

Sustainable Reduction of SF₆ Emission – OEMs, Users, new EU-F-Gas Regulation

2017 Workshop for SF₆ Emission Reduction Strategies
Peter Glaubitz, Siemens AG

Agenda

- Fluorinated greenhouse gases and the EU*-F-Gas-regulation
- SF₆ in CIGRÉ
- SF₆ in the IEC
- SF₆-Emission reduction
- Installed Base and the application of SF₆ in the manufacturing process
- Alternative solutions
- Conclusion

*EU = European Union

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The Kyoto Protocol of the UNFCCC was the start of the EU-F-Gas-regulation and has the target to reduce greenhouse gas emissions into the atmosphere



- SF₆ emission reduction is the focus of every (F-Gas-) regulation



1997
Kyoto Protocol



2006
First EU-F-Gas-regulation (EC) 842/2006

2011
Report of the EU-commission on the application, effects and adequacy of the F-Gas-regulation (EC) 842/2006



2014
Second EU-F-Gas-regulation (EC) 517/2014

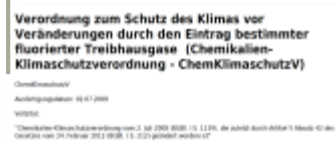
1997

TODAY

2005
German voluntary self-commitment



2008
German national Chemicals Sanction regulation



- The EU-F-Gas-regulation had to be implemented by every European member state

- Additionally national regulations define further standards for fluorinated gases

EU-F-Gas-regulation (EG) 517/2014 involves 28 member states



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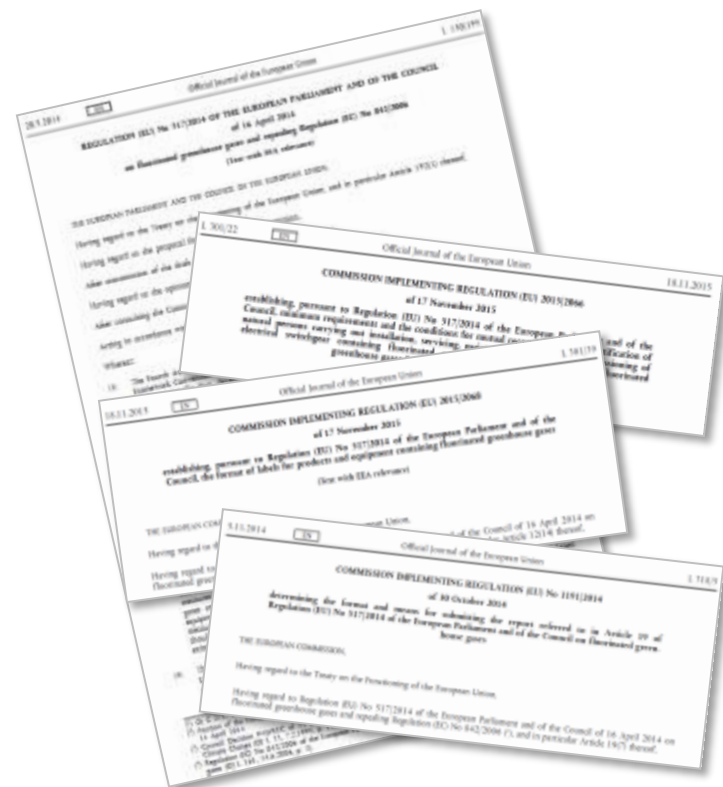


- Complex, because 28 „man-made-substances“ (all F-gases) are considered
- No restrictions on the application of SF₆ in electrical power equipment and SF₆ switchgear
- Contains requirements for producers and operators of SF₆ electrical power equipment and implementation dates
- The new F-Gas-regulation has to be transferred into national regulations **until January 1st, 2017** (Article 25)
- **Until July 1st, 2020**, the Commission shall publish a report assessing if reliable alternatives exist, which will allow the replacement of F-Gases in new MV secondary switchgear (Article 21)
- Further report on the effects of the regulation to be published **in 2022** (Article 21)

Link for all regulations: www.eur-lex.europa.eu

Implementing Regulations for SF₆ electrical power equipment derived from the EU-F-Gas-regulation 517/2014

EU-F-Gas-regulation		Implementing Regulations
	517/2014	
Training and Certification	Article 10	(EU) 2015/2066 (17. Nov 2015)
Labelling	Article 12	(EU) 2015/2068 (17. Nov 2015)
Reporting	Article 19	(EU) 1191/2014 (30. Oct 2014)



Important articles of the EU-F-Gas-regulation 517/2014 have been detailed in implementing regulations for easier application

EU-F-Gas-regulation 517/2014 – Prevention of emissions, leak checks and leakage detection systems

Art. 3 – 5

Article

3

4

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12

19

21

- **Intentional release** shall be prohibited
- **Leakages** have to be minimized, detected leakages have to be repaired without undue delay, verify effective repair (< 1 Month)
- **Leak checks** → SF₆ electric power equipment is not affected provided they comply with one of the following conditions

	MV	HV
– Tested leakrate of less than 0.1% per year	✓	✓*
– Equipped with a pressure or density monitoring device	✓	✓
– Or it contains less than 6kg of fluorinated greenhouse gases (per compartment)	✓	

- **Leakage detection systems** have to be installed **from 1st January 2017** – for functionality reasons, in most of the cases, already implemented in the past
- **Leakage detection systems** shall be checked at least once every 6 years
- SF₆ electric power equipment containing less than 500ton CO₂e (approx. 22kg SF₆) do not need a leakage detection system

* Type tested

Article

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Art. 8

- Operators shall ensure that the recovery of fluorinated gases is carried out by natural persons that hold the relevant certificates provided for by Article 10

Art. 10

- As per **1st July 2017** the persons carrying out the tasks below shall be trained and hold a certificate provided for by Article 10

Installation, servicing, maintenance, repair and decommissioning of SF₆ electric power equipment + recovery of fluorinated greenhouse gases

- Only for on-site works → No certification in the factory as processes are automated (attention: maintenance of SF₆-handling equipment in factory)
- Existing certificates issued in accordance with regulation (EC) no. 842/2006 remain valid
- Member States shall recognize certificates issued in another Member State (attention: language)

EU-F-Gas-regulation 517/2014 – Labelling



Article

- 3
- 4
- 5
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- 10
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- 12
- 19
- 21

- Products and equipment must be labelled
- Reference to fluorinated greenhouse gases **(A)** and **(B)** amount in kg SF₆ → 2015; and **(B)** CO₂e and GWP* → 2017
- Labels shall be placed on the equipment
- Information shall be included in instruction manuals and in descriptions used for advertising

* Global Warming Potential

Art. 12

Example of EU-label

GWP SF₆: 22800

EN: Contains fluorinated greenhouse gases

LT: Sudėtyje yra fluoruoti šiltnamio efekta sukkeliančių dujų

LV: Satur fluorētas siltumnīcefekta gāzes

MT: Kontenut gas tat tip "fluorinated greenhouse"

NL: Bevat defluoreerde broeikasgasen

DE: Enthält fluoriertes Treibhausgas

EN: Contains fluorinated greenhouse gas

BG: Съдържа флуорирани парникови газове

FI: Sisältää fluorattuja kasvihuonekaasuja

FR: Contient du gaz à effet de serre fluoré

GA: Ina bhfuil gás cheaptha teasa fhlúairínithe

HR: Sadržaji fluorirane stakleničke plinove

RU: Содержит фторированный парниковый газ

SK: Obsahuje fluorovaný skleníkový plyn

SL: Vsebuje fluorirane toplogredne pline

SV: Innehåller fluorerade växthusgasar

Example of SF₆ quantity label

Fabrik-Nr. Serial no.	12 345 678	LS	CB	Anlage Switchgear					
Gasraum	Gas compartment	00	01	02	03	04	05	06	
SF ₆ -Überdruck Gauge pressure	Fülldruck bei Filling pressure at	20°C	5.6	4.5	4.5	4.5	4.5	4.5	4.5
[bar]					4.0	4.0	4.0	4.0	
[kg]	SF ₆ -Füllmenge Banked mass of SF ₆				6.0	6.0	6.0	6.0	
Treibhauspotenzial	Global warming potential								22.800
[t]	CO ₂ e-Füllmenge Banked mass of CO ₂ e								

Article

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- Record keeping (installed amount, leaking quantities) for equipment containing SF₆ is **not** required as a leakage detection system (pressure or density monitoring device with remote signalling function) is installed according to Article 4

However operators of SF₆ electric power equipment should continue with their established internal documentation processes as agreed upon national self commitments

- On 31 March of each year (introduced in 2015), the amount of bulk SF₆ imported into or exported from the EU has to be reported, with reference to the previous year

This is valid for manufacturers and operators

In addition operators have to report the amount of SF₆ contained in equipment imported into the EU

CIGRÉ brochures give guidance for the environmental friendly handling of SF₆

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2003
CIGRÉ
recycling
guide



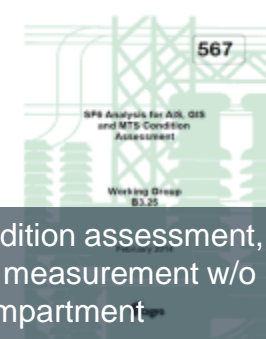
Assure long-term application of SF₆

2010
CIGRÉ
tightness
guide



Guarantee of SF₆ tightness due to state-of-the-art equipment and testing

2014
CIGRÉ
Guide for
SF₆ analysis

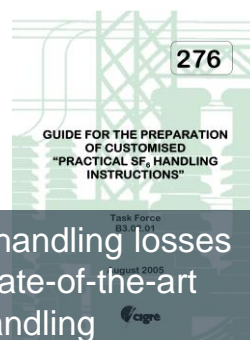


SF₆ analysis for condition assessment, including dew point measurement w/o opening compartment

2003

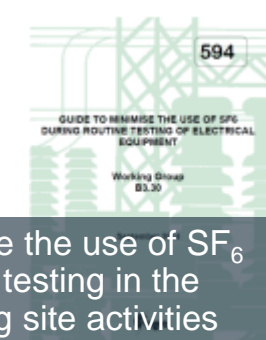
TODAY

2005
CIGRÉ
handling
guide



Avoid SF₆ handling losses due to state-of-the-art handling

2014
minimization
of SF₆ during
routine testing



Guide to minimize the use of SF₆ during routine testing in the factory including site activities

Current CIGRÉ activity regarding SF₆

WG B3.40 “Measuring the parameters of SF₆-Gas” (publication planned in 2017)

Link: www.e-cigre.org

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CIGRÉ SF₆-brochures

Concepts

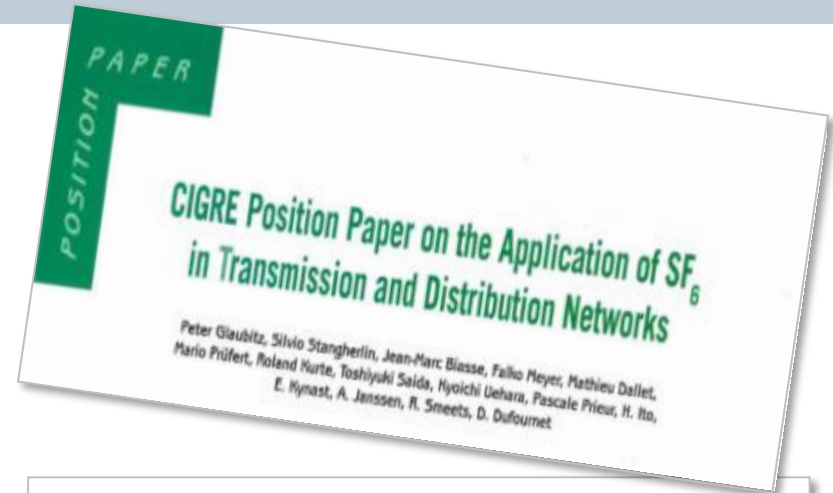
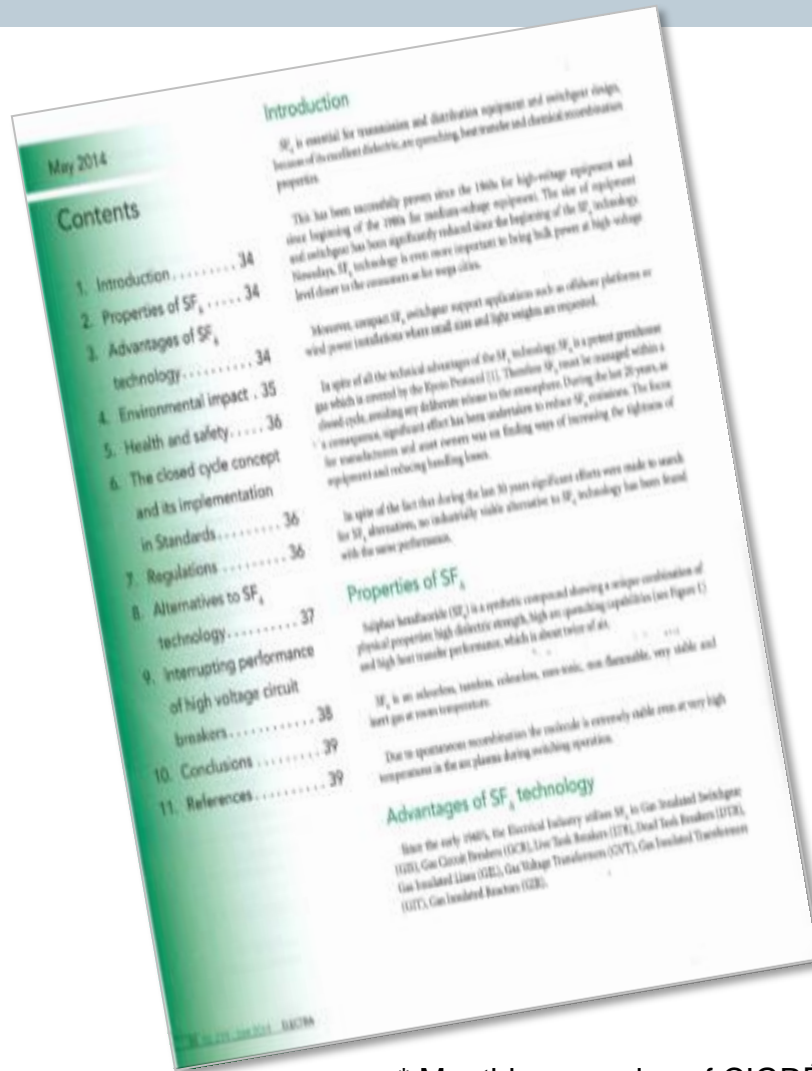
- Keep SF₆ in a closed cycle
- Avoid any deliberate release
- Allow SF₆ re-use on-site

Sustainable application of SF₆

- **State-of-the-art** handling-equipment → recover all SF₆ (0 mbar/psig*)
- **State-of-the-art** SF₆ quality checks → gas collecting capability
- **State-of-the-art** measurement → clear parameters
- **State-of-the-art** equipment → extended maintenance intervals
- Best available processes → trained and certified service staff for SF₆ handling
- **Many CIGRÉ brochures have been transferred into Standards and regulations**
- **CIGRÉ “SF₆ Green Book” planned**

* 1 mbar = 0.0145 psig

The CIGRÉ ELECTRA* Position Paper...



- Published in the **ELECTRA** magazine no. 274, in June 2014

... gives a general overview of SF₆ and its application in the electrical industry

* Monthly magazine of CIGRÉ

IEC and the application and handling of sulfur hexafluoride (SF₆) in high-voltage switchgear and controlgear

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Focus on SF₆ Quality

Focus on avoiding emissions

1995

IEC 61634

Use and handling of sulfur hexafluoride (SF₆) in high-voltage switchgear and controlgear

Was issued considering Health and Safety aspects

2005

IEC 60376

Specification of technical grade SF₆ for use in electrical equipment



2013

IEC 62271-4

Handling procedures for SF₆ and its mixtures

Replaced the first edition of IEC/TR 62271-303

1995

TODAY

2004

IEC 60480

Guidelines for the checking and treatment of SF₆ taken from electrical equipment and specification for its re-use



2008

IEC/TR 62271-303

Use and handling of sulphur hexafluoride (SF₆)

Major revision of the former IEC 61634, includes sections of the CIGRÉ handling guide no. 276 issued in 2005

Focus on SF₆ Quality

Which Measures have been implemented by Operators in order to reduce emissions?

What is SF₆ emission?

Leakage losses



Handling losses



SF₆-Emission



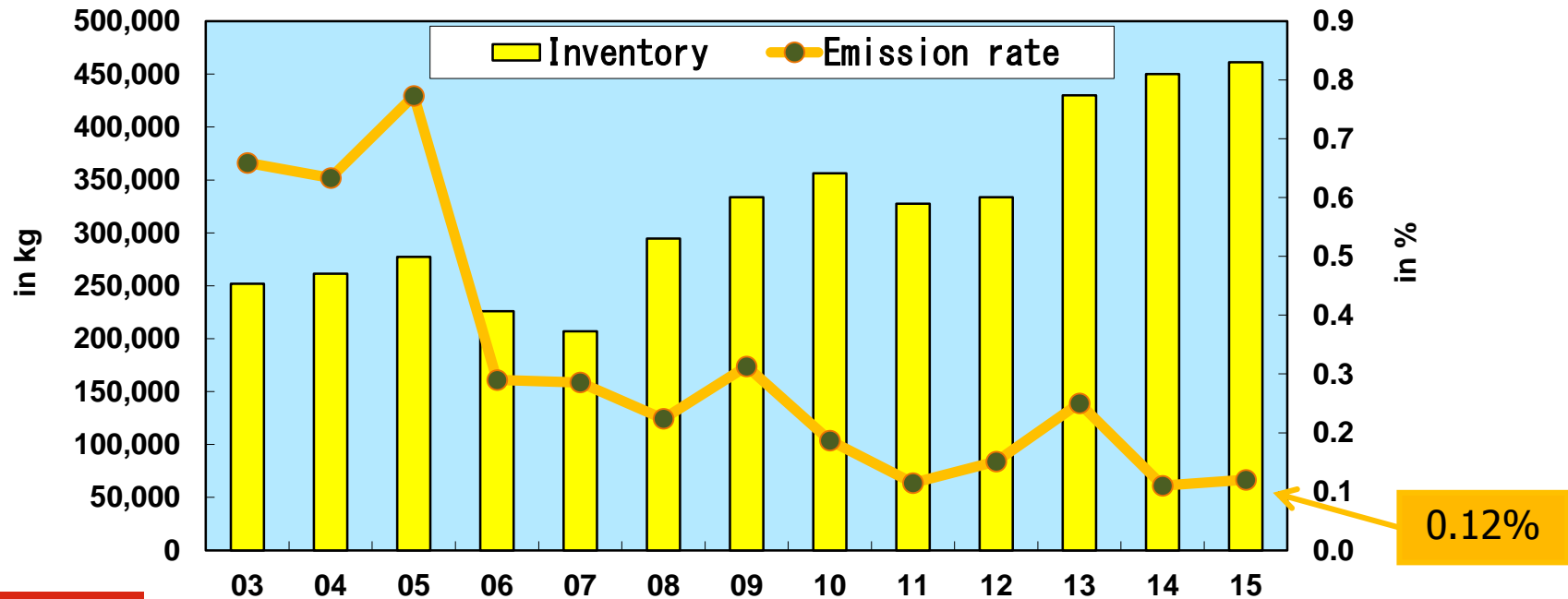
leakage losses can be avoided by...

- Gas-tight equipment
- SF₆ leak detection systems
- Immediate repair of leaks
- Replacement of electric power equipment, even before end of lifetime

handling losses can be avoided by...

- Trained personal
- State-of-the-art handling- and measurement equipment
- Long maintenance intervals to reduce openings

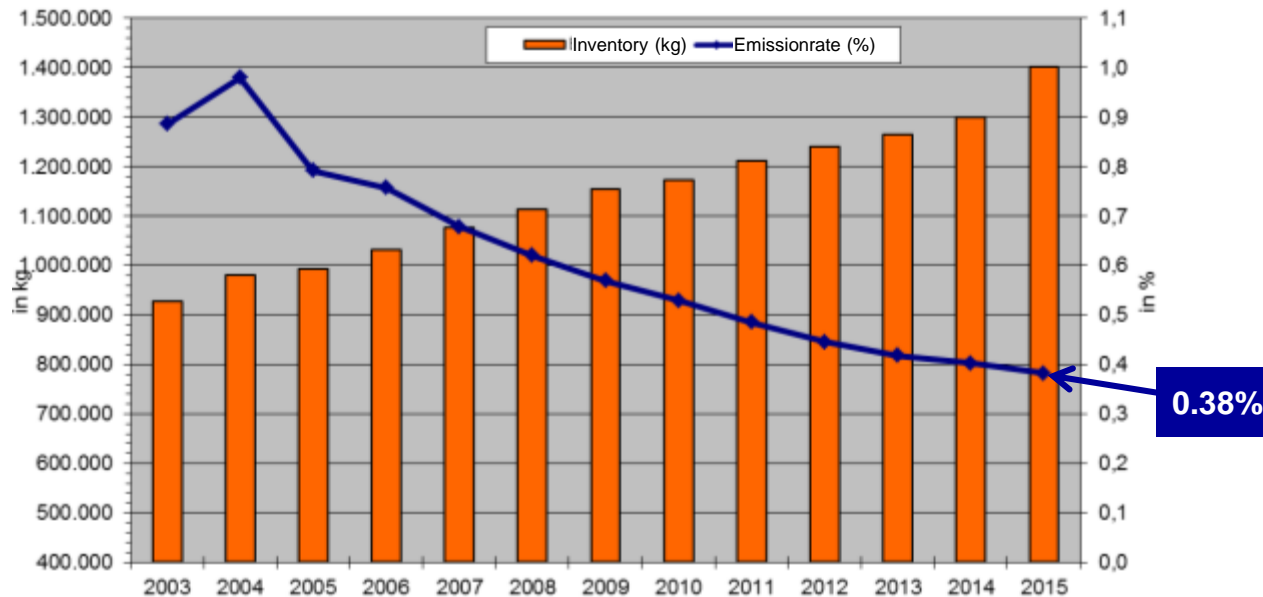
Installed base and emission of SF₆ in electric power equipment in Switzerland



SF₆ - inventory and emission rate of electric power equipment Ur ≥ 52kV in operation from 2003 – 2015 in Switzerland (Data SwissMEM SF₆-balance 2015)

- The finally achieved emission rate for Switzerland of 0.12% seems to be very close to the possible optimum
- All known measures have been implemented including the replacement of leaking equipment and controlled pressure systems

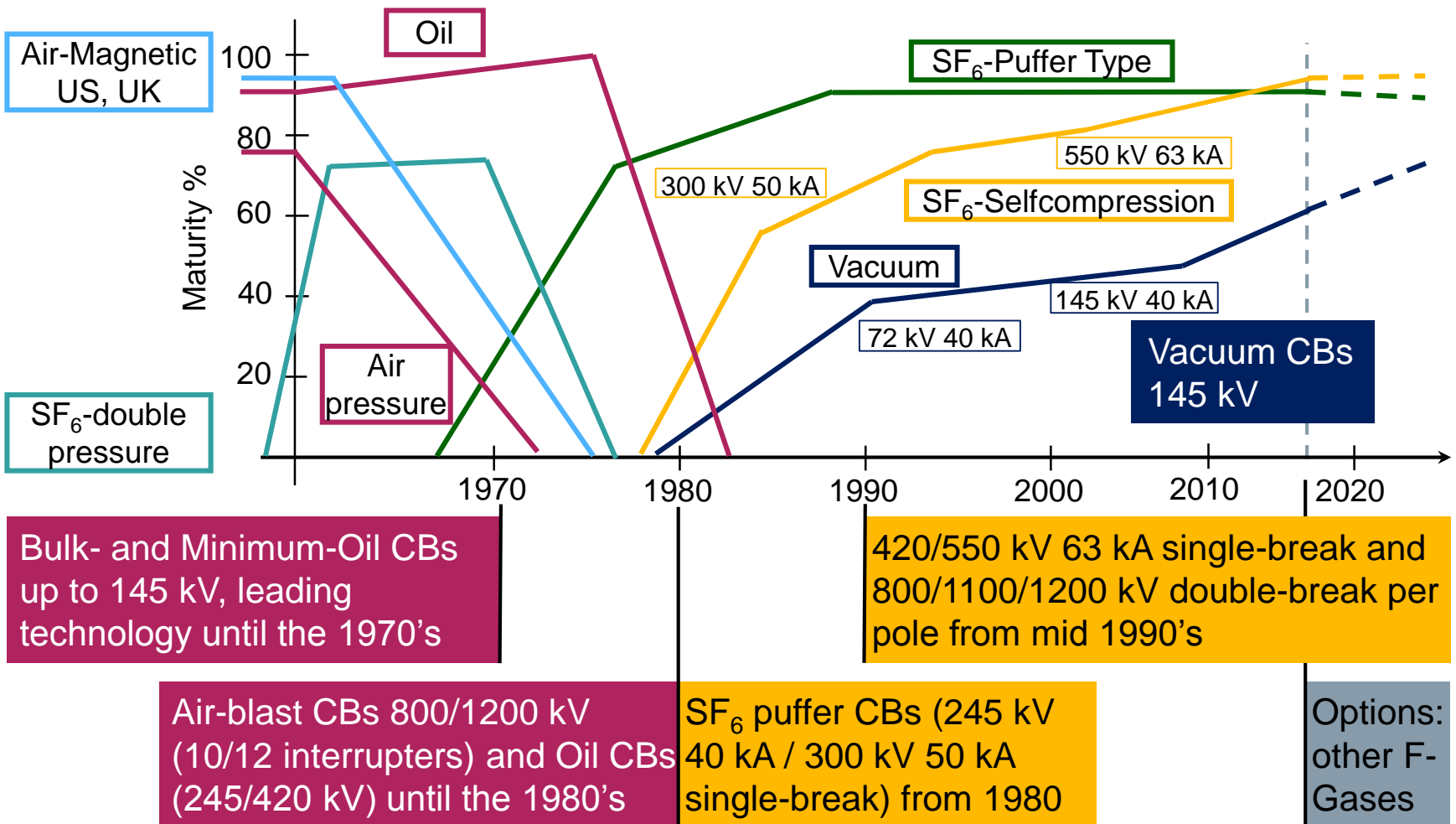
Installed base and emission of SF₆ in electric power equipment in Germany



 SF₆ - inventory and emission rate of electric power equipment Ur ≥ 52kV in operation from 2003 – 2015 in Germany (Data of FNN, VIK, ZVEI and Solvay)

- Compared to Switzerland the SF₆-emission can still be reduced
- The biggest lever seems to be the replacement of 1st generation controlled pressure systems (high leakage rates)

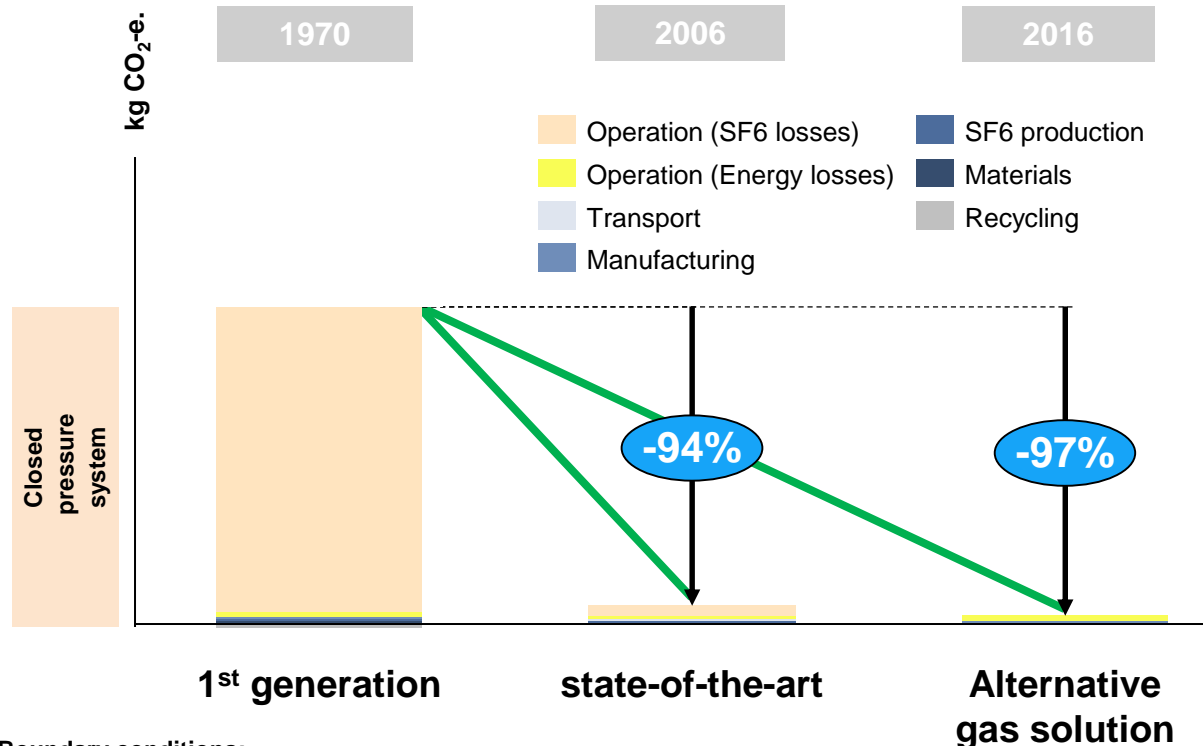
Development of arc quenching technologies



Source: Taskforce Siemens
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Gas Insulated Switchgear: Significant reduction of Global Warming Potential with SF₆-Technology, further reduction with Vacuum-Technology achieved

Model calculation for 145 kV GIS rated voltage class



94% GWP-reduction with SF₆:

- Very low leakage rate
- Reduction of gas volume
- Shorter sealing length
- Design optimization

97% GWP-reduction with alternative gas solutions

- No emissions of F-gas
- High recycling rates
- Maintenance-free operation

Boundary conditions:

145 kV GIS „Old“ : lifetime 40 years; SF₆: 180kg, 3% leakage rate in operation, maintenance not included
 145 kV GIS „state-of-the-art“: Lifetime 50 years; SF₆ 83 kg, 0,1% leakage rate in operation;
 145 kV GIS „Alternative“: 15 kg CleanAir, one maintenance interval after 25years

How can an alternative solution look like?

Switching-Technology – Which benefit offers the Vacuum Switching-Technology?

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- Excellent arc quenching capability and proven technology in Medium-Voltage for many decades
- Excellent at low ambient temperature
- High number of C-O operations



72,5 kV
31,5 kA
2500 A

145 kV
40 kA
3150 A



Insulating Medium 100% N₂

- 5 Vacuum Live-Tank Circuit Breaker 72.5 kV in operation since 2010

Vacuum-Circuit Breakers show no discrepancies in their performance in relation to SF₆-Circuit Breakers

Alternative Gas Solution Clean-Air Switchgear

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72.5 kV Clean-Air application for Windtower



145 kV Clean-Air GIS

- Vacuum tubes for Circuit Breaker switching
- Clean-Air insulation → 80% N₂ and 20% O₂
- No Global Warming Potential (GWP) = 0
- Low boiling point and no liquidation at low temperatures
- Known and proven material compatibility
- Low requirements for transportation, installation, operation, documentation and recycling
- C-Gas-free → without risk of Carbon by-products in switching and insulating gas compartments
- The F-Gas-regulation does not apply to vacuum/Clean-Air electric power equipment, which reduces extensive requirements



Conclusion

To avoid SF₆ emission ...

- All known sustainable measures have to be implemented, especially
 - Replacement of equipment and controlled pressure systems which cannot be tightened
 - Gas handling only by certified staff
- SF₆ emission can be reduced to 0.1% based on the installed SF₆ - inventory, further reduction is utmost challenging
- SF₆ respectively F-Gas replacement solutions are under investigation – first pilot projects in place

Contact



Thank you
for your attention

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