**CIGRE Study Committee B4**

**PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP**

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| **WG B4.95** | **Name of Convenor:** Joerg Dorn (GERMANY)<br>**E-mail address**: joerg.dorn@siemens-energy.com |
| **Strategic Directions #[2]: 1** | **Sustainable Development Goal #[3]: 7, 9, 13** |
| **The WG applies to distribution networks: ☒ Yes / ☐ No** | |
| **Potential Benefit of WG work #[4]: 1, 2, 4** | |
| **Title of the Group: Developments in Power Semiconductor Technologies and Applications in HVDC/FACTS** | |

**Scope, deliverables, and proposed time schedule of the WG:**

**Background:**

Power semiconductors are key components of HVDC converters and most FACTS projects. Together with their gate control circuits and other main components such as the associated DC capacitor (in VSC applications) they form a functional unit which strongly defines the converter performance and protection. Their properties and characteristics have a considerable influence on the power electronic system behaviour, such as losses, dynamic performance, fault handling and reliability.

Nowadays all converters in HVDC and FACTS are based on silicon devices. Thyristors are standard devices for LCC whereas IGBTs (Insulated Gate Bipolar Transistor) and associated freewheeling diodes are used in VSC. However, thyristors might also be used in VSC for protection purposes and other devices, such as IGCTs (Integrated Gate-commutated Thyristors) are also proposed to be used in high power multilevel converters.

Semiconductor power devices for use in HVDC and FACTS has been covered previously in CIGRE Technical Brochure 112 published in 1997. The technology of semiconductors has been further advanced over the last 20 years in terms of materials and ratings which has enabled the increased applications of VSC technologies in high voltage and high power HVDC transmission system which is playing the most important role in green energy transition. Wide bandgap semiconductors such as silicon carbide might also be an option in the future providing new chances and challenges. Thus, it is considered critical and timely to provide an update on power semiconductors in HVDC and FACTS applications in both transmission and distribution systems.

**Purpose/Objective/Benefit of this work:**

This WG will provide a technical overview of semiconductor devices and materials, their control, and interactions to other components including an update on the technology of semiconductors. The influence on the power electronic system behaviour and properties will also be addressed.

**Scope:**

The working group would investigate and report on:

1. Power semiconductor materials and their properties.
2. Power semiconductor devices, their static and dynamic characteristics and impact on losses.
3. Housing and mounting technologies of power semiconductors including cooling aspects.

4. Control of power semiconductor devices and influence on their characteristics.
5. Interaction between power semiconductors, DC link capacitors and parasitic elements like stray inductances.
6. Series and parallel connection of semiconductors
7. Influence of power semiconductors on the power electronic system properties. Topics like current turn-off capabilities, losses, short circuit behaviour and fault handling would be considered.
8. Performance aspects such as failure rates and reliability.
9. Design factors that affect the ratings of a semiconductor device
10. New developments and outlook.

**Deliverables:**

☒ Annual Progress and Activity Report to Study Committee
☒ Technical Brochure and Executive Summary in Electra
☒ Electra Report
☐ Future Connections
☐ CIGRE Science & Engineering (CSE) Journal
☐ Tutorial
☒ Webinar

**Time Schedule**:

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| • Recruit members (National Committees) | Q4 2023 |
| • Develop final work plan | Q1 2024 |
| • Draft TB for Study Committee Review | Q3 2026 |
| • Final TB | Q4 2026 |
| • Webinar | Q1 2027 |

**Approval by Technical Council Chairman**:

**Date**: June 9th, 2023

Notes:
[1] Working Group (WG) or Joint WG (JWG),
[2] See attached Table 1,
[3]See attached Table 2 and CIGRE reference Paper: Sustainability – at the heart of CIGRE's work.
[4] See attached Table 3

WG Membership: refer Comments at end of document

**Table 1: Strategic directions of the Technical Council**

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| **1** | The electrical power system of the future reinforcing the End-to-End nature of CIGRE: respond to speed of changes in the industry by preparing and disseminating state-of-the-art technological advances |
| **2** | Making the best use of the existing systems |
| **3** | Focus on the environment and sustainability (in case the WG shows a direct contribution to at least one SDG) |
| **4** | Preparation of material readable for non-technical audience |

**Table 2: Environmental requirements and sustainable development goals**

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| | CIGRE selected the 7 SDGs that are the most relevant to CIGRE. In case the WG work refers to other SDGs or do not address any specific SDG, it will be quoted 0. |
| **0** | Other SDGs or not applied |
| **7** | **SDG 7: Affordable and clean energy**<br>Increase share of renewable energy; e.g. expand infrastructure for supplying sustainable energy services; ensure universal access to affordable, reliable, and modern energy services; energy efficiency; facilitate access to clean energy research and technology |
| **9** | **SDG 9: Industry, innovation and infrastructure**<br>Facilitate sustainable infrastructure development; facilitate technological and technical support |
| **11** | **SDG 11: Sustainable cities and communities**<br>Increase attention on sustainable and resilient buildings utilizing local (raw) materials, power for electric vehicles, strengthening long-line transmission and distribution systems to import necessary power to cities, developing micro-grids to reinforce the sustainable nature of cities; protect and safeguard the world's cultural and natural heritage; reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and waste management |
| **12** | **SDG 12: Responsible consumption and production**<br>E.g. Promote public procurement practices that are sustainable; address reducing use of SF6 and promote alternatives, encourage companies to adopt sustainable practices and to integrate sustainability information into their reporting cycle, address inefficient fossil-fuel subsidies that encourage wasteful consumption |
| **13** | **SDG 13: Climate action**<br>E.g. Increase share of renewable or other $CO_2$-free energy; energy efficiency; expand infrastructure for supplying sustainable energy; strengthen resilience and adaptive capacity to climate-related hazards and natural disasters; integrate climate change measures into national policies, strategies and planning; improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning |
| **14** | **SDG 14: Life below water**<br>E.g. Effects of offshore windfarms; effects of submarine cables on sea-life |
| **15** | **SDG 15: Life on land**<br>E.g. Attention for vegetation management; bird collisions; integration of substations and lines into the landscape |

**Table 3: Potential benefit of work**

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| **1** | Commercial, business, social and economic benefits for industry or the community can be identified as a direct result of this work |
| **2** | Existing or future high interest in the work from a wide range of stakeholders |
| **3** | Work is likely to contribute to new or revised industry standards or with other long term interest for the Electric Power Industry |
| **4** | State-of-the-art or innovative solutions or new technical directions |
| **5** | Guide or survey related to existing techniques; or an update on past work or previous Technical Brochures |
| **6** | Work likely to contribute to improved safety. |

**Comments:**

**1) CIGRE Official Study Committee Rules: WG Membership**

https://www.cigre.org/GB/about/official-documents

a. Only one member per country (by exception of SC Chair)

b. WG nominees must first be supported by their National Committee (or local SC Member) as an appropriate representative of their country.

c. Acceptance of the nomination is granted by the SC Chair and advised to the WG Convener

**2) Collaboration Space**

https://www.cigre.org/article/GB/collaborative-tools-2

CIGRE will provision the WG with a dedicated Knowledge Management System Space.

The WG will use the KMS for drafting collaboration, capture and retention of discussion and meeting records.

Official country WG Members will be sent registration instructions by the Convener.

Official country WG Members may request the WG Convener to allow additional access for an extra national subject matter specialist to aid in the work at the national level, including NGN members.