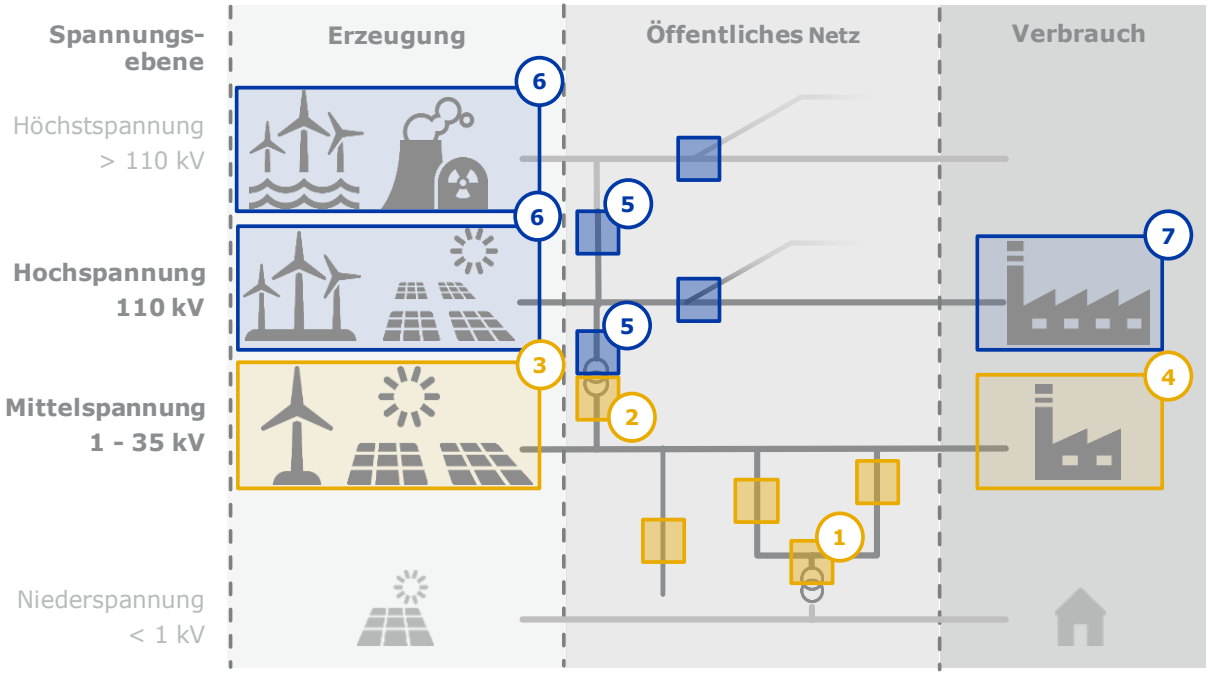
The intensive involvement of all stakeholders is a central element of the investigation.

- **Expert interviews** with various manufacturers and users of electrical medium- and high-voltage switchgear
- **Interim reports** (also as a basis for further stakeholder consultation)
- **Presentations** and **expert talks / workshops** in front of international experts to examine validity of research results
- Participation in **committees**

Project schedule

> **Already completed**
  - Interviews with 23 manufacturers and users
  - Inventory of equipment with SF6 as well as alternatives
  - Review of the regulatory framework in Germany and selected countries
  - Analysis of global and regional SF6 emissions

Use of SF6 as insulation and extinguishing medium



Equipment:

- Switchgear in medium and high voltage
- Other: Gas-insulated lines (GIL), bushings and instrument transformers

SF6-free systems from European manufacturer for **medium voltage** with vacuum switch (examples)

Secondary distribution

Primary distribution

Eaton Xpert UX
solid

Eaton Xpert FMX
solid

Siemens NXAIR
air

Schneider Premset
solid

ABB AirPlus
ketone

Eaton Xiria
solid

Cellpack ECOS-C
ester

Overview of the current state for switchgear in **medium voltage**

Insulation medium	Air (AIS)	Alternative gas	Alternative gas	Solid	Fluid
Extinguishing medium	**Vacuum**	**Vacuum**	**Alternative gas**	**Vacuum**	**Vacuum**
MV- switchgear primary distribution	implemented, >5 years on the market	implemented, <5 years on the market	Not implemented	implemented, >5 years on the market	Not implemented
MV- switchgear secondary distribution	implemented, >5 years on the market	implemented, <5 years on the market	Not implemented	implemented, >5 years on the market	implemented, >5 years on the market

Comparison of plants of European manufacturers for **high voltage**

						
	ABB ELK-14C 245 kV	**ABB GLK-14 170 kV Pilot plant**	**ABB ELK-04C 170 kV**	**GE F35 145 kV**	**GE F35 g3 145kV**	**Siemens 8VN1 145 kV**
Isolation	SF6	C5-PFK/CO2/O2	SF6	SF6	C4-PFN/CO2	Air (N2/O2)
Circuit breaker	SF6	C5-PFK/CO2/O2	SF6	SF6	C4-PFN/CO2	Vacuum
Rated current (A)	3150	1250	4000	3150	3150	3150
~Volume (m^3)	21	21	17-19	7	7	18
~Weight (tons)	6	6	2.4-3.8	2.5	2.5	5
Minimal temperature (°C)	-25	-5	-30	-30	-25	-50

Overview of the current state for switchgear in **high voltage**

Isolation medium **Extinguishing medium**	**Alternative gas** **Vacuum**	**Alternative gas** **Alternative gas**	**Solid** **Vacuum**	**Solid** **Vacuum**
HV switchgear	implemented, <5 years on the market	implemented, <5 years on the market	Not implemented	Not implemented

In our report we adress the following issues.

- Overview of relevant eletrical equipment and their parameters
- Overview of relevant applications and population of switch gears and further equipment (Germany)
- Comparison of equipment with SF_6 and without SF_6
- Regulatory framework (Germany)
- Overview of various stakeholder positions

Conclusion

- In **medium-voltage** applications SF6-free technologies have been partially available for years. **Full coverage seems technically possible**. Additional costs are to be expected.
- An SF6-free technology in **high voltage** does **not** appear possible in the foreseeable future **without technical compromises**.
- At the moment there are numerous developments in the area of SF6-free switchgear.
- We see potential for further development of monitoring in Europe; especially for the monitoring of emissions within the group «further equipment».

Next steps

- Constant involvement of stakeholders in further work steps: Your assessment is explicitly welcome!
- Within our expert workshops we will discuss the results.
- Derivation and classification of regulatory possibilities for action ("concept").

Update: status of T&D Europe working group documents

Discussion of European context

Discussion of European context

- Associations and ongoing/planned activities in other countries
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- Asset population in Europe (age, emissions, controlled pressure,…)

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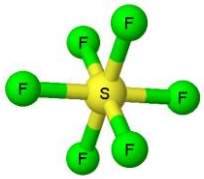
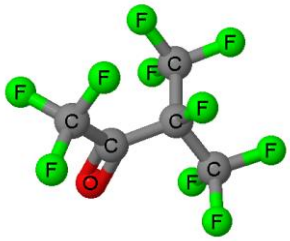
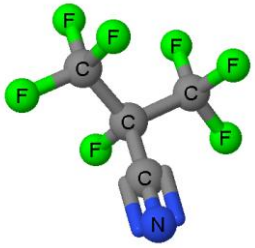
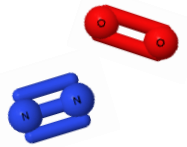
Eigenschaften von Alternativgasen und SF6









	Schwefel-hexafluorid SF6	Fluoriertes Keton C5-PFK	Fluoriertes Nitril C4-PFN	Luft N2/O2
Summenformel	SF6	C5F10O	C4F7N	N2, O2
Siedepunkt	-64°C	+27°C	-4.7 °C	-196°C, -183°C
Einsatzbereich	MS + HS	MS + HS	HS	MS + HS
Atmosphärische Lebensdauer	3200 Jahre	16 Tage	32 Jahre	
GWP	23500	<1	2100	0
Gasmischungen in Anwendung	meistens pur (100%) für kalte Regionen: N2 oder CF4 GIL:~20% SF6 in N2	MS GIS: ~7…14% in Luft HS GIS: ~6% in O2 und CO2	~4-10% in CO2 GWP: ~330-690	~20% O2 in N2
Minimale Betriebstemperatur	~-40°C	MS GIS: -15/-25°C HS GIS: -5°C	-25°C	-50°C