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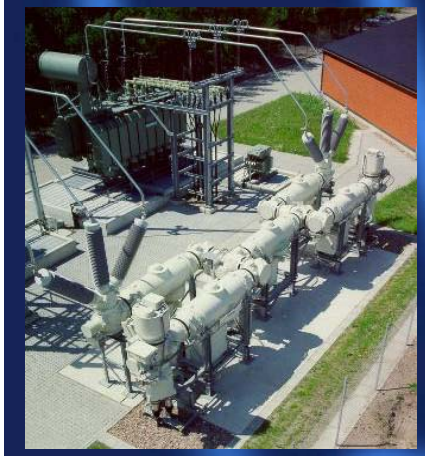
Gas-Insulated-Substations SF_6 gas handling

EPA‘s 2012 Workshop on SF_6-emission reduction strategies
Atlanta, Georgia; April 17-18, 2012





Peter Glaubitz
Christian Wallner

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Content

- Introduction
- SF_6 in a lifecycle process
- CO_2-footprint reduction of GIS
- Handling of SF_6
- Regulations on SF_6
- Conclusion

Power Transmission
is a Part of the Power Matrix

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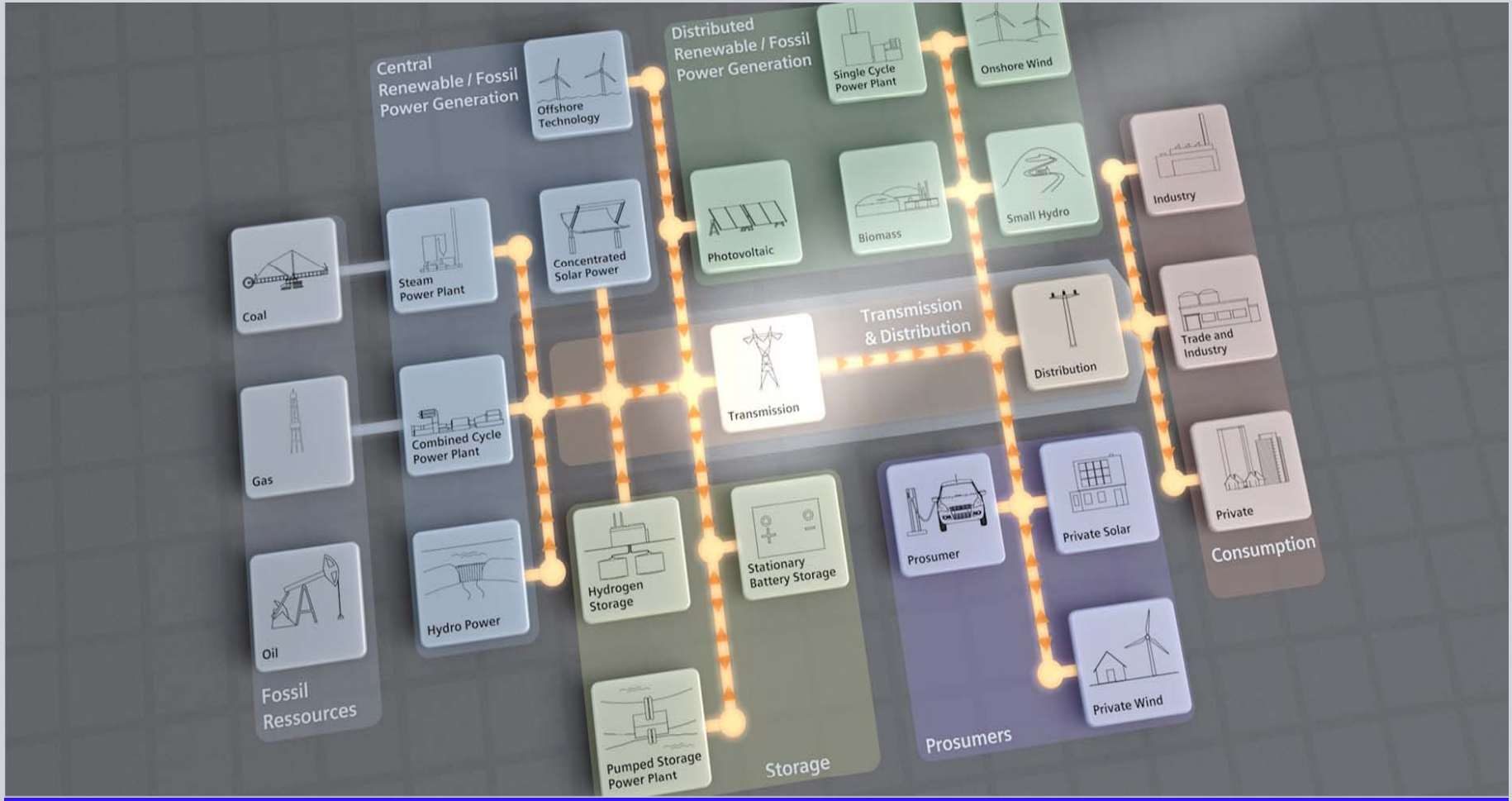

High Voltage Substations are the backbone of the Transmission System

Requirements for Gas-Insulated Substations

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- High system reliability
- High flexibility of its solutions (modularity, expandability)
- Compact space saving solutions
- Innovative solutions (devices, switchgears)
- Low life cycle costs
- Reliable and competent partners (operator, manufacturer)
- Smart and Power grid adaptation
- Environmental-sustainability





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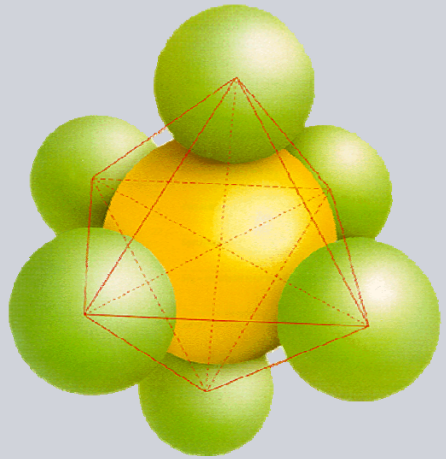
Characteristics of SF_6

- SF_6 is colorlessly, odorless and a chemical neutral (inerted) gas
- SF_6 is 5x heavier than air, is not toxic and has no dangerous components inside
- SF_6 is no hazardous material
- SF_6 has no eco-toxic potential
- SF_6 has no impact for the ozonosphere
- SF_6 is a potent greenhouse gas (GWP* → 22,800** x CO_2)
- SF_6 has excellent electrical characteristics



* Global Warming Potential; ** according to EU-F-Gas regulation

SF_6-emissions in the lifecycle process of switchgear

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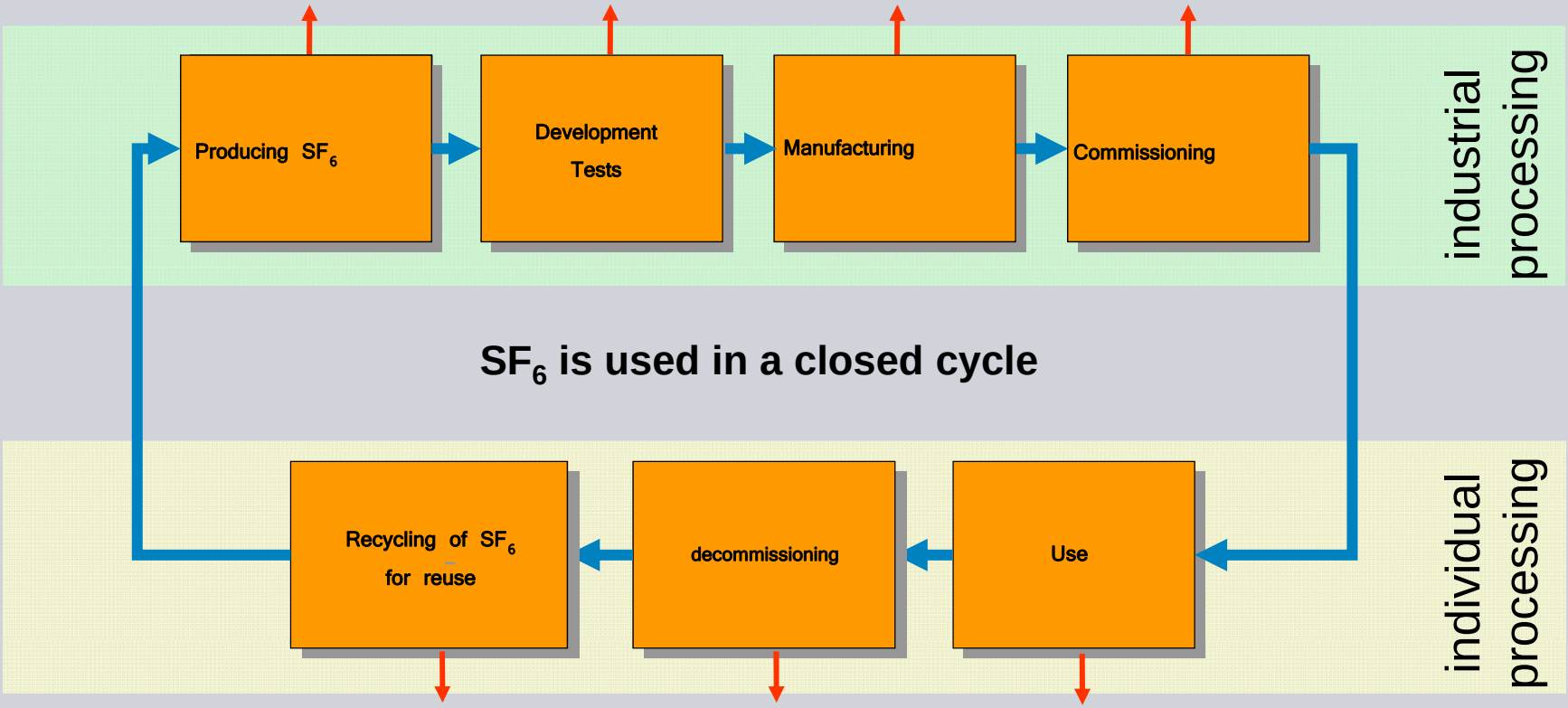
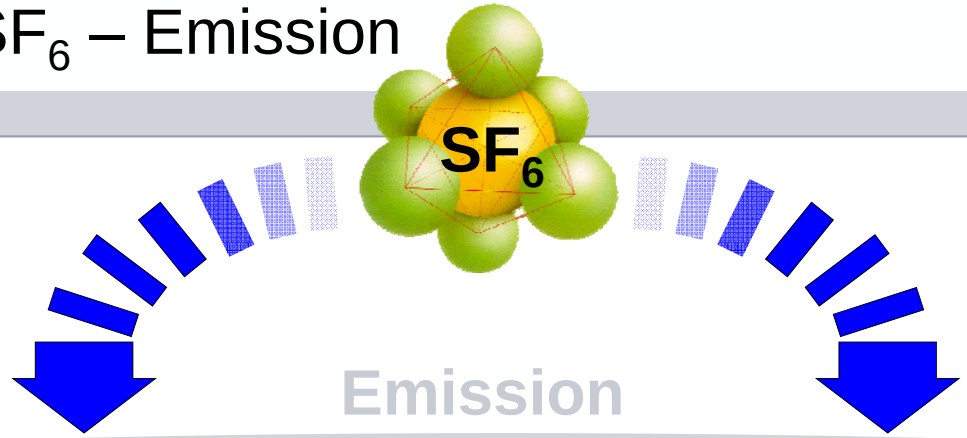


Definition of SF_6 – Emission

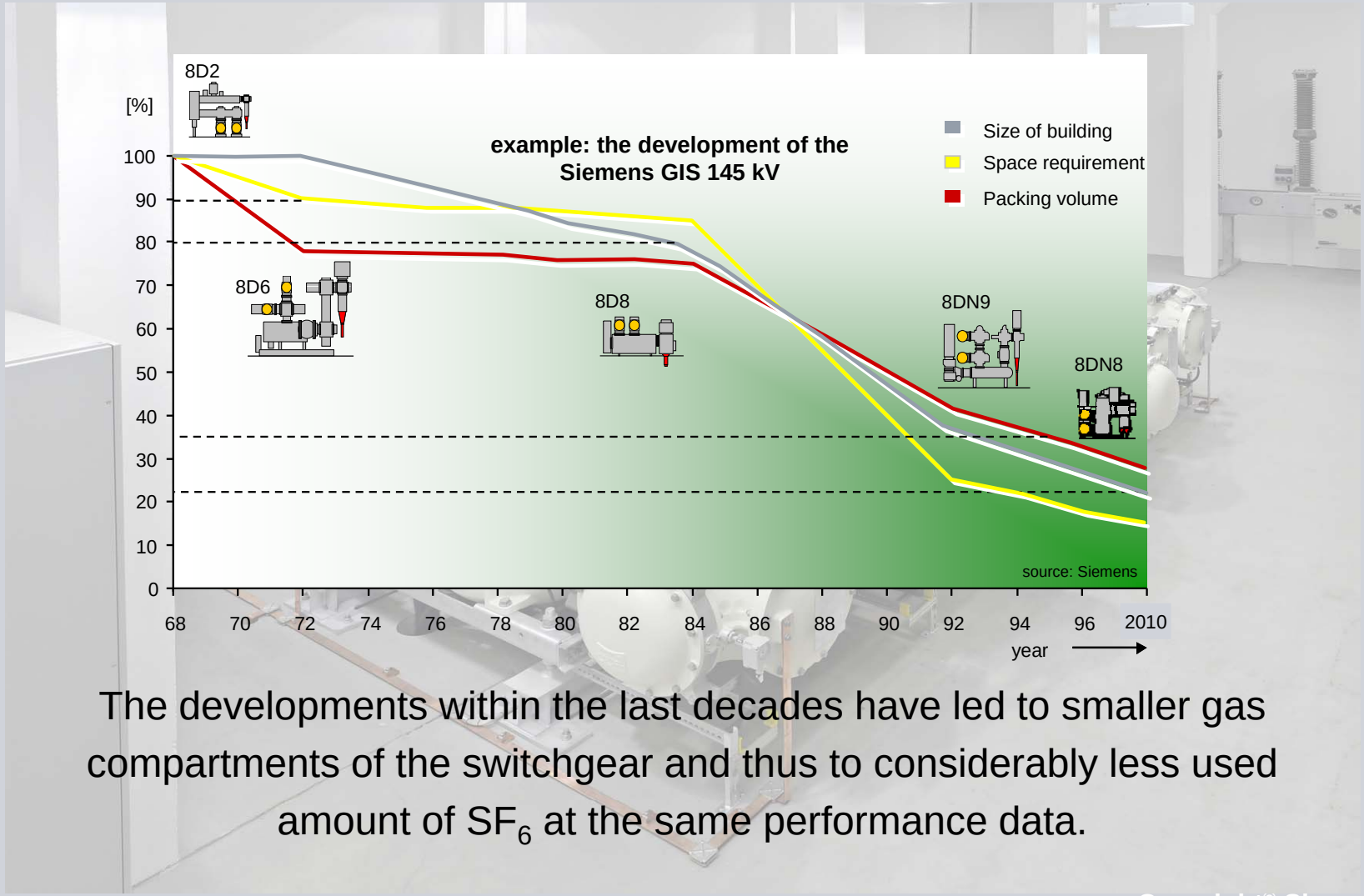


SF_6-handling losses + **SF_6-leakage**

Technical recommendation in e.g.
Cigré SF_6-Handling Guide No. 276

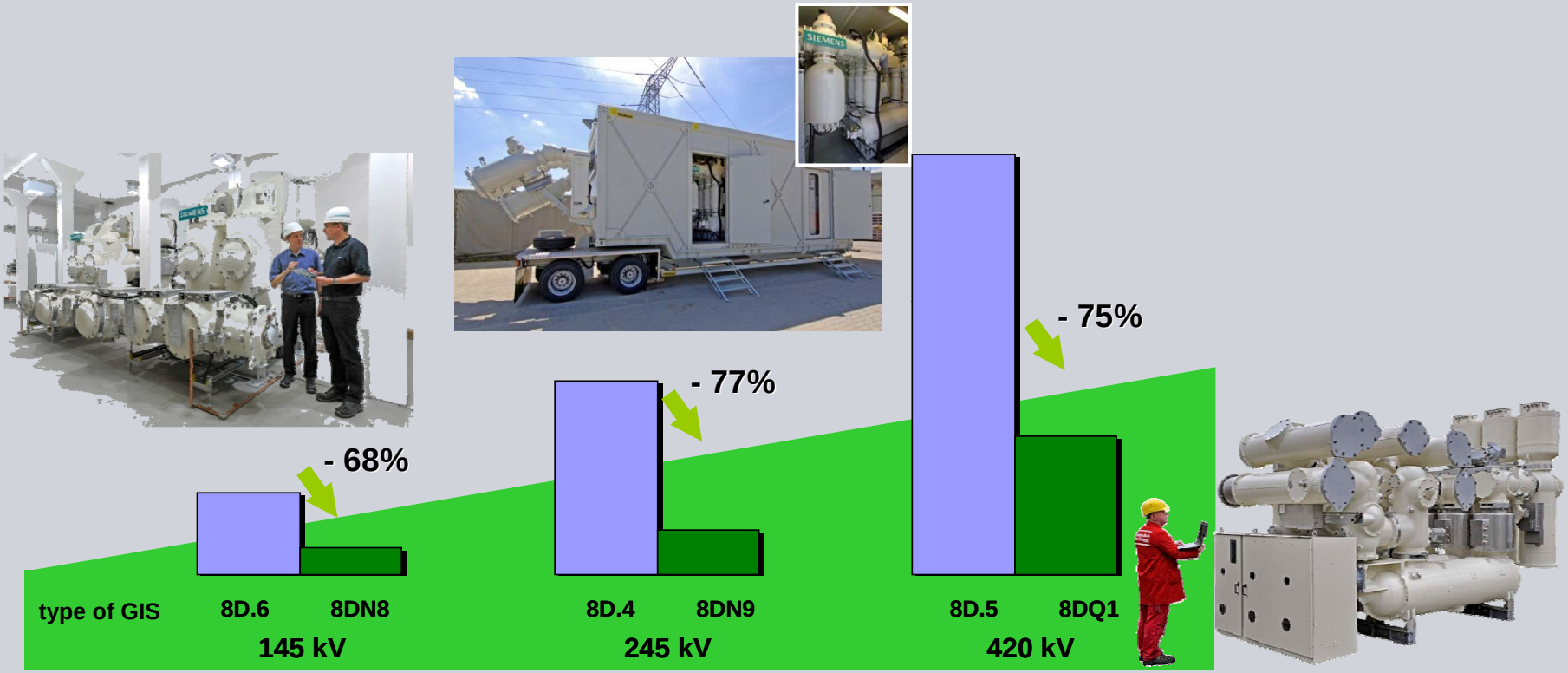
Definition in IEC-standards,
like IEEE C37.122, IEC 62271-203,
Cigré SF_6-Tightness Guide No. 430

Permanent CO_2-footprint reduction of GIS



The developments within the last decades have led to smaller gas compartments of the switchgear and thus to considerably less used amount of SF_6 at the same performance data.

Significant reduced amount of SF_6 in the equipment



Siemens GIS, Cable bay with double busbar system including 2 BB DS, 1 line DS, 1 CB, 3 ES

A significant reduction of SF_6 was reached by using modern development tools, new materials and optimized production processes since the introduction of the GIS-technology in 1968

Reduction of SF_6-emissions in the factory – Type testing internal arc

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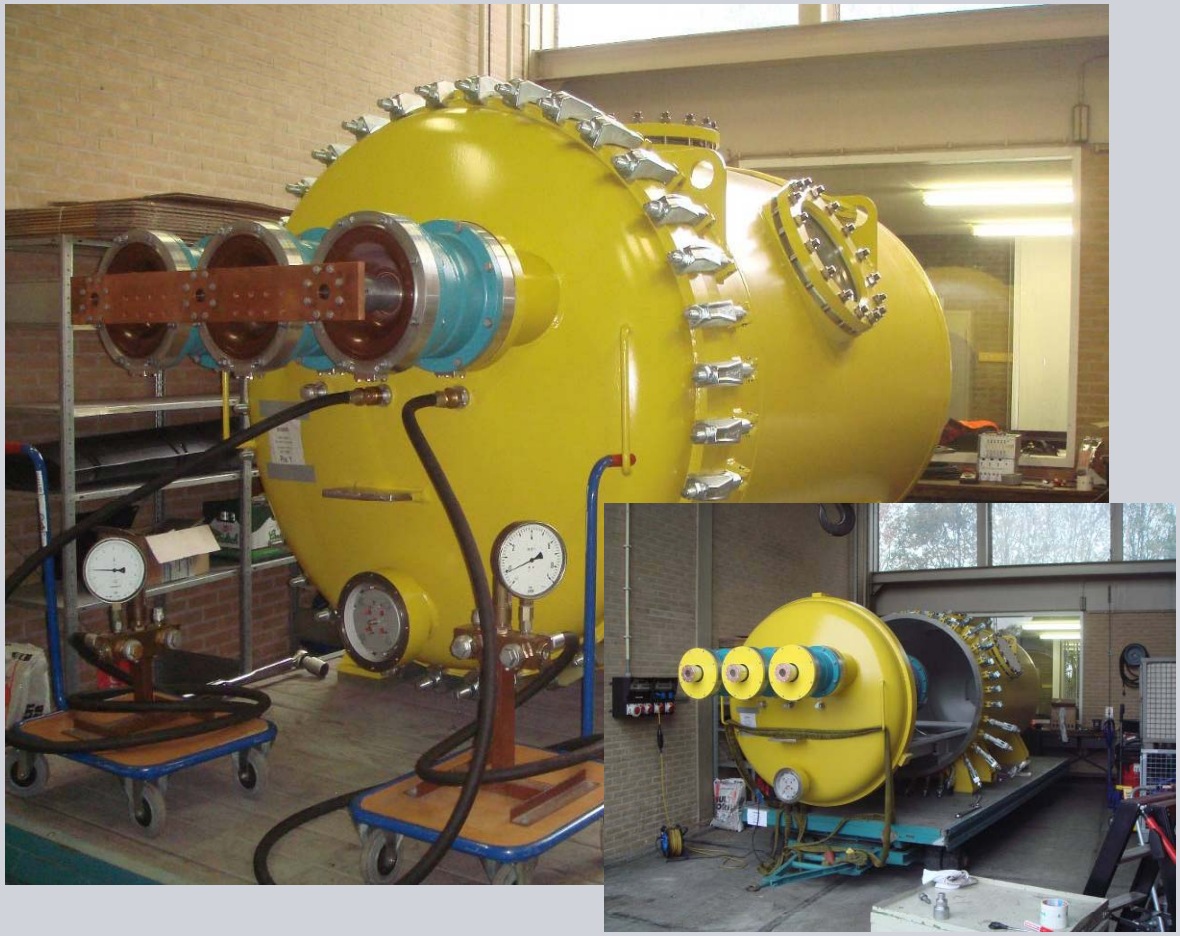
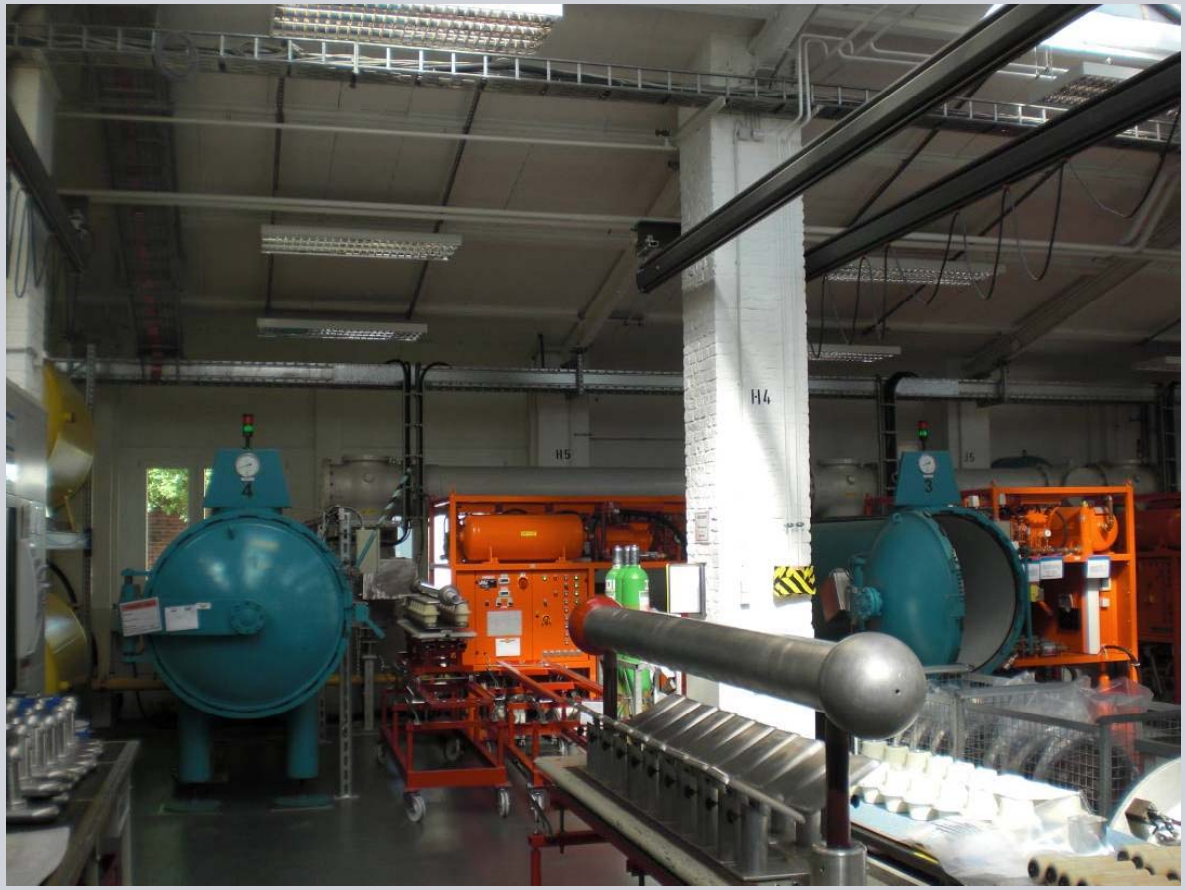


- Test object is inside test box
- Test box is equipped with inspection windows
- All connections are gastight
- Operation of rupture disc will allow SF_6 to emitt in the test box only
- SF_6 will be collected in a closed cycle after testing

Internal arc testing without SF_6-emission

Reduction of SF6-emissions in the factory

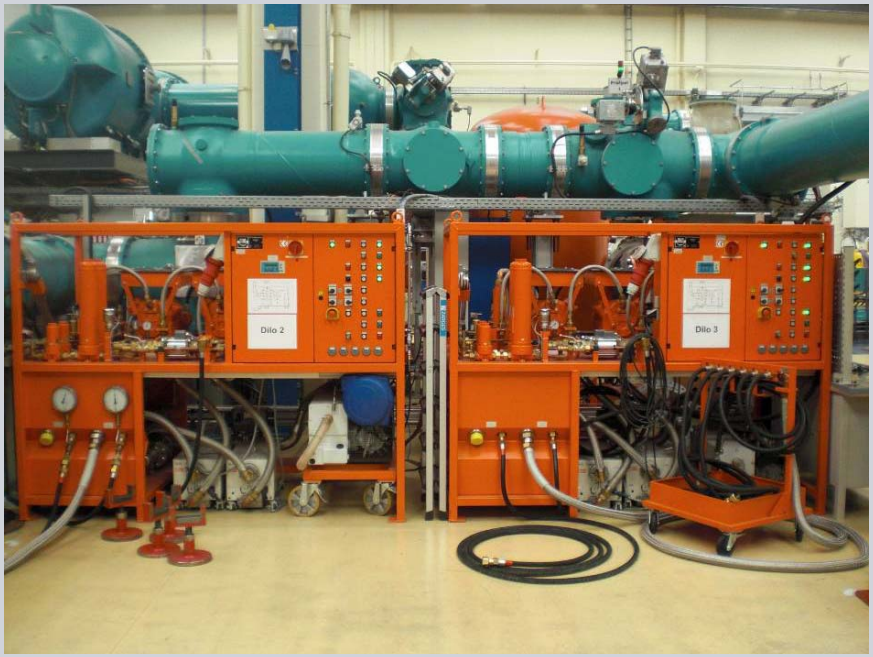


The component testing must assure very low SF_6 emission by using state-of-the-art-handling equipment in the factories

Internal tightness of components

Reduce SF_6-emissions in the factory

State-of-the-art-handling equipment …

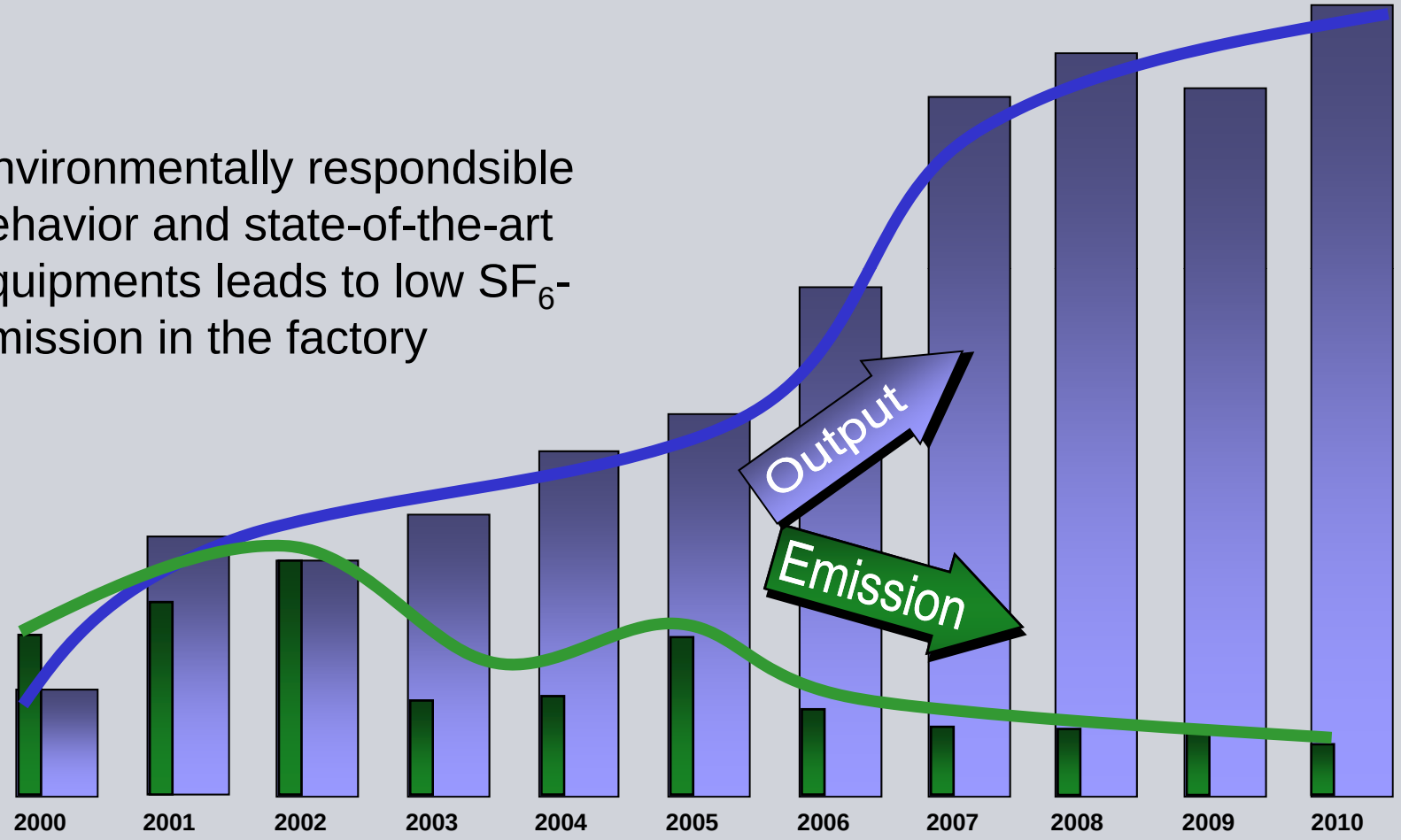


…regularly checks and trained staffs…

Achieving low SF_6 emission during production

Reduce SF_6-emissions in the factory

Environmentally respondsible behavior and state-of-the-art equipments leads to low SF_6-emission in the factory



Source: GIS Factory Berlin

Optimized gas work needs „State-of-the-Art“ equipment – especially on site

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1 mbar SF_6-maintenance unit

Source: DILO

SF_6- measurement device
%- SF_6,
dew-point temperature,
SF_6-byproducts

SF_6- collecting device
for measurement of gas

SF_6 Recollection
during measurements of gas quality

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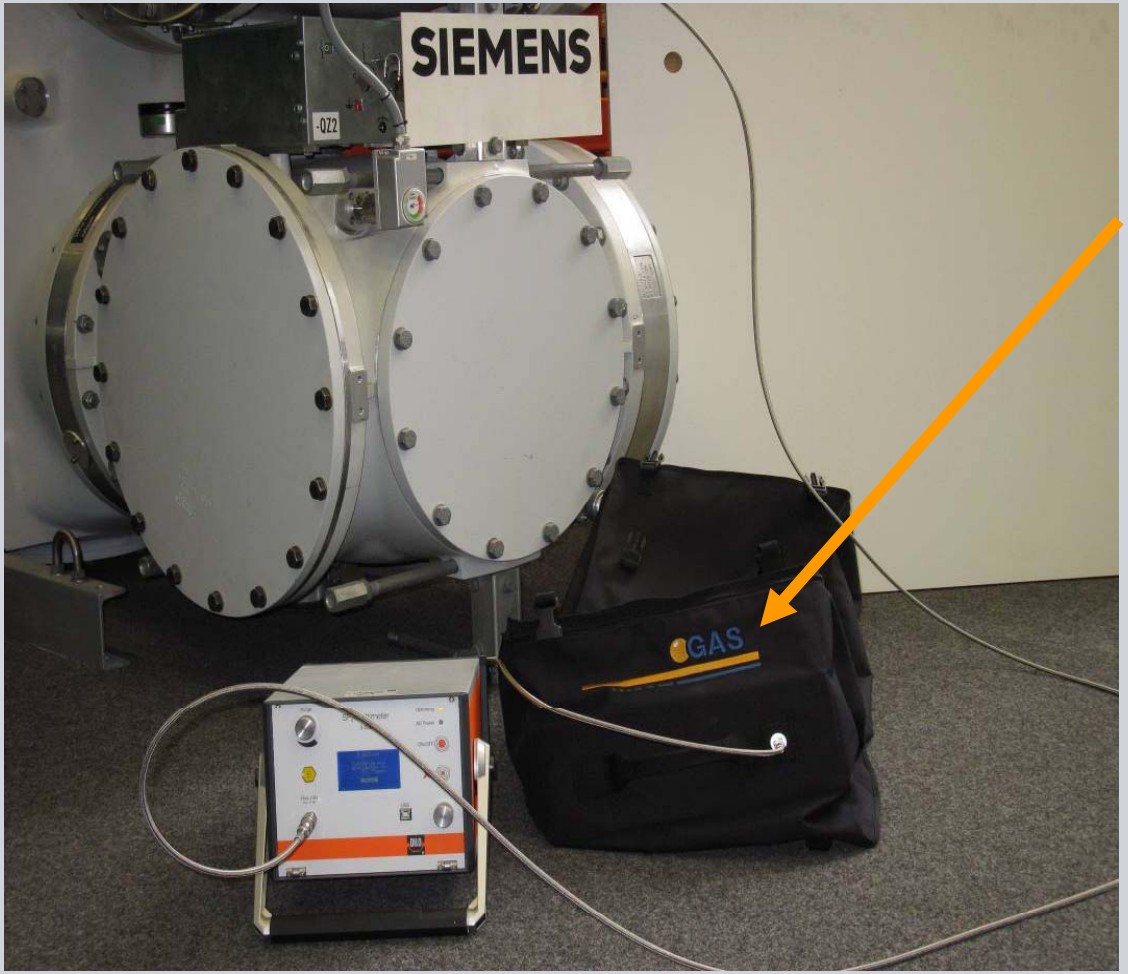


Gas flows through the instrument into recovery bag (SF_6-recollecting pipe)

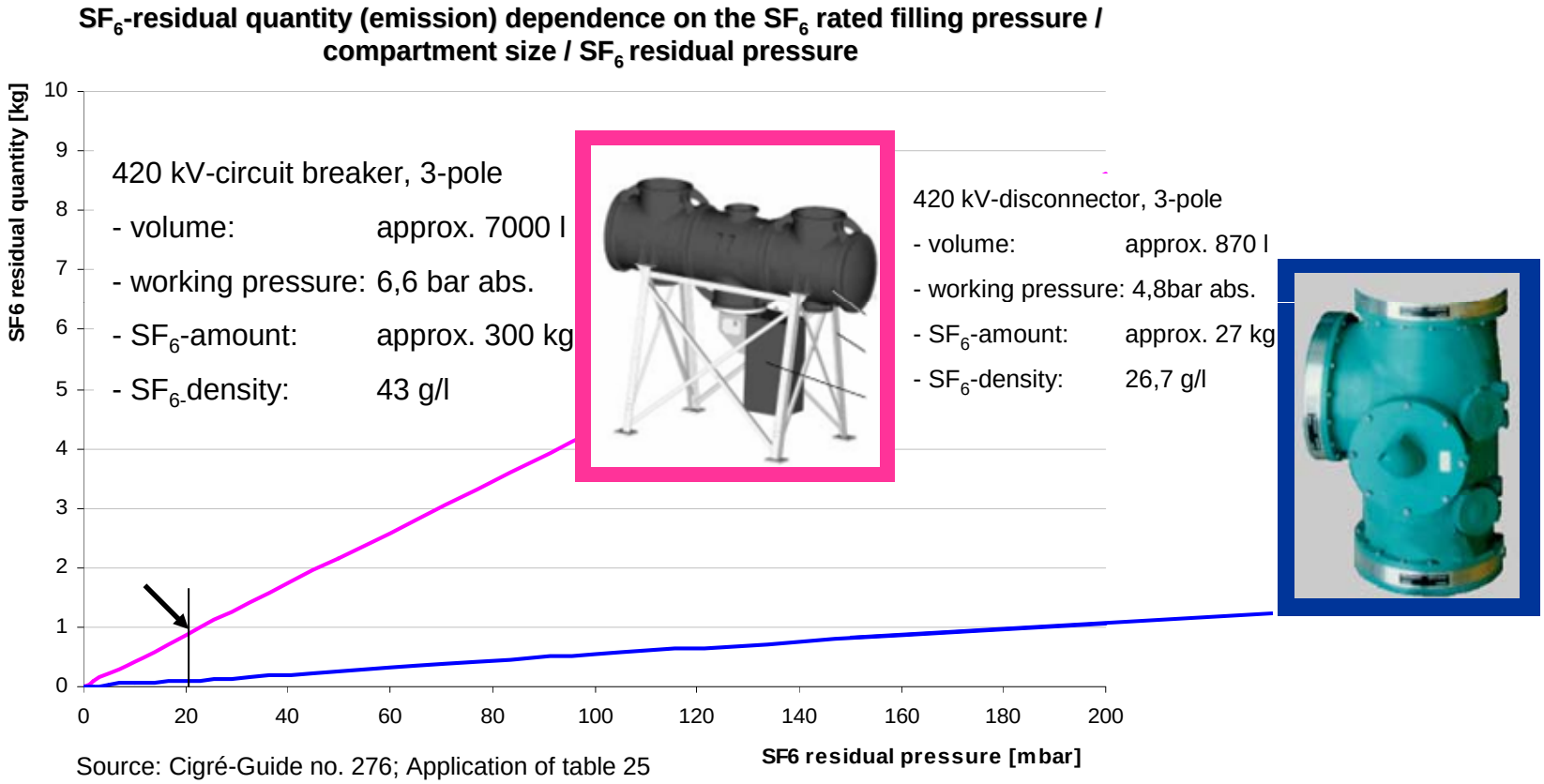
No emission!

Source: DILO, GAS-WIKA-Siemens

Handling of SF_6 on site

- Use of “strong and big” maintenance units - should be able to recover gas to a residual pressure of < 1mbar
- Minimum Residual pressure to be achieved < 20mbar - according to IEC 62271-303
- Target → below 1 mbar - nevertheless due to the design and size of gas compartments it's not always possible.

Optimized SF_6 handling



Source: Cigré-Guide no. 276; Application of table 25

With State-of-the-art-handling equipment SF_6 recovery of each gas compartment till very low pressure (1 - 20 mbar) is possible, thus securing losses of at least less than 2% during maintenance and end of life.

Gas-tightness – Functionality and environmental protection

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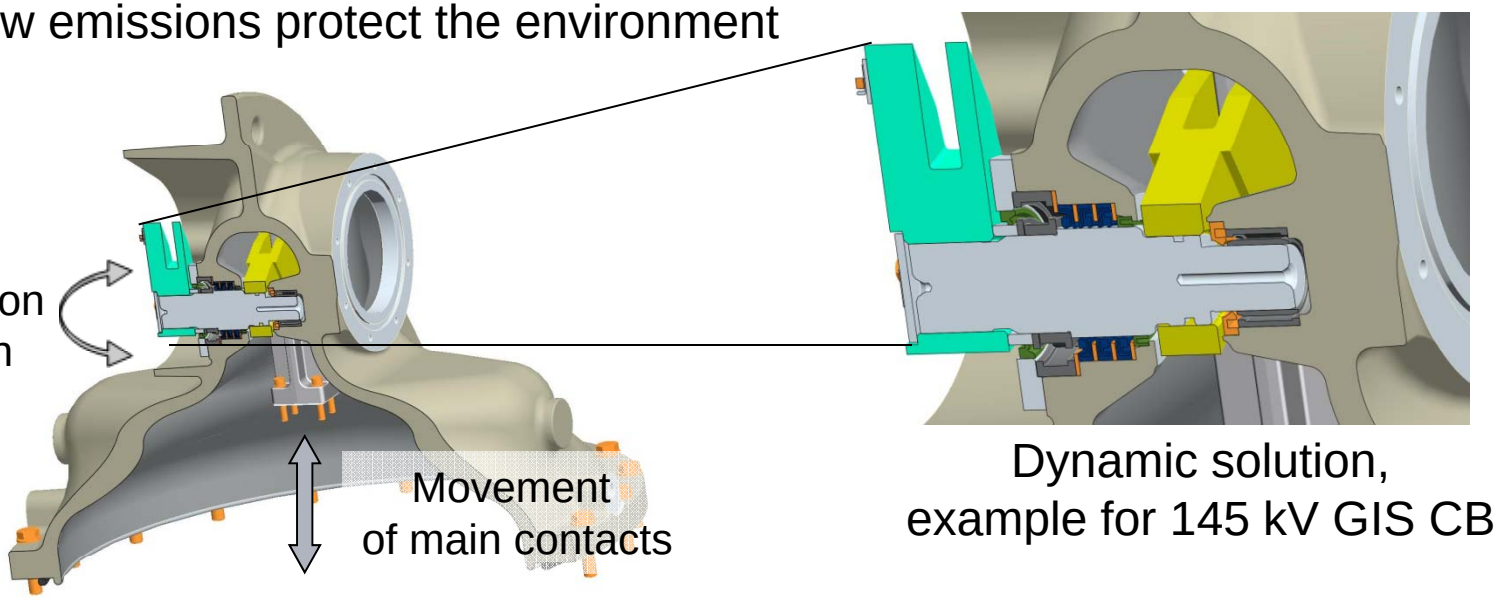
- Gas-tightness essential for the functionality ➡ static and dynamic solutions
- Design and material assure extreme low leakage rate

IEC 62271-203 High-voltage switchgear and controlgear – Part 203: Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV (09/2011)

⇨ **required leakage rate <0.5% / year / gas compartment**
state-of-the-art design <0.1% / year / gas compartment

➢ Extreme low emissions protect the environment



Dynamic solution,
example for 145 kV GIS CB

➢ Proven tightness on installed GIS for decades

Type testing on SF_6-tightness according to IEC/IEEE part of the quality assurance process

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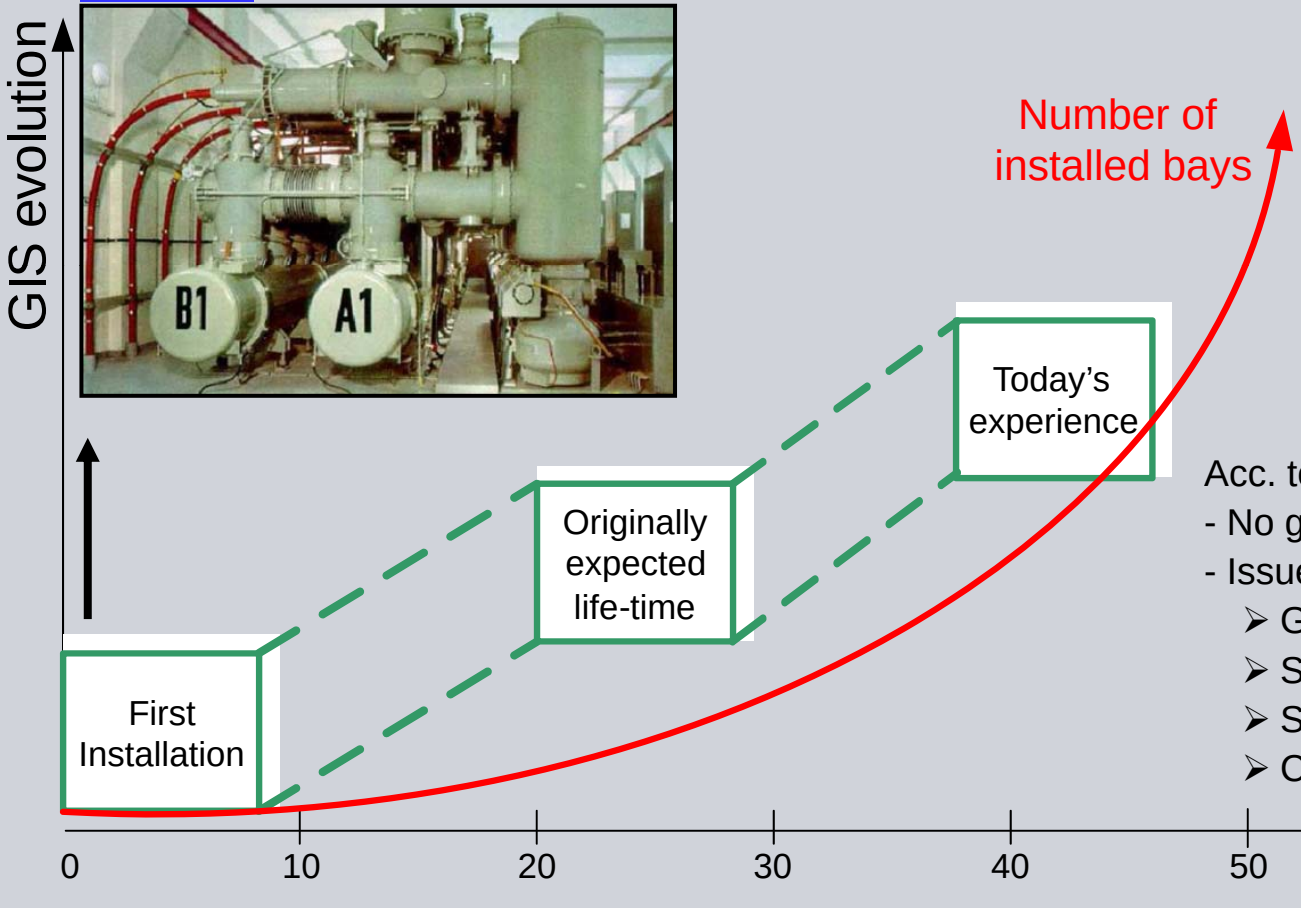
Nowadays SF_6-tightness can be confirmed (integral measuring process with state-of-the-art measurement devices) in the range of <0,01%/year/gas compartment compared with the required <0,5%/year/gas compartment in the relevant standards

Expected life-time of GIS

1968 145 kV

State-of-the-art 145 kV

2012



Acc. to CIGRÈ study
- No generic life limitation
- Issues of aging and deterioration
  - Gas leakages
  - Specific material design issues
  - Secondary systems
  - Corrosion

Continuous development assures the sustainable performance

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GIS-Concepts for low SF_6-emission

In the Past	State-of-the-art-technology
Large gas compartments	Optimized gas compartments
Short maintenance intervals (frequent opening of gas compartments)	2 openings during life time: once after 25 years of service, once during end-of-life procedure after 40-50 years.
Limited SF_6-handling instruction	Detailed explained SF_6-handling instruction and regulations
SF_6-maintenance units with a minimum SF_6-recovering pressure of 50-100 mbar	High power SF_6-maintenance units with SF_6-recovering pressure till 1 mbar
Insensitive SF_6-leakage detectors	Sensitive SF_6-leakage detectors to find smallest leaks
SF_6-measuring instruments without collecting the used gas	SF_6-measuring instruments collecting the gas are now offered
Fundamental tests and implementation of new production processes	Using Helium for leakage detection where possible (e.g. housing leakage test)

Since the implementation is a continuous improvement

SF_6 History – 2005 Implementation of the German Voluntary Commitment

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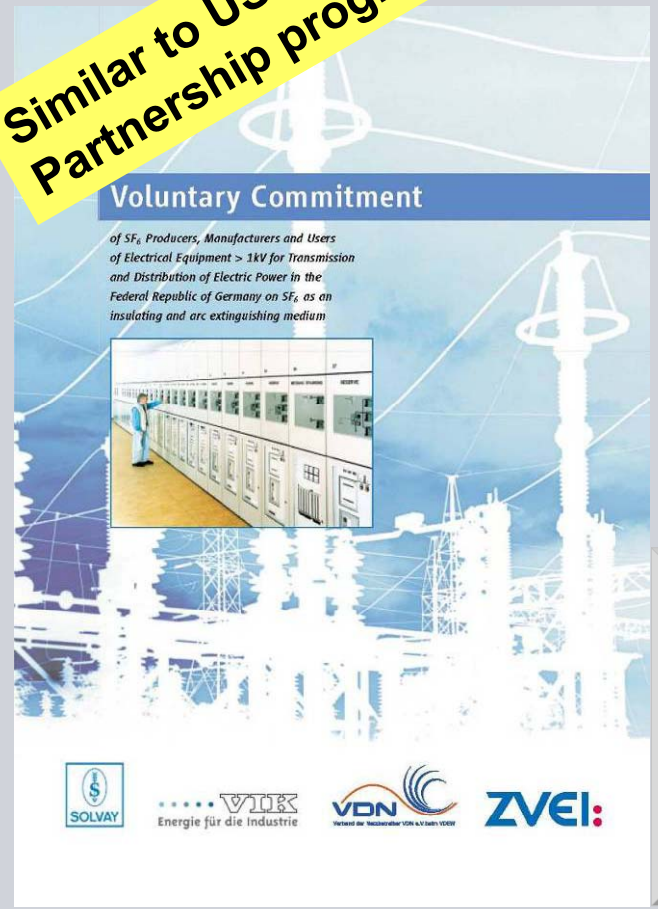
Similar to US-EPA-Partnership program



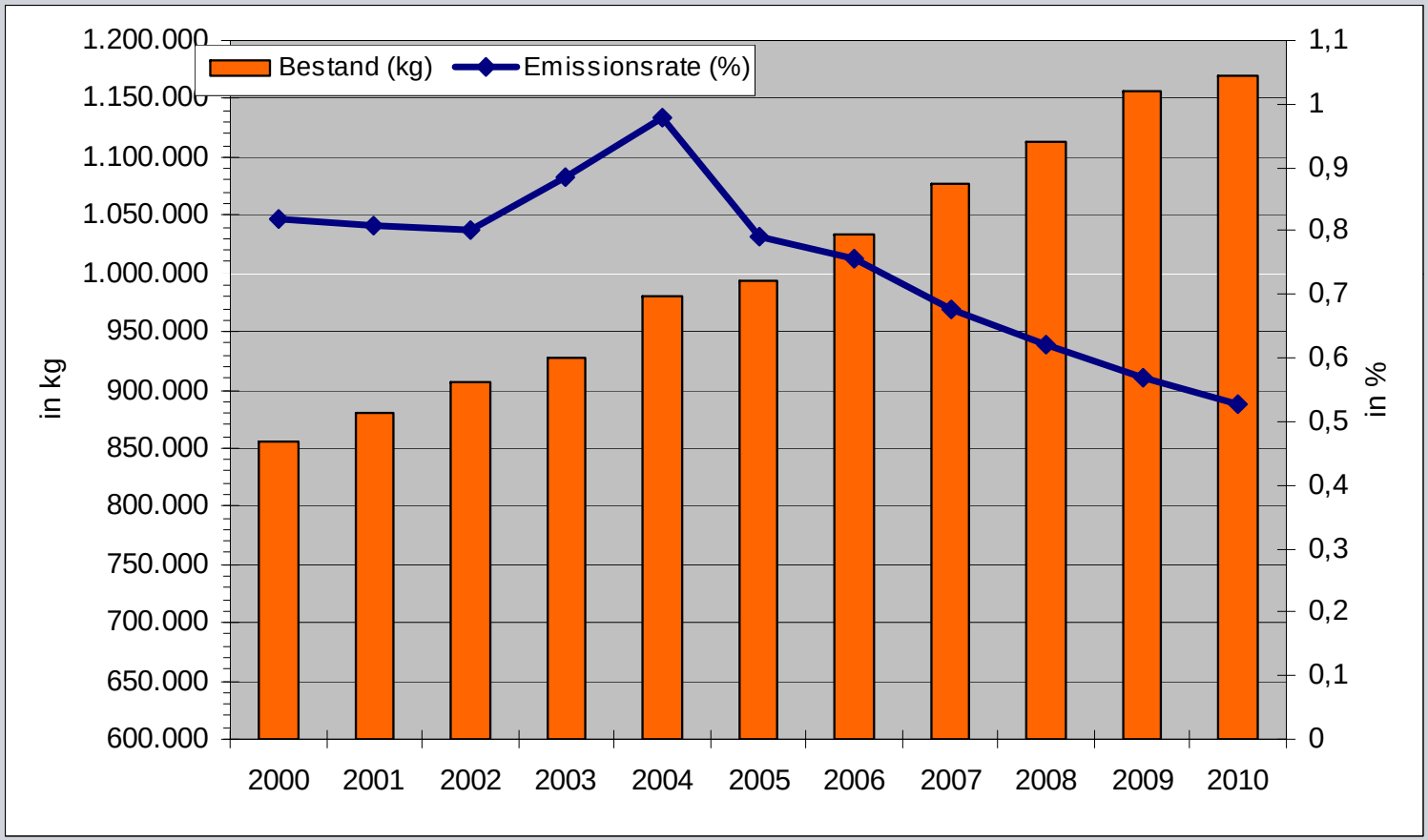
- Based on the previous voluntary commitment (1996)
- Agreed with and recognized by the German Government in 2005
- Scope: Switchgear and Components >1 kV
- Quantified and dedicated targets for 2020 by lifecycles and responsibilities
- Annual monitoring of activity data and emissions according to IPCC 2006 Guidelines for verification

Mission:

SF_6-emissions should be avoided wherever possible.

The specific quantity of SF_6 used to fulfill functions is to be minimized.

German SF_6 data bank



Source: ZVEI (Zentralverband Elektrotechnik- und Elektronikindustrie e.V.

Emission on electric power equipment 2000 - 2010

SF_6-emissions in the lifecycle process of switchgear

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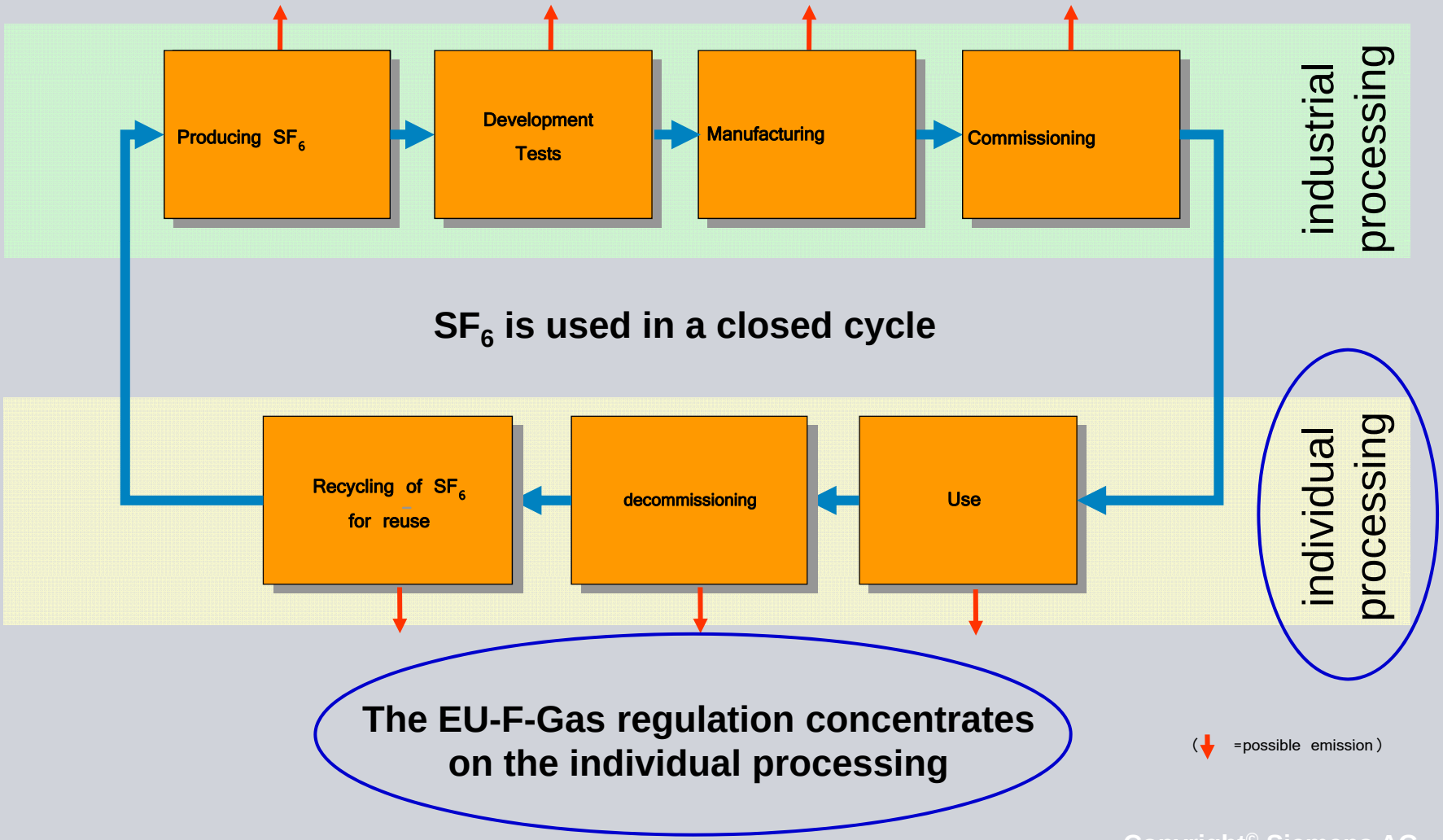

EU-F-Gas regulation 842/2006 ("a bit" like new regulation of CARB*)

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„Regulation (EC) No 842/2006 of the European Parliament and of the Council on fluorinated greenhouse gases"

SF_6 is considered in limited products only

The use of SF_6 in electric power equipment is permitted

Certain measures to be carried out by manufacturers and users have been implemented

Amendments have been released to describe measures more in detail

*California Air Resources Board

European F-Gas-regulation 842/2006 - Main articles for SF_6 electric equipment

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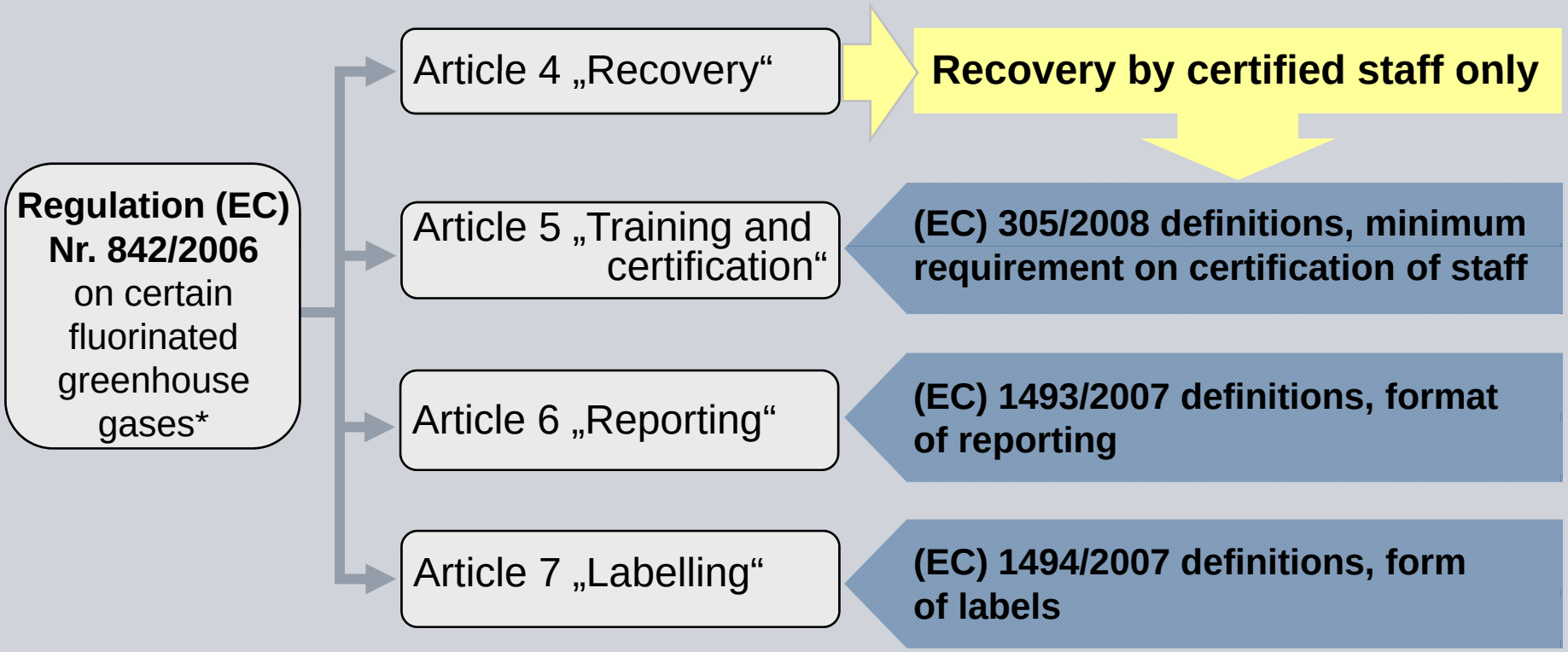

***) “certain fluorinated greenhouse gases” means hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6)**

European F-Gas-regulation 842/2006, article 2 „Definitions“

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Definitions for SF_6-handling

- **Recovery**

  Collection and storage of SF_6 from electric power equipment or containers
  → ***in practice: taking out SF_6 from equipment and putting it into a container***

- **Recycling**

  Reuse of recovered SF_6 following a basic cleaning process
  → ***in practice: recycling of SF_6 on site***

- **Reclamation**

  Reprocessing of recovered SF_6 in order to meet a specific standard* of performance
  → ***in practice: used SF_6 is reprocessed (e.g. SF_6-production plant)***

- **Destruction**

  Transformation or destruction into one or more stable substances which are not fluorinated GHG
  → ***in practice: burning of SF_6***

***) - IEC 60376 “Specification of technical grade sulfur hexafluoride (SF_6) for use in electrical equipment”**
- IEC 60480 “Guidelines for the checking and treatment of sulfur hexafluoride (SF_6) taken from electrical equipment and specification for its re-use”

European F-Gas-regulation 842/2006, article 5 „Training and certification“ together with regulation 305/2008*

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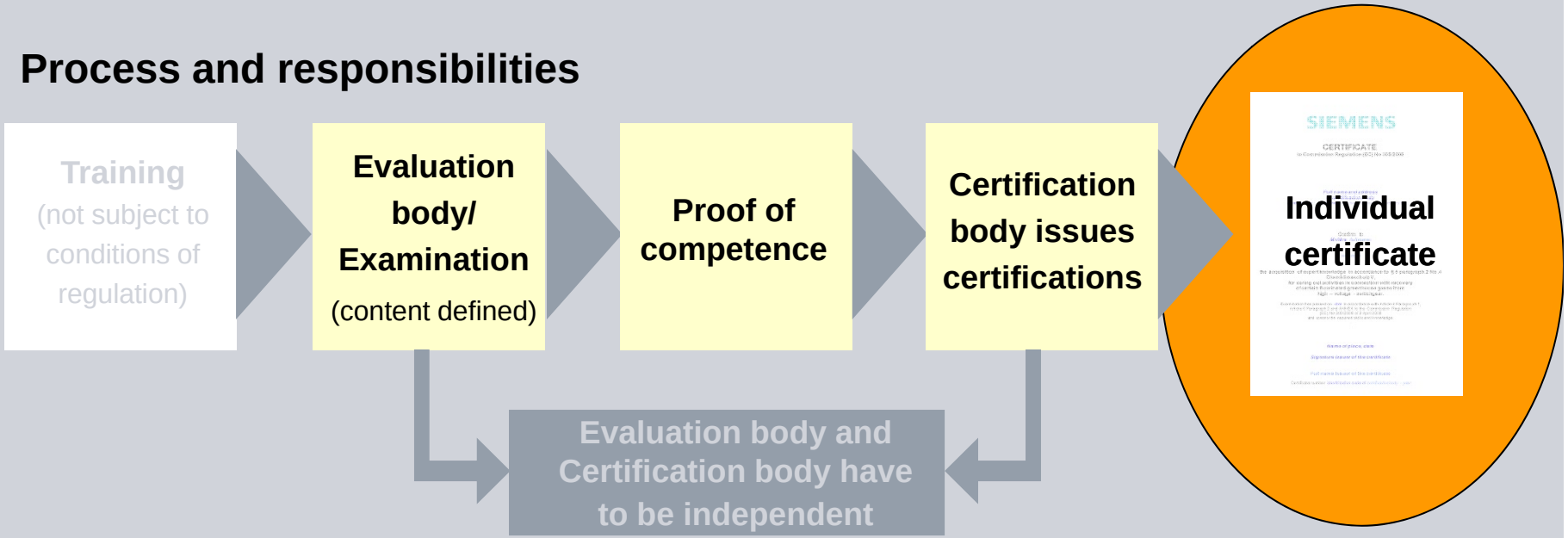
„Commission regulation No. 305/2008 establishing minimum requirements and the conditions for mutual recognition for the certification of personnel recovering certain fluorinated GHG from HV switchgear“

Process and responsibilities



*) regulation refers to HV switchgear only

European F-Gas-regulation 842/2006, article 6 „Reporting“ together with regulation 1493/2007

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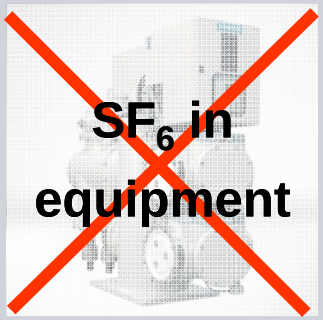
The reporting is a must to do in case of…

The reporting is not necessary for…



In some countries additional voluntary commitments regarding reporting exist

European F-Gas-regulation 842/2006, article 7 „Labelling“ together with regulation 1494/2007

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Standards required SF_6-weight already in the past: declaration of *„weight of gas”* according to IEEE C37.122 or IEC 62271-203

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Year of manufacture / No.		2006 / K 31251030
Type		8DN8
Rated voltage		145 kV
Rated impulse withstand voltage		650 kV
Rated power–frequency withstand voltage		275 kV
Rated frequency		50 Hz
Rated normal current	Busbar	2500 A
	Bus Coupler	2500 A
Rated short-time withstand current		40 kA
Rated duration of short-circuit		3 s
Circuit-breaker	Rated short-circuit breaking current	40 kA
	First – pole – to – clear factor	1,5
	Rated operating duty	O-0,3s-CO-3min-CO
	Rated out of phase breaking current	10 kA
SF_6 – pressures see inside		
Weight of SF_6 – filling		99 kg
Weight with SF_6 – filling		3,1 t
Ambient air temperature		-5…+50 °C
Standards: IEC-Publ.62271-100, 62271-102, 62271-203		
MADE IN GERMANY		

NEW additional label*

The label shall be placed clearly, indelibly and adjacent to the service point of the equipment

*) Content defined in the regulation but the form can vary between the different manufactures

Review EU F-Gas-regulation in progress

- **Review required 5 years after implementation (7/06→7/11)**
- **Report of the commission published on September 26, 2011**
  - → includes 26 substances, one is SF_6
  - → positive results regarding our electrical power applications
  - → strong reduction of F-gas-emission demanded in general
- **No modification for electrical power equipment, very small adjustments**
  - → mainly reporting, no restriction on SF_6-electrical power equipment
- **Other branches/ substances strongly affected**
- **Draft of modified EU-F-Gas-regulation**
  - → will be available autumn 2012 (planned by EU-commission)
- **Final decision by the EU Parliament**
  - → Scheduled until beginning of 2014

Link: http://ec.europa.eu/clima/policies/f-gas/index_en.htm

Cigré publications on SF_6

SF_6 RECYCLING GUIDE

No. 234

2003

SF_6 HANDLING GUIDE

No. 276

2005

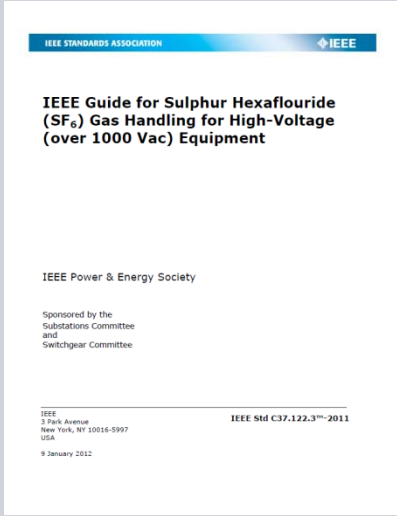
SF_6 TIGHTNESS GUIDE

No. 430

2010

Assure long term use of SF_6

Avoid SF_6 handling losses due to state-of-the-art handling


IEEE STANDARDS ASSOCIATION

IEEE Guide for Sulphur Hexaflouride (SF_6) Gas Handling for High-Voltage (over 1000 Vac) Equipment

IEEE Power & Energy Society

Sponsored by the Substations Committee and Switchgear Committee

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

9 January 2012

IEEE Std C37.122.3™-2011

2012

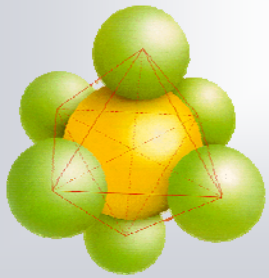
Guarantee of SF_6 tightness due to state-of-the-art equipment and testing

Cigré SC B3 delivers and bundles all technical and environmentally aspects on SF_6

Current CIGRÉ activities on SF_6

- WG B3.17 “Residual life concepts applied to HV GIS“ (Finished, will be published in 6/2012)
- WG B3.25 “SF_6 analysis for AIS[1]/GIS and MTS[2] Condition Assessment”
- WG B3.30 “Guide to minimize the use of SF_6 during routine testing”

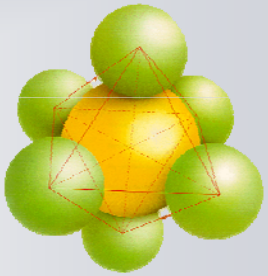
[1] Air Insulated Switchgear
[2] Mixed Technology Switchgear



Brochures can be downloaded on http://www.e-cigre.org/

Standards

- IEC 62271-1 Common specifications for SF_6-insulated and air-insulated high-voltage switchgear and controlgear
- IEC 62271-200 Standard of medium-voltage SF_6-GIS
- IEC 62271-203 High-voltage switchgear and controlgear >52 kV Revision published in 9/2011
- IEC 62271-303[1] Use and handling of SF_6
- IEC 60376[2] Specification for new SF_6-gas
- IEC 60480[2] Checking and treatment of sulfur hexafluoride (SF_6) taken from electric equipment
- IEEE C37.122 Gas Insulated Substations
- IEEE C37.122 IEEE Guide for Sulphur Hexaflouride
- ASTM D2472-00 SF_6-gas



[1] Revision in progress: IEC 62271-4

[2] Maintenance of the standard scheduled until 2014.

Target: 1 standard only, SF_6-Gas mixtures to be included, recommendation on monitoring

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Conclusion

- Implementation of adequate maintenance strategy for aged equipment
- Evaluation of each SF_6-leakage for systematical or individual failure
- Gas tight equipment and low SF_6-emission reduce life-cycle costs
- Residual Life of equipment goes in line with low SF_6-emission
- For end-of-life procedures, SF_6 has to be kept in a closed cycle

Thank you for your attention!

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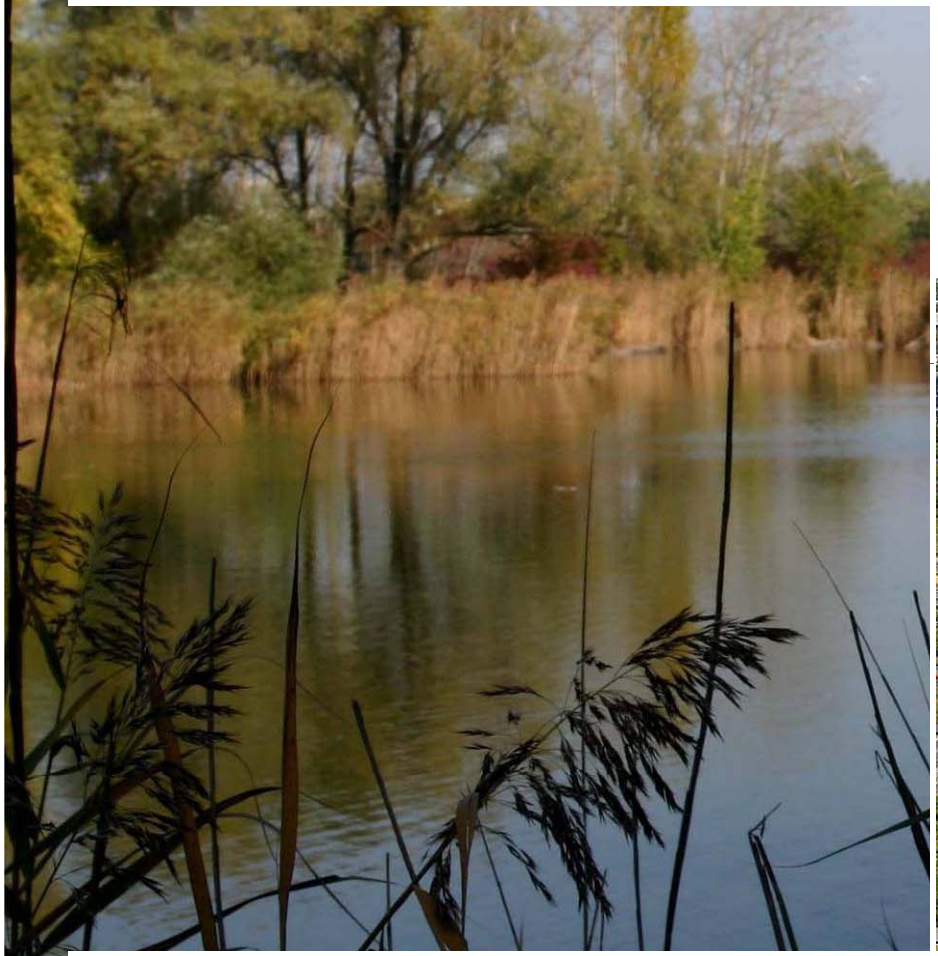

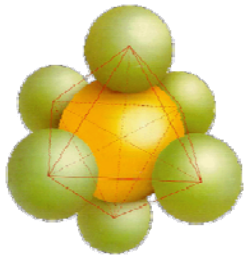

Dr. Christian Wallner
Tel. +49 9131 7 33811
eMail christian.wallner@siemens.com

Peter Glaubitz
Tel. +49 9131 7 35010
eMail peter.glaubitz@siemens.com