

Scope of work & activities

STUDY COMMITTEES 2022

Editorial

The CIGRE Technical Council is the main backbone of the organization's technical activities, which comprise all permanent activities of the 16 Study Committees (SC), such as, the management of the internal Working Groups (WG), as well as planning and organizing all CIGRE activities like Symposia, Colloquia, Workshops, Tutorials and related events.

Technical Council (TC) Study Committee Chairs are, in fact, true leaders in their respective fields. The TC gathers the 16 SC Chairs, the Technical Council Chair, the CIGRE Secretary General and two representatives of the CIGRE Administrative Council. The TC reports to the Administrative Council. The TC Chair is also a member of the Steering Committee meetings and shares views and decisions on recommendations delivered to the highest management levels of the organization.

With this formation, CIGRE becomes able to bring together the diverse range of issues and topics that are of interest to our stakeholders and to establish the appropriate work programmes to deliver valuable outputs in the target areas.

Within the framework established by the Technical Council, each Study Committee, consisting of National Committee representatives and active experts such as Working Group convenors and Strategic Advisory Groups, has the responsibility to manage the programme of work within its technical area of responsibility. Delivery of the technical work of CIGRE, overseen by the Technical Council, assumes the following main forms:

- publication of technical reports prepared by international Working Groups (Technical Brochures, ELECTRA articles);
- preparation of technical events such as the Paris Sessions, conferences, symposia, colloquia, tutorials & workshops, and, last but not least
- having in mind all current and future needs to align CIGRE with the most relevant and timely topics of the electric power industry.

Through these routes we actively promote the development of skills and knowledge and provide a wide range of opportunities for stakeholders of all types to share knowledge and experience and to collaborate in the development of themselves and of the future of societies around the world.

Particular strengths of CIGRE are its well-established Working Group structure and its

wide international engagement. We typically have in excess of 250 260 active Working Groups and around 4300 active experts engaged in CIGRE activities at any one time. We exploit the enormous expertise of our stakeholders worldwide to drive innovation, to develop solutions and to provide trusted, impartial, non-commercial guidance and advice. At the same time, we are developing programmes to encourage active participation from a truly diverse range of interest groups and to ensure that CIGRE's enormous body of knowledge and expertise is exploited fully in support of nations & regions at all stages of economic development.

Whilst we have delivered excellent service to the electric power industry for almost 100 years, we are presently more focused than ever before on the timely issues of energy transition, ESG practices, active energy resources in the distribution area, hydrogen as a new fuel, full digitalization of installations, new materials, more effective asset management, new challenges for system operation among others to keep the added value for CIGRE members and how we can broaden our appeal and create a strong, sustainable organization which is fit for the present, and also robust enough to deal with an exciting but uncertain future. CIGRE, by being recognized as an End-to-End (E2E) organization, which covers all technical matters from the internal parts of generators to the consumer end of the electricity meter, demonstrates its continued worldwide technical & scientific leadership.

This has been done, since it is no longer possible to establish rigid edges among segments of Generation, Transmission and Distribution, under the environment of the 4.0 Industrial thinking, which leads to broken down and re-imagine the electric power business.



Marcio Szechtman
CIGRE Technical Council Chair



About CIGRE

Founded in 1921, CIGRE, the International Council on Large Electric Systems, is an international non-profit association for promoting collaboration on a national and international level.

With **more than 10000 individual members** including student, researchers, academics, engineers, technicians, ceos and other decision makers, and with **more than 1300 collective members** (companies and universities), cigre allows experts from around 107 different countries, to share and join forces in order to improve existing systems and build the electrical power systems of the future.

Cigre, who counts national committees in **61 different countries**, achieve its mission through the work of its specialized **16 Study committees and 266 Working groups**, and through events (Session, Symposia) .

To know more about CIGRE: www.cigre.org



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Technical Committee statistics

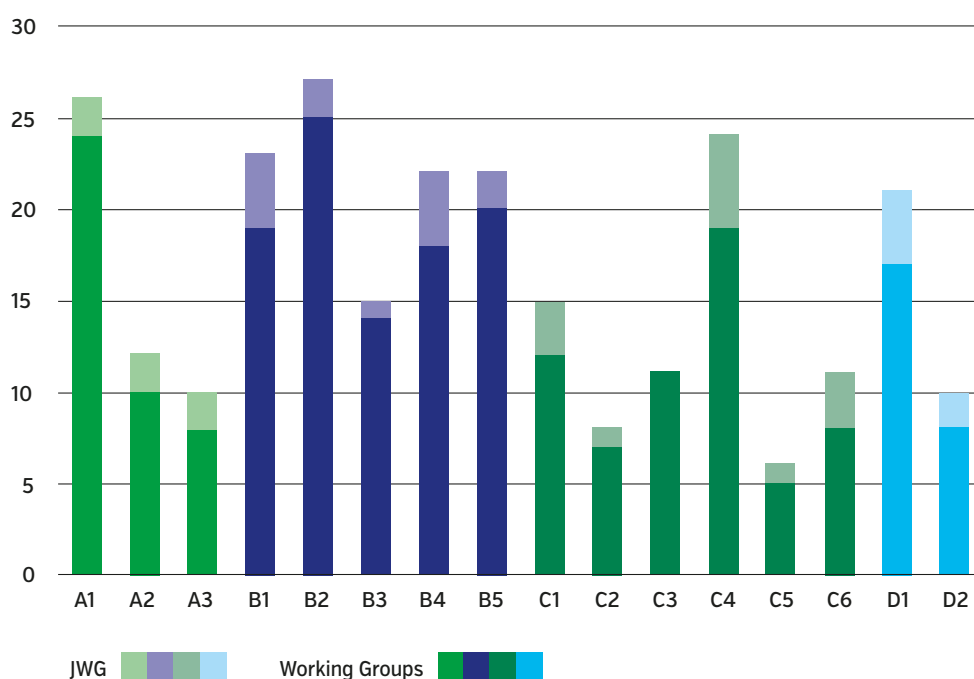
From a statistical point of view the 2020 technical activity can be summarized as follows. On January 2022, **266 Working Groups** including **40 Joint Working Groups** (involving several Study Committees or other organizations like CiRed or IEEE) were active. From January 2021 to December 2021, the 16 study committees created 29 new Working Groups and 26 working groups completed their work and disbanded.

4350 experts coming from 74 different countries were involved for approximately 5970 positions.

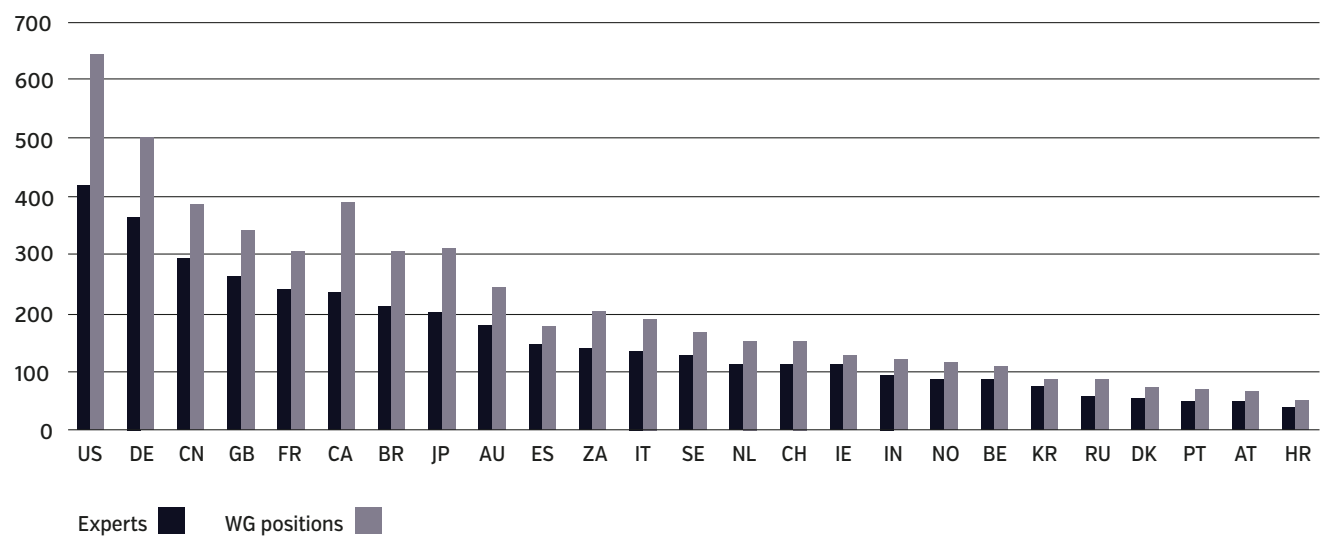
[it means that a significant number of experts contribute to several Working Groups]. 9 % of the CiGRE's experts were women, 18 were Working Group conveners and 26 were Working Group secretaries. In average, female experts occupy 1.36 positions in Working Groups.

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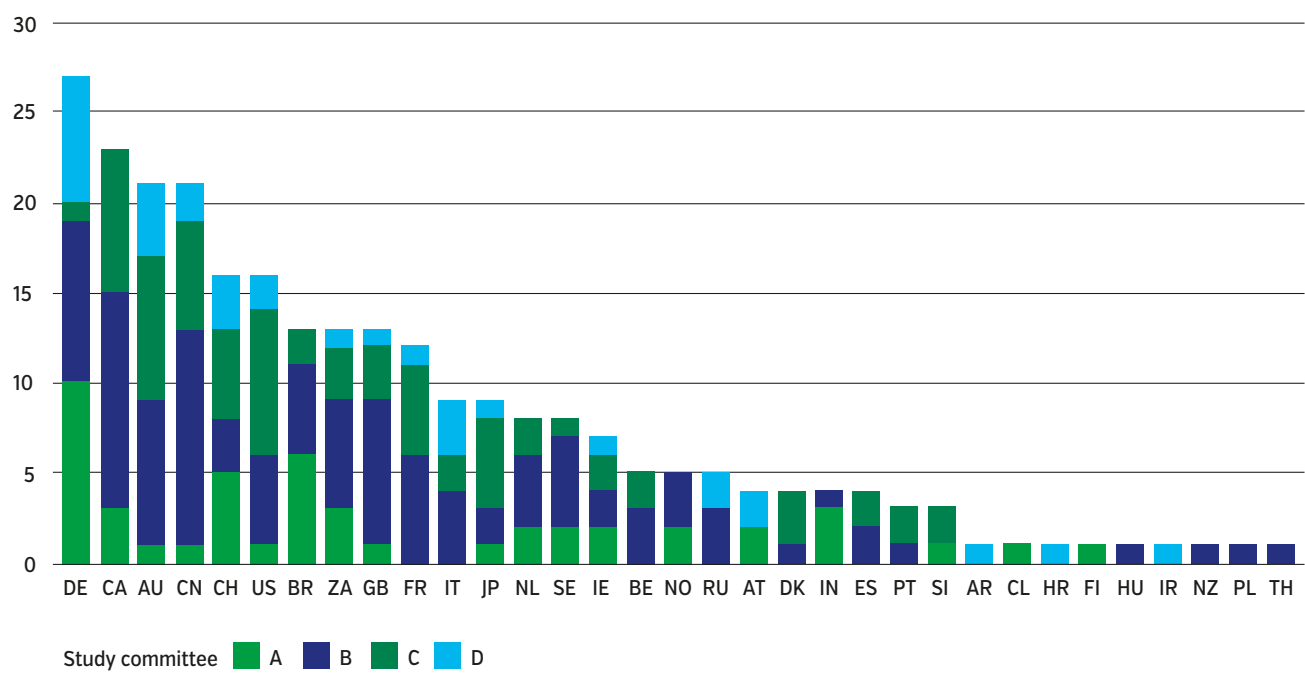
Number of Working Groups per Study Committee



Number of experts per country (25 first countries)



Conveners per country
35 countries provide WG Conveners



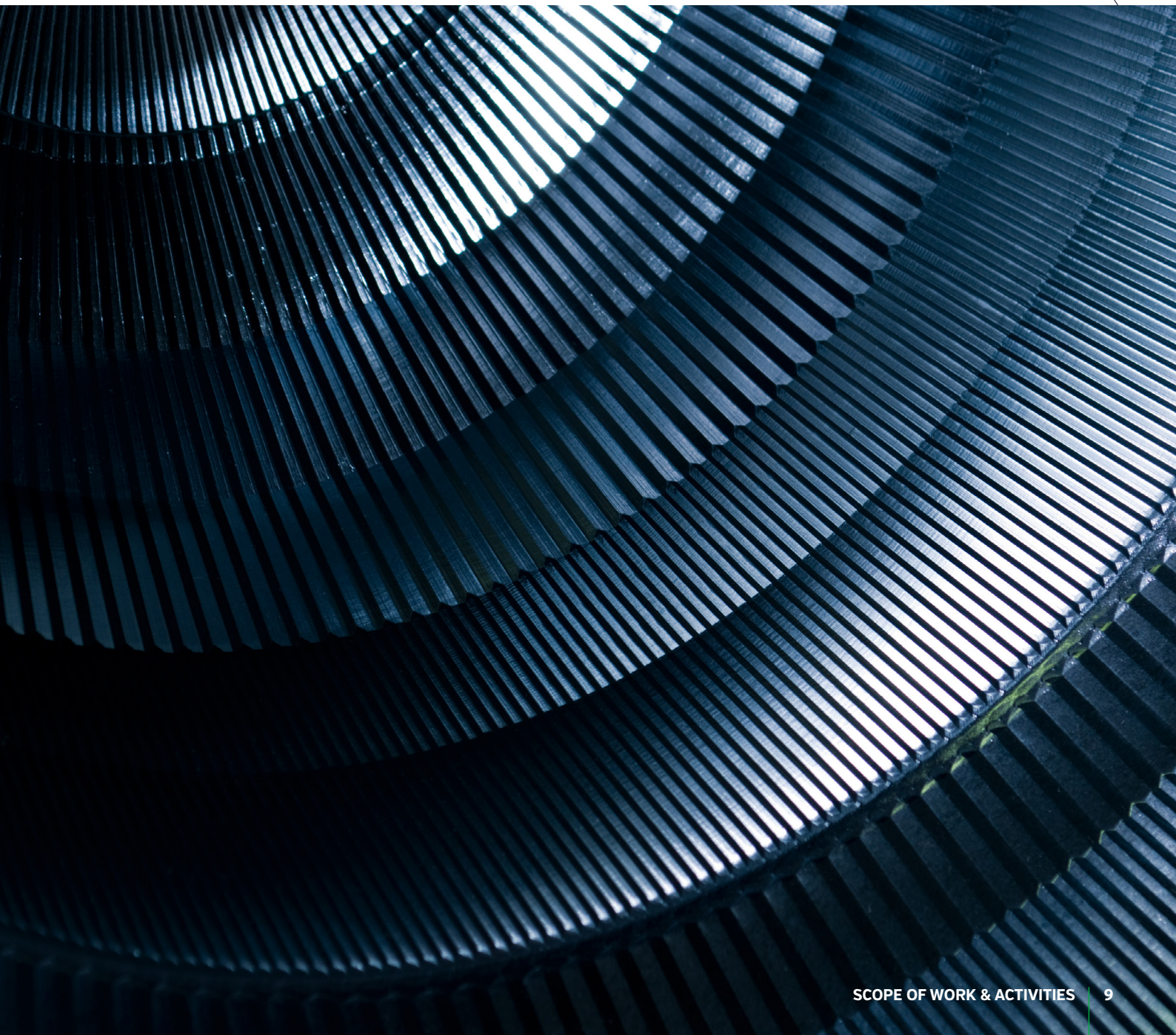
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Rotating Electrical Machines

A1

The SC covers all aspects of rotating electrical machines associated with power generation and grid support ranging from research, development, design, manufacture, and testing of new machines to the commissioning, operation, condition assessment, maintenance, refurbishment, upgrades, life extension, conversion, storage, and de-commissioning of existing machines. Within these fields, SC A1 promotes the international exchange of information, knowledge, practice and experience, and adds value by synthesizing state-of-the-art practices to develop guidelines and recommendations.



A1 Rotating Electrical Machines



Principal areas of interest

Enhancements in the design, construction and performance of rotating electrical machines including large turbo and hydro-generators, synchronous compensators, large motors, high efficiency motors, and wind turbine generators.

New technologies related to rotating electrical machines used in power generation.

Performance improvements of rotating electrical machines due to the development of new materials, improved cooling and insulation or excitation and auxiliary systems of generators and motors.

Monitoring, diagnosis, and prognosis of rotating electrical machines to optimise maintenance strategies.

Asset management to extend the life of existing generators or to recommend their replacement.

The application and changing role of rotating electrical machines in supporting the performance and reliability of power generation networks in the face of the increasing integration of renewable generation sources.



Current activities

SC A1 currently has 25 working groups addressing a range of aspects within the areas of interest. Two of these are joint working groups with SC C4. Eight of these working groups have completed the work and pending issue of the final report or are expected to complete their work in 2022. **Contribution to symposiums including tutorials based on working group reports.**



Key projects / forthcoming events

CIGRE Paris Session 2022: August 28th to September 2nd.



Other specific interests

- **Impact and effect of increasing** the renewable power mix on new and existing generators, generator auxiliaries and motors.
- **Hydro-generator pumped storage schemes.**
- **Synchronous compensator** and high inertia machine design and performance for supporting power generation networks, including conversion of existing decommissioned generators to synchronous compensators.
- **Adaptation of international standards** for electrical machine design and performance to current power grid requirements.



Main areas of attention

Study Committee A1 plays a pivotal role in the field of rotating electrical machines by actively promoting and facilitating international cooperation at conferences, symposiums, colloquiums and regional meetings, and by convening collaborative working groups with diverse membership drawn from equipment manufacturers, contractors, owners, operators, consultants, and academia from across the globe.

Ultimately the aim is to meet the interests of all parties in improving the performance, efficiency, availability and reliability of rotating electrical machines and their contribution to safe and reliable power generation networks.



Within its field of activity shall

Serve all involved in the field of rotating electrical machines in power generation by means of:

- Providing a forum where suppliers, consultants, users and technical experts can share and exchange experiences and information.
- Anticipating the changing role of electrical machines and evolving customer needs and expectations.
- Monitoring and reporting on international developments.
- Promoting beneficial trends and best practices.
- Issuing guidelines and recommendations based on working group findings.
- Reporting recent developments in design, materials, insulation, cooling and bearing technology and improvements in efficiency, monitoring & diagnosis, and maintenance practices.
- Promote innovative solutions and concepts considering all relevant factors (economic, technical, environmental and others).
- Development of younger engineers through participation and knowledge sharing.

Topics of Working Groups

Wg A1.42*	Influence of Key Requirements on the Cost of Hydrogenerators
Wg A1.43*	State of the Art of Rotor Temperature Measurement
Wg A1.44*	Guideline on Testing of Turbo and Hydrogenerators
Wg A1.45	Guide for determining the Health Index of Large electric motors
Wg A1.48*	Guidance on the Requirements for High Speed Balancing / Overspeed Testing of Turbine Generator Rotors following Maintenance or Repair
J Wg A1.52	Wind Generators and Frequency-active Power Control of Power Systems
Wg A1.53	Guide on Design Requirements of Motors for Variable Speed Drive Application
Wg A1.54*	Impact of flexible operation on large motors
Wg A1.55	Survey on Split Core Stators
Wg A1.56*	Survey on Lap and Wave Winding and their Consequences on Maintenance and Performance
Wg A1.58	Selection of Copper Versus Aluminium Rotors for Induction Motors
Wg A1.59*	Survey on Industry Practices and Effects associated with the Cutting Out of Stator Coils in hydrogenerators
Wg A1.60	Guide on Economic Evaluation for Refurbishment or Replacement Decisions on Hydro Generators
Wg A1.61	Survey on Partial Discharge Monitoring in Large Motors
Wg A1.62	Thrust Bearings for Hydropower - A Survey of Known Problems and Root Causes
Wg A1.63	Turbo Generator Stator Winding Bushings
Wg A1.64	Guide for Evaluating the Repair/Replacement of Standard Efficiency Motors
J Wg A1.66*	Guide on the Assessment, Specification and Design of Synchronous Condensers for Power Systems with Predominance of Low or Zero Inertia Generators
Wg A1.67	State of the Art in methods, experience and limits in end winding corona testing for Hydro Generators
Wg A1.68	Evaluating Quality Performance of Electric Motor Manufacturing and Repair Facilities
Wg A1.69	Hydro-Generator Excitation Current Anomalies
Wg A1.70	Dielectric Dissipation Factor Measurements on Stator Windings
Wg A1.71	Survey on damper-winding Concepts and its operational experience on hydro generators and motor-generators
Wg A1.72	Survey on multi-turn coils with dedicated turn insulation versus coils without dedicated turn insulation
Wg A1.73	Customer Requirements for Qualification of Form Wound Stator Insulation Systems for Hydro Generators

* For these groups, the work has been completed and final report in the review and release phase or the work is nearing completion.

Latest publications

TB 860	Guide for Cleanliness and Storage of Generators
TB 813	Magnetic core dimensioning limits in hydro generators
TB 776	Factory Quality Assurance Testing Requirements for Turbo-Generator Components - Stator Bars
TB 774	State of the Art of Stator Winding Supports in Slot Area and Winding Overhang of Hydro Generators
TB 772	Turbo-generator stator windings support system experience
TB 769	Dielectric Dissipation Factor Measurements on New Stator Bars and Coils
TB 743	Guide on New Generator Grid Interaction Requirements
TB 729	Technological Feasibility Studies for Super and Ultra-Premium Efficient Motors
TB 724	Guide on Use of Premium Efficiency IE3motors for Determining Benefits of Greenhouse Gas Emission Reduction
TB 690	Vibration and Stability Problems Met In New, Old and Refurbished Hydro Generators, Root Causes and Consequences
TB 682	Survey on hydro generator instrumentation and monitoring
TB 665	Generator Behaviour under Transient Conditions
TB 641	Guide on Economic Evaluation of Refurbishment / Replacement Decisions on Generators
TB 621	Generator On-line Over and Under Excitation Issues
TB 582	Survey on Hydrogenerator Cleaning
TB 581	Guide: Corona Electromagnetic Probe Tests [TVA]
TB 574	Guide for Consideration of Duty on Windings of Generators
TB 573	Guide for Minimizing the Damage from Stator Winding Ground Faults in Hydrogenerators
TB 558	Guide for the Monitoring, Diagnosis and Prognosis of Large Motors
TB 552	Guide of Methods for Determining the Condition of Stator Winding Insulation and their Effectiveness in Large Motors
TB 551	Feasibility of updating from Class F to Class H the Electrical Insulation Systems in Electrical Rotating Machines
TB 522	Generator Stator Winding Stress Grading Coating Problem
TB 517	Guide for Prevention of Overfluxing of Generators
TB 503	State of the Art and Capacity for Robotic Inspection of Turbogenerators
TB 491	Generator end-Winding Retaining Rings - A Literature Survey and Care Guideline
TB 454	Hydrogenerator Fire Protection Update
TB 437	Guide for On-line Monitoring of Turbogenerators
TB 480	Guide on Stator Water Chemistry Management
TB 470	Life Extension of Large Electric Motors in Nuclear Power Plants
TB 469	State of the Art in Efficiency of Hydrogenerators Commissioned since 1990
TB 454	Hydrogenerator Fire Protection Update
TB 437	Guide for On-line Monitoring of Turbogenerators
WR A1-34	Testing voltage of doubly-fed asynchronous generator-motor rotor windings for pumped storage system [ELECTRA 306]

All of the above TBs are available for download from www.e-cigre.org

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A2

Power Transformers and Reactors

Within its technical field of activity, Study Committee A2 addresses topics throughout the asset management life-cycle phases; from conception through research, design, production, deployment, operation, and end-of-life.



A2 Power Transformers and Reactors



Principal areas of interest

At all stages, technical, safety, economic, environmental, and social aspects are addressed as well as interactions with, and integration into, the evolving power system and the environment.

All aspects of performance, specification, testing, and the application of testing techniques are within scope, with a specific focus on the impact of changing interactions and demands due to evolution of the power system. Life cycle assessment techniques, risk management techniques, education and training are also important aspects.

Within this framework additional specific areas of attention include:

- Theory principles and concepts, functionality, technology development, design, performance and application of materials, efficiency.
- Manufacturing, quality assurance, application guidance, planning, routing and location, construction, installation, erection, installation.
- Reliability, availability, dependability, maintainability and maintenance, service, condition monitoring, diagnostics, restoration, repair, loading, upgrading, uprating.
- Refurbishment, re-use/re-deployment, deterioration, dismantling, disposal.



Forthcoming events

- **3rd SEERC Conference 2020:** Vienna, Austria; May 30th to June 6th, 2022.
- **CIGRE Paris Session 2022:** August 28th to September 2nd.
- **CIGRE Workspot X (regional colloquium):** Foz do Iguaçu, Brazil; November 27th to 30th, 2022.
- **CIGRE Study Committee A2 Colloquium:** Split, Croatia, October 2023.



Main areas of attention

The technical field of activity of Study Committee A2 is:

- Power transformers; including industrial, dc converter, and phase-shifting transformers.
- Reactors: including shunt, series and saturated.
- Transformer components: including bushings, tap changers and accessories.
- Lower voltage applications including distribution, renewable energy systems, traction, small industrial units.
- Digitalisation technologies including databases, artificial intelligence, modelling, and digital twins applied to transformer lifecycle management and operation.

A2 Power Transformers and Reactors

Topics of Working Groups

JWG A2/C4.52	High-frequency transformer and reactor models for network studies
WG A2.54	Power transformer audible sound requirement
WG A2.55	Transformer life extension
WG A2.56	Power transformer efficiency
WG A2.57	Effects of DC bias on power transformers
WG A2.58	Installation and pre-commissioning of transformers and shunt reactors
WG A2.60	Dynamic thermal behaviour of power transformers
WG A2.62	Analysis of AC transformer reliability
WG A2.63	Transformer impulse testing
WG A2.64	Condition of cellulose insulation in oil immersed transformers after factory acceptance test
JWG A2/D2.65	Transformer digital twin - Concept and future perspectives
JWG A2/D1.66	Breathing systems of liquid filled transformers and reactors
JWG A2/D1.67	Guideline for online Dissolved Gas Analysis monitoring

Latest publications

TB 857	On-site assembly, on-site rebuild and on-site high voltage testing of power transformers
TB 861	Improvements to PD measurements for factory and site acceptance tests of power transformers

Both of the above TBs are available for download from www.e-cigre.org

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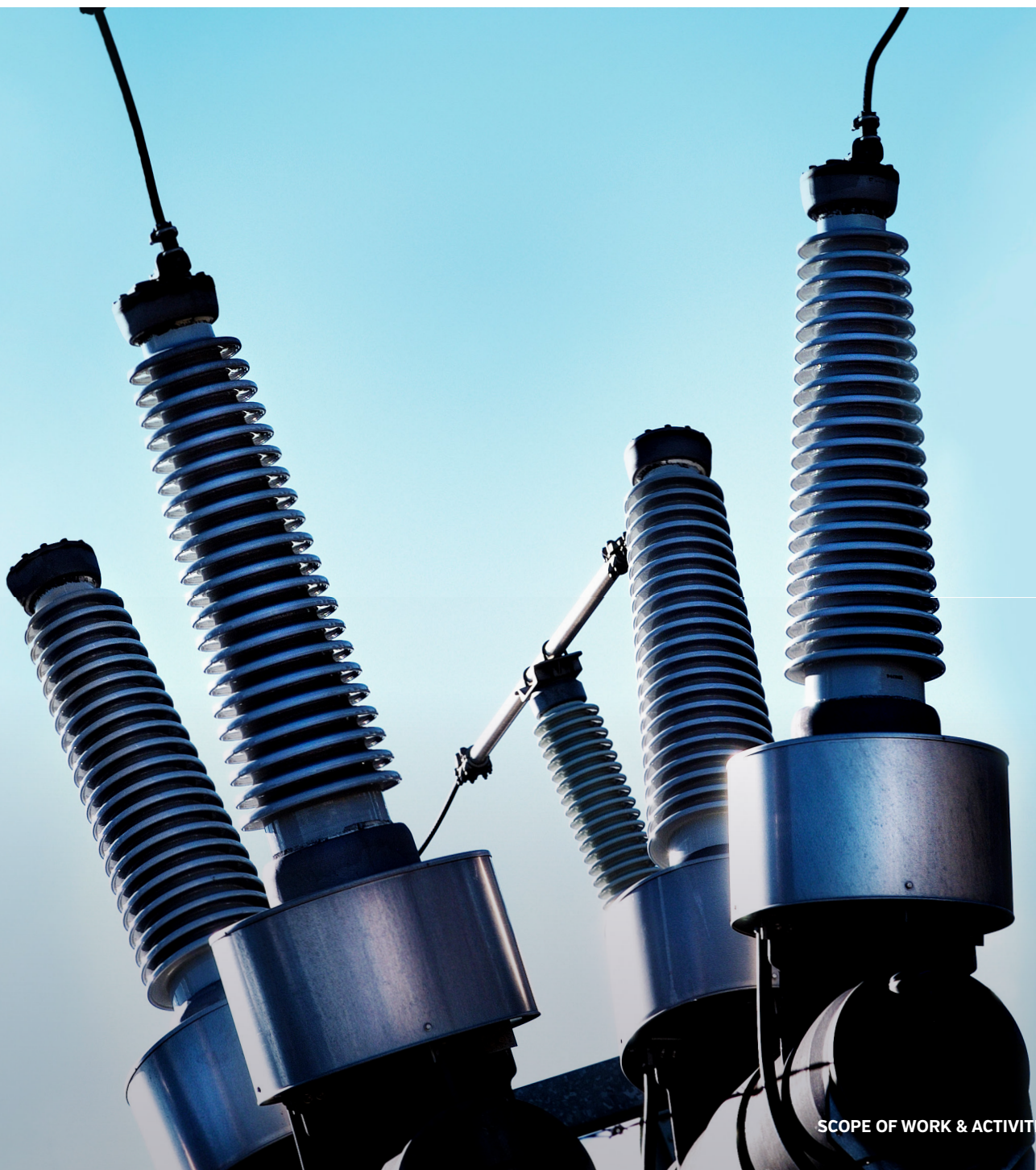
Secretary Marc Foata – m.foata@reinhausen.com



Transmission and Distribution Equipment

A3

The scope of SC A3 covers the whole life cycle of AC and DC T&D Equipment. This includes theory, development, design, performance, testing, installation, operation and maintenance of all switching devices, current limited fuses, surge arrestors, capacitors, busbars, instrument transformers and other equipment not covered under other study committees.



A3 Transmission and Distribution Equipment



Principal areas of interest

- Innovative design and technologies for changing network conditions [e.g. DC circuit breakers, higher ratings, smaller, smarter, environmental friendly].
- Focus on environment and sustainability [e.g. lower carbon footprint of T&D equipment with alternative solutions to sulfurhexafluorid].
- Incorporation of intelligence into T&D equipment [e.g. controlled switching].
- Impact of inverter-based technologies on T&D equipment.
- Advanced, high accuracy sensors, monitoring and diagnostics of T&D equipment.
- New and improving testing techniques.
- Reliability assessment and lifecycle management of ageing equipment.
- More resilient equipment for harsh conditions, [e.g. flooding, strong winds, ice storms, off-shore].
- Digital twins, machine learning, virtual and augmented reality.



Future events

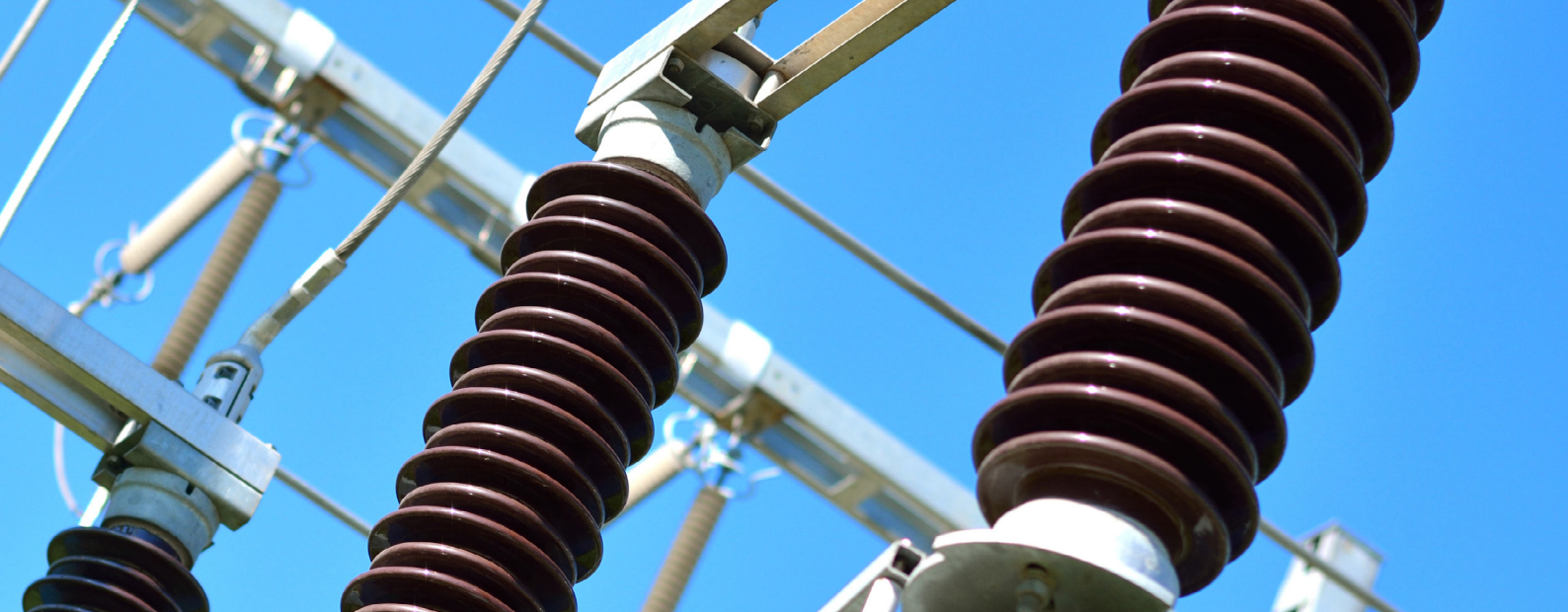
- **CIGRE Paris Session 2022:** August, Paris France.
- **CIGRE Colloquium 2023:** June, UK.
- **CIGRE Session 2024:** August, Paris France.



Main areas of attention

SC A3 provides the information on new technologies, improved specifications, reliability, and lifecycle management of transmission and distribution equipment. This scope is well suited to the various technical needs of utilities that require technical and sustainable solutions for emerging problems and challenges in changing network conditions.

SC A3 increases its educational and tutorial activities on all relevant subjects not only within the CIGRE community but also to IEEE, IEC, and many related international conferences and exhibitions.



Topics of Working Groups

WG A3.39	Application and field experience with Metal Oxide Surge Arresters
WG A3.40	Technical Requirements and Testing Recommendations for MV DC switching equipment at distribution levels
WG A3.41	Interrupting and switching performance with SF6 free switching equipment
WG A3.42	Failure analysis and risk mitigation for recent incidents of AIS instrument transformers
WG A3.43	Tools for lifecycle management of T&D switchgear based on data from condition monitoring systems
WG A3/A2/A1/B1.44	Consequence of High Voltage Equipment operating exceeding highest system voltages
WG A3.45	Methods for identification of frequency response characteristic of voltage measurement systems
WG A3.46	Generator Circuit-Breakers: review of application requirements, practices, in-service experience and future trends
WG A3/B3.60	User guide for non-SF6 gases and gas mixtures in Substations
WG A3.47	Lifetime Management of Medium Voltage Indoor Switchgear

Latest publications

TB 830	Application and Benchmark of Multiphysics Simulation Tools for Temperature rise calculations
TB 817	Shunt capacitor switching in distribution and transmission systems
TB 816	Substation equipment overstress management
TB 757	Guidelines and best practices for the commissioning and operation of controlled switching projects
TB 737	Non-intrusive methods for condition assessment of distribution and transmission switchgear
TB 725	Ageing High Voltage substation equipment and possible mitigation technique
TB 716	System conditions for and probability of Out-of-Phase
TB 696	MO varistors and surge arresters for emerging system conditions
TB 693	Experience with equipment for Series / Shunt Compensation
TB 683	Technical requirements of state-of-the-art HVDC switching equipment
TB 624	Influence of Shunt capacitor bank on CB fault interruption Duties
TB 602	Tools for simulation of the internal arc effects in HV & MV switchgear
TB 589	Vacuum Switchgears at Transmission voltages
TB 570	Switching Phenomena for EHV and UHV equipment
TB 544	Metal oxide [MO] surge Arresters - Stresses and Test Procedures
TB 514	Reliability of high voltage equipment - Part 6: Best practices
TB 513	Reliability of high voltage equipment - part 5: Gas Insulated switchgear
TB 512	Reliability of high voltage equipment - part 4: Instrument Transformers
TB 511	Reliability of high voltage equipment - part 3: DS & Earthing switches
TB 510	Reliability of high voltage equipment - part 2: SF6 Circuit Breakers
TB 509	Reliability of high voltage equipment - part 1: General Matters
TB 497	Applications and Feasibility of Fault Current limiters in power systems

All of the above TBs are available for download from www.e-cigre.org

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B1

Insulated Cables

The scope of SC B1 covers the whole Life Cycle of AC and DC Insulated cables for Land and Submarine Power Transmission, which means theory, design, applications, manufacture, installation, testing, operation, maintenance, upgrading and uprating, diagnostics techniques.



B1 Insulated Cables



Principal areas of interest

- **Underground and Submarine Cables**, AC and DC, with growing focus on submarine and HVDC underground.
- Accessories, with the inclusion of new monitoring equipment, Installation Techniques, New Testing and Diagnosis Techniques, the use of Artificial Intelligence for supervision.
- New materials, new applications.
- Environmental, safety, sustainability aspects for cable systems.



Current activities

- Preparation of Recommendations for further Standardization by IEC.
- Tutorials and Webinars for Technical and Non-Technical Audiences.



Key projects / forthcoming events

Reinforced cooperation with other Study Committees and external organizations in order to anticipate interface issues. Main focus is around “Power Systems of the Future”. Most discussed topics are about HVDC and Submarine cables, technical and environmental aspects. Webinars and tutorials are the bases for the educational program of the Study Committee B1.



Main areas of attention

The activities of CIGRE Study Committee B1 cover all types of AC and DC insulated cable systems for power transmission, distribution and generation connections on land and in submarine applications.

Within its technical field of activity, Study Committee B1 addresses topics throughout the asset management life-cycle phases: from conception, through research, development, design, production, deployment, operation and end-of life.

At all stages, technical, safety, economic, environmental and social aspects are addressed as well as interactions with, and integration into, the evolving power system and the environment. All aspects of performance, specification, testing and the application of testing techniques are within scope, with a specific focus on the impact of changing interactions and demands due to evolution of the power system. Life cycle assessment techniques, risk management techniques, education and training are also important aspects.



Within this framework additional specific areas of attention include:

- Theory, principles and concepts, functionality, technological development, design, performance and application of materials, efficiency.
- Manufacturing, quality assurance, application guidance, planning, routing and location, construction, erection, installation.
- Reliability, availability, dependability, maintainability and maintenance, service, condition monitoring, diagnostics, restoration, repair, loading, upgrading, uprating.
- Refurbishment, re-use/re-deployment, deterioration, dismantling, disposal.
- Safety issues : assessment, prevention and mitigation of risks, at all different lifetime phases of cable systems.

At the end of 2021, around 400 experts worldwide are participating to the work of SC B1.

B1 Insulated Cables

Topics of Working Groups

WG B1.54	Behavior of Cable Systems under Large Disturbances (Earthquake, Storm, Flood, Fire, Landslide, Climate change)
WG B1.56	Cable Ratings Verification
WG B1.58	Asset Management in MV Cables Networks
WG B1.61	Installation of HV Cable Systems
WG B1.64	Evaluation of losses in armoured three core power cables
WG B1.65	Installation of offshore Cable Systems
WG B1.67	Loading pattern on windfarm array and export cables
WG B1.68	Condition evaluation and lifetime strategy of HV cable systems
JWG B1/C4.69	Recommendations for the insulation coordination on AC cable systems
WG B1.70	Recommendations for the use and the testing of optical fibres in submarine cable systems
WG B1.71	Guidelines for safety risk management in cable systems
WG B1.72	Cable rating verification – application in complex situations
WG B1.73	Recommendations for the use and the testing of Fibre Optic Cables in land cable systems
JWG B1/B3.74	Recommendations for a performance standard of insulated busbars
JWG B1/D1.75	Interaction between cable and accessory materials in HVAC and HVDC application
WG B1.76	Enhancing Quality Assurance/Quality Control Procedures for (E)HV Cable Systems
JWG B1/B3/D1.79	Recommendations for dielectric testing of HVDC gas insulated system cable sealing ends
WG B1.80	Guidelines for Site Acceptance Tests of Distributed Temperature Sensing (DTS) and Distributed Acoustic Sensing (DAS) Systems when used for power cable systems monitoring
WG B1.82	MVDC Cable System Requirements
WG B1.83	Grounding aspects for HVDC land cable connections
WG B1.86	Assessment, Prevention and Mitigation of Safety Risk in Cable Systems
WG B1.87	Finite Element Analysis for Cable Rating Calculations

Latest publications

Green Book	Accessories for HV and EHV Extruded Cables - Volume 1: Components
Green Book	Electricity Supply Systems of the Future (Chapter on Insulated Cables)
TB 862	Recommendations for mechanical testing of submarine cables for dynamic applications
TB 853	Recommendations for testing DC lapped cable systems for power transmission at a rated voltage up to and including 800 kV
TB 852	Recommendations for testing DC extruded cable systems for power transmission at a rated voltage up to and including 800 kV
TB 841	After laying tests on AC and DC cable systems with new technologies
TB 825	Maintenance of HV Cable Systems
TB 815	Update of service experience of HV underground and submarine cable systems
TB 801	Guidelines for safe work on cable systems under induced voltages or currents
TB 797	Sheath bonding systems of AC transmission cables - design, testing, and maintenance
TB 784	Standard design of a common, dry type plug-in interface for GIS and power cables up to 145 kV
TB 773	Fault Location On Land And Submarine Links (AC & DC)
TB 770	Trenchless technologies
TB 758	Test regimes for HV and EHV cable connectors
TB 756	Thermal monitoring of cable circuits and grid operators' use of dynamic rating systems
TB 748	Environmental issues of high voltage transmission lines in urban and rural areas
TB 722	Recommendations for additional testing for submarine cables from 6 kV (Um = 7.2 kV) up to 60 kV (Um = 72.5 kV)
TB 680	Implementation of Long AC HV & EHV Cable Systems
TB 640	A guide for Rating Calculations of Insulated Cables
TB 623	Recommendations for Mechanical Testing of Submarine Cables
TB 610	Off shore generation cable connections
TB 531	Cable systems Electrical Characteristics
TB 490	Recommendations for testing of long AC submarine cables with extruded insulation for System Voltage above 30[36] to 500[550] kV

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Overhead Lines

Study Committee B2 covers the design, construction and operation of overhead lines. This includes the mechanical and electrical design and experimental validation of new line components [e.g. conductors, ground wires, insulators, accessories, structures and their foundations], the study of in-service line performance and assessment of aged line components, line maintenance, the refurbishment and life extension as well as upgrading and uprating of existing overhead lines.

Overhead lines play an important role for the Power System of the Future and its challenges. The activities of SC B2 are full in line with this important aspect of CIGRE's mission.

B2



B2 Overhead Lines



Principal areas of interest

- Route selection.
- Optimized line design.
- Line maintenance & service.
- Refurbishment of existing lines.
- Design specifications.
- Increased power flow of existing lines.
- Asset management guidelines.
- Real-time monitoring systems.
- New materials.
- Sustainability of line components.
- Minimizing the environmental impact of lines.



Current activities

- **CIGRE Paris Session 2022** : August 28th to September 2nd.
- **B2 Annual Meeting at the Paris Session.**



Key projects / forthcoming events

- **CIGRE Paris Session 2022** : August 28th to September 2nd.
- **B2 Annual Meeting at the Paris Session.**



Other specific interests

Strong emphasis on B2 tutorials and the publication of CIGRE Technical Brochures and Green Books.



The Study Committee covers

All aspects of overhead line design (AC and DC), construction and maintenance, including modification of existing lines and environmental considerations.



Specific areas of interest

Electrical Performance

deals with utilization of new and existing overhead power lines including modification of existing lines to allow increased power flow and economic design of new lines.

Towers, Insulators and Foundations

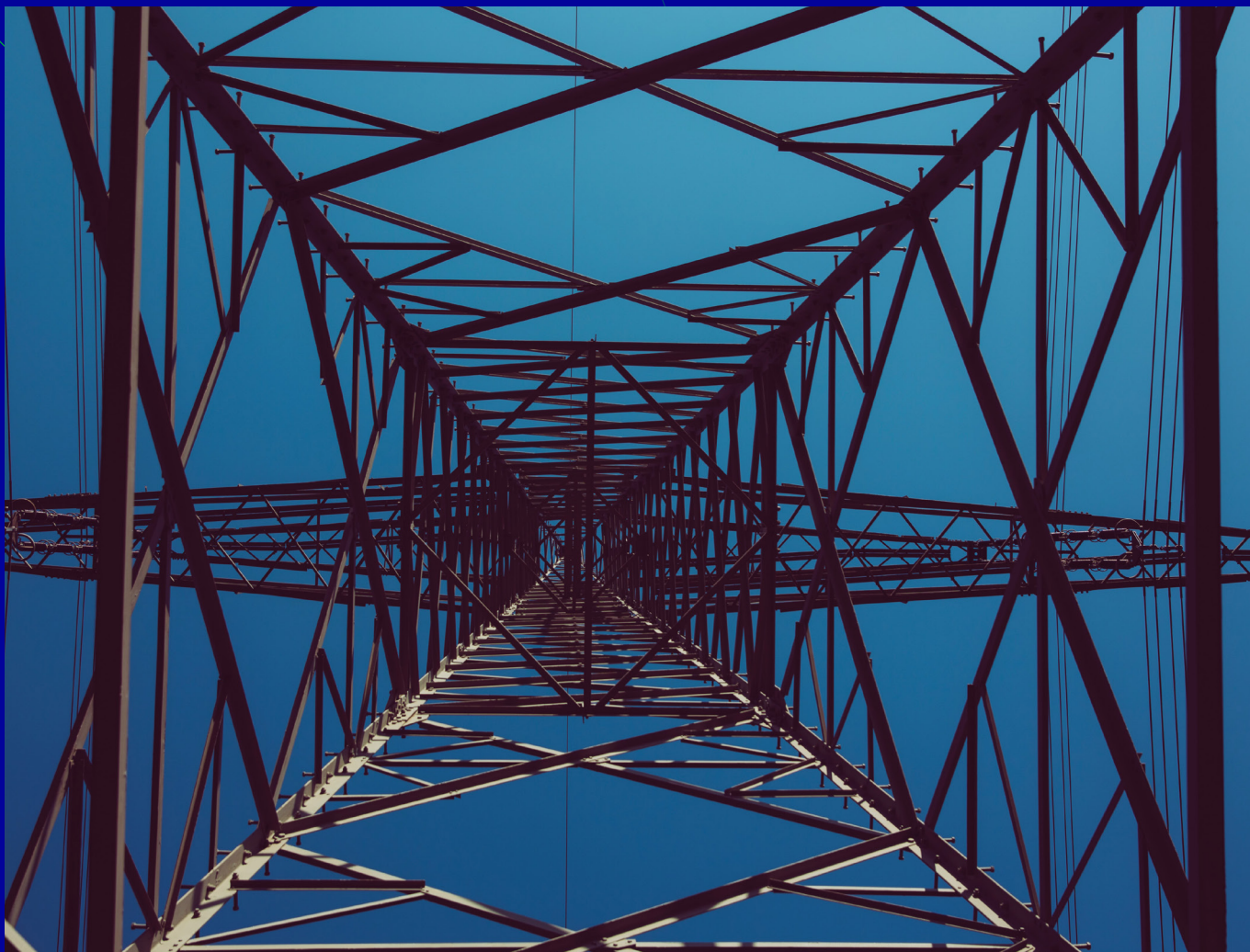
seek to improve diagnostic tools and modeling of in-service components, both dynamic and static foundation & structure loads, repair of corrosion in structures, and evaluation of new materials for line supports.

Conductors and Fittings

covers conductor fatigue and endurance capability, protection against wind induced vibrations, assessment of aged fittings and support in the preparation of standards, e.g. for fittings, conductor self-damping and conductor fatigue.

Asset management

considers electrical and civil aspects of line reliability and availability, including climatic loads, electrical clearances and live-line working.



Topics of Working Groups

B2.50	Safe handling of fittings and conductors
B2.57	Survey of Operational Composite Insulators Experience & Applications
B2.59	Forecasting dynamic line ratings
B2.60	Affordable Overhead Transmission Lines for Sub-Saharan Countries
B2.64	Inspection and Testing of Equipment and Training for Live-Line Work on Overhead Lines, Anchors and Foundations
B2.65	Detection, Prevention and Repair of Sub surface Corrosion in Overhead Line Supports
B2.66	Safe handling and installation guide for high temperature low sag (HTLS) conductors
B2.67	Assessment and Testing of Wood and Alternative Material Type Poles
B2.68	Sustainability of OHL conductors and fittings – Conductor condition assessment and life extension
B2.70	Aircraft warning markers and bird flight diverters for Overhead Lines – Experience and recommendations
B2.71	Recommendations for Interphase Spacers of Overhead Lines
JWG B2/D2.72	Condition Monitoring and Remote Sensing of Overhead Lines (lead B2)
B2.73	Guide for Prevention of Vegetation Fires Caused by Overhead Line Systems
B2.74	Use of unmanned aerial vehicles (UAVs) for assistance with inspection of overhead power lines
B2.75	Application guide for insulated and un-insulated conductors used on medium and low voltage overhead lines
JWG B2/C4.76	Lightning & Grounding Considerations for Overhead Line Rebuilding and Refurbishing Projects, AC and DC, (lead B2)
B2.77	Risk Management of Overhead Line networks: A model for identification, evaluation and mitigation of operational risks
B2.78	Use of High Temperature Conductors in New Overhead Line Design
B2.79	Enhancing Overhead Line Rating Prediction by Improving Weather Parameters Measurements
B2.80	Numerical Simulation of electrical fields on AC and DC Overhead Line Insulator Strings
B2.81	Increasing the Strength Capacity of Existing Overhead Transmission Line Structures
B2.82	Overhead Line Foundations for Difficult Soil and Geological Conditions
B2.83	Mitigation of induced noises by corona activity in overhead AC and DC lines
B2.84	Assessment of the methodologies to analyse wind induced overhead line conductors motion: applications and limitations
B2.85	Emergency Restoration Systems for Overhead Lines - Guide for Design
B2/C1.86	Approach for Asset Management of Overhead Transmission Lines
B2.87	Live line and vicinity working on overhead lines: Safe Management Guidelines

B2 Overhead Lines

Latest publications

GREEN BOOKS	
Green Book	Techniques for Protecting Overhead Lines in Winter Conditions
Green Book	Technical Brochure: Modelling of Vibrations of Overhead Line Conductors
Green Book	Overhead Lines
TECHNICAL BROCHURES	
TB 865	Inspection and testing of tools, equipment and training for live-line work on overhead lines, February 2022
TB 838	Coatings for protecting overhead power networks against icing, corona noise, corrosion and reducing their visual impact, June 2021
TB 837	Coating for improvement of electrical performance of outdoor insulators under pollution conditions, June 2021
TB 831	Compact DC overhead lines, March 2021
TB 828	Vibration modelling of High Temperature Low Sag conductors – Self-damping characterization
TB 818	Transmission Lines with Fiber Reinforced Polymer (FRP) Composites
TB 809	Dynamic loading effects on overhead lines: Impact on structures
TB 792	Compact AC overhead lines
TB 788	Dynamic loading effects on overhead lines- Impact on foundations
TB 767	Vegetation fire characteristics and the potential impacts on overhead line performances
TB 763	Conductors for the Uprating of Existing Overhead Lines
TB 748	JWG C3-B1-B2 Environmental issues of high voltage transmission lines for rural and urban areas
TB 746	JWG D2-B2.39 Design, deployment and maintenance of Optical Cables associated to Overhead HV Transmission Lines
TB 744	Management Guidelines for balancing in-house and outsourced Overhead Transmission Line Technical Expertise
TB 731	The Use of Robotics in Assessment and Maintenance of Overhead Lines
TB 708	Guide on repair of conductors and conductor-fitting systems
TB 695	Experience with the mechanical performance of non-conventional conductors
TB 694	Ground potential rise at overhead AC transmission line structures during power frequency faults
TB 653	Safe Design Tension for Single Conductors Fitted With Elastomer Cushioned Suspension Units
TB 645	Meteorological Data for Assessing Climatic Loads on Overhead Lines
TB 643	Guide to the Operation of Conventional Conductor Systems above 100°C
TB 638	Guide to Overall Line Design
TB 631	Coatings for Protecting Overhead Power Network Equipment in Winter Conditions
TB 601	Guide for Thermal Rating Calculations of Overhead Lines
TB 585	Guidelines for the management of risk associated with severe climatic events and climate change on overhead lines
TB 583	Guide to the Conversion of existing AC lines to dC operation
TB 561	Live Work - A Management Perspective
TB 545	Assessment of In-service Composite Insulators by using Diagnostic Tools
TB 516	Geotechnical Aspects of Overhead Transmission Line Routing - An Overview
TB 515	Mechanical Security of Overhead Lines Containing Cascading Failures and Mitigating their Effects
TB 498	Guide for Application of Direct Real-Time Monitoring Systems
TB 485	Overhead Line Design Guidelines for Mitigation of Severe Wind Storm Damage
CIGRE SCIENCE AND ENGINEERING	
CSE nr. 20	Development of Innovative Test Procedure for Evaluation of Adhesion of Core-Housing of Composite Insulators: from Root Cause of Failures in Service to Reproducible Test Procedure
CSE nr. 21	A numerical procedure for the analysis of the buckling and post-buckling behavior of steel lattice towers in overhead transmission lines
CSE nr. 21	Explosively Compressed Connector Failure Mode Requires New Rigorous Inspection Method
CSE nr. 21	Development of Innovative Test Procedure for Evaluation of Adhesion of Core-Housing of Composite Insulators
CSE nr. 22	A Semi-Autonomous Cost Effective Erection Method for Overhead Line Towers
CSE nr. 22	Estimation of 'wet conductor' audible corona noise from I-type suspension insulator strings at HVAC overhead power lines
CSE nr. 22	Estimation of cumulative loss of strength of fittings for high temperature low sag overhead line conductors over their service life

All of the above publications are available for download from www.e-cigre.org

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Substations and electrical installations

B3

Study Committee B3 [or SC B3] addresses a wide range of topics that apply to the entire life cycle of substation assets; from conception, through research, development, design, production, deployment, maintenance, operation, and end-of-life and emission management. Our activities address all stages of asset life and include not only technical aspects but also safety, economic, environmental, and social aspects. All issues of performance, specification, testing, monitoring, and the application of diagnostic testing techniques are within scope, with a specific focus on the impact of changing demands for substations due to Increased impact of clean energy transition. Safety and life cycle condition assessment techniques, health indexing, risk management techniques, knowledge transfer and education are also important topics for our work.



B3 Substations and electrical installations



Principal areas of interest

Our principal areas of interest include the following:

- New substation concepts including hybrid solutions and new applications to support energy transitions, and reduction of carbon footprint impact by new technologies.
- Substation ownership issues including human resource and training needs, in-service support, including quality control and maintenance. Management of assets including environmental, health, safety, and security.
- Life-cycle management of substations, including renovation, maintenance, monitoring, reliability and sustainability issues.
- Integration of intelligence for digitalization on substations including new digital technologies (Artificial Intelligence, Internet of Things, 3-Dimensional technology etc.) and applications to be used in all types of substations, increased use of advanced information and communication technologies.



Current activities

SC B3 has more than 360 experts in 13 active Working Groups, 6 Joint Working Groups (4 B3 lead and 2 led by other SCs) and 1 SF6 Green book project, focusing on activities in 4 different topic streams relating to the following substation technical and operational areas:

- Substation Concepts and Developments.
- Gas insulated substations (includes gas insulated lines).
- Air Insulated Substations.
- Substation Management & Digital Integration.



Key projects / forthcoming events

• CIGRE Paris Session 2022, including

- B3 tutorial "Asset health indices for equipment in existing substations" on Tuesday August 30th 2022.
- A3&B3 joint workshop "SF6 alternatives for T&D substations and its switchgear" on Wednesday August 31st 2022.
- B3 workshop "Knowledge transfer of substation engineering and experiences" on Friday September 2nd 2022.

- **CIGRE Brazil**, X International WORKSPOT on Power Transformers, Equipment, Substation and Materials, Foz do Iguaçu, Paraná, Brazil, November 27th-30th 2022.

• Regular Working Groups and other meetings.



Other specific interests

- SC B3 maintains close relationships with SC A2 - Power transformers and reactors, SC A3 - Transmission and distribution equipment, SC B1 - Insulated cables, SC B5 - Protection and automation, SC C3 - Power system environmental performance, C6 - Active distribution systems and distributed energy resources and D1 - Materials and emerging test techniques.
- SC B3 members support CIGRE work and activities in extending the electricity system in sub-Saharan Africa and developing countries globally.



Transmission and Distribution substations play a key role as active nodes within electrical networks, providing the ability for the network to deliver reliable energy with high availability.

SC B3 aims to serve a broad range of target groups in the electric power industry whose needs include the technical, economic, environmental, and social aspects of substations.

The recently revised SC B3 mission is to:

- Facilitate and promote the progress of substation engineering and the international exchange of information and knowledge in the substations field.
- Add value to this information and knowledge by synthesizing state-of-the-art practices and developing recommendations and guidance.

Major objectives for SC B3 include improving reliability and availability, optimizing substation asset management, identifying best value solutions, and minimizing environmental impact while recognizing social needs and priorities in facilitating the sustainable development of substations.

In its work, SC B3 maintains close liaison and working relationships with other study committees and constitutes a bridge between the "system" study committees (the C-committees) and the more specialized "equipment" committees (the A-committees).



Topics of Working Groups

The list of active working groups in Study Committee B3 is continually evolving to meet the needs of our stakeholders. The current working groups include the following:

WG B3.41*	Mobile substations incorporating HV GIS - Design Aspects
WG B3.49*	Review of busbar component reliability
WG B3.50	Concepts for onsite testing of GIS
WG B3.52	Neutral grounding method selection and fault handling for substations in the distribution grid
WG B3.54	Earthing system testing methods
WG B3.56*	Application of 3D technologies in substation engineering works
WG B3.57	Impact on Engineering and Lifetime Management of Outdoor HV GIS
WG B3.58	Knowledge transfer of substation engineering and experiences
JWG B3/A3.59	Guidelines for SF6 end-of-life treatment of T&D equipment (>1kV) in Substations
JWG B3/A3.60	User guide for non-SF6 gases and gas mixtures in Substations
WG B3.61	Risk and asset health based decision making in existing substations
JWG B3/D2.62	Life-long Supervision and Management in Substations by Sensors, Mobile Devices and ICTs
JWG B3/D1.63	Guideline for assessing the toxicity of used SF6 gas onsite and in the lab of T&D equipment above 1 kV in substations
WG B3.64	Guidelines on Optimising Seismic Design of Substations for Power Resiliency
JWG B1/B3/D1.79	Recommendations for dielectric testing of HVDC gas insulated system cable sealing ends
JWG B1/B3.74	Recommendations for a performance guideline of Polymer Insulated Busbars
Special project*	SF6 Green Book

WG B3.XX* plan to publish Technical Brochure in 2022.

Go to https://www.cigre.org/article/GB/news/the_latest_news/cigre-active-working-groups--call-for-experts for the latest info

Latest publications

As each working group completes its work a Technical Brochure is produced and available for reference. These documents are a valuable resource for the industry. The most recent publications include:

TB 834	Reliability analysis and design guidelines for LV AC auxiliary systems
TB 858	Asset health indices for equipment in existing substations
TB 869	Design guidelines for substations connecting battery energy storage solutions (BESS)
TB 870	Service continuity guide for HV GIS above 52kV
WG B3.53	Guidelines for fire risk assessment and mitigation in substations

All of the above TBs are available for download from www.e-cigre.org

B3 Substations and electrical installations



Tutorials

SC B3 provides tutorials and expert presenters on a range of important topics. These tutorials can be delivered anywhere around the globe to add value to industry conferences and other events. The list of Tutorials is continuously growing and can be tailored for your specific event requirements. The following topics are available for your event:

- Savings through optimised maintenance of air-insulated substations.
- Air-insulated substation design for severe climate conditions.
- Upgrading and uprating of Substations.
- Obtaining [business] value from online condition monitoring.
- Standardisation versus innovation in substation design.
- Application guidelines for turn-key projects.
- Circuit configuration optimisation.
- Responsible use of SF₆ – challenges and options.
- SF₆ analysis for AIS, GIS and MTS substation condition assessment.
- High voltage off-shore substations.
- Considerations for AC Collector systems and substations connected with HVDC wind installations.
- Contemporary design solutions for low-cost substations.
- Substation earthing system design optimisation through the application of quantified risk analysis.
- Grounding and insulation coordination.
- Managing Risk in Substations.
- Expected impact of future grid concept on substation management.
- Application of non-SF6 gases or mixtures in MV and HV GIS.
- Guidelines for Safe Work Methods in Substations.
- Application of Robotics in Substations.
- Impact of LPIT applications on HV Gas Insulated Switchgear.
- Substation servicing and supervision using mobile devices and smart sensing.
- Reliability analysis and design guidelines for LV AC auxiliary systems.
- Asset health indices for equipment in existing substations.
- Service continuity guide for the maintenance, repair and extension of HV GIS.
- Design guidelines for substations connecting battery energy storage solutions [BESS].
- Guidelines for fire risk assessment and mitigation in substations.

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SC B3 website <https://b3.cigre.org/>

DC Systems and Power Electronics

B4

The scope of Study Committee B4 includes the applications of Direct Current (DC) and Power Electronics (PE) in both transmission and distribution systems. The study committee also addresses DC Converters for the integration of distributed renewable (PVs) and energy storage as well as power quality control. SC B4 covers the full spectrum of DC systems and PE devices including specification, design, implementation, operation, maintenance, refurbishment of DC, FACTS and power electronic devices from transmission to distribution systems.



B4 DC Systems and Power Electronics

As the key technology enabler, the DC systems together with other PE based devices continue to play a significant role during the transition from a physically inertial system to a de-carbonized low and virtually inertial system. As shown in **Figure 1**, after a peak in 2017, the installed DC power capacity reached to about 315GW in year 2022. Both DC capacity and number of DC projects will most likely be double by the year 2050 as projected in **Figure 1** and **Figure 2**.

Figure 1 : DC Power Transmission Capacity since 1970

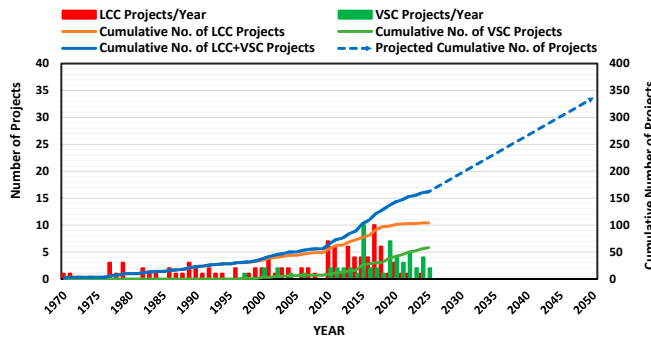
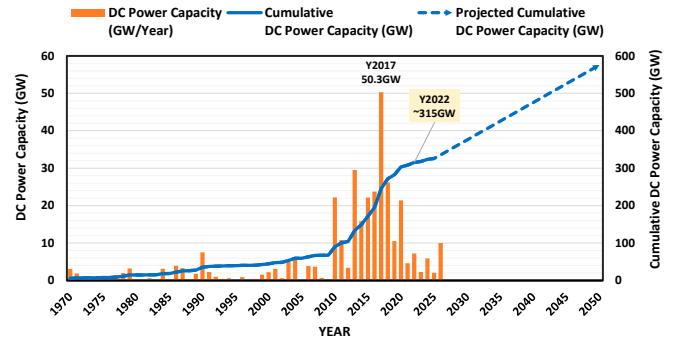


Figure 2 : DC Projects since 1970



Principal areas of interests

Our principal areas of interests include the following

- Application of increased power and voltage rating of VSC HVDC for both offshore and onshore renewable energy interconnections.
- Development of the technologies of inverters with Grid-Forming control capabilities to improve and enhance the reliability and stability of the PE dominated power system with integration of growing renewable generations and battery storage resources.
- Implementation of Interoperability of HVDC systems constructed by various HVDC OEMs for flexible and reliable operation and control of largely interconnected power system through HVDC system.
- Tackling the technical challenges associated with increasing penetration of power electronics system/devices in the power system.
- Application of higher power and voltage rating of FACTS device to support the flexible transmission of AC power, improve voltage stability and the change of generation patterns within the ac networks.
- Application of DC technologies and PE in distribution system for better power quality control.



Current Activities

The members of SC B4 come from manufacturers, utilities, transmission system operators (TSOs), distribution system operators (DSOs), consultants and research institutes. SC B4 has 539 experts from 39 countries including 48 women engineers. The B4 members are actively involved in 18 Working Groups including 4 JWG and 1 task force. SC B4 is also developing a Green book on HVDC. The activities of SC B4 WGs focus on the following areas.

- Technical aspects associated with HVDC in low inertia system.
- Insulation coordination of VSC converters and DC cables.
- Hybrid LCC/VSC technology.
- Interoperability in HVDC system.
- DC system/converter modelling.
- DC grids including DC breakers, fault current limiting.
- Operation and maintenance of HVDC/FACTS.
- PE in distribution system.



Key projects / forthcoming events

- SC B4 has the following key events at CIGRE Paris Session 2022.
- Tutorial "DC grid benchmark models for system studies" on August 29th 2022.
- SC B4 Group Discussion Meeting (GDM) on August 31st 2022.
- SC B4 Study Committee meeting on September 1st 2022.
- Symposium CIGRE Symposium, Cairns, Australia, September 4th-7th 2023.



Topics of Working Groups

B4.64	Impact of AC System Characteristics on the Performance of HVDC schemes
B4.69	Minimizing loss of transmitted power by VSC during Overhead line fault
B4.71	Application guide for the insulation coordination of Voltage Source Converter HVDC (VSC HVDC) stations
B4/B1/C4.73	Surge and extended overvoltage testing of HVDC Cable Systems
B4.79	Hybrid LCC/VSC HVDC Systems
C4/B4.52	Guidelines for Sub-synchronous Oscillation Studies in Power Electronics Dominated Power Systems
B4/A3.80	HVDC Circuit Breakers - Technical Requirements, Stresses and Testing Methods to investigate the interaction with the system
B4.81	Interaction between nearby VSC-HVDC converters, FACTS devices, HV power electronic devices and conventional AC equipment
B4.82	Guidelines for Use of Real-Code in EMT Models for HVDC, FACTS and Inverter based generators in Power Systems Analysis
B4.84	Feasibility study and application of electric energy storage systems embedded in HVDC systems
B4.85	Interoperability in HVDC systems based on partially open-source software
B4/A3.86	Fault Current Limiting Technologies for DC Grids
B4.87	Voltage Source Converter (VSC) HVDC responses to disturbances and faults in AC systems which have low synchronous generation
TF B4/B1 88	Insulation coordination procedure for DC cable systems in HVDC stations with Voltage Source Converters (VSC)
B4.89	Condition Health Monitoring and predictive maintenance of HVDC Converter Stations
B4.90	Operation and maintenance of HVDC and FACTS Facilities
B4.91	Power-electronics-based transformer technology, design, grid integration and services provision to the distribution grid
B4.92	STATCOMs at Distribution Voltages

Latest publications

Technical Brochures (2021)	
B4.76	DC/DC converters in HVDC Grids and for connections to HVDC systems [TB 827]
B4.70	Guide for Electromagnetic Transient Studies involving VSC converters [TB 832]
B4.75	Feasibility Study for assessment of lab losses measurement of VSC valves [TB 844]
B4.78	Cyber Asset Management for HVDC/FACTS Systems [TB 847]
AG.04	HVDC transformer failure survey results from 2013 to 2020 [TB 859]
Technical Brochures (2022)	
B4.74	Guide to Develop Real Time Simulation Models (RTSM) for HVDC Operational Studies [TB 864]
B4.83	Flexible AC Transmission Systems (FACTS) controllers' commissioning, compliance testing and model validation tests [TB xxx, soon to be issued]
C6/B4.37	Medium Voltage DC distribution systems [TB xxx, soon to be issued]

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B5

Protection and Automation

Focuses on Protection, Control, Monitoring and Metering, and aims to cover the whole Power system, end to end related to this topic, from transmission, to distribution systems, including generation and HVDC systems.



B5 Protection and Automation



The Mission of SC B5 is as follows

The mission of SC B5 is to facilitate and promote the progress of engineering and the international exchange of information and knowledge in the field Protection and Automation, focused on Protection, Control, Monitoring and Metering, with the aim to cover the whole Power system, end-to-end, related to this topic. To add value to this information and knowledge by means of synthesizing state-of-the-art practices and developing recommendations.



The vision of SC B5 is as follows, the terms

- Be recognized as the leading worldwide reference on Protection, Control, Monitoring and Metering [Automation].
- Be the provider of a global perspective on the issues and challenges facing the Protection, Control, Monitoring and Metering of electrical power system.
- Be an independent analyzer of different solutions and provider of high quality unbiased publications about Protection, Control, Monitoring and Metering.



Scope of SC B5

Within its technical field of activity, Study Committee B5 addresses topics throughout the asset management life-cycle phases; from conception, through research, development, design, production, deployment, operation, and end-of life. At all stages, technical, safety, economic, environmental and social aspects are addressed as well as interactions with, and integration into, the evolving power system and the environment. All aspects of performance, specification, testing and the application of testing techniques are within scope, with a specific focus on the impact of changing interactions and demands due to evolution of the power system. Life cycle assessment techniques, risk management techniques, education and training are also important aspects.



Current activities

The following aspects are of current interest for SC B5:

- Substation Automation and Remote Control covers all aspects of co-ordinated and integrated systems for protection and automation of substation [TM51].
- Protection and Monitoring covers the protection and monitoring of primary plant and circuits, to maintain power system security, to limit plant damage and to ensure the safety of personnel [TM52].
- New Network Requirements covers the design and application of digital technology and modern communication system for the benefit of modern and future networks featuring embedded generation and smart grid techniques [TM53].



Main areas of attention

The activities of CIGRE Study Committee B1 cover all types of AC and DC insulated cable systems for power transmission, distribution and generation connections on land and in submarine applications.

Within its technical field of activity, Study Committee B1 addresses topics throughout the asset management life-cycle phases: from conception, through research, development, design, production, deployment, operation and end-of life.

At all stages, technical, safety, economic, environmental and social aspects are addressed as well as interactions with, and integration into, the evolving power system and the environment. All aspects of performance, specification, testing and the application of testing techniques are within scope, with a specific focus on the impact of changing interactions and demands due to evolution of the power system. Life cycle assessment techniques, risk management techniques, education and training are also important aspects.



Within this framework additional specific areas of attention include:

- Theory, principles and concepts, functionality, technological development, design, performance and application of materials, efficiency.
- Manufacturing, quality assurance, application guidance, planning, routing and location, construction, erection, installation.
- Reliability, availability, dependability, maintainability and maintenance, service, condition monitoring, diagnostics, restoration, repair, loading, upgrading, uprating.
- Refurbishment, re-use/re-deployment, deterioration, dismantling, disposal.
- Safety issues : assessment, prevention and mitigation of risks, at all different lifetime phases of cable systems.

At the end of 2021, around 400 experts worldwide are participating to the work of SC B1.

B5 Protection and Automation



Key projects / forthcoming events

- **Reference book (Green Book)** about standard IEC 61850.
- **CIGRE Paris session 2022** August.
- **PS 1** Addressing protection related challenges in network with low-inertia and low fault-current levels.
- **PS 2** Applications of emerging technology for protection, automation and control.
- **PS 3** Integration of intelligence on substations [Joint PS with B3].
- **CIGRE Symposium Cairns**, September 2023.
- **PS 1** Interoperability for IEDs of different manufacturers integrated in one PAC.
- **PS 2** IEC 61850 engineering & test tools & settings.
- **PS 3** Improvement in fault detection.



Other specific Interests

Technical brochures from finalised working groups in SC B5 in 2021 [eCigre]:

- TB 854, WG B5.52 Analysis and comparison of fault location systems in AC power networks.
- TB 843, WG B5.62 Life Cycle Testing of Synchrophasor Based Systems used for Protection, Monitoring and Control.
- TB 829, JWG C4.B5.41 Challenges with series compensation applications in power systems when overcompensating lines.

Topics of Working Groups

WG B5.48	Protection for developing network with limited fault current capability of generation
WG B5.51	Requirements and Use of Remotely Accessed Information for SAS Maintenance and Operation
WG B5.55	Application of Travelling Wave Technology for Protection and Automation
WG B5.56	Optimization of Protection Automation and Control Systems
WG B5.57	New challenges for frequency protection
WG B5.58	Faster protection and network automation systems: implications and requirements
WG B5.59	Requirements for Near-Process Intelligent Electronic Devices
WG B5.60	Protection, Automation and Control Architectures with Functionality Independent of Hardware
WG B5.63	Protection, Automation and Control System Asset Management
WG B5.64	Methods for Specification of Functional Requirements of Protection, Automation, and Control
WG B5.65	Enhancing Protection System Performance by Optimising the Response of Inverter-Based Sources
WG B5.68	Optimisation of the IEC 61850 Protection, Automation and Control Systems (PACS) Engineering Process and Tools
WG B5.69	Experience gained and Recommendations for Implementation of Process Bus in Protection, Automation and Control Systems (PACS)
WG B5.70	Reliability of Protection Automation and Control System (PACS) of power systems – Evaluation Methods and Comparison of Architecture
WG B5.71	Protection, Automation and Control Systems Communication Requirements for Inter-Substation and Wide Area Applications
WG B5.72	Modelling, Assessment, and Mitigation of Protection Performance Issues caused by power plants during Dynamic Grid Events
WG B5.73	Experiences and Trends related to Protection Automation and Control Systems Functional Integration
WG B5.74	Busbar Protection Considerations When Using IEC 61850 Process Bus
WG B5.75	Documentation and version handling related to Protection, Automation and Control functions
WG B5.76	Architecture, Standards and Specification for metering system in a Digital Substation and Protection, Automation and Control (PACS) Environment
WG B5.77	Requirements for Information Technologies (IT) and Operational Technology (OT) managed of Protection, Automation and Control Systems (PACS)
JWG B5/C4.61	Impact of Low Inertia Network on Protection and Control
JWG B5/D2.67	Time in Communication Networks, Protection and Control Applications – Time Sources and Distribution Methods



Lastest publications

TB 854	Analysis and comparison of fault location systems in AC power networks
TB 843	Life Cycle Testing of Synchrophasor Based Systems used for Protection, Monitoring and Control
TB 829	Challenges with series compensation applications in power systems when overcompensating lines
TB 819	IEC 61850 based substation automation systems – Users expectations and stakeholders interactions
TB 810	Protection and Automation issues of islanded systems during system restoration/black start
TB 800	Network protection performance audits
TB 790	Cybersecurity Requirements for PACS and the Resilience of PAC Architectures
TB 789	Improved Metering Systems for Billing Purposes in Substations
TB 768	Protection Requirements on Transient Response of Digital Acquisition Chain
TB 760	Test Strategy for Protection Automation and Control (PAC) Functions in a Fully Digital Substation based on IEC 61850 Applications
TB 739	Protection and Local Control of HVDC Grids
TB 716	System conditions for and probability of out-of-phase
TB 711	Control and automation systems for Electricity Distribution Networks (EDN) of the future
TB 687	Experience concerning availability and reliability of digital substation automation systems (DSAS)
TB 664	Wide area protection & Control technologies
TB 637	Acceptance, Commissioning and Field Testing Techniques for Protection and Automation Systems
TB 629	Coordination of Protection and Automation for Future Networks
TB 628	Documentation requirements from design to operation to maintenance for Digital Substation Automation Systems
TB 613	Protection of Distribution System with Distributed Energy Resources
TB 603	Application and management of cyber security measures for Protection & Control systems
TB 599	Education, Qualification and Continuing Professional Development of Engineers in Protection and Control
TB 587	Short circuit protection of circuits with mixed conductor technologies in transmission networks
TB 584	Implications and Benefits of Standardised Protection and Control Schemes
TB 546	Protection, Monitoring and Control of Shunt Reactors
TB 540	Applications of IEC 61850 Standard to Protection Schemes
TB 539	Life-time Management of Relay Settings
TB 479	International Guide on the Protection of Synchronous Generators
TB 466	Applications of IEC 61850 Standard to Protection Schemes
TB 465	Modern Techniques for Protecting and Monitoring of Transmission Lines
TB 464	Maintenance Strategies for Digital Substation Automation Systems
TB 463	Modern Techniques for Protecting, controlling and monitoring power transformers
TB 448	Refurbishment Strategies based on Life Cycle Cost and Technical Constraints
TB 432	Protection Relay Coordination
TB 431	Modern Techniques for Protecting Busbars in HV Networks
TB 427	The Impact of Implementing Cyber Security Requirements using IEC 61850
TB 424	New Trends for Automated Fault and Disturbance Analysis
TB 421	The Impact of Renewable Energy Sources and Distributed Generation on Substation Protection and Automation
TB 411	Protection, Control and Monitoring of Series Compensated Networks
TB 404	Acceptable Functional Integration In HV Substations

All of the above TBs are available for download from www.e-cigre.org

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C1

Power System Development and Economics

The work of Study Committee C1 covers all system development and economic issues relevant to the electricity power industry and focuses on those topics currently of interest to its target groups.

SC C1's scope of work includes issues, methods and tools related for the development and economics of power systems, including the drivers to: invest in expanding power networks and sustaining existing assets, increase power transfer capability, integrate distributed and renewable resources, manage increased horizontal and vertical interconnection, and maintain acceptable reliability in a cost-efficient manner.

The SC aims to support planners to anticipate and manage change by providing guidelines and recommendations.



C1 Power System Development and Economics



Principal areas of interest

- Role of Hydrogen in energy transition.
- Energy sector integration and impact on power grids.
- Resilient system by design.
- Evolving metrics in Cost-Benefit Analysis.
- Methods and practices for system development.
- Business investment.
- Interface and allocation issues in multi-party/cross-jurisdictional projects.
- Asset management.

These focus areas are particularly important during the on-going electricity system paradigm shift brought about by rapid evolution in generation patterns and economics, demand response, ICT, and in social, environmental and regulatory frameworks and expectations.



Current activities

- System planning and securing investment in transmission and distribution networks against a backdrop of increasing uncertainty.
- Reviewing best practice in the management of interface and allocation issues in multi-party/cross-jurisdictional projects.
- Reviewing the application of enhanced asset management methodologies and the role of valuation in asset management decisions.
- Global electricity network feasibility study.
- Planning coordination between SO, TO and DSO.
- Review of Large City & Metropolitan Area power system development trends.



Key projects / forthcoming events

- **In June 2022**, at the postponed online SEERC meeting, C1 will deliver a Tutorial on “Multi-party interconnections”.
- **At CIGRE Paris Session 2022**, where C1 will meet in person, we will deliver:
 - Tutorial on “Global Grids Interconnections” based on the work of C1.44.
 - Joint Workshop with B2, B1 and C4 on “Extra-long transnational transmission lines”.
- **Gulf Cooperation Council Conference** October 2022.
- **Oman Symposium** March 2023.
- **Symposium in Cairns Australia** September 2023.



Main areas of focus

System planning

- System planning and technology issues in specific contexts e.g. off-shore wind, large surpluses/deficits in available RES, and power exchange with distribution systems.
- Methods and tools for steady state and dynamic analysis in system planning.
- Energy sector integration.
- Power system planning under increasing uncertainty and with increasingly active distribution systems.
- Impact of increased interaction between transmission and distribution systems on definitions of reliability, adequacy and security.
- Power system development trends in large city and metropolitan areas.

Asset management

- High level asset management strategies in defining sustainable policies and optimal practices.
- Using total life cycle cost of asset ownership to inform investment decisions.
- Risk-based analysis aimed at identifying existing assets that require attention.
- Optimal power system resilience in future grid design.
- Asset analytic data platforms and tools to support asset management.

Business management

- Impact of business models on system development.
- Scenarios and methodologies for quantitative studies on future power systems.
- Timely engagement of stakeholders in investment decision processes.
- Role of green Hydrogen.
- Bridging the gap in the understanding of specialists and wider societal stakeholders.

Interconnections – horizontal/vertical

- Global electricity network – effects of storage, demand response and trading rules.
- Interface and allocation issues in planning and delivery of multi-party/cross-jurisdiction projects.
- Planning regulated/non-regulated transmission assets in parallel, optimal sizing of interconnectors
- Coordinated planning with evolving smart and active distribution systems.
- Cost benefit analyses for interconnection projects.

C1 Power System Development and Economics

Topics of Working Groups

WG C1.23	Transmission Investment Decision Points and Trees
WG C1.33	Interface and Allocation Issues in Multi-party and/or Cross-jurisdiction Power Infrastructures Projects
JWG C1/C4.36	Review of Large City & Metropolitan Area power system development trends taking into account new generation, grid and information technologies
WG C1/C6/Cired.37	Optimal transmission and distribution investment decisions under growing uncertainty
WG C1.41	Close the gap in understanding between stakeholders and electrical energy specialists
WG C1.42	Planning tools and methods for systems facing high levels of distributed energy resources
WG C1.43	Establishing requirements for asset management platforms that will allow integration of data/information from different sources
WG C1.44	Impact of storage, demand response and trading rules on Global Interconnections
WG C1.45	Harmonised metrics and consistent methodology for benefits assessment in interconnections' Cost-Benefit Analysis (CBA)
JWG C1/C4.46	Optimising power system resilience in future grid design
WG C1.47	Energy Sectors Integration and impact on power grids
WG C1.48	Role of hydrogen in energy transition: opportunities and challenges from technical and economic perspectives
JWG B2/C1.86	Approach for Asset Management of Overhead Transmission Lines

Latest publications

TB 715	The future of reliability - Definition of reliability in light of new developments in various devices and services which offer customers and system operators new levels of flexibility
TB 775	Global electricity network (feasibility study)
TB 786	Investment decisions in a changing and uncertain environment
TB 787	ISO series 55000 standards: Implementation and information guidelines for utilities
TB 820	Optimal power system planning under growing uncertainty
TB 848	Planning Coordination between System Operators, Transmitters and Distributors: Frameworks, Methods, and Allocation of Costs and Benefits
TB 863	Multi-energy System Interactions in Distribution Grids

All of the above TBs are available for download from www.e-cigre.org

Green Book on “Asset Management” is currently being printed by Springer
 Electra articles on: “Role of green hydrogen in energy transition”, “Global interconnections”,
 “Africa energy future” & “Sector coupling”.

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System Operation and Control

C2

The scope of the SC C2 covers the technical, human resource and institutional aspects and conditions for a secure and economic operation of power systems in a way that is in compliance with requirements for network security, against system disintegration, equipment damages and human injuries, and security of electricity supply. The members of C2 mainly come from transmission system operators. The SC is encouraging young members to participate in its activities.



C2 System Operation and Control



Principal areas of interest

- Real-time System Operation and Control.
- System Operational Planning and Performance Analysis.
- Control Centre Infrastructure and Human Resources for System Operation.



Current activities

Wide area monitoring protection and control systems. Operator training at different control levels and for different participants in the new environment. Evaluation of impact of electricity market interventions on power systems operation. Evaluation of impact of growing use of artificial intelligence in operation and control of power systems.



Key projects / forthcoming events

- **Publication 2022** Technical Brochures for WGs C2.18, C2.24, C2.26 and C2.39.
- **CIGRE Paris Session 2022:** August 28th to September 2nd.
- **Workshop** C2&C5 Large Disturbances Workshop during CIGRE Paris Session 2022, August 29th.
- **Tutorial** TSO-DSO Co-Operation Control Centre Tools Requirements during CIGRE Paris Session 2022, September 1st.
- **Symposium CIGRE Symposium, Cairns, Australia**, September 4th-7th 2023.
- **Tutorial** Mitigating the Risk of Fire Starts and the Consequences of Fires near Overhead Lines for System Operations during CIGRE Symposium, Cairns, Australia, September 2023.



Main areas of attention

SC C2 focuses on the control, monitoring and switching of equipment, management of ancillary services, such as voltage and frequency control, monitoring of operational limits and actions to maintain network security and to avoid congestion (e.g. short-term planning and coordination of capacity calculation).

Developments and changes in the business of System Operators and its integration in the evolving environment: energy transition impact, integration of new technologies, operation and management of new solutions (e.g. large-scale energy storage and transition to hybrid AC/DC systems), including cross-border interconnection, and common and coordinated activities.

Evaluation and benchmarking of the system's performance in terms of disturbance frequency, power interruptions, power quality, operational and outage planning efficiency, both from the technical and economical points of view. To this end, attention is given to emergency management, restoration practices, resilience enhancement strategies, and also to interactions and coordination between active players in the power system.

The integration of PMU-based WAMS within the control centre environment and its contribution to power system analysis and security assessment functionalities is one of the recent attention points within the SC. Furthermore, continued efforts are made to document requirements, methods, tools and performance indicators for control centres and training of system operators, as these are specific to and essential for System Operation.

Topics of Working Groups

WG C2.18	Wide Area Monitoring Protection and Control Systems – Decision Support for System Operators
WG C2.24	Mitigating the Risk of Fire Starts and the Consequences of Fires near Overhead Lines for System Operations
WG C2.26	Power system restoration accounting for a rapidly changing power system and generation mix
WG C2.39	Operator Training in Electricity Grids at Different Control Levels and for Different Participants/Actors in the New Environment
WG C2.42	The Impact of the growing use of machine learning/Artificial Intelligence in the operation and control of Power Networks from an Operational perspective
JWG C2/C5.06	The Impact of Electricity Market Interventions by System Operators during Emergency Situations

Latest publications

TB 833	Operating strategies and preparedness for system operational resilience – WG C2.25
TB 845	TSO-DSO Co-Operation Control Centre Tools Requirements – WG C2.40
TB 851	Impact of High Penetration of Inverter-based Generation on System Inertia of networks – JWG C2/C4.41

The above publications are available for download from www.e-cigre.org

Contacts

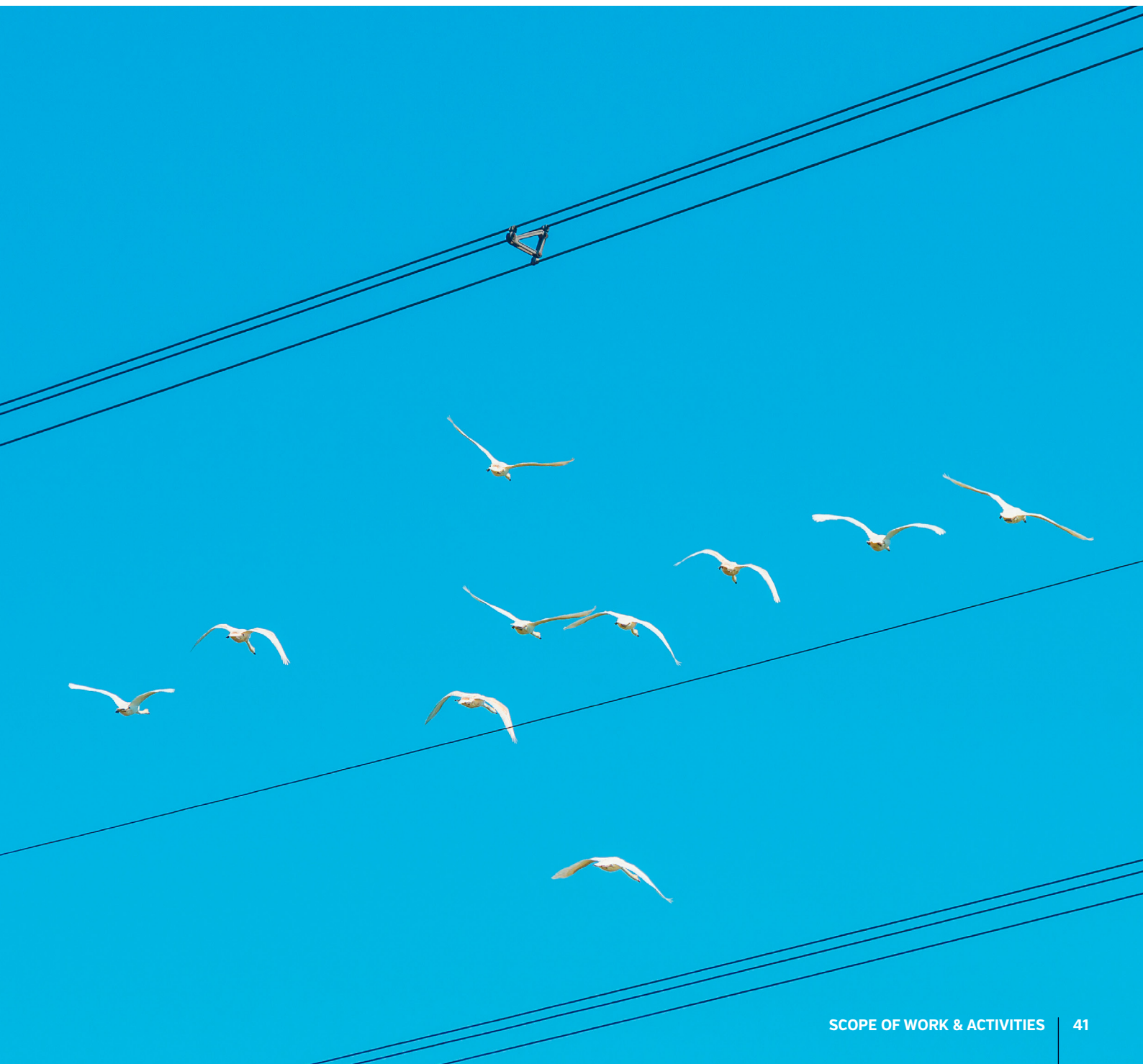
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System Environmental Performance

The mission of the SC C3 is to facilitate and promote the principles of sustainable development through the global exchange of information and knowledge in the field of system environmental performance. To add value to this information and knowledge by means of synthesizing state-of-the-art practices and developing recommendations in line with global best practice.

C3



C3 System Environmental Performance



Principal areas of interest

- Environmental impacts of power system development and operation (life cycle approach).
- Role of the power system regarding sustainable development (positive and negative): impact on climate change and achievement of SDGs.
- Stakeholders' engagement and communication, effective communication and cooperation with the public and regulatory authorities, public acceptance of power system infrastructure.



Other specific interests

- Sustainability of the system, CIGRE's responsibility.
- Environmental implications of renewable energy and storage technologies.
- Tools and measures for quantifying, controlling, and mitigating the environmental impact based on the sustainable development goals of the UN such as life-cycle assessment (LCA), environmental product declarations (EPD), global benchmarking, etc.



Main areas of attention

The scope of the SC C3 covers the identification, assessment, and management of the interactions between the natural and social environments, and the end-to-end electric power system, recognising the importance and influence of a wide range of stakeholders and communities. Recommendations for appropriate monitoring, management, and control measures in fields such as greenhouse gases (SF6), air, soil and water pollution, electromagnetic fields, noise, visual amenity, land use and biodiversity.

In 2018, SC C3 defined its Strategic Plan 2018-2028 including in the objective of SC C3 a focus on sustainability and added to its original mission the promotion of the principles of sustainable development through the global exchange of information and knowledge in the field of system environmental performance. To add value to this information and knowledge by means of synthesizing state-of-the-art practices and developing recommendations in line with global best practice.



Topics of Working Groups

WG		Convener
SAG		Mercedes Vázquez (ES)
AG C3.01	EMF and Human Health(Advisory group)	Michel Plante (CA)
WG C3-09	A Corridor management	Aleš Kregar (SL)
WG C3-14	Impact of Environmental liability on transmission and distribution activities	Vincent Du Four (BE)
WG C3-15	Best environmental and socio-economic practices for improving public acceptance of high voltage substations	<i>Marijke Wassens (NL)</i>
WG C3-16	Interactions between electrical infrastructure (overhead lines and substations) and wildlife	<i>Cécile Saint-Simon (FR)</i> <i>Anaëlle Brand (FR)</i>
WG C3-17	Interactions between wildlife and emerging renewable energy sources and submarine cables	<i>Katherine Palmquist (USA)</i>
WG C3-18	Eco-friendly approaches in transmission and distribution	<i>Anne-Sophie Desaleux (FR)</i>
WG C3-20	Sustainability goals in the electric power sector	<i>Christian Capello (AT)</i> <i>Lou Cecere (USA)</i>
WG C3-21	Including stakeholders in the investment planning process (Renewed TOR of former JWGC1/C3.31)	Susana Batel (PT)
WG C3-22	Vegetation management in substations	Vincent Du Four (BE)
WG C3-23	Eco-design methods for TSOs/DSOs under environmental transition	Guillaume Busato (FR)
JWG B1/C85	Environmental impact of decommissioning of underground and submarine cables	Kieron Leeburn (SA)
	To start in 2022 (not approved yet and looking for a convenor)	
WG C3-12 A.	Greenhouse Gas Emissions inventory and report for transmission system operators (Re-start)	<i>Mercedes Vázquez (ES)</i>

Names in italics mean former convenor. The designation of new convenors is still pending for many WGs.

All of the above TBs are available for download from www.e-cigre.org

Contacts

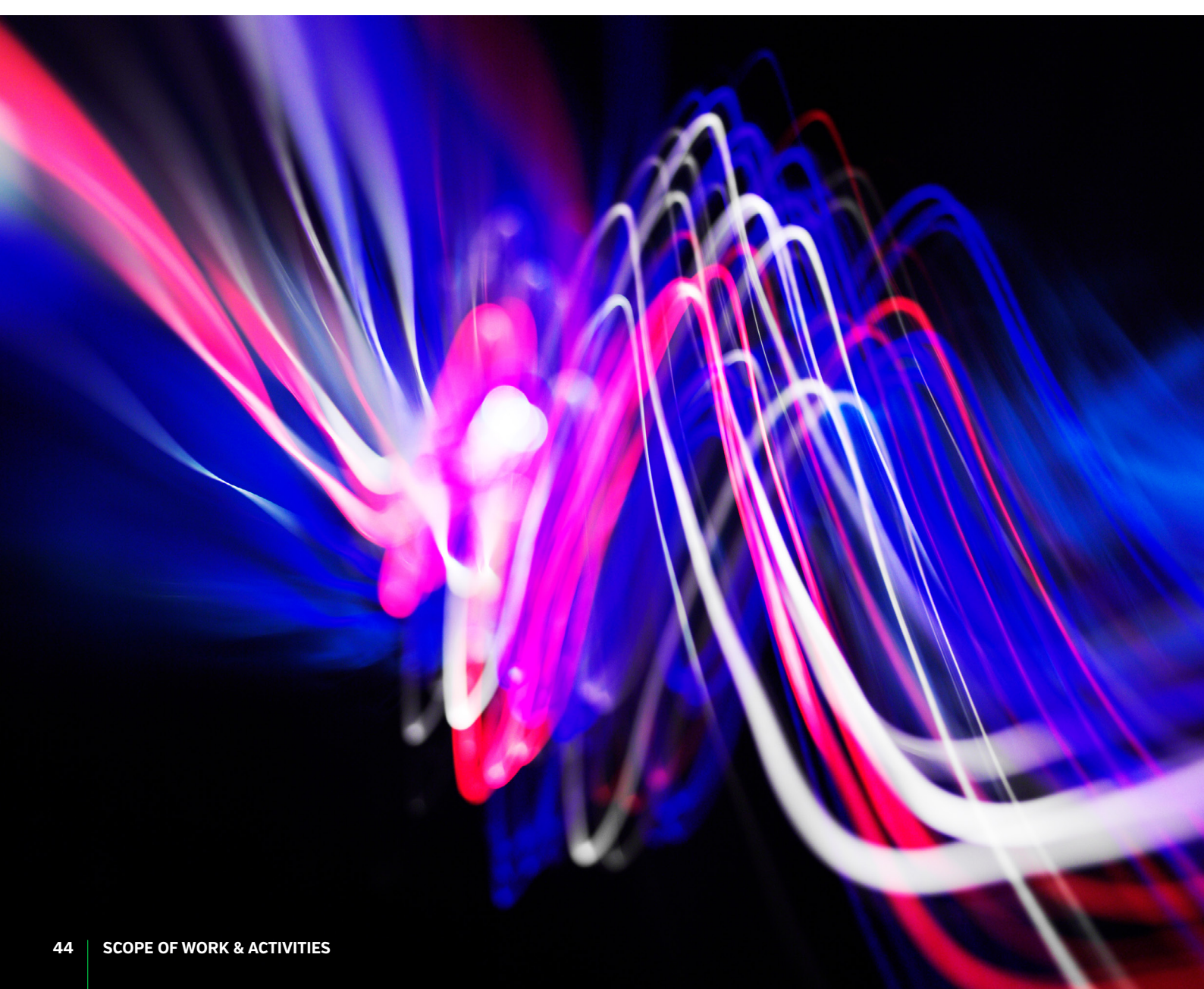
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C4

Power System Technical Performance

The scope of SC C4 covers system technical performance phenomena that range from nanoseconds to many hours. SC C4 has been engaged in the following topics: Power Quality, EMC/EMI, Electromagnetic Transients and Insulation Coordination, Lightning, Power Systems Dynamics Performance, and Numerical Analysis. Study Committee C4 deals with methods and tools for analysis related to the technical performance of power systems, with particular reference to dynamic and transient conditions and to the interaction between the power system and its apparatus/sub-systems, between the power system and external causes of stress and between the power system and other installations.



C4 Power System Technical Performance



Principal areas of interest

- Power Quality, Electromagnetic Compatibility and Electromagnetic Interference (EMC/EMI).
- Lightning, Electromagnetic Transients and Insulation Coordination.
- Power System Dynamics Performance and Numerical Analysis.



Current activities

- Power Quality and EMC – Modelling, Assessment and Standardization.
- Power System Resilience.
- Evaluation of Lightning Performance of Power Systems.
- Evaluation of Overvoltages and their Withstand Characteristics.
- Advanced Modelling and Analysis Techniques.



Key projects / forthcoming events

CIGRE Cairns Symposium: Cairns, Australia, 2023.



Other specific interests

- Evaluation of System Technical Performance of Traditional Power Systems.
- Development of Advanced System Analysis Tools for Smart Grids.



Main areas of attention

The SC C4 scope covers system technical performance phenomena that range from nanoseconds to many hours, in the following fields:

Power Quality Performance: Continuity of end-to-end electric power supply and voltage waveform quality (magnitude, frequency, symmetry). Analysis covers emission assessments from disturbing installations, measurement and simulation methods, identification of quality indices, monitoring techniques, immunity of sensitive installations, and mitigation techniques taking into account a coordinated approach across all voltage levels.

Electromagnetic Compatibility (EMC): High frequency disturbances on the end-to-end electricity supply and all disturbances (HF or LF) reaching equipment other than through the electricity supply. Studies include measurement and simulation methods.

Insulation Coordination: Methods and tools for insulation co-ordination and electromagnetic transient analysis (eg. ferroresonance, temporary overvoltages, transformer energization) in electric power systems and equipment, contributing to optimisation of their cost and reliability.

Lightning: Analysis of lightning characteristics and interactions of lightning with electric power systems and equipment, including lightning protection of MV and LV networks, lightning protection of renewable energy systems, and their standardization.

Power System Dynamics and Numerical Analysis: Development of advanced tools, new analytical techniques for assessment of power system dynamic/transient performance, security, design of controls and modelling of existing and new equipment, real time stability evaluation and control. Numerical techniques for the computation from steadystate to very fast front transients; modelling unsymmetrical conditions of power systems.

C4 Power System Technical Performance

Topics of Working Groups

WG C4.36	Winter Lightning – Parameters and Engineering Consequences for Wind Turbines
JWG C4.40/CIRED	Revisions to IEC Technical Reports 61000-3-6, 61000-3-7, 61000-3-13, and 61000-3-14
JWG C4.42/CIRED	Continuous assessment of low-order harmonic emissions from customer installations
WG C4.43	Lightning Problems and Lightning Risk Management for Nuclear Power Plants
WG C4.44	EMC for Large Photovoltaic Systems
WG C4.46	Evaluation of Temporary Overvoltages in Power Systems due to Low Order Harmonic Resonances
WG C4.47	Power System Resilience
WG C4.48	Overvoltage Withstand Characteristics of Power System Equipment 35-1200 kV
WG C4.49	Wideband stability of grid-tied converter-based modern power systems
WG C4.50	Evaluation of Transient Performance of Grounding System in Substation and Its Influence on Secondary System
WG C4.51	Connection of Railway Traction Systems to Power Networks
JWG C4/B4.52	Guidelines for Sub-synchronous Oscillation Studies in Power Electronics Dominated Power Systems
JWG C4/A3.53	Advanced metal-oxide varistors for surge arresters with better protection properties
WG C4.54	Protection of high voltage power network control electronics from the High-altitude Electromagnetic pulse [HEMP]
WG C4.55	EMC-related very-fast transients in gas-insulated substations
WG C4.56	Electromagnetic transient simulation models for large-scale system impact studies in power systems having a high penetration of inverter connected generation
WG C4.57	Guidelines for the Estimation of Overhead Distribution Line Lightning Performance and its Application to Lightning Protection Design
JWG C4/C2.58/IEEE	Evaluation of Voltage Stability Assessment Methodologies in Transmission Systems
JWG C4/C2.62/IEEE	Review of Advancements in Synchrophasor Measurement Applications
WG C4.59	Real-time Lightning Protection of the Electricity Supply Systems of the Future
WG C4.60	Generic EMT-Type Modelling of Inverter-Based Resources for Long Term Planning Studies
WG C4.61	Lightning transient sensing, monitoring and application in power systems
WG C4.63	Harmonic power quality standards and compliance verification – a comparative assessment and practical guide
WG C4.64	Application of Real-Time Digital Simulation in Power Systems
WG C4.65	Specification, Validation and Application of Harmonic Models of Inverter Based Resources
WG C4.66	New concept for analysis of multiphase back-flashover phenomena of overhead transmission lines due to lightning
WG C4.67	Lightning Protection of Hybrid Overhead Lines
WG C4.68	Electromagnetic Compatibility [EMC] issues in modern and future power systems
WG C4.69	Quantifying the lightning response of tower-footing electrodes of overhead transmission lines: methods of measurement
WG C4.70	Application of space-based lightning detection in power systems
WG C4.71	Small signal stability analysis in inverter based resource dominated power system
JWG C4/B4.72	Lightning and switching induced electromagnetic compatibility (EMC) issues in DC power systems and new emerging power electronics-based DC equipment
JWG A2/C4.52	High-Frequency Transformer Models for Non-Standard Waveforms
JWG A1/C4.52	Wind generators and frequency-active power control of power systems
JWG B4/B1/C4.73	Surge and Extended Overvoltage Testing of HVDC Cable Systems
JWG B5/C4.61	Impact of Low Inertia Network on Protection and Control
JWG C1/C4.36	Review of Large City & Metropolitan Area power system development trends taking into account new generation, grid and information technologies
JWG B1/C4.69	Recommendations for the insulation coordination on AC cable systems
JWG A1/C4.66	Guide on the Assessment, Specification and Design of Synchronous Condensers for Power Systems with Predominance of Low or Zero Inertia Generators
JWG B2/C4.76	Lightning & Grounding Considerations for Overhead Line Rebuilding and Refurbishing Projects, AC and DC
JWG C1/C4.46	Optimising power system resilience in future grid design

Latest publications

TB 855	Effectiveness of line surge arresters for lightning protection of overhead transmission lines
TB 851	Impact of High Penetration of Inverter-based Generation on System Inertia of networks
TB 839	Procedures for Estimating the Lightning Performance of Transmission Lines – New Aspects
TB 836	Measuring techniques and characteristics of fast and very fast transient overvoltages in substations and converter stations
TB 829	Challenges with series compensation application in power systems when overcompensating lines

All of the above TBs are available for download from www.e-cigre.org

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Electricity Markets and Regulation

Study Committee C5 bridges the gap between engineering, economics and regulation. It analyses the impacts of different approaches to markets, regulation and differing market structures [Institutions, participants and stakeholders] on the planning, operation and regulation of electric power systems. Examining the role of competition and regulation in the electricity industry assists in the orderly transition of the power system and improvements to its end-to-end efficiency.

C5



C5 Electricity Markets and Regulation



Current activities of the Study Committee

- Changes in regulatory roles and jurisdictional regulation related to the interaction between the transmission system and the distribution system.
- The role of markets and regulation regarding:
 - the integration and coordination of distributed energy resources and new technologies;
 - wholesale market price formation, including emissions pricing and the impact of non-wholesale market participants;
 - sector integration between gas (including renewable gases) and electricity.
- The impact of emerging technologies on system operations.
- Market clearing procedures, techniques and principles used to take advantage of the flexibility of aggregating large numbers of end-users.
- Potential Market rule changes to address changes in traditional ancillary service products.



Main areas of focus

Market structures and products such as physical and financial markets and the interaction between them, contracts, internationally integrated markets.

Emerging technologies, including renewable gases, and sector coupling.

Techniques and tools to support market actors such as demand and price forecasting profit estimation, financial risk management etc.

Regulation and legislation such as regulation objectives, extension and limits, price regulation of transmission, and ancillary services, transmission/distribution coordination and interactions, international harmonization, environmental and regulatory objectives etc.

Evolution of markets and regulation from wholesale transmission focus to include retail distribution. The increasing interaction between regulation and markets throughout the electric power system value chain and the ability of markets and regulation to cater to rapid evolutions in dynamic/variable generation, demand and storage technologies and behaviours.

Coordination of regulation, funding and trading arrangements for new assets and technologies expansion in new market structures, including the trend of decentralization of operations with distributed applications; the remaining assets coexisting with the retirement of other in utilities; the consideration of legacy trading arrangements in the new market arena.

Topics of Working Groups

C5.28	Energy Price Formation in Wholesale Electricity Markets
C5.31	Wholesale and Retail electricity cost impacts of flexible demand response
C5.32	Carbon pricing in wholesale electricity markets
C5.33	Trading electricity with Blockchain systems
C5.34	Market integration of EVs
JWG C5/C6.29	New Electricity Markets, Local Energy Communities
JWG C5/C1.35	Integration of Hydrogen into electricity markets and regulation

Latest publications

TB 803	"Exploring the Market-based Value of Smart Grid Developments"
TB 808	"Market Design for Short-term Flexibility"
TB 824	"The Role of Blockchain in Electricity Markets"

The Technical Brochures listed above are available for download from www.e-cigre.org

In addition, Study Committee C5 provided Chapter 14 of the CIGRE Technical Council book "Electricity Supply Systems of the Future".

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Active Distribution Systems and Distributed Energy Resources

C6

SC C6 facilitates and promotes the progress of engineering and the international exchange of information and knowledge in the field of active distribution systems and distributed energy resources [DER]. The experts contribute to the international exchange of information and knowledge, among others by means of technical brochures and tutorials synthesizing state of the art practices and developing recommendations.



C6 Active Distribution Systems and Distributed Energy Resources



Principal areas of interest

Assessment of the technical impacts resulting from a more widespread adoption of DER on planning and operation and on approaches, and of enabling technologies and innovative solutions for DER integration in active distribution systems.



Current activities

The current working groups develop technical recommendations and best practices for above topics with focus on technologies and solutions for DER, impact of the new types of loads such as electric vehicles and energy storage systems on the distribution system, demand side integration and customer empowerment, multi-energy deployment in urban infrastructures including electric vehicles, MVDC (Medium Voltage DC) systems, electric railway distribution systems and rural electrification.

Membership profile

- Distribution system operators, specialists in asset management, system planning and operation.
- Power and system consultants.
- Technology providers.
- Rural electrification experts.
- Information and communication technology experts.
- Academia with relevant expertise.



Key projects / forthcoming events

International Symposium Cairns, Australia 2023.



Main areas of focus

- Enabling technologies for renewable and distributed energy resource integration and application: active network management, microgrids, virtual power plants, distribution management systems (DMS, ADMS, DERMS), DER monitoring and control, aggregation systems and platforms, blockchain applications.
- Innovative solutions for DER and distribution technology deployment: smart inverters and power electronic interfaces, interconnection and integration requirements, MV/LV DC supply systems, distribution system modernization.
- Storage technologies: deployment of various storage technologies such as electrochemical electric battery energy storage systems, flywheels, flow batteries, and new storage technologies, hydropower, hydrogen, multi-energy solutions (including thermal storage), power2X applications (including power to heat, power to gas), electric vehicles.
- New approaches to configure new distribution systems for enhanced reliability and resilience: islandable grid connected microgrids, power exchange between microgrids.
- New approaches to determine the impact and plan and operate distribution systems in the context of a wide deployment of DER, including the analysis of hosting capacity and protection.
- Consumer integration and empowerment: demand side integration and participation, demand response, load management, smart load, new customer sectors such as electric vehicles, smart home and smart meter applications with impact on distribution systems.
- Smart cities: integrated distribution system technologies, power, control, and information and communication technology deployment for flexibility, integration of multi-energy systems.
- Rural Electrification: islanded power systems and individual customer off-grid systems, new solutions, weak grid connected systems.



Topics of Working Groups

WG C6/C1.33	Multi energy system interactions in distribution grids
WG C6/C2.34	Flexibility provision from DER
WG C6.35	DER aggregation platforms for the provision of flexibility services
WG C6.36	DER models for impact assessment
JWG C6/B4.37	Medium Voltage DC distribution systems
WG C6.39	DER customer empowerment
WG C6.40	Electric Vehicles
WG C6.41	Technologies for Electrical Railway Distribution Supply Systems
WG C6.42	Electric Transportation Energy Supply Systems
WG C6.43	Aggregation of battery energy storage and distributed renewable generation
WG C6.44	Nodal Value of Distributed Renewable Energy Generation

Latest publications

TB 721	The impact of battery energy storage systems on distribution networks
TB 726	Asset management for distribution networks with high penetration of DER
TB 727	Modelling of inverter based generation for power system dynamic studies
TB 782	Utilization of data from smart meter system
TB 793	MVDC feasibility study
TB 26	Hybrid systems for Offgrid-Supply
TB 835	Rural electrification
TB 863	Multi-energy system interactions in distribution grids

All of the above TBs are available for download from www.e-cigre.org

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D1

Materials and Emerging Test Techniques

The scope of Study Committee D1 covers new and existing materials for electrotechnology, diagnostic techniques and related knowledge rules, as well as emerging test techniques with expected impact on power systems in the medium to long term of information, knowledge, practice and experience, and adds value by synthesizing state-of-the-art practices to develop guidelines and recommendations.



D1 Materials and Emerging Test Techniques



Principal areas of interest

- Insulating gases and gaseous insulation systems.
- Liquid and liquid impregnated insulation systems.
- Solid materials.
- High voltage and high current testing and diagnosis.



Current activities

- Characterization of materials and electrical insulation systems (EIS).
- Study of emerging test and diagnosis techniques for HVDC.
- Development of diagnostic tools and related knowledge rules.



Key projects / forthcoming events

- **SC D1 Meeting at CIGRE Paris Session 2022.**
- **SC D1 participating at CIGRE Symposium**, September 4th-9th 2023, Cairns, Australia.



Other specific interests

- Give guidance in the performance and use of materials in electrical insulation systems.
- Dissemination of knowledge, e.g., by tutorials.



Main areas of attention

The Study Committee deals with the performance of materials and electrical insulation systems (EIS) with respect to electrical, thermal, mechanical, chemical, and environmental stresses. Based on this knowledge, test and measurement procedures are evaluated and developed, if necessary.

These procedures can be applied to generate new diagnostic tools for asset management of electrical apparatus to aid the work of equipment, subsystem, and system committees. Special attention is paid to the area of emerging UHVAC and UHVDC technologies.

The Study Committee strives to facilitate and promote the progress of engineering and the international exchange of information and knowledge. This is achieved through the synthesis of state-of-the-art practices and developing recommendations and guidelines.

To support the development of international standards the Study Committee seeks to establish close cooperation with standardization bodies and provides the relevant technical information as well as the scientific background.

D1 Materials and Emerging Test Techniques

Topics of Working Groups

WG D1.50	Atmospheric and Altitude Correction Factors for Air Gaps and Clean Insulators
WG D1.54	Basic Principles and Practical Methods to Measure the AC and DC Resistance of Conductors of Power Cables and Overhead Lines
WG D1.58	Evaluation of Dynamic Hydrophobicity of Polymeric Insulating Materials under AC and DC Voltage Stress
WG D1.60	Traceable measurement techniques for very fast transients
WG D1.61	Optical Corona Detection and Measurement
WG D1.62	Surface Degradation of Polymeric Insulating Materials for Outdoor Applications
WG D1.63	Partial Discharge Detection under DC Voltage Stress
WG D1.65	Mechanical Properties of Insulating Materials and Insulated Conductors for Oil Insulated Power Transformers
WG D1.66	Requirements for partial discharge monitoring systems for gas insulated systems
WG D1.68	Natural and synthetic esters – Evaluation of the performance under fire and the impact on environment
WG D1.69	Guidelines for test techniques of High Temperature Superconducting (HTS) systems
WG D1.70	Functional properties of modern insulating liquids for transformers and similar electrical equipment
WG D1.72	Test of material resistance against surface arcing under DC
WG D1.73	Nanostructured dielectrics: multi-functionality at the service of the electric power industry
WG D1.74	PD measurement on insulation systems stressed from HV power electronics
WG D1.76	Tests for verification of quality and ageing performance of cellulose insulation for power transformers
JWG D1/A2.77	Liquid tests for electrical equipment
JWG D1/B1.75	Strategies and tools for corrosion prevention for cable systems
JWG B1/D1.75	Interaction between cable and accessory materials in HVAC and HVDC applications
JWG B1/B3/D1.79	Recommendations for dielectric testing of HVDC gas insulated cable sealing ends

Latest publications

TB 705	Guidelines for altitude correction of pollution performance of insulators
TB 706	Guidelines for the use of statistics and statistical tools on life data
TB 730	Dry air, N ₂ , CO ₂ , and N ₂ /SF ₆ mixtures for gas-insulated systems
TB 738	Ageing of liquid impregnated cellulose for power transformers
TB 741	Moisture measurement and assessment in transformer insulation - Evaluation of chemical methods and moisture capacitive sensors
TB 751	Electrical properties of insulating materials under VLF voltage
Tb 765	Understanding and mitigating corrosion
TB 771	Advances in DGA interpretation
TB 779	Field experience with transformer solid insulation ageing markers
TB 783	DGA monitoring systems
TB 794	Field grading in electrical insulation systems
TB 822	Methods for dielectric characterization of polymeric insulating materials for outdoor applications
TB 842	Dielectric testing of gas insulated HVDC systems
TB 846	Electrical Insulation Systems at Cryogenic Temperatures
TB 849	Electric performance of new non- SF ₆ gases and gas mixtures for gas-insulated systems
TB 850	Harmonised test for the measurement of residual methane in insulating materials
TB 856	Dielectric performance of insulating liquids for transformers
TB 861	Improvements to PD measurements for factory and site acceptance tests of power transformers

All of the above TBs are available for download from www.e-cigre.org

Contacts

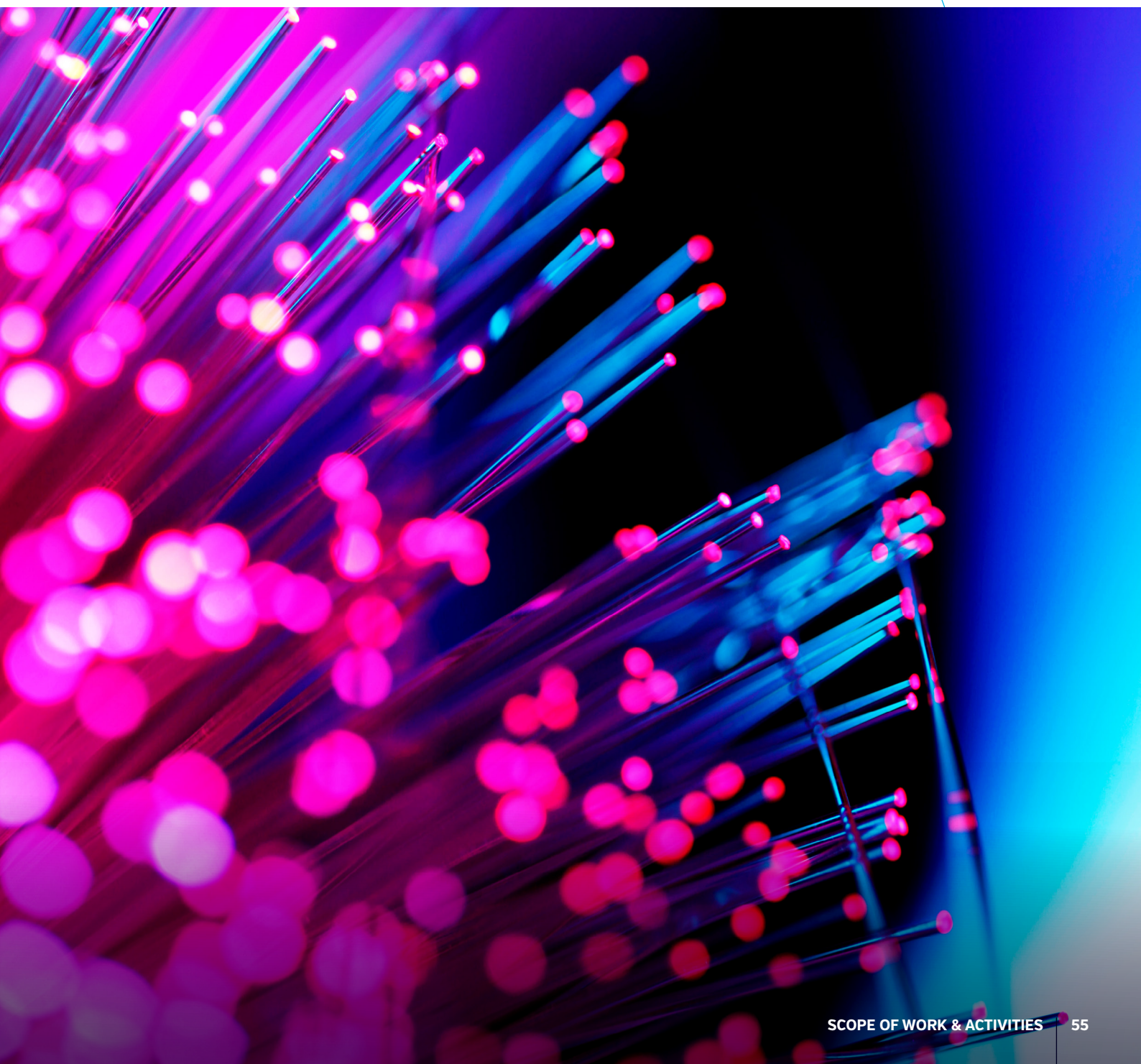
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Information Systems and Telecommunication

D2

The scope of this SC is focused on the fields of information systems and telecommunications for power systems. SC D2 contributes to the international exchange of information and knowledge, adding value by means of synthesizing state of the art practices and drafting recommendations.



D2 Information Systems and Telecommunication



Principal areas of interest

- Studying and considering the evolution of information and telecommunication technologies to cope with traditional and new requirements driven by the digital transformation in power industry including extension of Distributed Energy Resources.
- Assessment of Technologies and architecture to assure business continuity and disaster recovery.
- Overcoming security threats in the deployment of the networks of the future and especially in Smart Grids.



Current activities

SC D2 has over 200 experts contributing to international exchange by means of participation in Working Groups and Joint Working Groups, strengthening communication with other SCs as well as external International Standardisation Organisations, developing technical recommendations and best practices through Technical Brochures and Green Books, delivering tutorials at CIGRE web platform as well as during the international conferences, Symposiums, Colloquiums, etc.



Key projects / forthcoming events

- **CIGRE Paris Session 2022** (August 28th – September 2nd), including the tutorial: “Artificial Intelligence Application and Technology in Power Industry” and the workshop “Standardization of cyber-security in power utilities digital infrastructures – a joint vision from IEC, IEEE and CIGRE” to be held on August 30th 2022, Paris.
- **The SEERC Colloquium 2022 in Vienna, Austria** (May 30th - June 2nd) participation with tutorial “Cyber Security Management – a key player in the EPU resilience strategy” to be held on November 24th 2022, Vienna.
- **CIGRE Symposium 2023 in Cairns, Australia** (September 4th – 07th, 2023), SCs C2 & C5 [lead] with the participation of B1, B3, B5, C1, C4, C6, D1, D2.



Main areas of attention

Interoperability and data exchange between Electricity Network Grid Operators, System Operators, Market Operators, Generation Companies, Industrial Product Manufacturers, Telco Operators, ICT services providers, Energy Regulators, Certification Entities.

Telecommunication network technologies and management:

- Studying and considering telecommunication technologies and architecture evolution.
- Assessment of technologies and architecture to ensure business continuity, disaster recovery and suitability for power utility use cases.
- Telecommunication network management when deploying new technologies and architectures.

Implementation of the networks of the future:

- Monitoring of on-the-field experiences and proof of concepts of smart technologies.
- Impact on the existing ICT systems such as telecommunication network and equipment.
- SCADA, enterprise business functions [Smart Grid Architecture Model domain].

New digital trends used by EPU and new business services:

- Monitoring on the field experiences on the deployment of digital equipment such as IEDs, PMUs, IoT, Fog and Cloud Computing, Network Function Virtualization, as well as the processing of large quantity of information (Big data) in the domains of asset health, system operation, smart metering.

Cyber Security:

- Assessment and promotion of best practices, tools and solutions of cyber security from field equipment (protection) to corporate IT supporting the whole resilience strategy along the system life cycle: design, implementation, testing, operation and maintenance. Cyber security challenges related to emerging services, technologies and DER interconnection and the additional data exchanges between Transmission System Operators, Distribution System Operators and Significant Grid Users, as required by an agile and flexible future grid.



Topics of Working Groups

WG D2.44	Usage of public or private wireless communication infrastructures for monitoring and maintenance of grid assets and facilities
WG B5/D2.67	Time in Communication Networks, Protection and Control Applications – Time Sources and Distribution Methods
WG D2.45	Impact of governance regulations and constraints on EPU sensitive data distribution and location of data storage
JWG D2/C6.47	Advanced Consumer Side Energy Resource Management Systems
JWG D2/C2.48	Enhanced Information and Data Exchange to enable Future Transmission and Distribution Interoperability
WG D2.49	Augmented reality / Virtual reality to support Operation and Maintenance In Electric Power Utilities
JWG B2/D2.72	Condition Monitoring and Remote Sensing of Overhead Lines
WG D2.51	Implementation of Security Operation Center in Electric Power Industry as Part of Situational Awareness System
WG D2.52	Artificial Intelligence Application and Technology in Power Industry
WG D2.53	Technology and Applications of Internet of Things in Power Systems
WG D2.54	Regulatory approaches to enhance EPU's cybersecurity frameworks
WG D2.55	Application of 5G Technology to Smart Grids
WG D2.56	Interdependence and Security of Cyber-Physical Power System (CPPS)
JWG A2/D2.65	Transformer Digital Twin – concept and future perspectives
JWG B3/D2.62	Life-long Supervision and Management of Substations by use of Sensors, Mobile Devices, Information and Communication Technologies

Latest publications

Green books	Utility Communication Networks and Services
Green books	Electricity Supply Systems of the Future
TB 746	Design, Deployment and Maintenance of Optical Cables associated to Overhead HV Transmission Lines.
TB 762	Remote Service Security Requirement Objectives
TB 782	Utilization of data from smart meter system
TB 796	Cyber security: future threats and impact on Electric Power Utility organizations and operations
TB 840	Electric Power Utilities' Cybersecurity for Contingency Operations
TB 866	Enabling software defined networking for electric power utilities

All of the above TBs are available for download from www.e-cigre.org

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Notes

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