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DC-LabSaxony

Challenges in Operational Design and Construction of a MV/LV-DC Laboratory in the Megawatt-Scale

Aachen, 17.04.2026

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IEEH

Agenda

Part I: Activities in the area of DC distribution level

1. Long Term Research Vision
2. DC Projects and Laboratories in Saxony

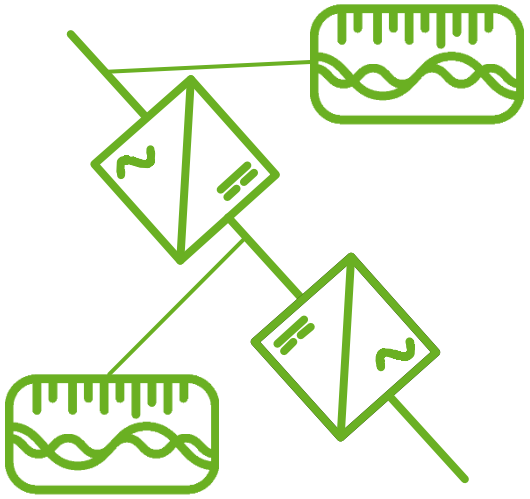
Part II: DC-LabSaxony - a hybrid MVAC/DC testbed

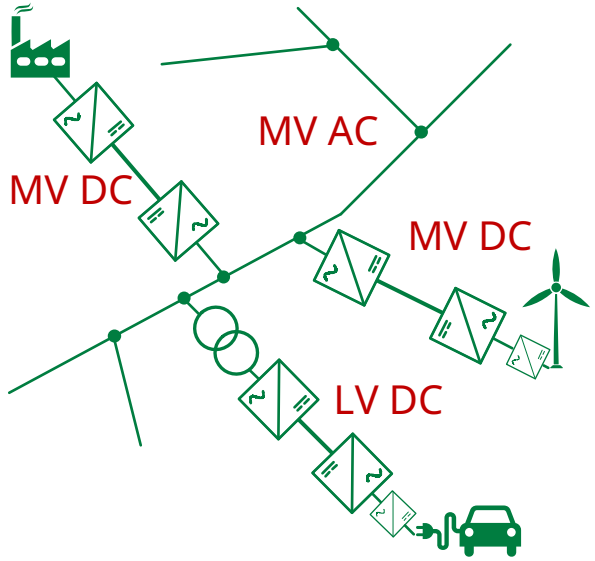
3. Insights into the main components
4. DC-LabSaxony – Planned Extension

Part I:
Activities in the Area of DC Distribution Level

1. **Long Term Research Vision**
2. DC Projects and Laboratories in Saxony

Long Term Research Vision





2020 **Phase 1** **prestudies** 2026

2024 **Phase 2** **proof of concept** 2030

2028 **Phase 3** **full integration in grids** 2038

Long Term Research Vision

Proof of Concept
Phase 2

Cable Components

- Diagnostics after failures
- Analyses on new cable terminators and joints for ±55-kV-DC applications

Interoperability

- Hybrid grids
- Multivendor Setups
- Power Quality Validation

Field Testing

- Representations of a MVDC to LVDC P2P connection with scaled
  - voltage
  - current
  - power

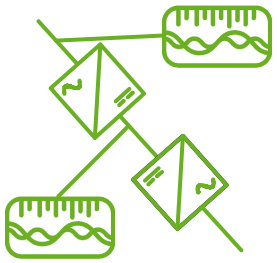
Laboratory Testing

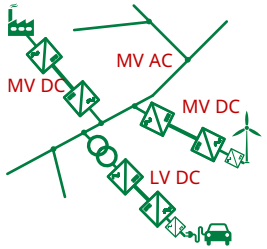
- Multi-terminal-DC (MTDC) grids
- Real switchgear setups
- Short circuit investigations

Part I:
Activities in the Area of DC Distribution Level

1. Long Term Research Project AC2DC
2. **DC Projects and Laboratories in Saxony**

DC Projects and Laboratories in Saxony – Overview





Phase 1

2020
- AC2DC Phase 1 (finished)
- Druckentwicklung bei DC-Lichtbögen (finished)

2021
- HyLeiT (finished)

2022
- Personensicherheit bei DC-Störlichtbögen I (finished)

2023
- Fremdschichtüberschlags-verhalten unter DC (in progress)

Phase 2

2024
- AC2DC Phase 2 (in progress)
- DC-LabSaxony (in progress)
- Hybrid+ (in progress)

2025
- Langzeitverhalten von PVC bei NSDC (started)

2026
- Personensicherheit DC-Störlichtbögen II (applied)
- MTDC Lab (in progress)
- DC-Ströme im Erdreich (in progress)

Phase 3

2027
- DC-LabSaxony Full Scale Extension (applied)

2030
- AC2DC Phase 3 (planned)

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*This is merely an overview; it does not reflect all activities

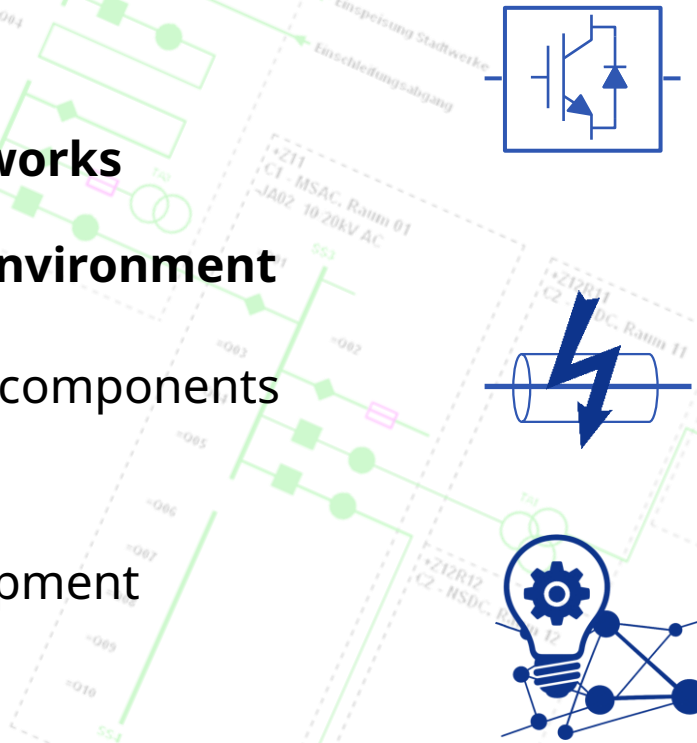
Part II: DC-LabSaxony – a hybrid MVAC/DC research site

3. **Insights into the main components**
4. DC-LabSaxony – Planned Extension

The Need for a Hybrid MVAC/DC Research Site

Establishment of a R&D site for (MV)DC components

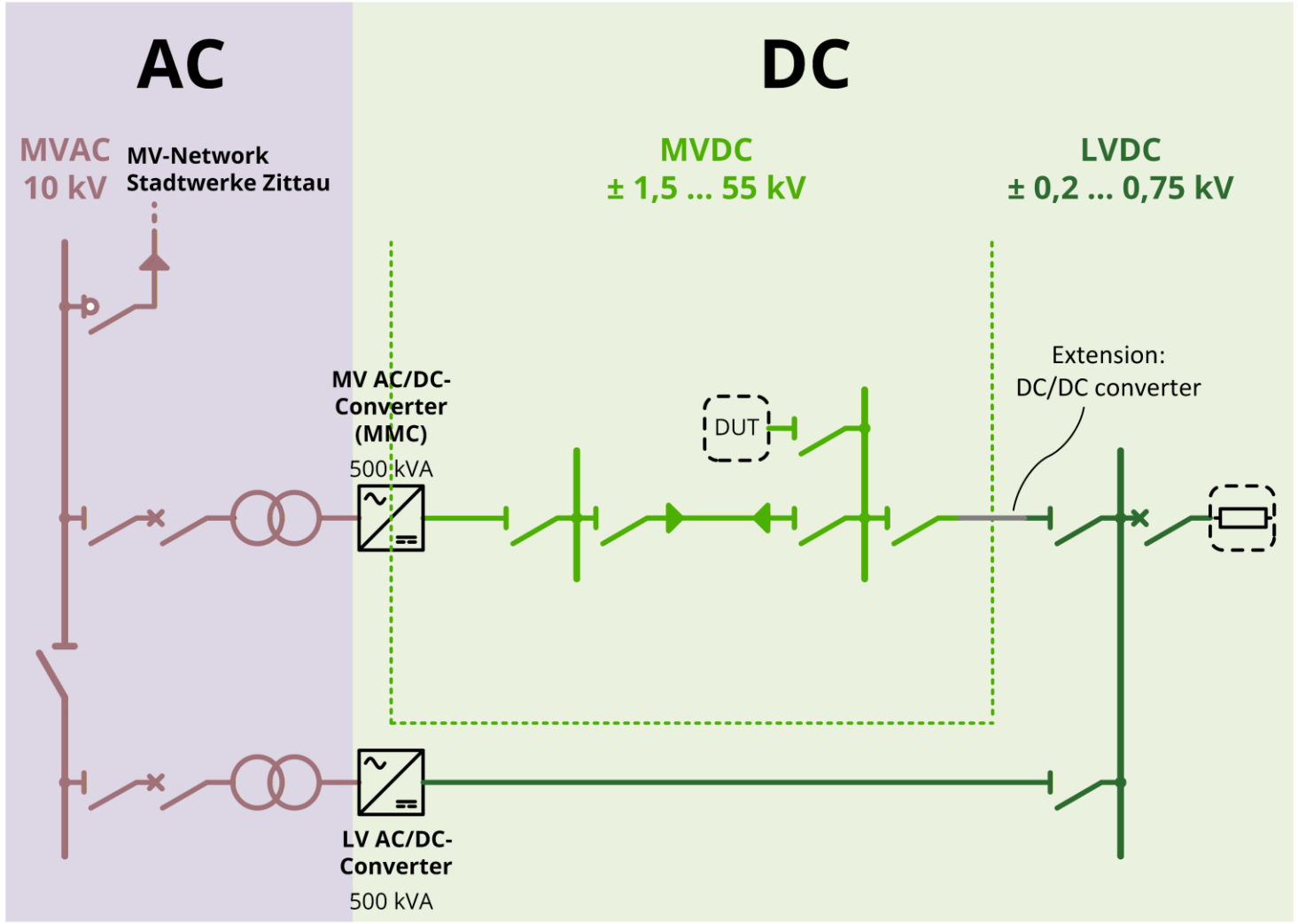
- MVDC switchgear prototype
- Evaluation of **new equipment in hybrid AC/DC networks**
- Investigation of system behavior in a **multivendor environment**
- Investigation of **electrical and thermal stresses** on components under realistic conditions
- Investigation of **operational characteristics** of equipment
  - **Power Quality** in normal operation
  - Contributions in the event of a fault
- Investigation of grounding and **protection concepts in multi-terminal setups**



DC-LabSaxony – a Hybrid MVAC/DC Research Site

55 kV DC laboratory

- Modular Multilevel Converter (MMC) (U_n = 55 kV)
- MVDC switchgear
- MVDC devices under test
- Junction via DC/DC converter
- LVDC converter (U_n = 0,7 kV)
- LVDC switchgear



DC-LabSaxony – Planned Research Site

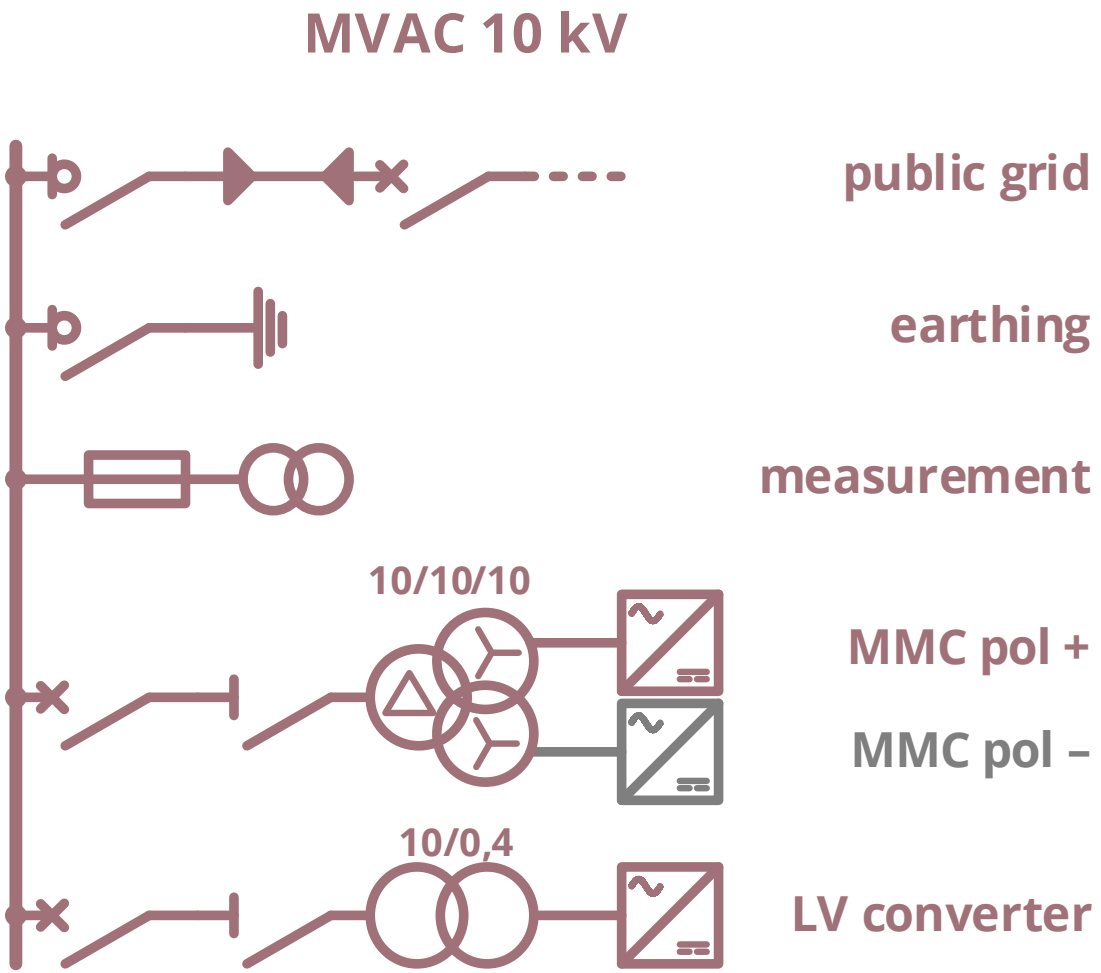
AI rendered image of the research site ©DC-LabSaxony

DC-LabSaxony – MVAC Switchgear

MVAC switchgear by Schneider Electric

- Encapsuled, insulation with synthetic air
- Adapted to laboratory needs → motorised earthing switch
- Busbar protection by modern central protection server
  - Based on IEC 61850 Sampled Values

Schneider RM AirSeT
https://www.se.com/de/de/product-range/21830554-rm-airset/#products



DC-LabSaxony – MMC

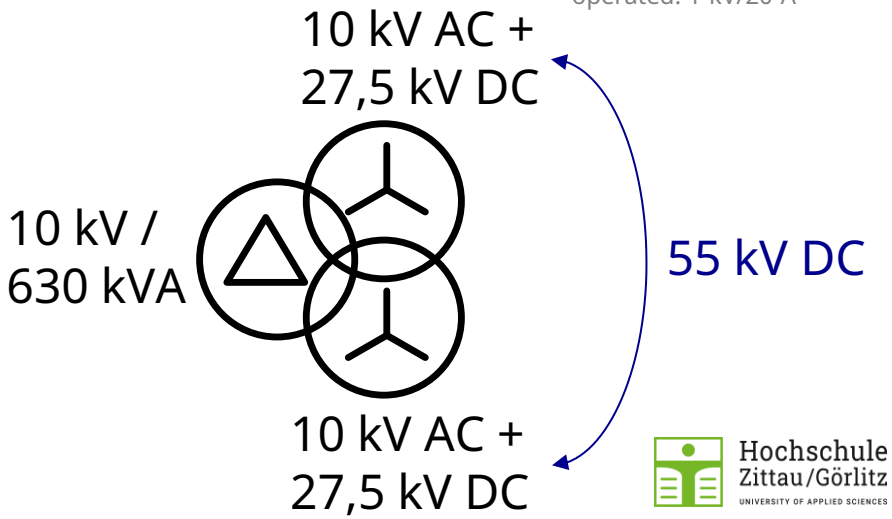
Full-bridge MMC by F&S Prozessautomation

- Pole (first of two) operates between 1,4 kV and 55 kV DC
- Current control scheme:
  - DC side: grid forming & active shutdown of fault currents
  - AC side: grid following
- Control model is provided in Simulink

3D view of a module of the Modular Multilevel Converter (MMC);
produced by F&S Prozessautomation
- rated: 1.8-kV/100-A
- operated: 1-kV/20-A

MMC transformer

- 3-winding transformer (designed for both MMC poles)
- Each secondary side must withstand an additional 27,5 kV DC offset



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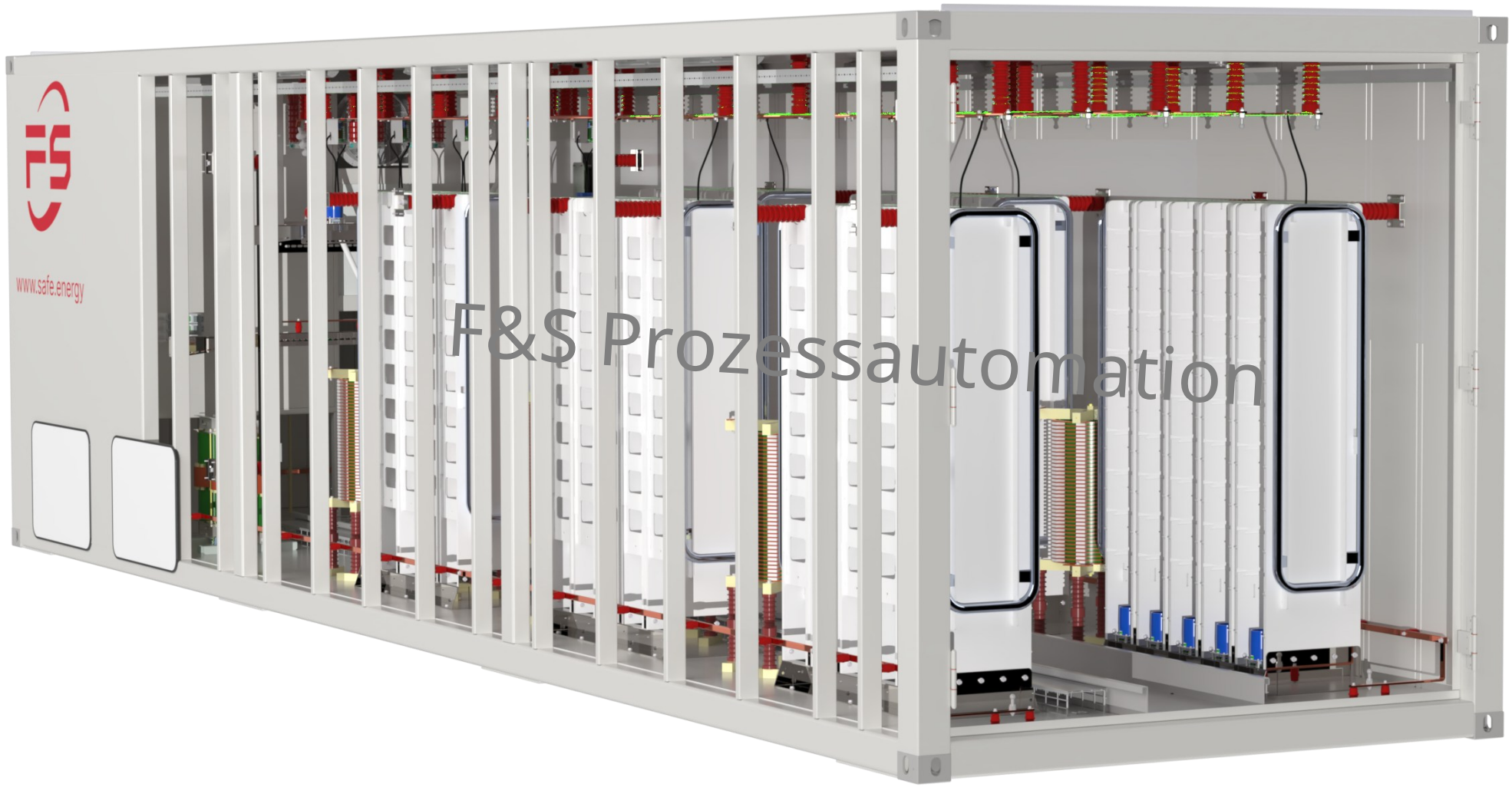
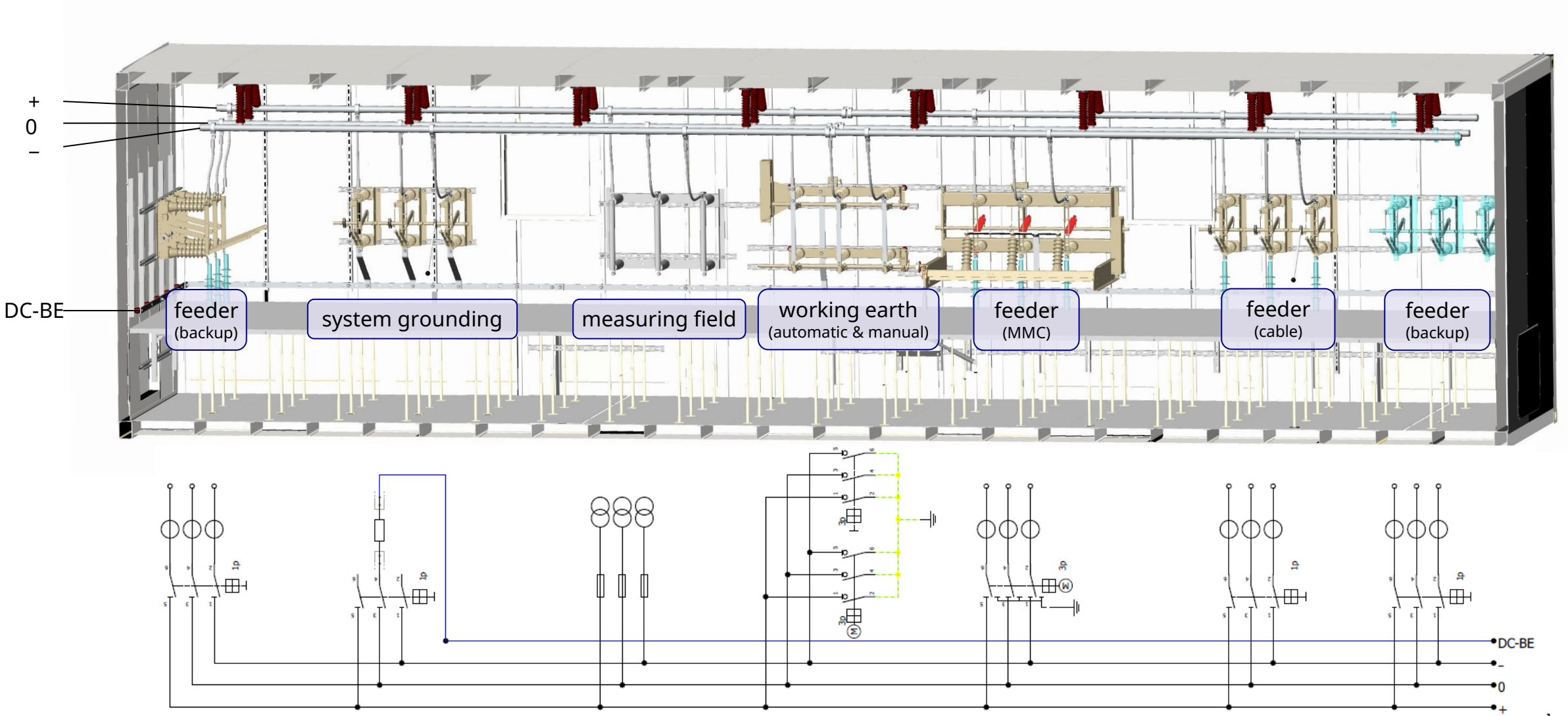
DC-LabSaxony – MMC



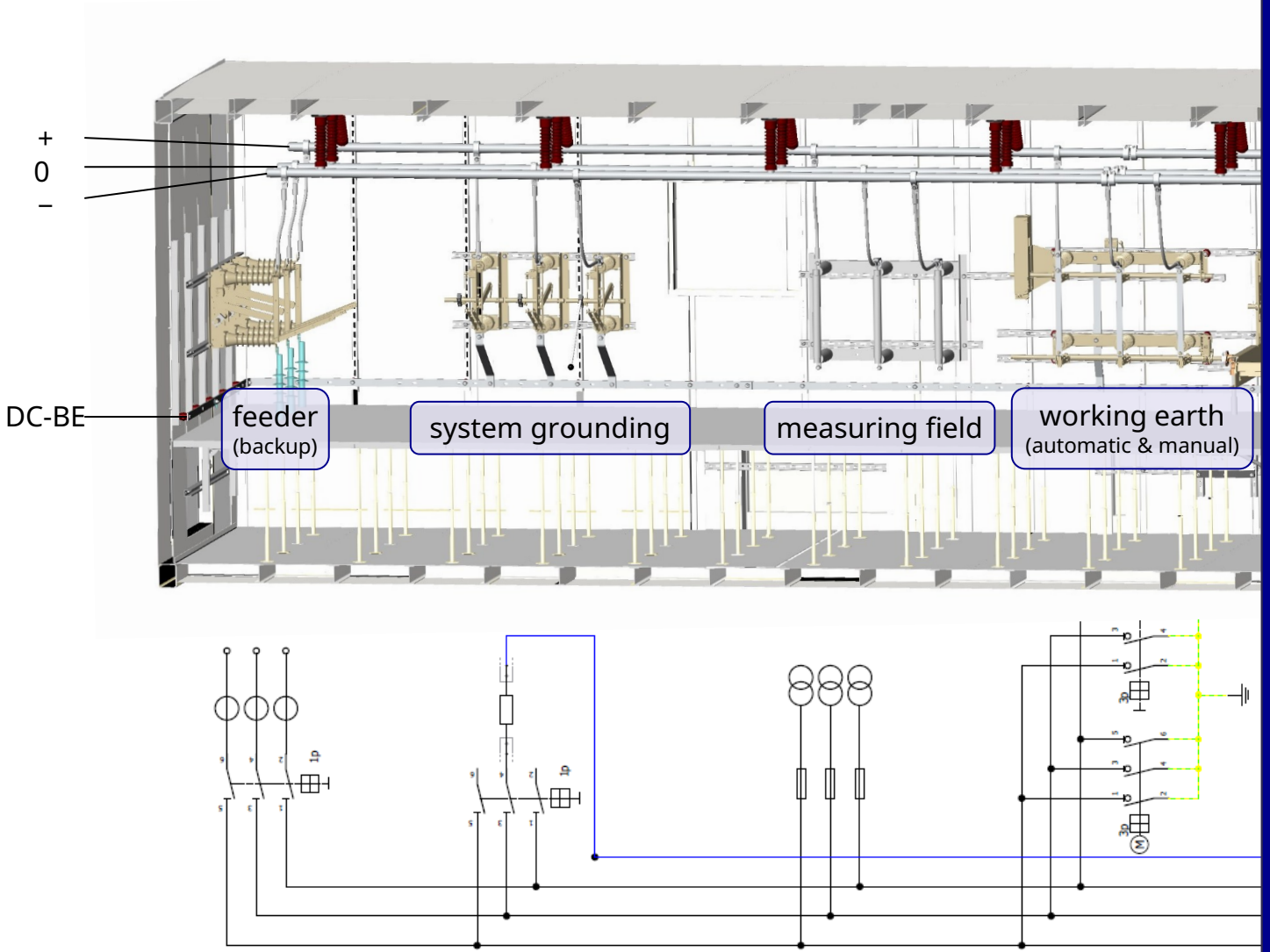
3D view of the container for the first MMC pole with a voltage up to 55 kV produced by F&S Prozessautomation

DC-LabSaxony – MVDC Switchgear



Rendered inner view of the MVDC switchgear container ©DC-LabSaxony

DC-LabSaxony – MVDC Switchge



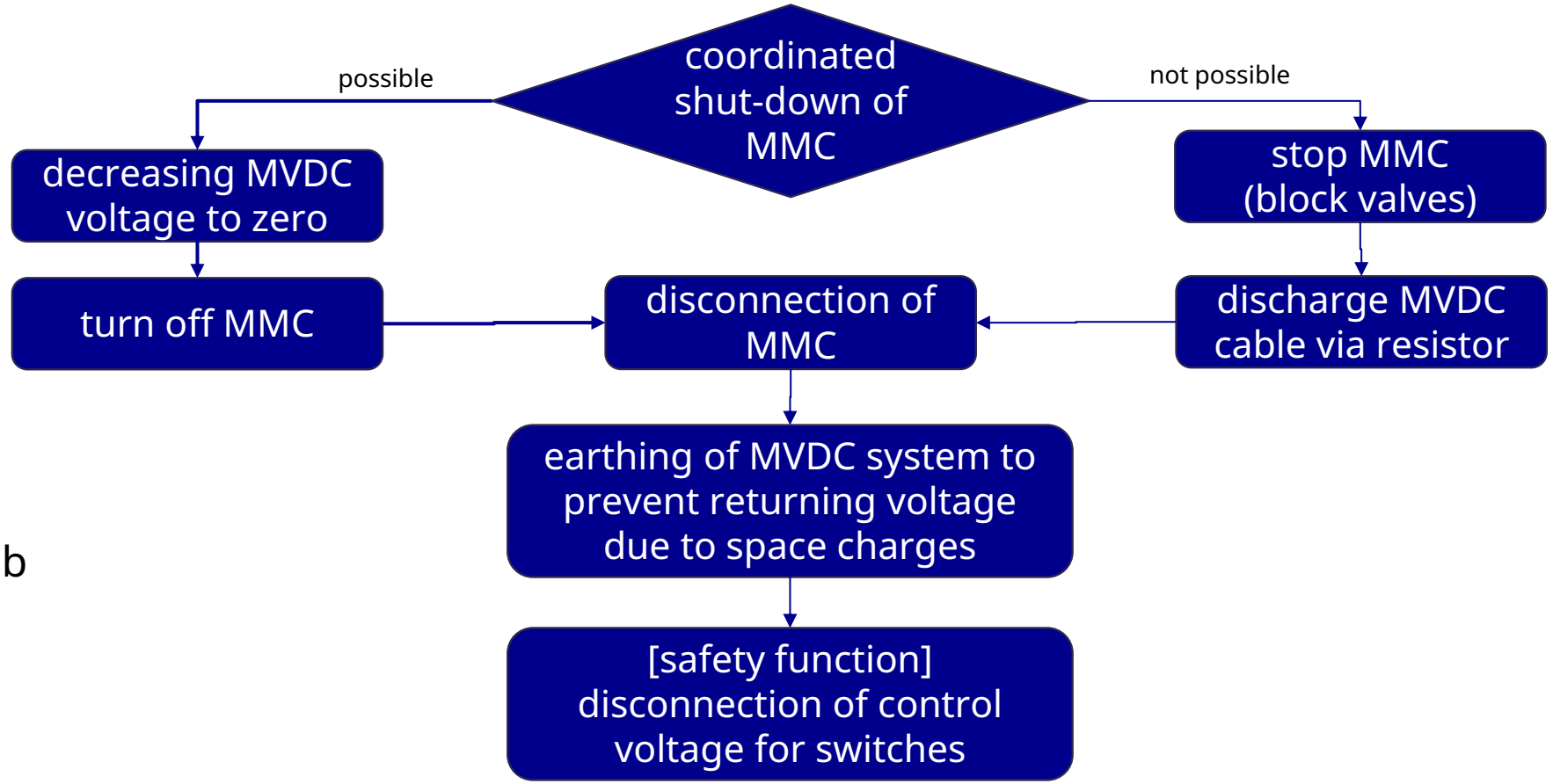
Properties

- disconnectors
  - 36-kV AC, air-insulated
- system grounding
  - via separate busbar (DC-BE)
  - all MVDC containers interconnected to prevent DC currents through earth
- current measurement devices
  - hall effect or zero flux
  - low currents (~5…20 A)
  - high jaw opening needed (d > 40 mm)
  - monitoring via station control by usage of analogue input modules

DC-LabSaxony – Operational challenges

High operational and personal safety necessary

- safety PLC
- control voltage of switches blocked via multiple trigger paths



Flexibility in usage of the lab

- Additional, insulated grounding path for DC must be monitored

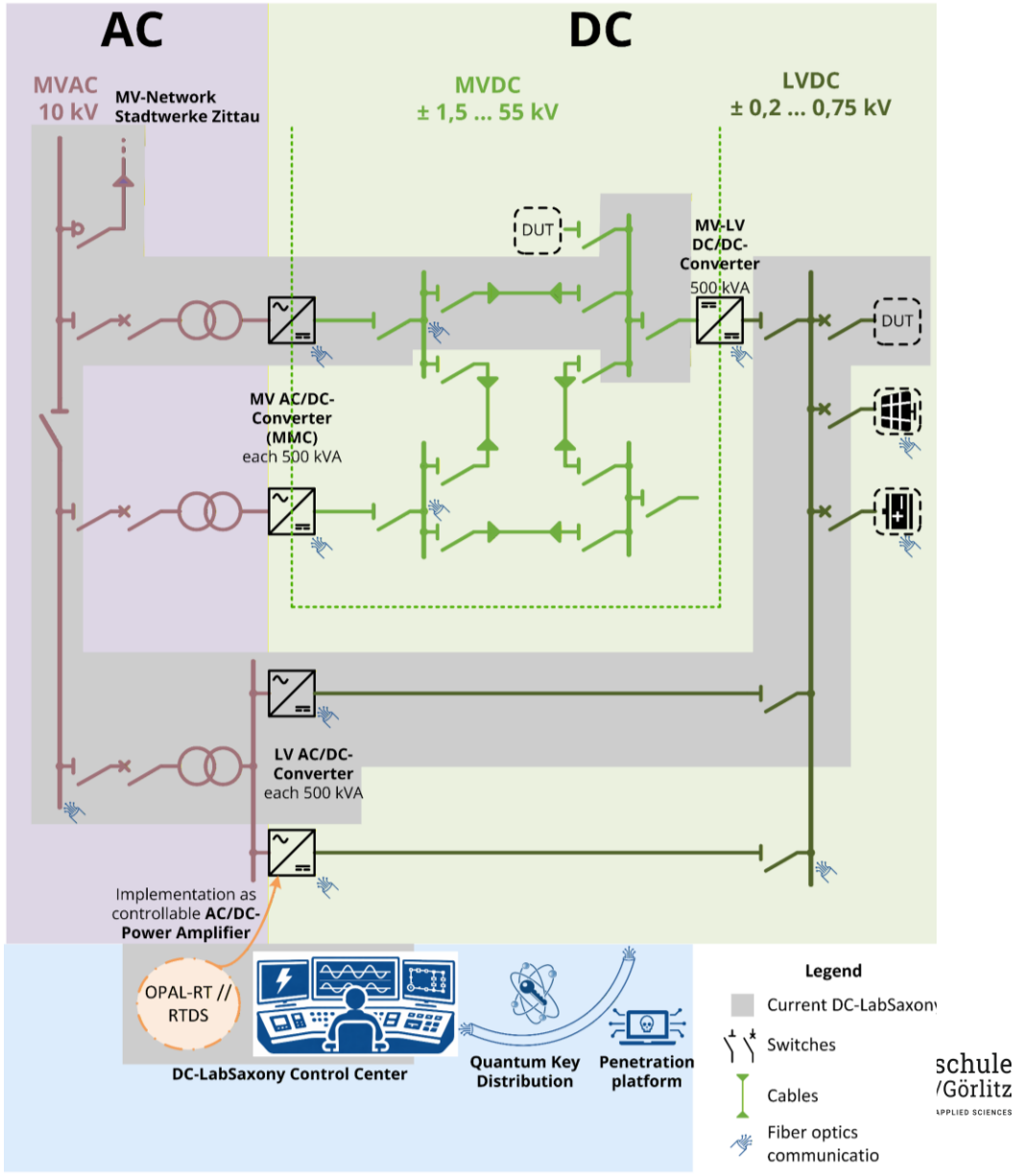
Part II:
DC-LabSaxony – a hybrid MVAC/DC research site

3. Insights into the main components
4. **DC-LabSaxony – Planned Extension**

DC-LabSaxony – Planned Extension

±55 kV DC laboratory
→ extension to real multi-terminal

- 2nd MMC for multi-terminal operation
- Extension of MVDC testfield to be fully multi-terminal
- MV/LV DC/DC converter
- 2th LVDC converter, as controllable power amplifier with Hardware-in-the-Loop interface
- Strengthening of communication infrastructure by usage of quantum key distribution based encryption



DC-LabSaxony – Use Cases: Manufactures

Cables & Switchgears

Investigation of LVDC switches under real operating conditions

Analysis of reconfigured MVAC-cables under DC operation
→ polarity change

Test of cable fault diagnosis approaches

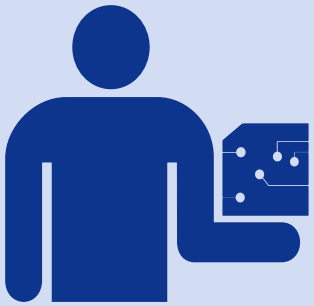
Power Electronics

Operational and EMC behavior in multi-vendor operation setup

Pre-qualification test

Test of DC/DC converter up to ±55/0,3 kV

Test of software components for LVAC/DC converters based on HIL setup



DC-LabSaxony – Use Cases: Grid Operators

Power Quality & Protection

Protection in multi-terminal DC grids (without switches)

Power Quality coordination

Traveling waves based protection for DC grids

Measuring converter setups and integration

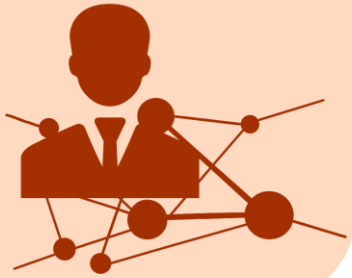
Grid Operation

Test of customer-specific AC/DC plant behavior during transient events (switching, faults)

Assessment of different grid topologies

Commissioning of load and generation prototypes

Stability evaluation in normal and stress situations



Operation of hybrid AC/DC grids

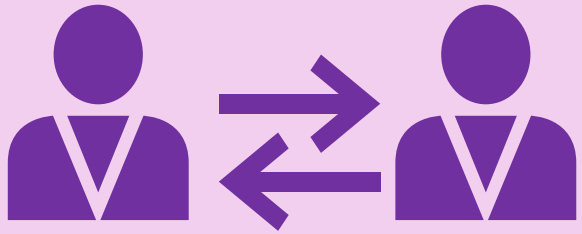
DC-LabSaxony – Use Cases: Educational Institutions

Research & Transfer

Research platform in respect to EMC standardization

Test of operation strategies on real hardware

Propagation of superimposed frequency components in DC grids



Training & Education

Interest groups from associations

Grid operator

Technicians and mounting personnel

Grid planer

Educational programs for students

Conclusion and Take Aways

- **DC-LabSaxony** is scheduled to **begin operations by October 2026**
  - One of the firsts 55-kV-MMC in realistic environment
  - Start with reduced voltage
  - Design of MVDC switchgear with AC assets

- **Benefits in costs are expected**, while not yet present
  - Scaling effects: expensive prototypes → cheap series production
  - Faster planning and implementation times
  - Hardware-reduction for lines (only two phases needed)

Conclusion and Take Aways

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DC laboratories:

The Key for Transitioning to DC

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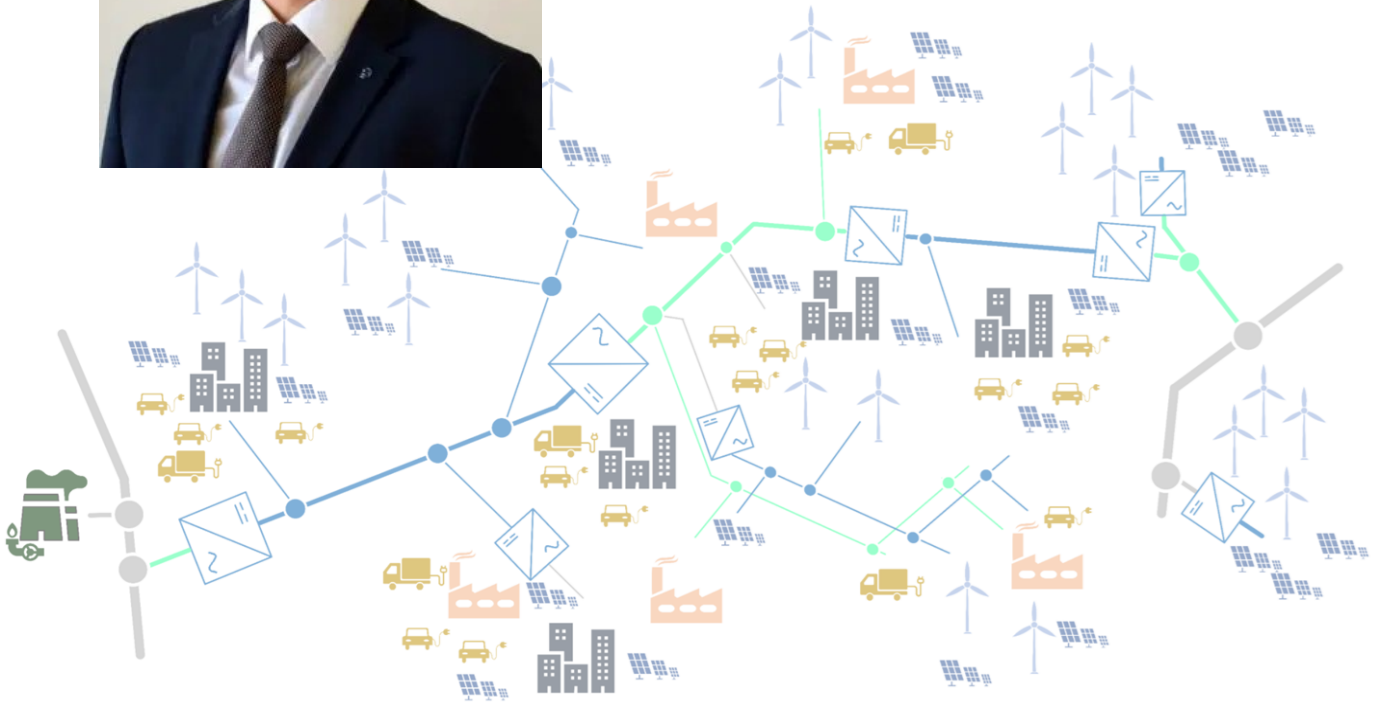

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IEEH DC CAMPUS Co-funded by the European Union

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