Study Committee B3

Substations and Electrical Installations

Paper ID_11077

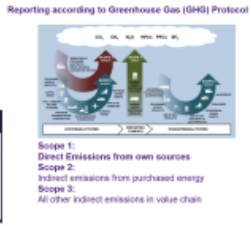
Test, Installation and Operational Experiences of World's First Substation Integrating Digital, Intelligent and Greenhouse-Gas Free T&D equipment

Dirk HELBIG[1], Marcel ENGEL[2], Matthias HEINECKE[1], Mark KUSCHEL[1], Peter MENKE[1], Fred OECHSLE[2], Richard SCHULZ[1], Puneet SINGH[1]

[1]Siemens Energy, [2]Netze BW, Germany

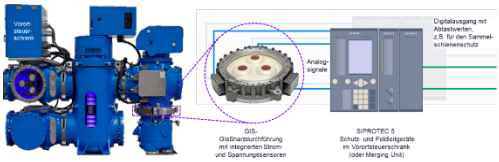
Motivation – The Need for a Next Sustainable Substation Generation

- Power grid operators globally are committed to the UN global sustainability goals, report according the GHG protocol and take actions to become carbon neutral.



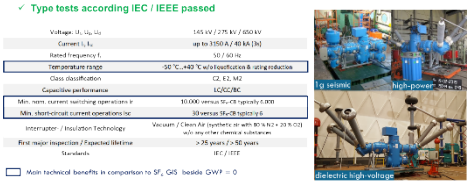
Action – Decarbonized and Digitalized Substations

- Decarbonization: as one important contribution, SF_6 in new switchgear (Direct emissions: Scope 1) must be substituted by a GHG-free gas
- Digitalization: Grids of the future need to handle fluctuating power: Digitalization is a key to handle this



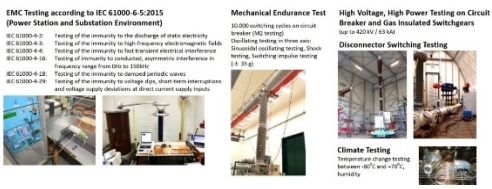
Tests and performance of GHG-free products

- Superior test results of GHG-free GIS compared to gas-breaker technologies; -50°C operating temperature, 10.000 min. nom. current switching operations, 30 min. short-circuit current operations



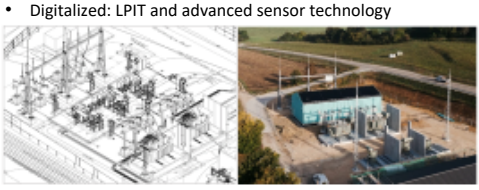
Test and performance of digitalized components and products

- All Sensors and components of digitalization were tested
- Severe EMC, mechanical endurance, high voltage, high power and climate tests were passed



Substation of the Future in Germany

- Layout and Construction site of the new 110/20 kV substation in Burladingen, Germany
- Decarbonized: SF_6 substituted by GHG-free clean air insulation technology and vacuum interrupters
- Digitalized: LPIT and advanced sensor technology



Eco-efficient and digitalized: GHG-free GIS including LPITs and advanced sensors during installation

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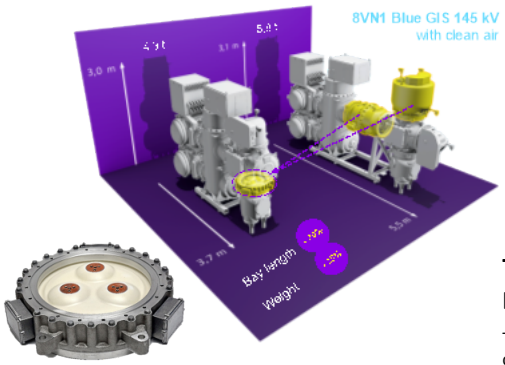
Digitalization: Low-Power Instrument Transformers (LPIT)

Photo of the 145 kV GIS partition with integrated LPIT Sensors (left) and schematic overview about the 145 kV synthetic air GIS space and weight savings by the LPIT.



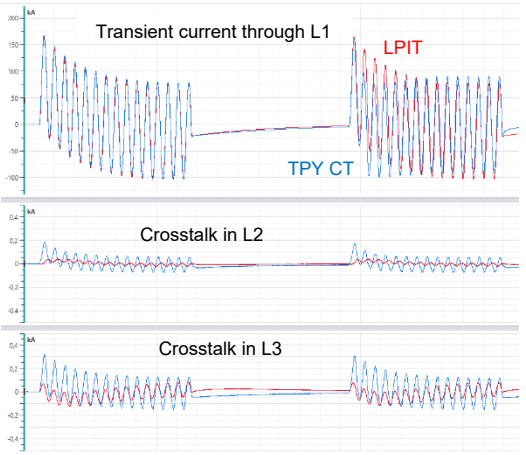
Test procedure of Low Power Instrument Transformers

Some of these tests plus some special test were done jointly in October 2021 at the Switchgear Factory Test Laboratories in Berlin.

IEC Product family standards		Standard	Products
61869-1 General requirements for instrument transformers	61869-6 Additional general requirement for electronic instrument transformers and low power stand alone sensors	61869-2	Additional requirements for current transformers
		61869-3	Additional requirements for inductive voltage transformers
		61869-4	Additional requirements for combined transformers
		61869-5	Additional requirements for capacitive voltage transformers
		61869-7	Additional requirements for electronic voltage transformers
		61869-8	Additional requirements for electronic current transformers
		61869-9	Digital interface for instrument transformers
		61869-10	Additional requirements for low power stand alone current sensors
		61869-11	Additional requirements for low power stand alone voltage sensors
		61869-12	Additional requirements for combined electronic instrument transformer or combined stand alone sensors
		61869-13	Stand alone merging unit

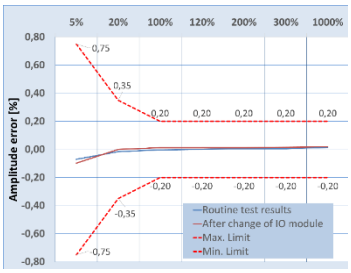
Test results – Example LPCT Transient performance

Transient Performance Test of a TPY CT and LPIT after calibration and routine test (I_k''=63 kA, i_p=170 kA)



Test results – Basic accuracy

Basic accuracy test results of the LPCT (Class 0,2) during routine tests and after a change of the IO Module



Conclusion

- The type tests carried out according to IEC 61869 were successfully passed.
- The tests according to the standard were supplemented by further tests in which the GIS LPIT was able to demonstrate its robustness and practical suitability. These included disconnector switching, a functional test of the distance protection and crosstalk in the event of a short circuit.
- Accuracy class was maintained after replacing connection box, cables, IO module and Merging units.

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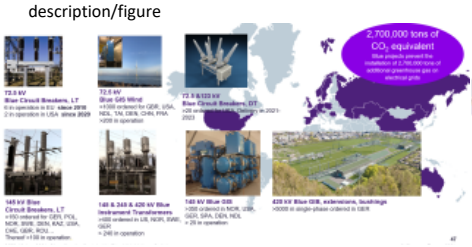
Decarbonization: GHG-free and T&D equipment

- Power grid operators globally take actions installing GHG-free power products
- >1900 units contracted; >700 units in operation
- 2,700,000 tons of CO_2e not produced and installed description/figure

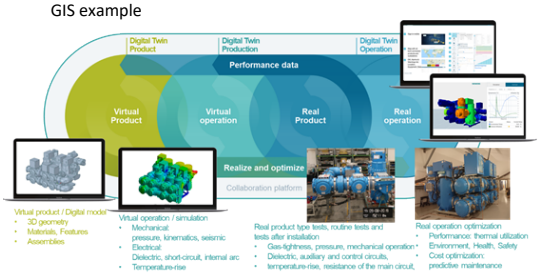


Decarbonization and Digitalization

- Digitally connected products merge reliable hardware and sensors with cloud connectivity, digital twins, and apps with artificial intelligence.
- The benefits are performance increase, health, safety and environment and cost and risk reduction for the benefit of grid operation, asset management, service and maintenance

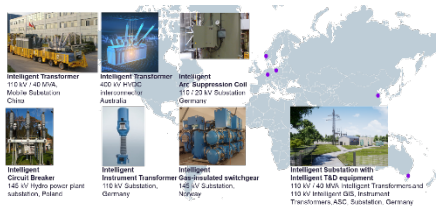
Digital Product Twins

- Digital twin operation to increase operational performance, GIS example



References

- Global installation examples of digitalized and intelligent substation equipment



Conclusion and Outlook- Decarbonized, Digitalized, Intelligent

- Eco-efficient and digitalized substations are the foundation of a CO_2 neutral power system and for global power grids of the future. Main values for society, grid owners and operators are:
- 1. Zero CO_2 emission
- 2. Compact design using LPITs
- 3. Flexible and resilient, integrating fluctuating renewable power generation
- 4. Easy operation, maintenance, and asset management