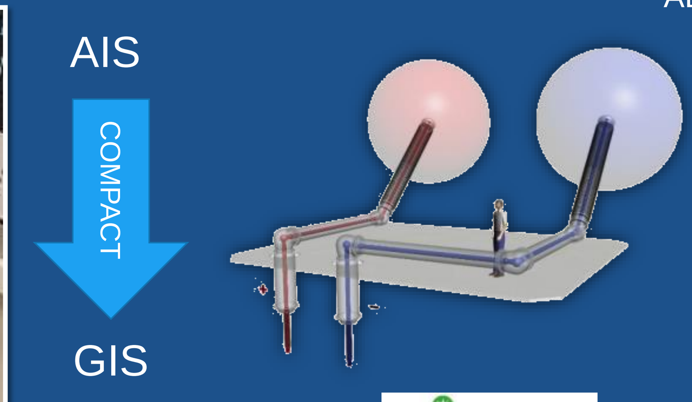
PROMOTioN

PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS

WP15 - HVDC GIS Technology Demonstrator

Key conclusions and Team

- Technology Readiness Level (TRL) is increased from 6 to 8 for HVDC GIS equipment.
- Recommendations for specifying gas-insulated (GIS) HVDC systems were developed.
- Testing requirements, procedures and methods were developed based on simulation analysis, real HVDC onshore and offshore experiences, and also based on CIGRE work.
- Monitoring and diagnostic methods for HVDC GIS were developed to ensure a safe operation.
- Monitoring methods are evaluated for SF6 alternatives.
- Long term testing of full power HVDC GIS were carried out according to developed test requirements and procedures and using developed monitoring and diagnostic methods.
- Results were used to improve models and develop understanding of failure modes.



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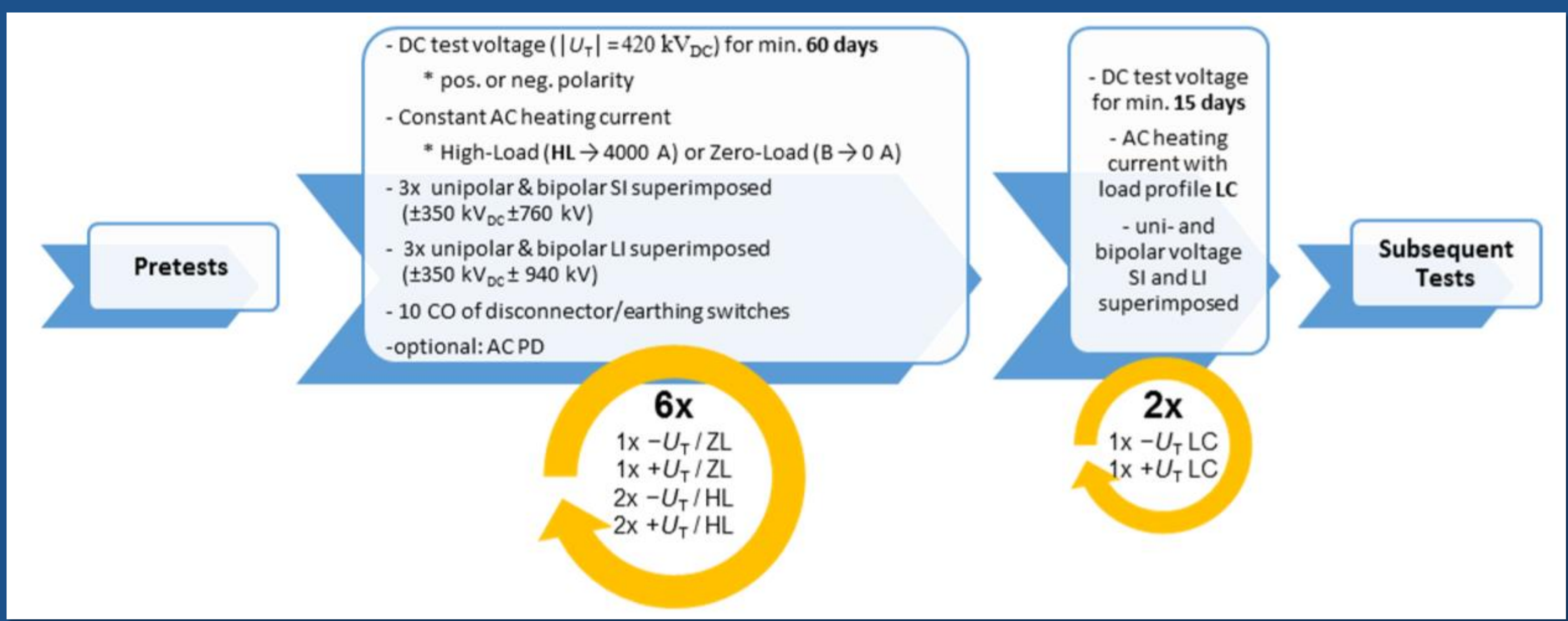
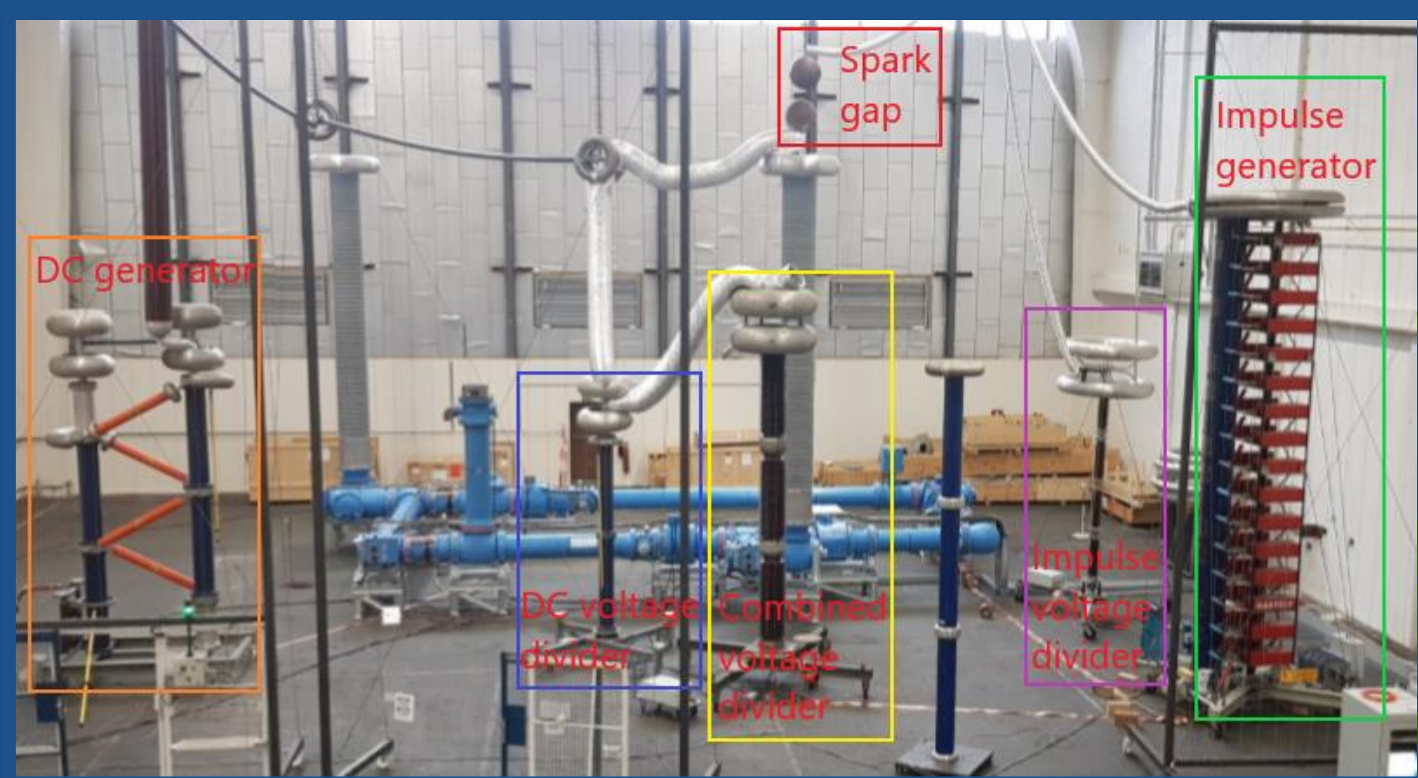
TU Delft
TenneT
SHE Transmission

Test Specification and Test Circuit

The long-term (> 1 year) performance test of the HVDC GIS includes Pretests, Prototype installation test, and Subsequent Tests. The prototype installation test covers three types of load conditions for each DC voltage polarity. After each test block, the superimposed impulse voltage test is required, and each connector/earthing switch subjects to 10 x mechanical Close/Open operation. A spark gap circuit is applied to realize the superimposed impulse voltage test.

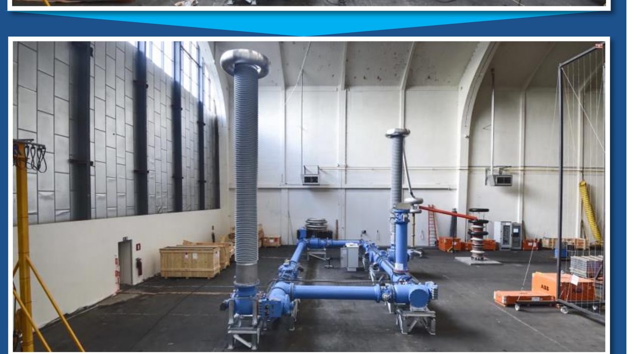


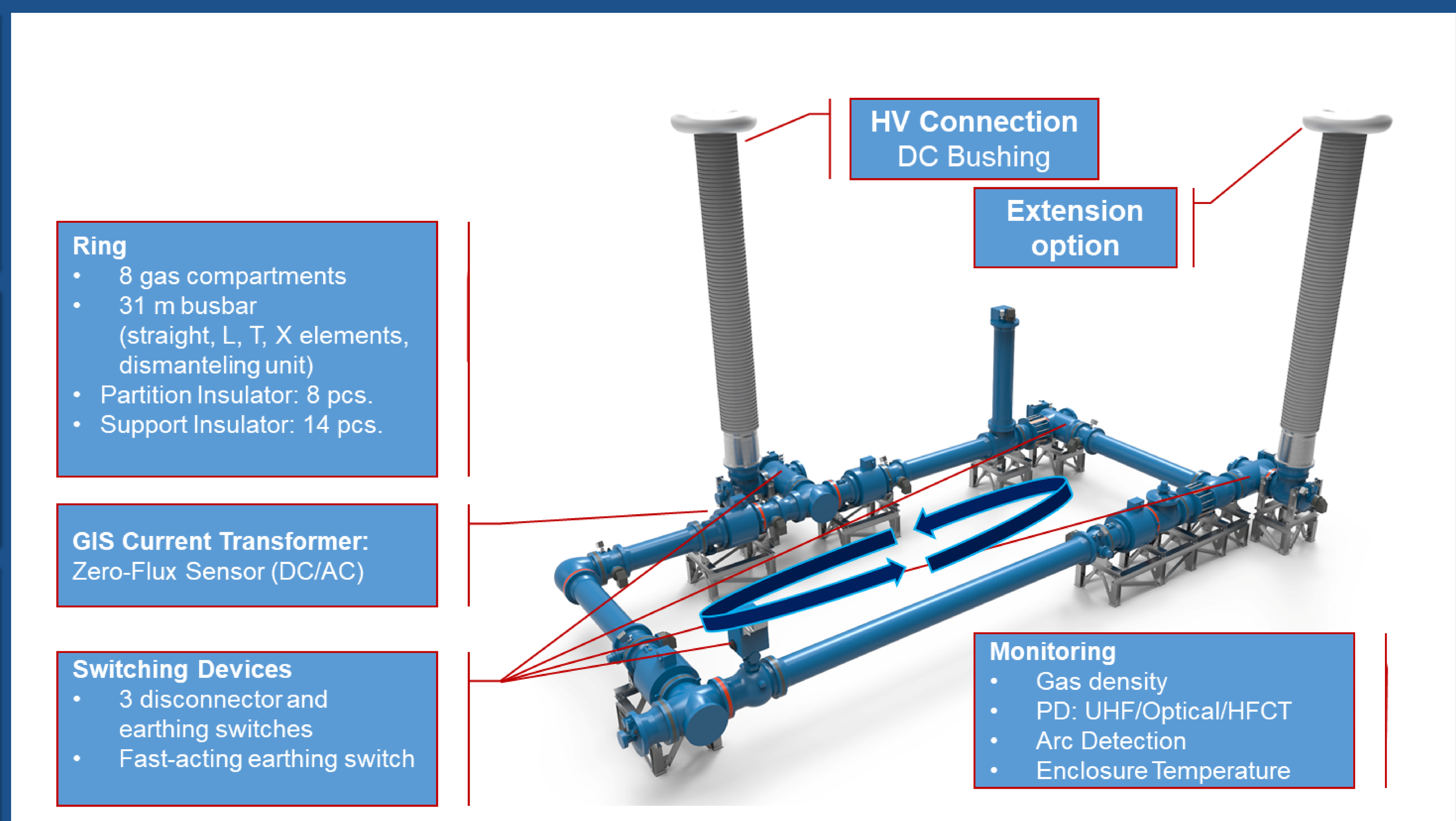


HVDC GIS

The test object is a 320 kV HVDC GIS, which was installed in 2018 at KEMA Labs, Arnhem, The Netherlands. To account for a realistic test setup, the test pole includes key components for HVDC Hub, such as more than 30 m of busduct, disconnector and earthing switches, DC current transformer, and various monitoring systems. All solid insulation systems are included and will be subjected to in-service stresses.

Nominal DC voltage U_n	± 320	kV_{dc}
Rated DC voltage U_r	± 350	kV_{dc}
Rated superimposed LI withstand voltage U_P / U_r		
Lightning impulse voltage	± 1050	kV
DC voltage	± 350	kV_{dc}
Rated superimposed SI withstand voltage U_S / U_r		
Switching impulse voltage	± 950	kV
DC voltage	± 350	kV_{dc}
Rated DC withstand voltage to earth U_w	± 610	kV_{dc}
Rated normal current I_r	4000	A_{dc}





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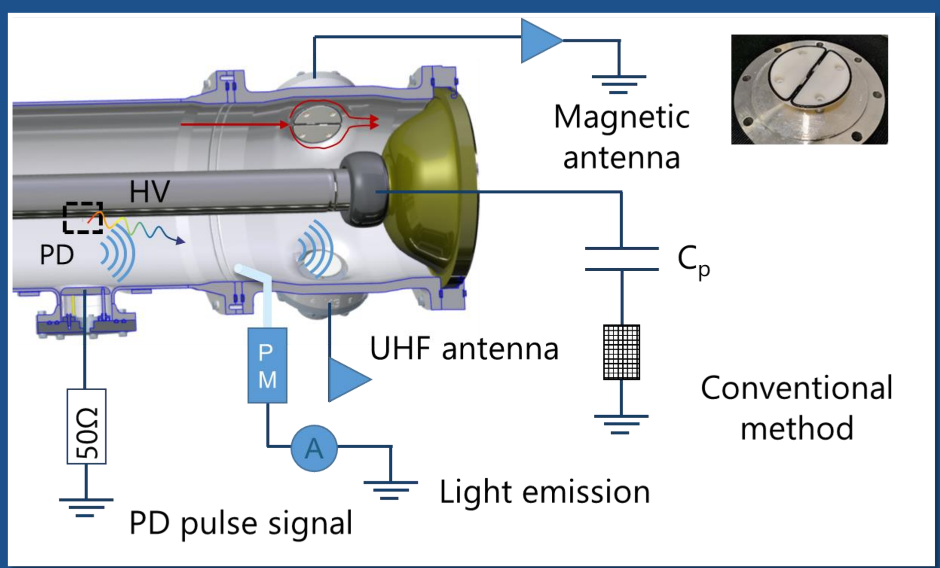
WP15 - HVDC GIS Technology Demonstrator

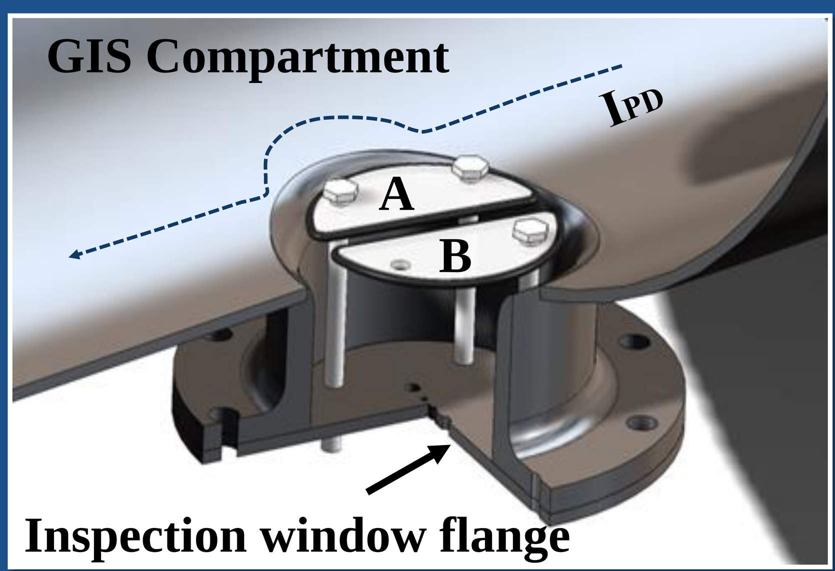
Partial Discharge Monitoring and Diagnostics

PROMOTioN WP15 is researching alternatives for PD monitoring and Diagnostics.

VHF/UHF have been the preferred conventional PD methods for GIS due to high noise immunity. Although their spatial sensitivity may be limited.



An experimental approach currently being researched by TU Delft is a magnetic-type sensor working around the HF range.



Magnetic-loop sensor A= magnetic loop 1
B= magnetic loop 2

Two single loops are inserted in the GIS inspection window. The PD current flowing along the GIS compartment induces a signal in each loop making it possible the detection of PD signals.

The detection is in the low frequency range where the PD signals are less attenuated. This favors the spatial sensitivity.

The two loops are independent and in a mirror-like disposition. Thus, the polarity of the picked-up signal is used to separate PD signals from noise.

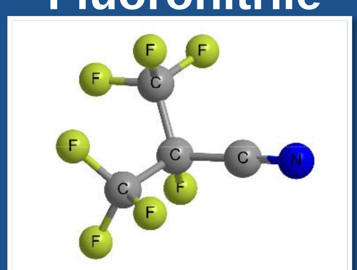
Charge estimation might be feasible.

However, the signal processing and hardware requirements may be higher than for conventional UHF methods. Thus, the magnetic detection is suitable for critical offshore installations.

Applicability of SF_6 Alternatives

SF_6 presents a very high Global Warming Potential (GWP) and should be replaced by new gases in the optic of eco-friendly HVDC GIS.

Fluoronitrile **Fluoroketone**



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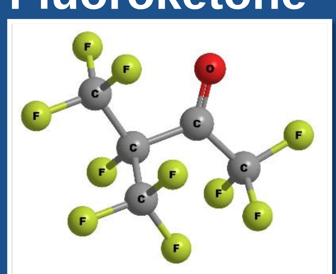

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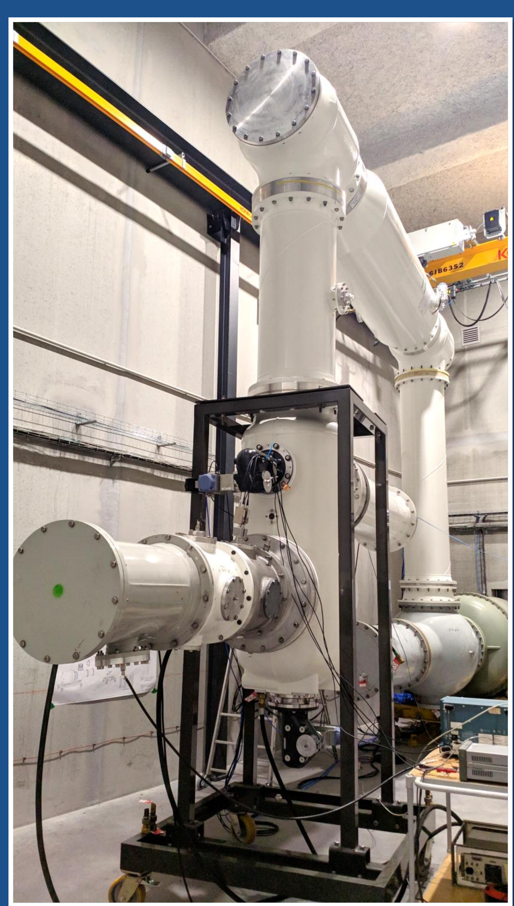
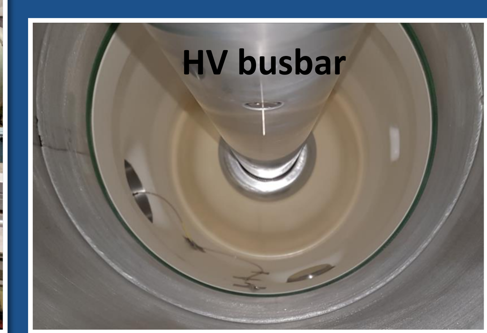
Buffer gases (CO_2 or air)

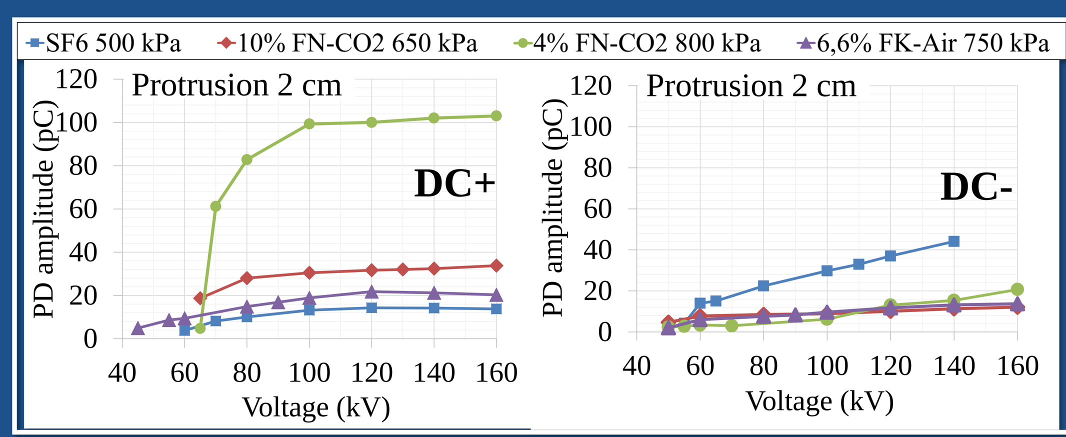
As these gases might replace SF_6 in HVDC GIS their PD behavior should be compared to the one of SF_6. Moreover the applicability of different measuring systems with these mixtures should be investigated.



Short term and long term PD behavior are analyzed under DC voltage in real scale GIS with two types of defects:

- Protrusion (1-2 cm) on HV busbar
- Metallic particle (1 cm) on solid insulator surface





Although some differences have been evidenced, the PD behavior of alternative gases is comparable to that of SF_6.

Different PD monitoring systems have been used and they are sensitive enough to detect PD above 3 pC.

On DC GIS the replacement of SF_6 by SF_6 alternatives is not an obstacle for an effective PD monitoring system.

Dissemination

Deliverables
D15.1 Recommendations for Specifying DC GIS Systems, 2019
D15.2 Document on test requirements, procedures and methods, 2019
D15.3 Report on DC GIS diagnostic and monitoring tools and methods, 2019
D15.4 Test report of prototype installation test on HVDC GIS, 2020
D15.5 Report on diagnostic analysis and condition assessment, 2020
D15.7 Report on PD characteristics of SF6 alternative gases: comparison with SF6, 2020.
D15.6 White- and position papers on pre-standardization of DC GIS testing, 2020
D15.8 Report on long term monitoring of DC GIS with defects, 2020

14 publications (conferences, journals)

Public demonstration HVDC GIS in Arnhem, Feb. 2020

Active participation in pre-standardization:

CIGRE JWG B1/B3/D1.79: new working group created "Recommendations for dielectric testing of HVDC gas insulated system cable sealing ends."
CIGRE JWG D1/B3.57: "Dielectric Testing of gas-insulated HVDC Systems"
CIGRE WG D1.63: "Partial Discharge Detection under DC voltage stress"
CIGRE WG D1.67: "Dielectric performance of new non-SF_6 gases and gas mixtures for gas-insulated systems"
Active participation in IEC standardization activities in IEC TC 17/17C and TC 99:
IEC TC 17 WG 6 Common specifications for DC switchgear
IEC TC 17C WG 42 DC gas-insulated switchgear assemblies

8 Deliverables
14 Publications
3 Demonstrations
4 Workshops

All deliverables and publications
https://www.promotion-offshore.net/

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For enabling a stronger, smarter and greener grid.

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