



SCOPE OF WORK & ACTIVITIES

STUDY COMMITTEES

2024

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 and participate at the Administrative Council reporting on the technical activities and sharing 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. In 2024, as part of the recommendations of the revised Strategic Plan of CIGRE, each Study Committee has increased the number of Regular Members from 24 to 34, as well as incorporating 2 additional Members, one nominated from WiE and one from NGN groups. These two will act as any other Regular member. 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, CSE);
- 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 and impacts of the so called Energy Transition topics. 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 260 active Working Groups and around 4500 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 over 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.

Having this in mind, the TC proposed to the Marketing team of CIGRE a new graphical format of what is being done in CIGRE on Energy Transition. This project has already been implemented in the "Knowledge Programme" of the website www.cigre.org.

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 4.0/5.0 Industrial thinking, which leads to broken down and re-imagine the electric power business.



Marcio Szechtman
CIGRE Technical Council Chair



ABOUT

The first Session of CIGRE took place in Paris in 1921. Today CIGRE is a non-for-profit association of professionals of the power systems, for promoting collaboration on a national and international level.

CIGRE has more than **11 000 individual members**, including engineers, technicians, students, researchers, academics, CEOs and other decision makers, and with more than **1300 collective members** (companies, associations and universities).

It allows experts from more than **120 countries** to share their knowledge and experience, and to join forces in order to improve existing power systems and build the electrical systems of the future.

CIGRE counts **61 National Committees** representing the Association in more than 80 countries. These National Committees provide the experts who collaborate in the **16 Study Committees and 260 Working Groups**, and organise national and regional events in addition to the international events (Paris Session and Symposia).

More about CIGRE : www.cigre.org



Philippe Adam
CIGRE Secretary General

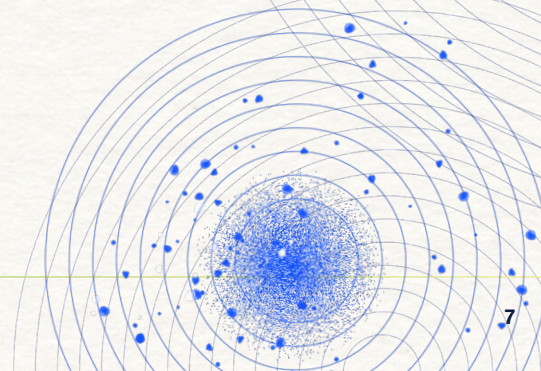
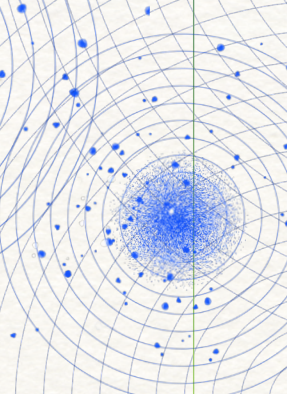
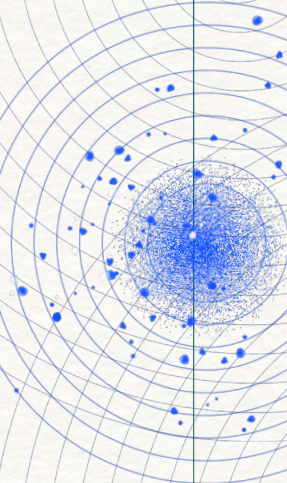
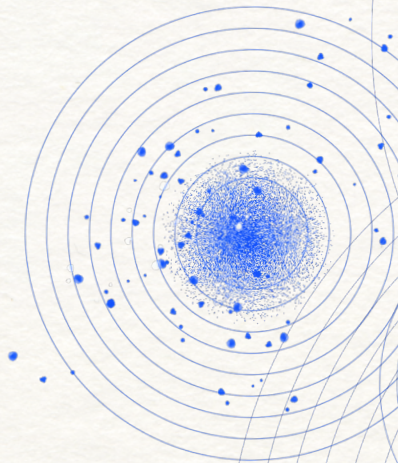
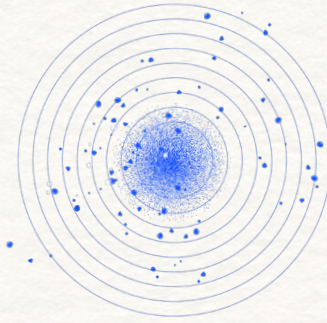
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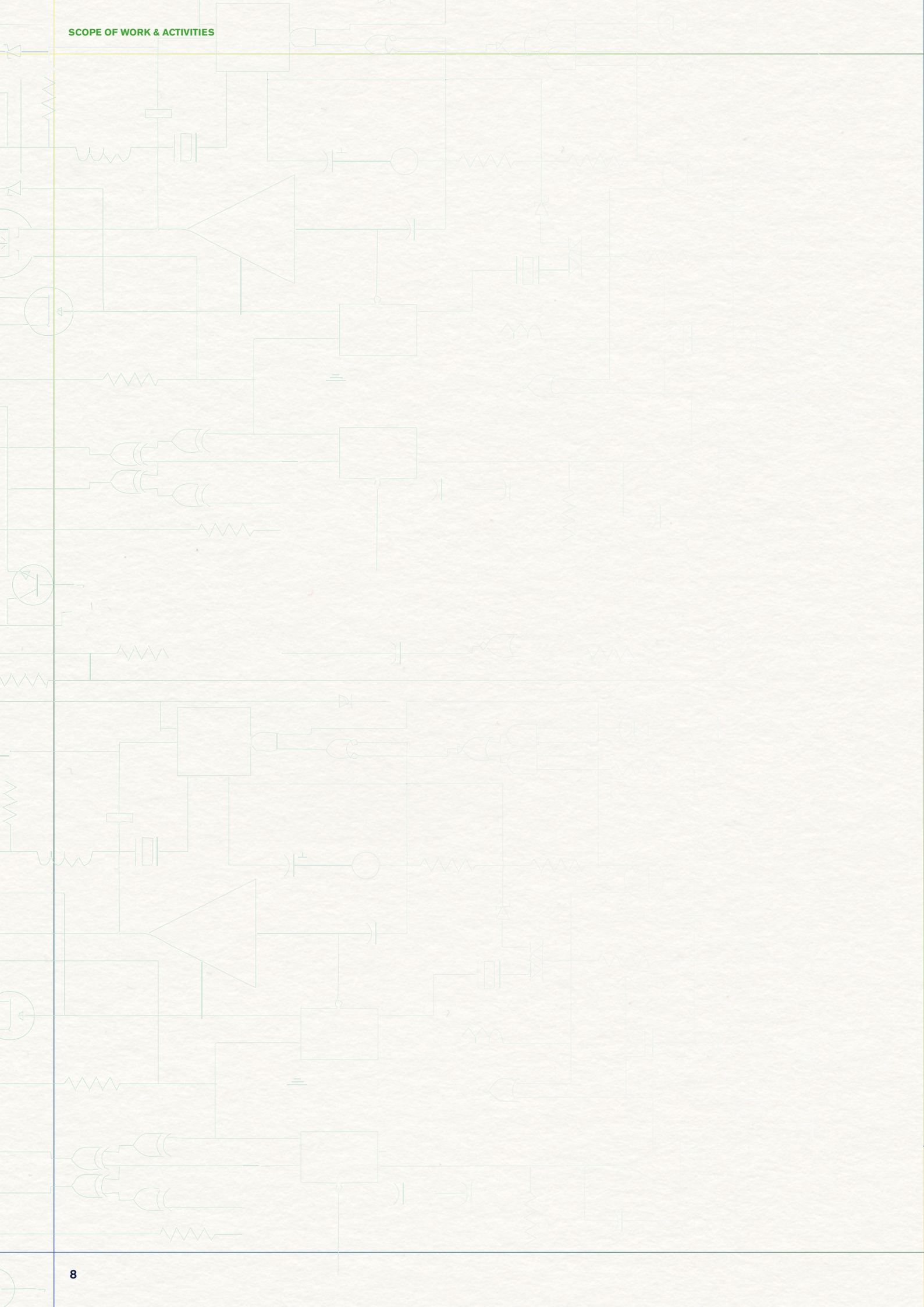
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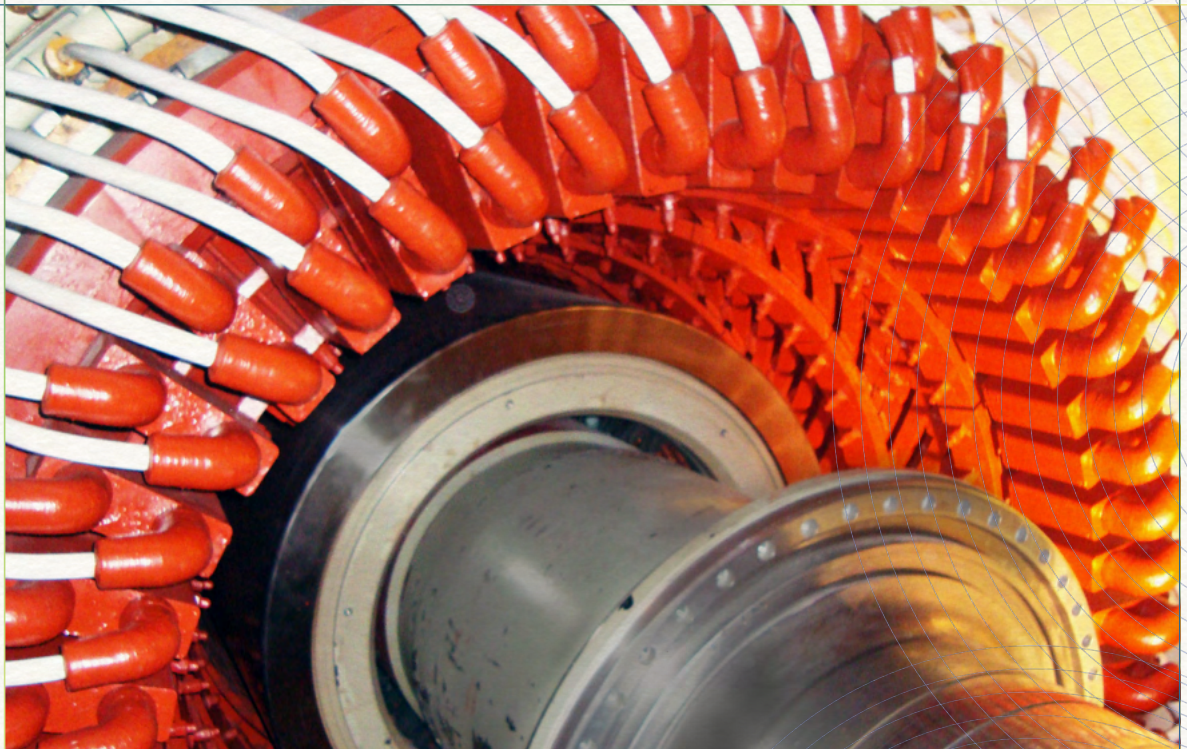


A1

POWER GENERATION AND ELECTROMECHANICAL ENERGY CONVERSION

In 2024 the SC changed its name from “Rotating Electrical Machines” to “Power generation and electromechanical energy conversion” to better serve the evolving landscape driven by the energy transition.

The SC covers the full equipment lifecycle from research, development, design, manufacture and testing of power generation and electromechanical energy conversion equipment and their associated auxiliaries, commissioning, operation, condition assessment, maintenance, life extension, refurbishment, upgrades, efficiency improvement, conversion (e.g. from power generation duty to synchronous condenser/compensator duty), storage, and de-commissioning. Within these fields, SCA1 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



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A1 • POWER GENERATION AND ELECTROMECHANICAL ENERGY CONVERSION

PRINCIPAL AREAS OF INTEREST

Technology and Lifecycle Management

- **New technologies related to equipment** used in power generation and industrial applications.
- **Enhancements in the design**, construction and performance of rotating electrical machines including large turbogenerators, hydro-generators and pump-storage schemes, large motors, high efficiency motors, generators for wind, solar, tidal, biomass & geothermal plant, and superconducting machines.
- **Synchronous compensator and high inertia machine** design and performance for supporting power generation networks, including conversion of existing decommissioned generators to synchronous compensators.
- **Power generation equipment** used in industrial process plant and microgrids, e.g., ships, aircraft etc.
- **Performance improvements of power generation** equipment and motors due to the development of new materials, improved cooling design, more effective insulation systems, enhanced excitation and auxiliary systems, and motor drive technologies.
- **Monitoring, diagnosis, and prognosis** of power generation equipment, motors and associated equipment to optimise maintenance strategies.
- **End-to-end lifecycle management** of assets to extend the life of existing machines or to recommend their replacement.

CURRENT ACTIVITIES

SC A1 currently has 23 active working groups addressing a range of aspects within the areas of interest. One of these is a joint working group with SC C4. Five of these working groups have completed the work and pending issue of the final report or are expected to complete their work in 2024, and three working groups will be re-assessed in 2024.

SC A1 also contributes to colloquiums and symposiums including tutorials based on working group reports.

OTHER SPECIFIC INTERESTS

Energy transition and Sustainability :

- **The changing role of equipment** used for power generation and industrial applications to meet the evolving market, customer needs and expectations resulting from the energy transition to sustainable, low carbon energy sources.
- **Innovative solutions and concepts** considering economic, technical, and environmental requirements.
- **Impact and effect of hybrid power generation** and storage schemes on the design and operational duty of new and existing power generation equipment, synchronous compensators, associated auxiliaries, and motors used in industrial applications.
- **Increased requirements on power generation equipment** to support the performance and reliability of power networks in the face of the increasing integration of renewable generation sources.
- **Adaptation of international standards** for equipment design and performance to reflect evolving market requirements.

KEY PROJECTS FORTHCOMING EVENTS

AUGUST 2024 : Paris session

MAIN AREAS OF ATTENTION

To facilitate and promote the progress of engineering and the international exchange of information and knowledge in the field of electromechanical energy conversion realised by rotating machines and associated equipment in both power generation and consumption, by providing a full E2E forum covering all aspects of equipment lifecycle including the influence/ impact of their operating environment. To add value to this information and knowledge by means of synthesizing state-of-the-art practices and developing recommendations.

Accomplishes a pivotal role 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.

WITHIN ITS FIELD OF ACTIVITY SHALL

Serve all involved in the field of power generation and electromechanical energy conversion 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.

A1 • POWER GENERATION AND ELECTROMECHANICAL ENERGY CONVERSION

TOPICS OF WORKING GROUPS

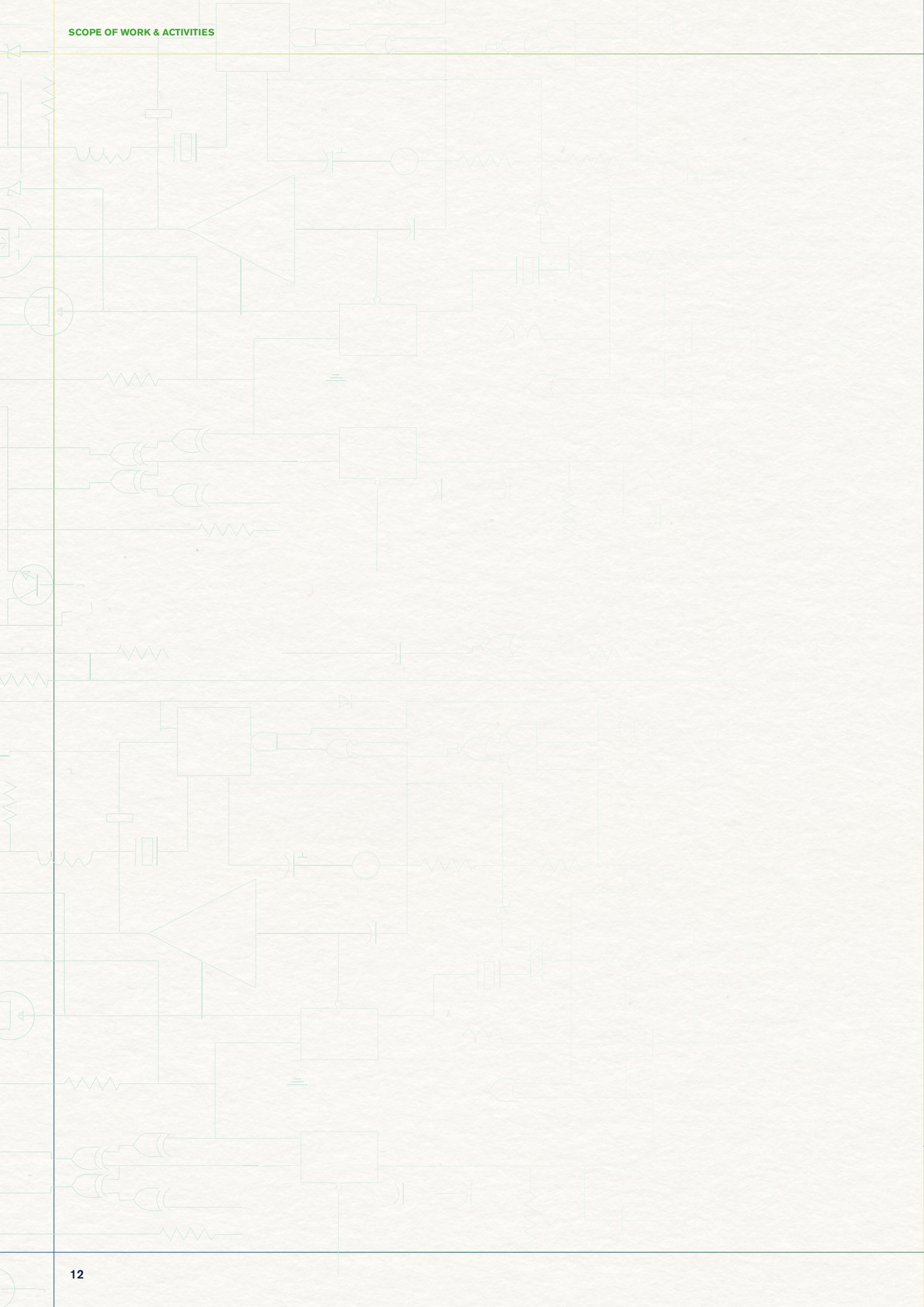
WG A1.42*	Influence of Key Requirements on the Cost of Hydrogenerators.
WG A1.43*	State of the Art of Rotor Temperature Measurement.
WG A1.45°	Guide for determining the Health Index of Large electric motors.
JWG A1 52	Wind Generators and Frequency-active Power Control of Power Systems.
WG A1.53	Guide on Design Requirements of Motors for Variable Speed Drive Application.
WG A1.55*	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 A1.60	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.
WG A1.67°	State of the Art in methods, experience and limits in end winding corona testing for Hydro Generators.
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.
WG A1.74	Evaluating quality of electric motors.
WG A1.75	Large air-cooled turbo-generator – state of the art, limits and perspectives for Small
WG A1.76	Study on Eco-Design, Circular economy and impacts on generator production process.
WG A1.77	Survey on Insulation Reliability of Induction and Synchronous Motors

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

° These working groups will be re-assessed in 2024.

LATEST PUBLICATIONS

TB 918	DDF Measurements on Stator Windings – Part 1 Survey Answers
TB 915	Survey on industry practices and effects associated with the cutting out of stator coils in hydrogenerators.
TB 890	Impact of Cycling on Large Electrical Motors
TB 885	Guide on the Assessment, Specification and Design of Synchronous Condenser for Power System With Predominance of Low or Zero Inertia Generators
TB 879	Guideline on Testing of Turbo and Hydro Generators
TB 878	Guidance on High-Speed Testing of Turbo Generator Rotors
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]



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.



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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

August 2024 : Paris session

September 2025 : CIGRE Symposium in Montréal, Canada

October 2025 : Joint A2/D1 Colloquium in Seoul, Korea

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

WG A2.54	Power transformer audible sound requirement
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
WG A2.68	Failure survey of lower voltage generator step up transformers installed in wind farms and photovoltaic parks
WG A2.69	Guide for transformer maintenance - Update
JWG A2/C3.70	Life Cycle Assessment (LCA) of Transformers
JWG A2/D1.71	Modern insulating liquids qualification for OLTC, bushings and other accessories
JWG A2/D1.72	Retrofill of mineral oil in transformers - Motivations, considerations and guidance

LATEST PUBLICATIONS

TB 900	High-Frequency Transformer and Reactor Models for Network Studies
Part A:	White Box Models
TB 901	High-Frequency Transformer and Reactor Models for Network Studies
Part B:	Black Box Models
TB 902	High-Frequency Transformer and Reactor Models for Network Studies
Part C:	Grey Box Models
TB 903	High-Frequency Transformer and Reactor Models for Network Studies
Part D:	Model Interfacing and Specifications
TB 904	High-Frequency Transformer and Reactor Models for Network Studies
Part E:	Measurements and Transformer design details

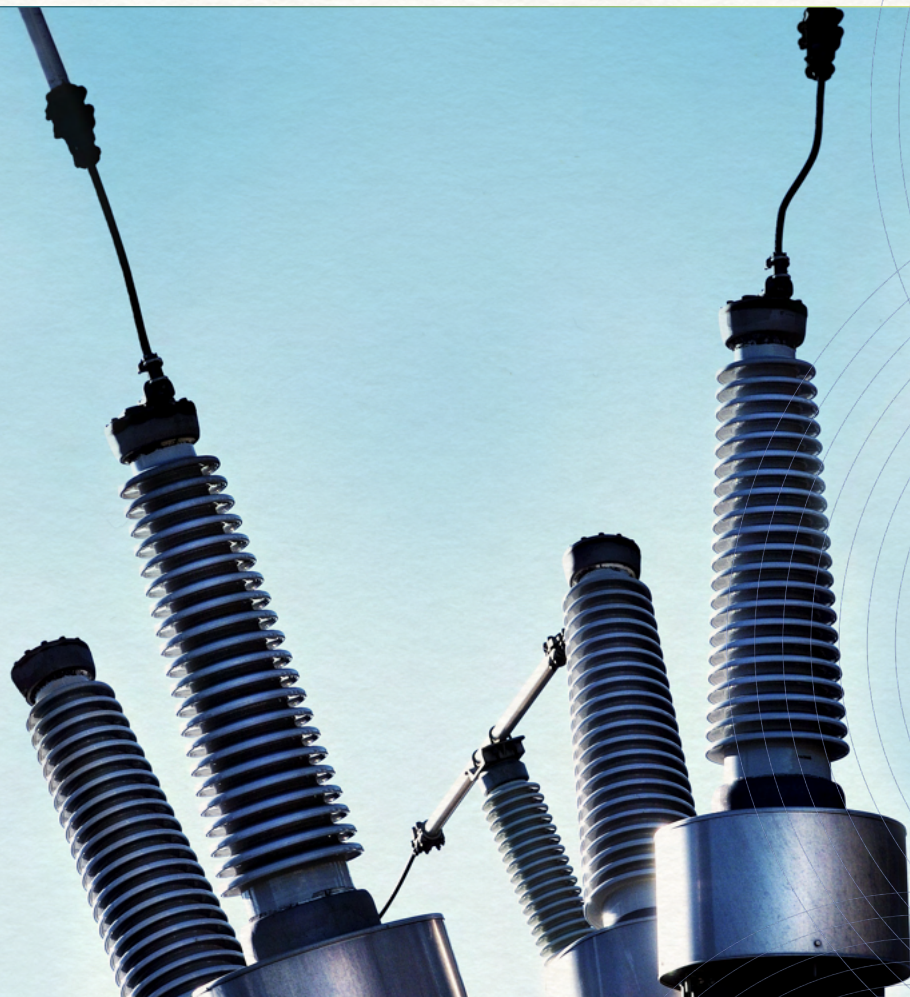
All of the above TBs are available for download from www.e-cigre.org



A3

TRANSMISSION AND DISTRIBUTION EQUIPMENT

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.



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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, environmentally friendly)
- Focus on environment and sustainability (e.g., lower carbon footprint of T&D equipment with alternative solutions to sulfur hexafluoride)
- 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

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.

FUTURE EVENTS

August 2024 : Paris session

March 2025 : CIGRE B3/A3 Forum, Klingenberg, Germany

May 2025 : Symposium, Trondheim, Norway

September 2025 : Symposium, Montreal, Canada



A3 • TRANSMISSION AND DISTRIBUTION EQUIPMENT

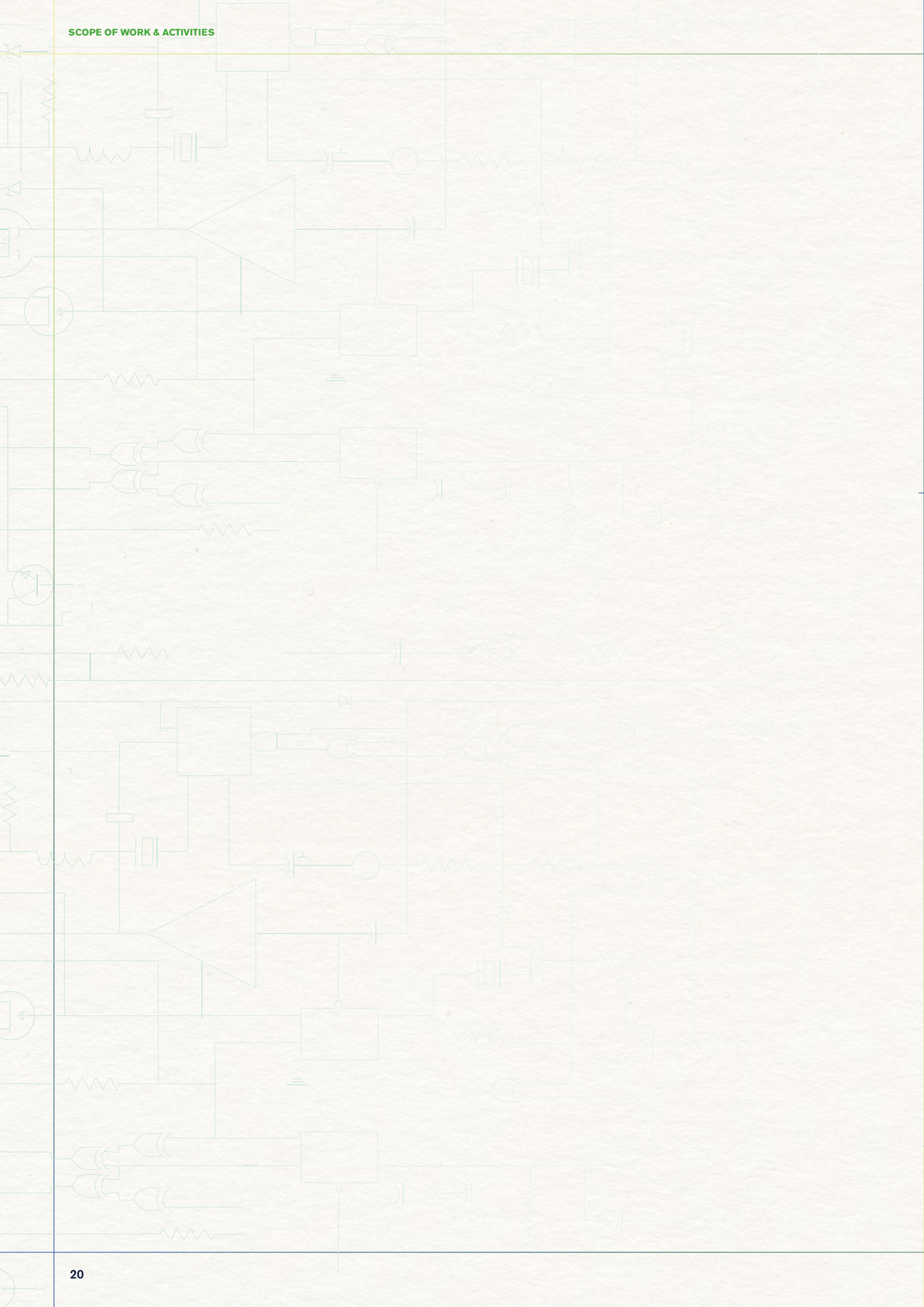
TOPICS OF ACTIVE WORKING GROUPS

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 A3.42	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 A3.47	Lifetime Management of Medium Voltage Indoor Switchgear
WG A3.48	4th CIGRE Reliability Survey on Transmission and Distribution Equipment
WG A3.49	Aging effects on accuracy class of Instrument Transformers
WG A3.50	On-site calibration and verification of the accuracy of instrument transformers
WG A3.51	Requirements for HV T&D Equipment operating under Abnormal Weather Conditions
JWG B3/A3.60	User guide for non-SF ₆ gases and gas mixtures in Substations
JWG B3/A2/A3/C3/D1.66	Guidelines for Life Cycle Assessment in Substations considering the carbon footprint evaluation
JWG B3/A3.67	Operational safety of Medium Voltage GIS in case of abnormal leakage
JWG C4/A3/B2/B4.75	Guide to procedures for the creation of contamination maps required for outdoor insulation coordination

LATEST PUBLICATIONS

TB 921	Applying Low-Residual-Voltage Surge Arresters to Suppress Overvoltages in UHV AC Systems
TB 914	Guidelines for SF ₆ end-of-life treatment of T&D equipment (>1 kV) in substations
TB 873	Design, test and application of HVDC circuit breakers
TB 871	Current Interruption in SF ₆ -free Switchgear
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

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



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 encompasses the life-cycle phases; from conception, through research, development, design, production, deployment, operation, and end-of life.

Life cycle assessment techniques, risk management techniques, education and training are also important aspects. Added focus on optimizing cable design for "unconventional" usage as part of the Energy Transition.



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B1 • INSULATED CABLES

PRINCIPAL AREAS OF INTEREST

- Theory, principles and concepts, functionality, technological development, design, performance and application of materials, efficiency.
- Manufacturing, testing, 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.
- 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.

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.

CURRENT ACTIVITIES

Preparation of Recommendations for further Standardization by IEC and the usage of cables to facilitate the Energy Transition. Tutorials and Webinars for Technical and Non-Technical Audiences.

MAIN AREAS OF ATTENTION

The main goals of SC B1 are the following :

- Promote and to contribute effectively to the progress in insulated cable systems technology and optimizing cable design for "unconventional" usage as part of the Energy Transition
- Facilitate the integration of insulated cable systems in electric power networks and in the environment, covering the complete life cycle of cables
- Maintain its leading position in the field of power cables by providing unbiased and without prejudice information on all essential cable aspects
- Be recognized by the Electric Power Industry as a leading and reliable partner with competence in all engineering issues related to insulated cable systems, i.e. technical, economical, ecological and social
- Monitor and assess current trends in cable technology.

At the end of 2023, almost 450 experts worldwide are participating to the work of SC B1.



B1 • INSULATED CABLES

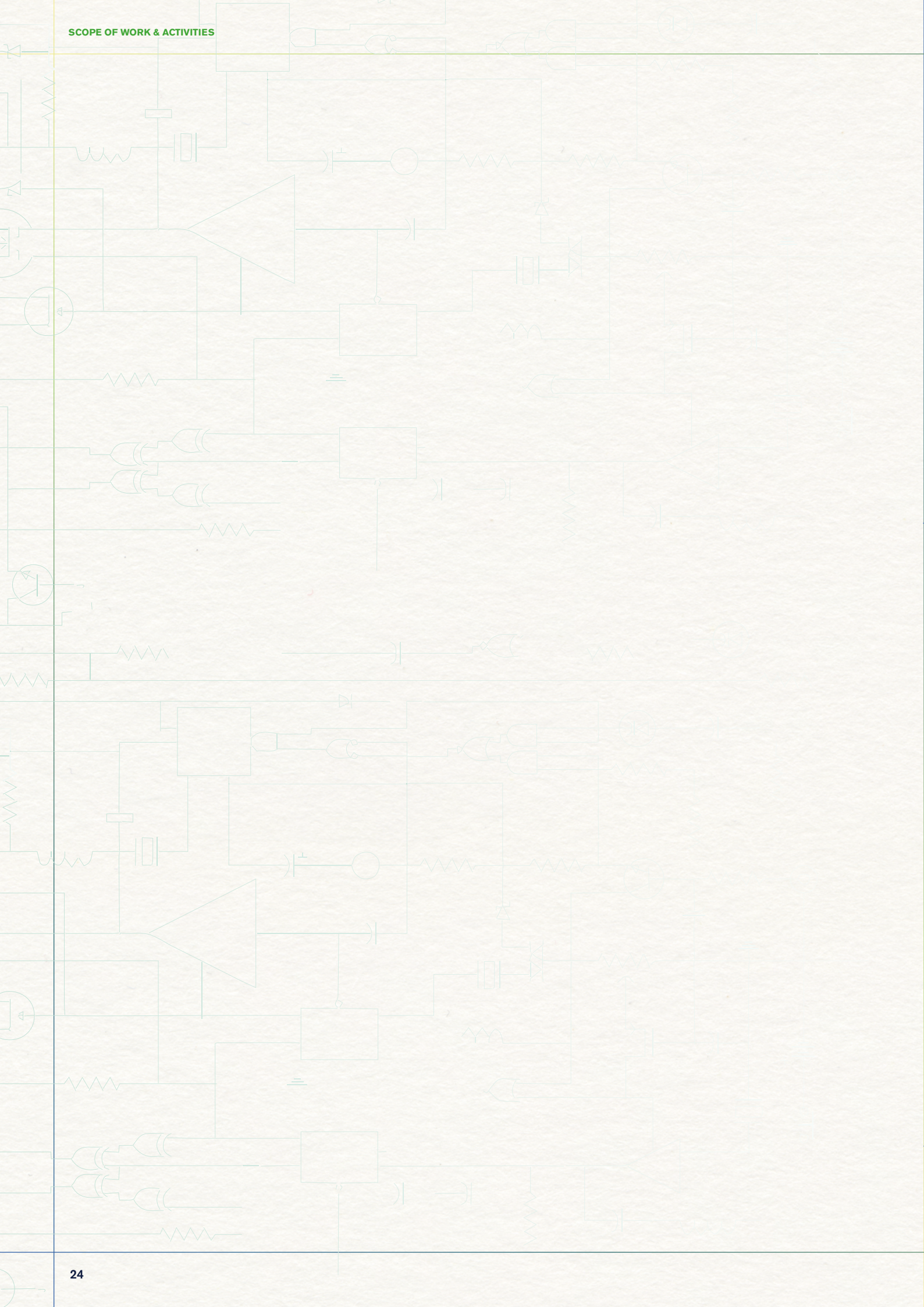
TOPICS OF WORKING GROUPS

WG B1.54	Behaviour of Cable Systems under Large Disturbances (Earthquake, Storm, Flood, Fire, Landslide, Climate change)
WG B1.58	Asset Management in MV Cables Networks
WG B1.67	Loading pattern on windfarm array and export cables
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
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
WG B1.88	Non-SF6 GIS terminations
WG B1.89	Guidance for conducting cable systems failure analysis
WG B1.90	Cable Systems Electrical Characteristics (Update of TB 531)
WG B1.91	Transient Thermal Modelling of Power Cables (update to IEC 60853)
WG B1.92	Qualification of Lead-free Submarine Cables at 72.5kV<Um<170 kV

LATEST PUBLICATIONS

TB 912	Condition evaluation and lifetime strategy of HV cable systems
TB 908	Evaluation of losses in armoured three core power cables
TB 899	Recommendations for the use and the testing of Fibre Optic Cables in land cable
TB 889	Installation of HV Cable Systems
TB 883	Installation of offshore Cable Systems
TB 880	Cable Ratings Verification
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

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



B2

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 fully in line with this important aspect of CIGRE's mission.



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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.

KEY PROJECTS FORTHCOMING EVENTS

CIGRE Symposium in Montreal, Canada in September 2025 (lead chair with SC B4)

OTHER SPECIFIC INTERESTS

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

CURRENT ACTIVITIES

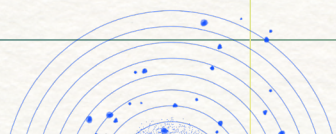
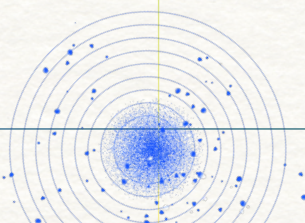
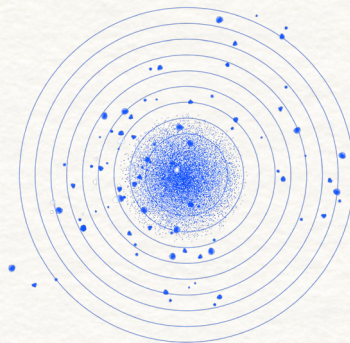
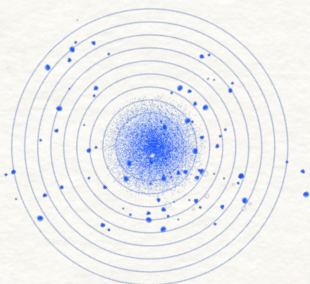
CIGRE Centennial Session Paris August 2024
B2 Annual Meeting at the Paris Session 2024.

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. Seeks to improve diagnostic tools and modelling of in-service components, both dynamic and static, foundation and 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

THE STUDY COMMITTEE COVERS

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



B2 • OVERHEAD LINES

TOPICS OF WORKING GROUPS

B2.59	Forecasting dynamic line ratings
B2.60	Affordable Overhead Transmission Lines for Sub-Saharan Countries
B2.65	Detection, Prevention and Repair of Sub surface Corrosion in Overhead Line Supports, Anchors and Foundations
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, Planning and Installation
B2/C1.86	Approach for Asset Management of Overhead Transmission Lines
B2.87	Live line and vicinity working on overhead lines: Safe Management Guidelines
B2.88	Guidelines for safety of overhead line construction, maintenance & operation
C4_A3_B4.75	Guide to procedures for the creation of contamination maps required for outdoor insulation coordination
B2.89	Impact of rain upon the characteristics of corona discharge from HV AC and DC overhead transmission lines
B2_B1.90	Transition facilities between overhead and underground lines
B2.91	Long overhead line spans design practices and field experience
B2.92	Update on Overhead Transmission Lines Construction Methodologies
B2.93	Artificial Intelligence (AI) Augmented Image-Based Transmission Line Inspection and Condition Assessment
B2.94	Inspection after installation, maintenance and end of life of high temperature conductors and fittings
B2.95	Impact of extreme weather events under climate change on high voltage overhead line design standards

LATEST PUBLICATIONS

GREEN BOOKS

Compact overhead line design, AC and DC lines, Rob Stephen, Javier Iglesias, January 2024.

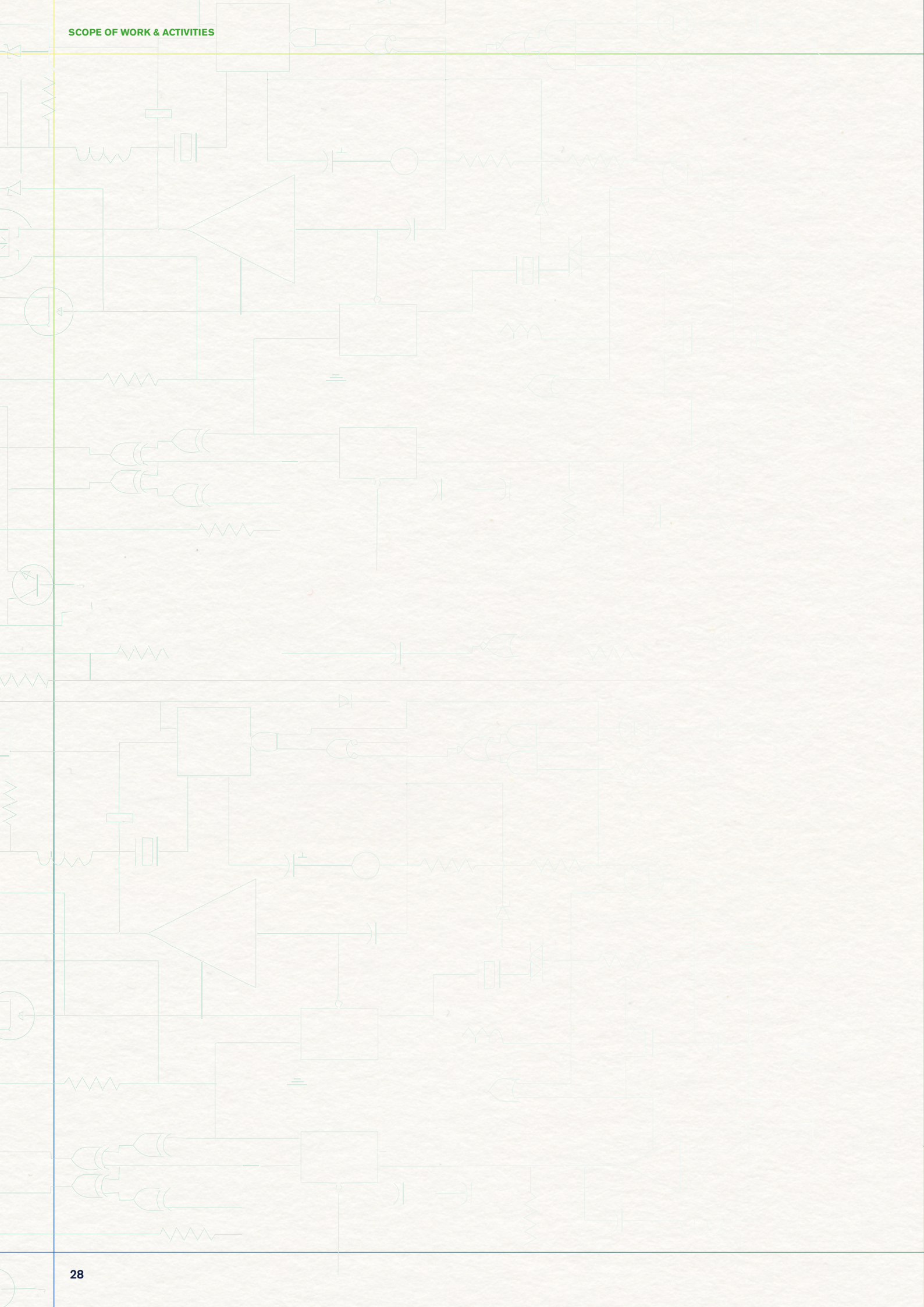
TECHNICAL BROCHURES

TB 905	Sustainability of overhead line conductors and fittings – Conductor condition assessment and life extension Volume 1: State of the art, WG B2.68, July 2023, 184 pages.
TB 916	Correct handling of fittings and conductors for overhead lines, WG B2.50, September 2023, 138 pages.
TB 919	Experience with and Application Guide for Composite Line Insulators, WG B2.57, November 2023, 149 pages.

CIGRE SCIENCE AND ENGINEERING

CSE No 23	Hydrophobicity Classification of Composite Insulators Using Convolutional Neural Networks, C.C. KOKALIS, T. TASAKOS, V.T. KONTARGYRI, G. SIOLAS, I.F. GONOS, C.A. CHRISTODOULOU, K.O. PAPAILIOU, December 2021.
CSE No 24	Comparison of electrical clearance between Japan and other countries, T. YAMANAKA, Y. SHIMOMURA, S. MURAKAMI, K.FUJITA, Y. KOYAMA, February 2022.
CSE No 24	Limits of electric field for composite insulators: state-of-the-art and recent investigations of overhead line insulators purchased by power utilities, P. SIDENVALL, I. GUTMAN, A. DECKWERTH, L. DIAZ, P. MEYER, J.F. GOFFINET, K. HALSAN, M. LEONHARDSBERGER, M. RADOSAVLJEVIC, P. TRENZ, K. VARLI, K. VALIMAA, February 2022.
CSE No 27	Latest Design Standard on Structures for Overhead Transmission Lines in Japan, Y. Kitano, S. Sugimoto, Y. Sato, H. Matsumiya, N. Soda, Y. Hattori, Y. Shiba, T. Ishikawa, S. Hatakeyama, T. Osono, M. Yamazaki, K. Kurita, H. Shigemoto, T. Kitashima, T. Ohkuma, January 2023, 16 pages.
CSE No 28	Condition assessment of line composite insulators: after-service test programs and their practical application, I. Gutman, J. Lundengård, P. Sidenvall, A. Deckwerth, L. Diaz, J.-F. Goffinet, K. Halsan, M. Leonhardsberger, M. Radosavljevic, P. Trenz, K. Varli, K. Välimaa, M. Heath, R. Davey, W. Vosloo, March 2023, 37 pages.
CSE No 29	Expanding smart grid capability using transmission lines – the formation of a Synergic Network, B.N. Aires, E. Ferreira da Costa, J.B. Rosolem, A. Dellallibera, C.A.M. do Nascimento, V. Naidoo, June 2023, 22 pages.
CSE No 29	Method for the site-specific conversion of weather parameters for probabilistic calculations of OHLs, S. Steevens, E. Ulloa Jimenez, C. Engelke, June 2023, 31 pages.
CSE No 30	Effect of temperature on overhead aluminium and aluminium alloy conductor creep, Omrani, A., Langlois, S., Demers, M., Binette, L., October 2023, 18 pages.

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



B3

SUBSTATIONS AND ELECTRICAL INSTALLATIONS

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.

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. B3 has long focused on the impact of the clean energy transition on changing substation demand. These activities align with and anticipate the «CIGRE 2023 Strategic Plan - Entering CIGRE's 2nd Century - Horizon 2030» published by CIGRE last year. Safety and life cycle condition assessment techniques, health indexing, risk management techniques, knowledge transfer and education are also important topics for our work



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B3 • SUBSTATIONS AND ELECTRICAL INSTALLATIONS

PRINCIPAL AREAS OF INTEREST

Our principal areas of interest include the following :

- New substation concepts include hybrid solutions, new applications to support energy transitions, and reduced carbon footprint impact by Life Cycle Assessment and new relevant technologies.
- Substation ownership issues, including human resource and training needs, and in-service support, 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 digitalisation 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.

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

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
- Application guidelines for turn-key projects
- Circuit configuration optimisation
- Contemporary design solutions for low-cost substations
- Substation earthing system design optimisation through the application of quantified risk analysis
- 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
- 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
- Impact on Engineering and Lifetime Management of Outdoor HV GIS
- Knowledge Transfer of Substation Engineering and Experiences
- Mobile Substations Incorporating HV GIS
- Guidelines for SF6 end-of-life treatment of T&D equipment (>1 kV) in substations

KEY PROJECTS FORTHCOMING EVENTS

2024 CIGRE Session, including :

- A2/A3/B3/D1 joint workshop "Driving T&D substations and equipment towards ZERO emissions" on Monday, 26 August 2024.
- B3 tutorial "Guidelines for SF6 end-of-life treatment of T&D equipment (>1kV) in substations" on Tuesday, 27 August 2024.

2025 Important events :

- 2025 B3/A3 Joint Colloquium, 24-28 March 2025 in Klingenberg, Germany.
- CIGRE Trondheim Symposium, 12-15 May 2025
- CIGRE Montreal Symposium, 29 September – 2 October 2025

B3 • SUBSTATIONS AND ELECTRICAL INSTALLATIONS

TOPICS OF WORKING GROUPS

SC B3 has more than 370 experts in 14 active Working Groups, including 7 Joint Working Groups (5 B3 lead) 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

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 B3.52*	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
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	Guideline for assessing the toxicity of used SF6 gas onsite and in the lab of T&D equipment above 1 kV in substations
JWGD1.63	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
WG B3.65	
WG B3/A2/A3/C3/D1.66	Guidelines for Life Cycle Assessment in Substations considering the carbon footprint evaluation
JWG B3/A3.67	Guidelines for SF6 end-of-life treatment of T&D equipment (>1kV) in Substations
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* plans to publish Technical Brochure in 2024.

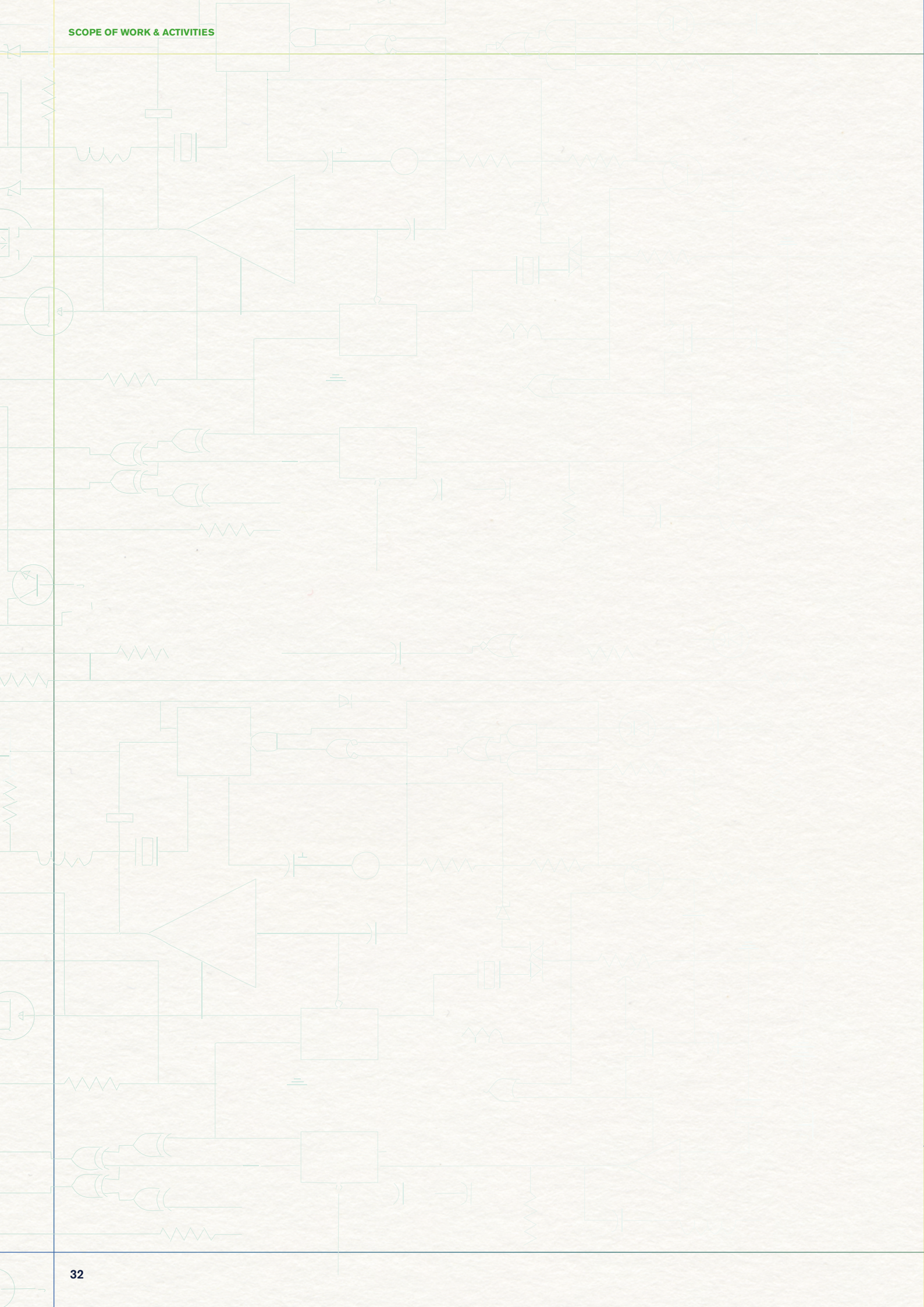
Go to https://www.cigre.org/article/GB/news/the_latest_news/cigre-active-working-groups--call-for-experts for the latest information.

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 895	Impact on Engineering and Lifetime Management of Outdoor HV GIS
TB 898	Knowledge Transfer of Substation Engineering and Experiences
TB 907	Mobile Substations Incorporating HV GIS
TB 914	Guidelines for SF6 end-of-life treatment of T&D equipment (>1 kV) in substations
TB 920	Concepts for on-site HV testing of GIS after installation, extension, retrofit or repair
TB 930	Review of substation busbar components reliability

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



B4

SYSTEMS AND POWER ELECTRONICS

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 other power electronic devices from transmission to distribution systems.



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B4 • SYSTEMS AND POWER ELECTRONICS

PRINCIPAL AREAS OF INTEREST

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
- DC interconnectors and establishment of DC grid(s) to increase power transmission capacities and to reduce existing network congestions, to enable power trading, to share spinning reserve, and to reduce energy costs etc.
- Application of higher power, voltage rating, active filtering of FACTS device to support the flexible transmission of AC power, improve voltage stability, the change of generation patterns and power quality within the ac networks.
- Application of DC technologies and PE in distribution system for better power quality control
- Learning the project and operational experience of VSC HVDC systems to further improve the application of this technology
- Application of DC and PE technology in Hydrogen production.

KEY PROJECTS FORTHCOMING EVENTS

SC B4 had the following key events in 2023 :

- CIGRE/GCC Muscat Symposium (March 6-8)
- 8 paper presentations
- Tutorial “Guide to Develop Real-Time Simulation Models (RTSM) for HVDC Operational Studies Models (RTSM)”
- WiE panel

B4 Colloquium in Vienna (September 9-15) in 2023 :

- SC B4 Study Committee meeting on September 11, 2023
- 2 days of paper presentations
- Technical tour
- Tutorials:
 - “Solid state transformer”
 - B4.84 “Feasibility study and application of electric energy storage systems embedded in HVDC systems”
 - B4.87 “Voltage Source Converters (VSC) HVDC responses to disturbances and faults in AC systems which have low synchronous generation”
 - B4.81 “Interaction between nearby VSC-HVDC converters, FACTs devices, HV power electronic devices and conventional AC equipment”

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 JWGs 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.

- Grid forming converters including HVDC, FACTS and energy storage system.
- Interaction between nearby VSC-HVDC converters, FACTs devices, HV power electronic devices and conventional AC equipment
- Electric energy storage systems embedded in HVDC systems
- HVDC for renewable generation such as PV interconnection
- Dynamic active and reactive power supporting devices for VSC HVDC Systems
- Offshore DC converter design aspects
- Interoperability in HVDC system
- Integration of DC systems to meshed DC/AC Transmission networks
- Harmonization of voltage designations and definitions across different HVDC component technologies
- Insulation coordination of VSC converters and DC cables
- Hybrid LCC/VSC technology
- DC system/converter modelling
- DC grids including DC breakers, fault current limiting
- Operation and maintenance of HVDC/FACTS
- PE in distribution system

B4 • SYSTEMS AND POWER ELECTRONICS

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
B4.81	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
B4.93	Development of Grid-Forming Converters for Secure and Reliable Operation of Future Electricity Systems
C2/B4.43	The impact of Offshore Wind power hybrid AC/DC connections on System Operations and System Design
B4.94	Application of grid-forming VSC-HVDC system in black start restoration
B1/B3/B4/C4/D1.95	Harmonization of voltage designations and definitions across different HVDC component technologies
C4/B4.72	Lightning and Switching Induced Electromagnetic Compatibility (EMC) issues in DC power systems and new emerging power electronics-based DC equipment
B4.95	Developments in Power Semiconductor Technologies and Applications in HVDC/FACTS
B4.96	HVDC connection of power system with high proportion of photovoltaic (PV) generation
C4/A3/B2/B4.75	Guide to procedures for the creation of contamination maps required for outdoor insulation coordination
B4/C1.97	Benchmarking of simulations models for control interaction in meshed AC networks with multiple converters
C1/B4.49	Offshore transmission planning
B4.98	Design considerations in integration of DC systems to meshed DC/AC Transmission networks
B4.99	Design and Construction of offshore Voltage Sourced Converter (VSC) Stations
B4.100	Dynamic Active and Reactive Power Supporting Devices for VSC HVDC Systems
B4.101	Industrial Implementation and Application of Grid Forming Energy Storage Systems (GFM ESS)

LATEST PUBLICATIONS

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 867)
C6/B4.37	Medium Voltage DC distribution systems (TB 875)
B4/A3.80	HVDC Circuit Breakers - Technical Requirements, Stresses and Testing Methods to investigate the interaction with the system (TB 873)
AG B4.04	Static Var Compensator/STATCOM performance survey results – 2017 and 2019 (TB 872)

TECHNICAL BROCHURES (2023)

C4/B4.52	Guidelines for Sub-synchronous Oscillation Studies in Power Electronics Dominated Power Systems (TB 909)
B4/B1/C4.73	Surge and extended overvoltage testing of HVDC Cable Systems (TB xxx, under 60-day review)
B4.79	Hybrid LCC/VSC HVDC Systems (TB xxx, under 60-day review)

CSE PAPERS

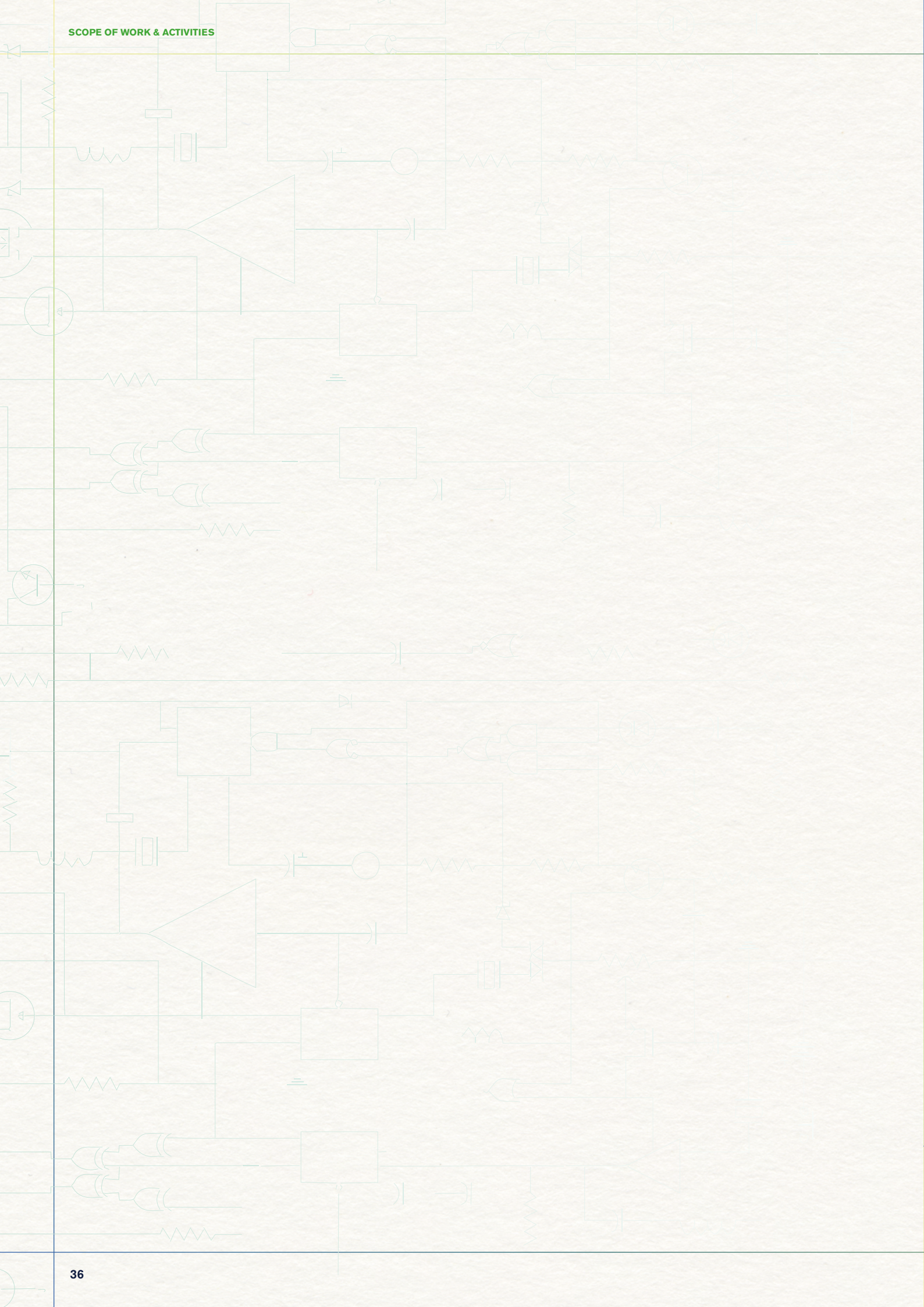
Case study of dc-MMC interconnecting two HVDC lines with different grid topologies (CSE024)
Hybrid HVDC Transmission System Using Grid Forming Converters to Supply Energy to Rural Areas (CSE026)
A Novel Offshore Grid Forming Control Concept for Parallel MMC VSC HVDC Bipoles (CSE026)
A Robust Energy Storage System Manager with Power Flow Controller for Maintaining Transient Stability in Power Plant Rely On Wind and Solar
Interest of a power flow controller for some upgrading scenarios in HVDC systems
The use of a power flow controller to optimise current sharing in parallel HVDC cable connections
Small-Signal Analysis Benchmarking of Three Control Algorithms for Grid-Forming Inverters
Real-Time Digital Twins of Multi-terminal HVDC Power Systems
Power-flow for archipelago-based multi-terminal HVDC grids

FUTURE CONNECTION

Development of Grid Forming Converters for Secure and Reliable Operation of Future Electricity Systems (FC Edition 10)
--

ELECTRA

HVDC Technology for Renewable Energy Dominated Power Systems
A three-terminal LCC-HVDC network upgraded from a point-to-point link in China



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.



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B5 • PROTECTION AND AUTOMATION

THE MISSION OF SC B5 IS AS FOLLOWS

The mission of SC B5 is to facilitate and promote international advancements in engineering, exchange of information, and expansion of knowledge in the field of Protection and Automation, focused on Protection, Control, Monitoring, Metering and Fault location, and aims to cover the whole Power system, from transmission, to distribution systems, including generation. This includes to add value to this information and knowledge by means of synthesizing state-of-the-art practices, identifying and evaluating technological and functional evolutions and developing recommendations.

THE VISION OF SC B5 IS AS FOLLOWS, THE TERMS :

- Be recognized as the leading global reference on Protection, Control, Monitoring, Metering, and Fault locating
- Be the provider of a global perspective on the issues and challenges related to Protection, Control, Monitoring, Metering, and Fault location
- Be an independent expert on emerging technologies and provider of high-quality unbiased publications about Protection, Control, Monitoring, Metering and Fault location

SCOPE OF SC B5

Within its technical field of activity, Study Committee B5 addresses topics throughout the Protection, Control, Monitoring, Metering, and Fault location devices. This covers the systems management life-cycle phases from design, through research, development, design, engineering, configuration, production, deployment, operation, and end-of life. At all stages, technical, safety interactions with, and integration into, the evolving Power system and the operating environment are addressed. 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 technology evolution and changing Power systems. Life cycle assessment techniques, risk management techniques, education and training are also included.

WITHIN THIS FRAMEWORK SPECIFIC AREAS OF ATTENTION INCLUDE :

- Theory, principles and concepts, functionality, technological development, design, performance and application of materials, efficiency.
- Application guidance, planning, installation, service conditions.
- Reliability, availability, dependability, maintainability and maintenance, service, Condition Monitoring, diagnostics, restoration, repair, loading, upgrading, uprating.
- Refurbishment, deterioration, dismantling, disposal.

MAIN AREAS OF ATTENTION

The following areas are of principal interest for SC B5 :

- Power system Protection, Automation and Control principles, methods and applications, including Protection of networks connected to renewable energy resources
- Functional integration and virtualization of Protection systems and substation Automation systems
- Protection, Automation and Control system architectures including process interfaces, digital signaling, communication architecture, time synchronisation, and related issues.
- New Network Requirements covering 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
- IEC 61850 based data modelling, Protection, Automation and Control configuration and engineering
- Metering
- Process Data acquisition, modelling and publication for Protection, fault recording, Monitoring, Metering and asset management applications (interface to HV equipment Monitoring, and HV equipment monitoring)
- Monitoring of Protection, Control, Metering, Fault locating devices and systems including associated communication equipment
- System-wide Protection and Control schemes.
- Exploring and evaluating emerging technology for Protection, Automation, and Control across Power system
- Design, engineering, Monitoring and performance assessment of System Integrity Protection Schemes (SIPS)
- Design, engineering, Monitoring and performance of protective relay based Power system security and stability enhancing schemes like Automatic Under Frequency Load Shedding (AUFLS), Automatic Under Voltage Load Shedding (AUVLS), Anti-Islanding, Fault Ride Through, Auto-Reclosure Scheme etc.

B5 • PROTECTION AND AUTOMATION

OTHER SPECIFIC INTERESTS

Technical brochures from finalised working groups in SC B5 in 2023 (eCigre):

- TB 891, WG B5.60 Protection, Automation and Control Architectures with Functionality Independent of Hardware
- TB 896, WG B5.48 Protection for Developing Network with Limited Fault Current Capability of Generation
- TB 829, JWG C4.B5.41 Challenges with series compensation applications in Power systems when over-compensating lines

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)

ACTIVITIES TOWARDS NEW CIGRE TOPICS

HYDROGEN

- In the future there could be advancement of Protection and Automation used in the Hydrogen plants

STORAGE

- In the future there could be Protection and Automation optimization for Long Duration energy storage

WIND & SOLAR

- Power system protection, automation and control principles, methods and applications, including protection of networks connected to renewable energy resources.
- New Network Requirements covering the design and application of digital technology and modern communication system for the benefit of modern and future networks featuring greater embedded generation and smart grid techniques
- Impact of harmonics and low inertia on Protection and Automation

GRIDS, MICROGRIDS INTEGRATION & FLEXIBILITY

- Protection and Automation for microgrid integration
- Sensor integration
- Condition assessment

CONSUMER, PROSUMERS AND EV

- In the future there could be Protection and Automation for integration of new technologies
- In the future there could be Circular Economy, End of Life of Protection and Automation, Condition assessment

SUSTAINABILITY & CLIMATE CHANGE

- Protection and Automation used to monitor and protect substations, overhead lines etc.
- Use of Protection and Automation to improve grid resilience related to climate change

DIGITALIZATION

- Functional integration and virtualization of Protection Systems and Substation Automation Systems
- IEC 61850 based data modelling, Protection, Automation and Control configuration and engineering
- Digital twins for Protection, Automation and Control

KEY PROJECTS / FORTHCOMING EVENTS

CIGRE Paris session August 2024

- PS 1 Practical experiences and new developments of process bus
- PS 2 Acceptance, commissioning, and field testing for Protection, Automation and Control Systems
- CIGRE SC B5 Colloquium Osaka, July 2025
- PS1 Interoperability of IEDs of different manufacturers and technologies integrated in one Protection Automation and Control System (PACS)
- PS2 Protection Automation and Control System (PACS) Life Cycle Performance and Longevity
- PS3 Experiences and possibilities on revised principles and policies related to modern Protection IEDs

B5 • PROTECTION AND AUTOMATION

TOPICS OF ACTIVE WORKING GROUPS

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 B5.63	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)
WG B5.78	New requirements of network Protection and Control for renewable energy integration
WG B5.80	Protection, Automation and Control Systems (PACS) design for reliability
WG B5.81	Obsolescence Management for Protection, Automation and Control Systems
WG B5.82	Education, Qualification and Continuing Professional Development of Engineers in Protection, Automation and Control
WG B5.83	Protection for modern distribution networks
JWG B5/	
C4.61	Impact of Low Inertia Network on Protection and Control
C4.79	Protection Roadmap for Low Inertia and Low Fault Current Networks

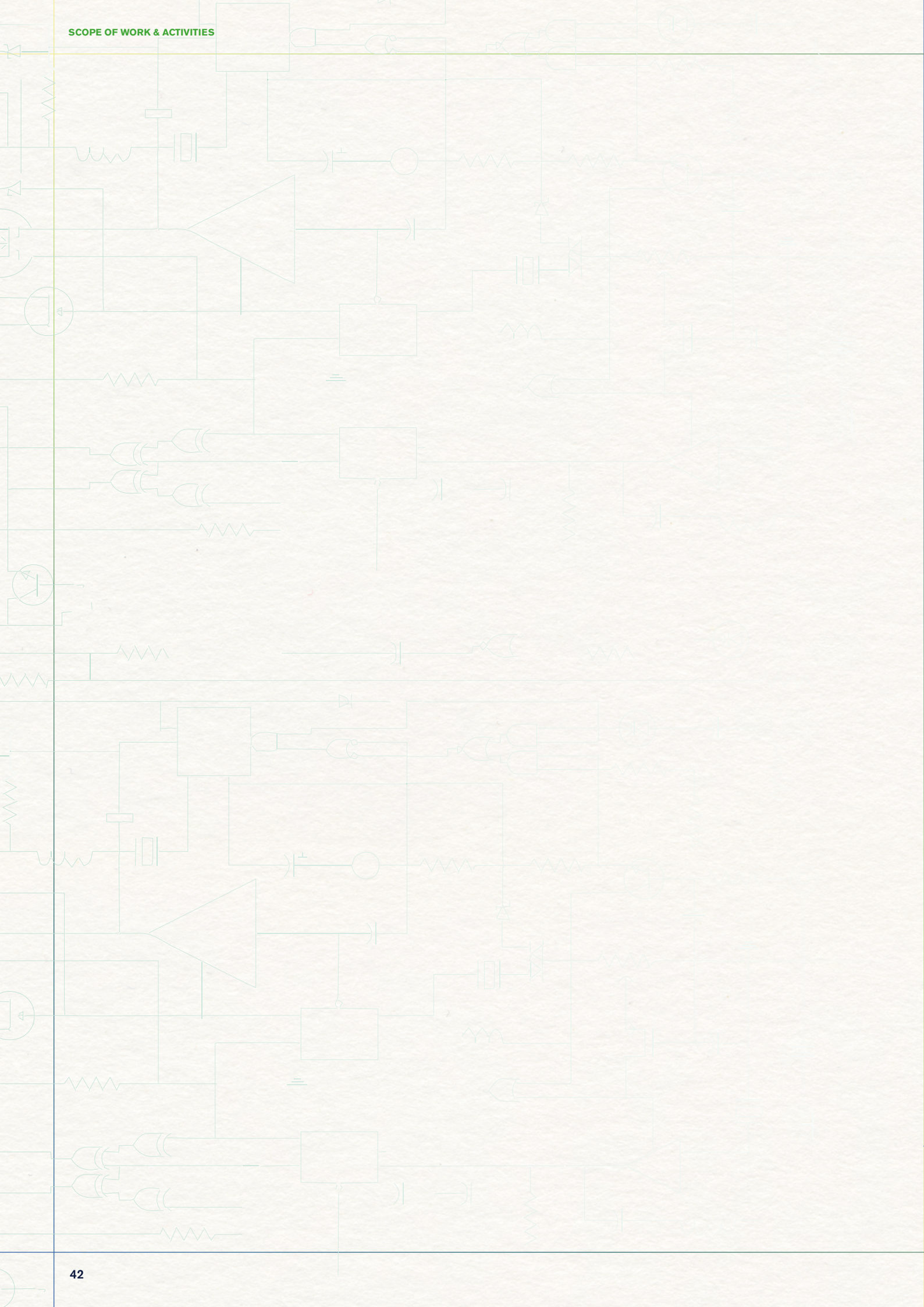
LATEST PUBLICATIONS

TB 896	Protection for Developing Network with Limited Fault Current Capability of Generation
TB 891	Protection, Automation and Control Architectures with Functionality Independent of Hardware
TB 884	Time in Communication Networks, Protection and Control Applications – Time Sources and Distribution Methods
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

B5 • PROTECTION AND AUTOMATION**LATEST PUBLICATIONS**

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	Engineering Guidelines for IEC 61850 Based Digital SAS
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



C1

POWER SYSTEM DEVELOPMENT AND ECONOMICS

MISSION

To support energy system planners, asset managers and decision makers worldwide in anticipating and successfully managing the system changes raised by Energy Transition. To address emerging needs, seize opportunities and tackle growing uncertainties, while respecting multiple constraints: security of operations, adequacy, resilience, affordability and sustainability. To facilitate and promote the progress of engineering and planning methods, to share state-of-the-art, best practices and recommendations.

SCOPE

The scope of work of Study Committee C1 covers all system development and economic issues relevant to a sustainable electricity industry and focuses on grid planning enshrined within the broader power system development framework. To elaborate scenarios and investment economics, identify mega trends and game changers, develop approaches for energy sectors integration and hydrogen economy deployment. To improve planning criteria and methodologies, in particular analysis of projects' costs, benefits & risks, to modernise asset management strategies. To introduce in system development processes all flexibility means, all forms of storage (short and long term) and the new active role of end users / demand management; to leverage on digitalisation, on results of innovation in technology and in processes, to strengthen stakeholders' involvement for the realisation of the planned infrastructures, to support evolution of environmental and regulatory frameworks.

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C1 • POWER SYSTEM DEVELOPMENT AND ECONOMICS

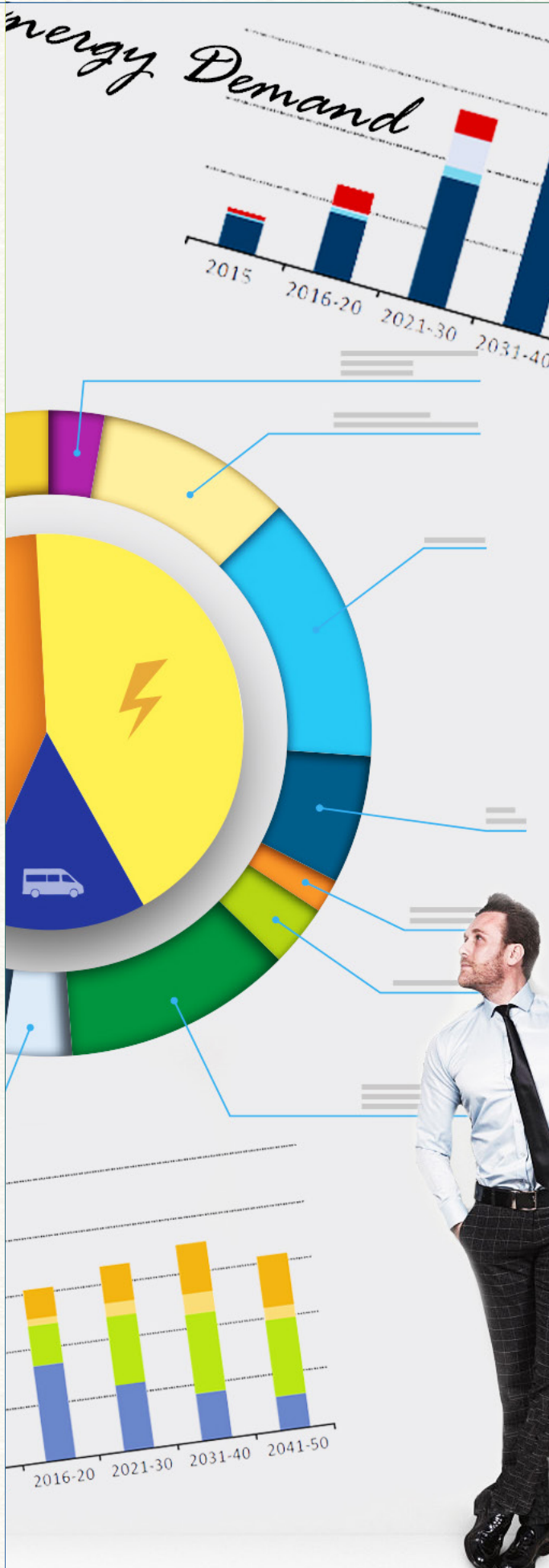
ENGAGEMENT TOWARDS THE ENERGY TRANSITION

Grid planning and the development of the broader energy system are undergoing major changes due to the fast decarbonisation of electricity system. Being forward-oriented by mission, Energy Transition for C1 is already present as main driver of studies and knowledge sharing activities on:

- Decarbonisation ambitious targets and implications
- Deep digitalization
- Governance changes & new actors/roles
- Resilience to crisis and multiple threats
- How to design a smooth transition path towards the final goal, avoiding stranded assets
- Offshore grid development
- In particular, C1 has fully embraced Cigre End-to-End approach, extending its activities to the outer edges of the transmission system:
 - New generation mix
 - Transmission-Distribution convergence
 - New role of demand and of consumers
 - Pivotal role of storage
 - Increasing interconnections, spreading from Super Grids to microgrids
 - Sector coupling
 - Hydrogen as third pillar of energy system.

SPECIFIC AREAS OF INTEREST

- Holistic scenarios towards an energy System of Systems
- Energy sector integration and impact on power grids
- Electrification of transport, heating and industrial processes
- Role of storage in energy transition
- Role of Hydrogen in energy transition and impact of electrolysers in grid planning
- Grid planning with high penetration of distributed resources, including energy communities and virtual power plants
- Resilient system by design and reserve needs assessment
- Flexibility needs and sources, including demand response management
- Demand and variable generation forecasting methods
- Evolving methodologies and metrics in Cost-Benefit Analysis
- Infrastructure investments and business models
- Interconnections and TSO-DSO coordinated planning
- Global grids pre-feasibility studies
- Power system development trends in large city and metropolitan areas



C1 • POWER SYSTEM DEVELOPMENT AND ECONOMICS

AREAS OF ACTIVITIES INCLUDE

System planning

- Planning criteria and methods in competitive and regulatory structures and with stakeholder involvement for public acceptance. Progress and new approaches in application of power system planning criteria and resilience (reliability, security, adequacy,) assessment.
- Methods and tools for steady state and dynamic analysis in system planning
- Capacity enhancement by use of risk-based security assessment and advanced information, communication and power-electronics technology for improving system stability and dynamic performance.
- Future dependence, requirements and economy of ancillary services for frequency and voltage control and other system needs (grid codes).
- System planning issues in newly industrialised and developing countries including metropolitan areas.
- System planning and technology issues in specific contexts e.g. off-shore wind, large surpluses/deficits in available RES, low inertia systems, bi-directional power exchanges with distribution systems, HVDC and meshed DC grids
- Power system development under increasing uncertainty and energy sectors integration: Transport, Heating, gas, hydrogen and synthetic fuels.
- 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
- Timely engagement of stakeholders in investment decision processes
- Bridging the gap in the understanding of specialists and wider societal stakeholders
- Cost-Benefit Analysis with evolving multi-criteria .

BUSINESS MANAGEMENT

- Scenario and methodologies definition/adoption for quantitative studies on future power systems;
- Prioritizing investments across a multitude of projects and programs addressing different system needs;
- Adapting to the changing levels of investment risk as the nature of the power system evolves.
- Impact on system development of new solutions and technologies in fields such as generation, demand side management (DSM), energy storage, smart grids and active distribution systems.
- The impact of pricing and tariff methods for transmission services on system development and project priorities in the context of market design and grid ownership structures.
- The impact of business models, cost-benefit-analyses and privatisation on system development (prioritisation of investments, infrastructure tenders, merchant lines, public-private partnerships, etc.);
- The impact of market design and regulation (pricing, tariffs, incentives, other aspects of market design etc.) on planning scenarios, and on transmission and distribution planning and investments

ASSET MANAGEMENT

- Asset management strategies, probabilistic and risk-based, and tools, total life cycle cost of ownership, scarce resources management.
- Growing inter-relationships between asset management, digitalisation and system planning (e.g. asset analytics platforms).
- Break-even conditions between preventive, containment and restoration measures.
- 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.
- Asset analytic data platforms and tools to support asset management

INTERCONNECTIONS HORIZONTAL, VERTICAL

- Planning issues related to long distance transmission and international interconnections.
- Interface and allocation issues in transmission and distribution planning, and delivery of multi-party/cross-jurisdiction projects.
- Global electricity network, including effects of storage, demand response and trading rules
- Planning regulated/non-regulated transmission assets in parallel, optimal sizing of interconnectors
- Coordinated planning with “smart” and evolving distribution systems, especially with uncertain evolution and markets for demand response, electric vehicles, empowered customers, dynamic pricing, distributed generation and battery costs;
- Planning methodologies and issues related to electrification of end uses in heating/cooling and transport

KEY PROJECTS FORTHCOMING EVENTS

- At Paris Session 2024, where C1 will meet in person, besides the traditional Group Discussion Meeting (this year with more papers submitted and accepted) C1 will also deliver:
- Tutorial on “Energy Sectors Integration and Impact on Power Grids” presenting the work of C1.47
- Tutorial on “Role of Green H2 in the Energy Transition and its impacts across the value chain”, jointly with C5.
- Joint workshop on “Resilience by design” with C4, based on the work of C1.46
- Participation and SC meeting in person at Symposium in Montreal (September 2025)
- Participation and SC meeting in person at Symposium in Jerusalem (spring 2027)

C1 • POWER SYSTEM DEVELOPMENT AND ECONOMICS**TOPICS OF WORKING GROUPS****EXISTING**

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
WG C1.42	Planning tools and methods for systems facing high levels of distributed energy resources.
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
WG C1/B4.49	Offshore transmission planning
WG C1.50	Global sustainable energy system coupling electricity and hydrogen.
WG C1.51	The potential roles of energy storage in electric power systems
JWG B2/C1.86	Approach for Asset Management of Overhead Transmission Lines
WG C1.52	Virtual Power Plants: Role and deployment in large power systems' operation and planning

PENDING APPROVAL/ IN DEVELOPMENT

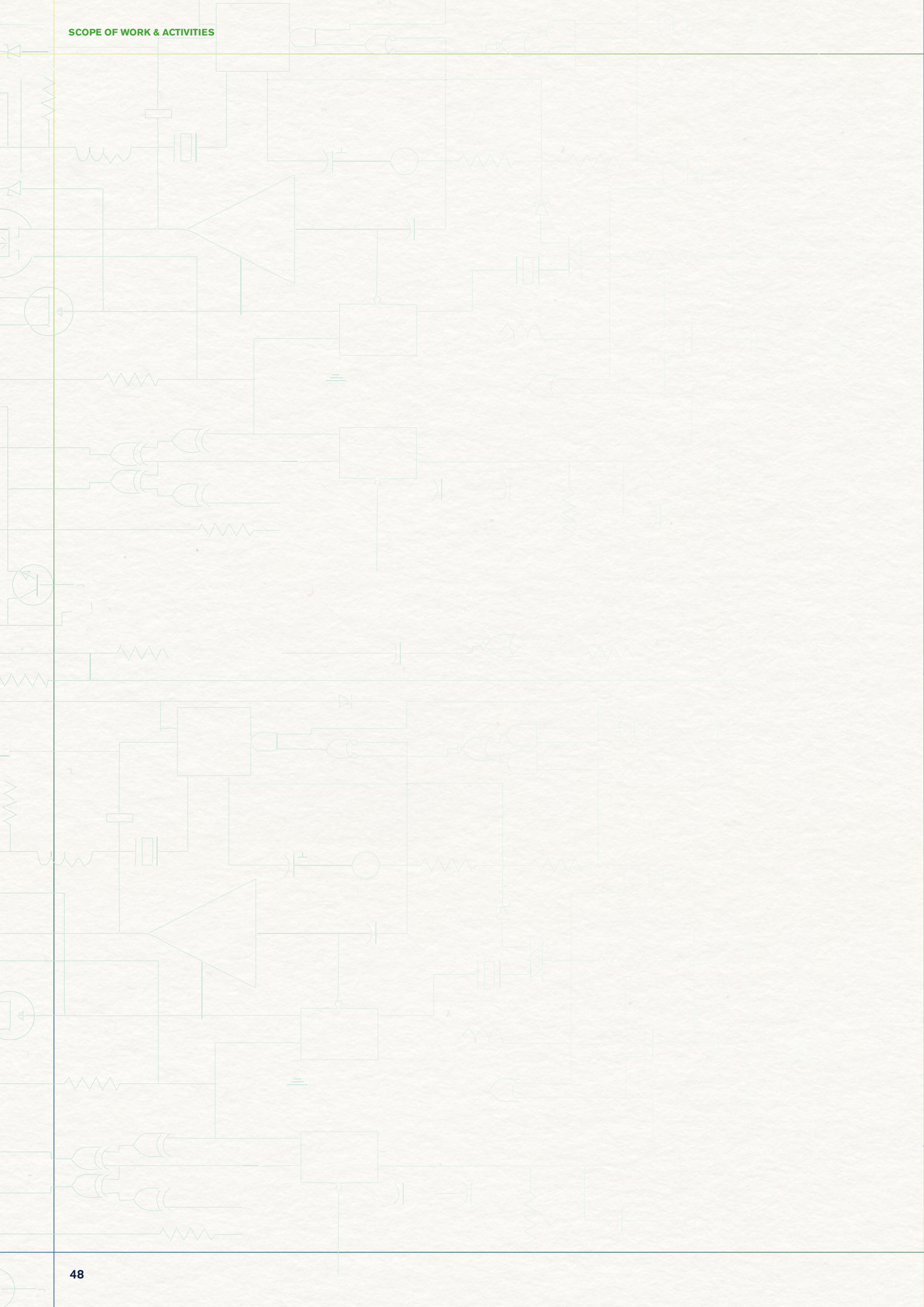
(WG C1.53)	Forecasting demand to include consumer behaviour decisions influenced by market signals
(WG C1.54)	Assessment of system reserves and flexibility needs in the power systems of the future.

LATEST PUBLICATIONS

TB 882	Closing the gap in understanding between stakeholders and electrical energy specialists.
TB 910	Business requirements for asset performance management.
TB 922	Review of Large City & Metropolitan Area power system development trends taking into account new generation, grid and information technologies.
TB 923	Optimal transmission and distribution investment decisions under increasing energy scenario uncertainty.

A Green Book on 'Asset Management' has been printed by Springer and is going to be translated also in Chinese language.

All of the TBs are available to download from <https://www.e-cigre.org/>



C2

SYSTEM OPERATION AND CONTROL

The scope of SC C2 covers the technical, human resources and institutional aspects and conditions for safe and economical operation of power systems in a manner that complies with network security requirements, against system disintegration, damage to equipment and human injuries, and security of electricity supply.

The changes brought to electrical systems by the global Energy Transition movement have opened up possibilities, expectations and the need for attention to these new aspects in general.

C2 members come mainly from transmission system operators.

The SC is encouraging young members and women to participate in its activities.



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C2 • SYSTEM OPERATION AND CONTROL

MAIN 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

- 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.
- Operational strategies to manage power system minimum operating conditions.
- Estimation, evaluation and provision of power system inertia in networks with a high share of renewable generation.
- The impact of offshore wind power hybrid AC/DC connections on system operations and system design.

KEY PROJECTS FORTHCOMING EVENTS

Publication: 2024 - Technical Brochures for WGs C2.39, C2.42 and C2/C5.06.

CIGRE Session 2024, Paris, France, 25 to 30 August 2024 :

- Workshop : C2&C5 Large Disturbances in Systems and Markets Workshop during CIGRE Session 2024, Paris, 26 August 2024
- Tutorial : Wide Area Monitoring Protection and Control Systems – Decision Support for System Operators – WG C2.18 during CIGRE Session 2024, Paris, 27 August 2024

Symposium : CIGRE Symposium, Trondheim, Norway, May 2025 :

- SC.C2 will be a participant with the presentation and discussion of papers and, probably, tutorials during the symposium.

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).

The changes brought to electrical systems by the global Energy Transition movement have opened up possibilities, expectations and the need for attention to these new aspects in general.

It was necessary to include the search for detailed knowledge and the consequences on the operation in new aspects that become part of the routine of technicians who work in the knowledge zone of our Study Committee. The main aspects are:

- Storage
- hydrogen
- Digitization
- Sustainability and Climate Change
- Grids and Flexibility
- Solar PV and Wind
- Consumers, Prosumers and Electrical Vehicles
- Sector Integration

Our studies must seek the correlation between one or more of these aspects with the topics described in our scope above, going deeper into the consequences of technological developments and the necessary solutions to the new problems arising from them.

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.

C2 • SYSTEM OPERATION AND CONTROL

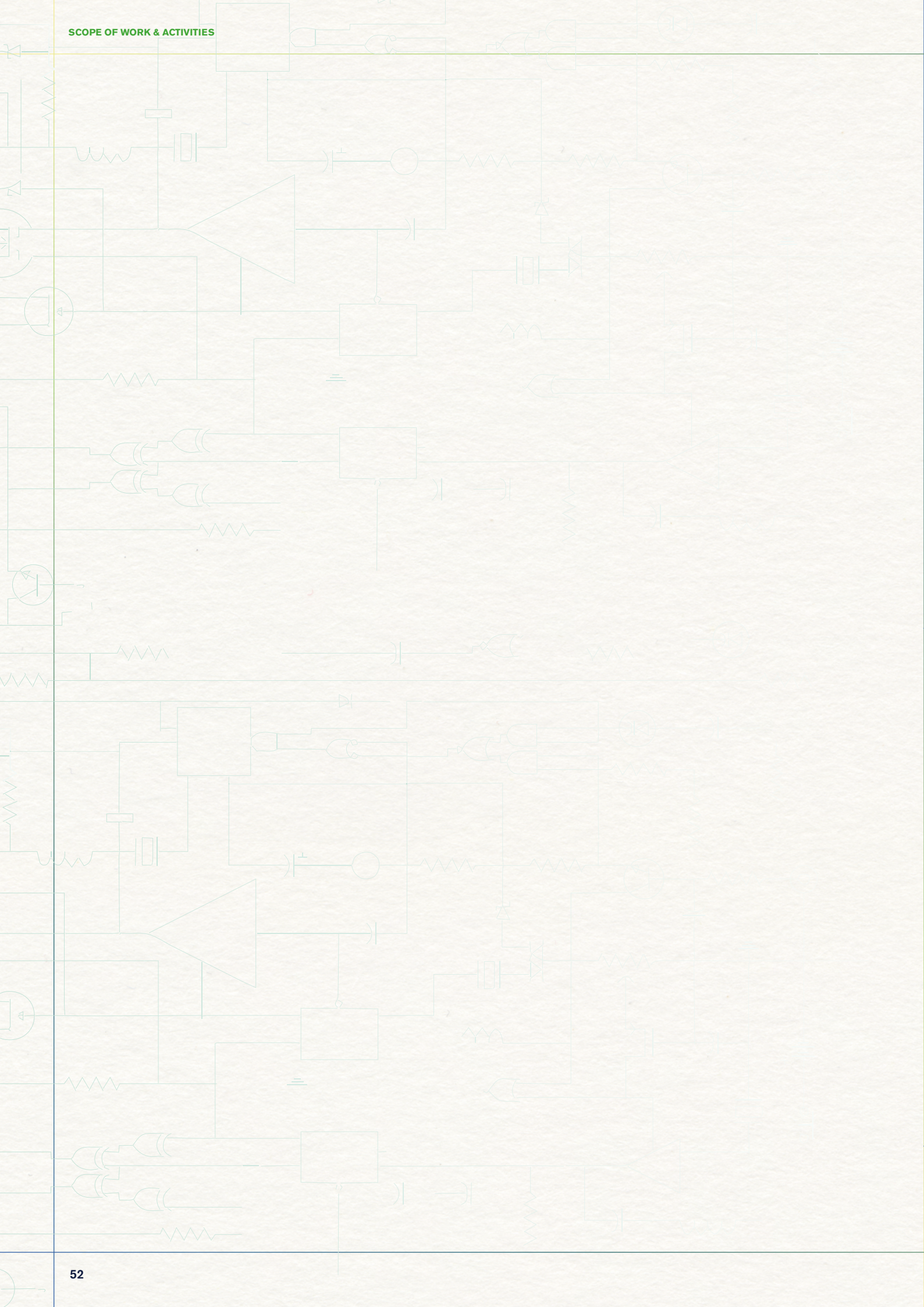
TOPICS OF WORKING GROUPS

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
WG C2.44	Operational strategies to manage power system minimum operating conditions
WG C2.45	Estimation, evaluation and provision of power system inertia in networks with a high share of renewable generation.
JWG C2/C5.06	The Impact of Electricity Market Interventions by System Operators during Emergency Situations
JWG C2/B4.43	The impact of offshore wind power hybrid AC/DC connections on system operations and system design.

LATEST PUBLICATIONS (2023)

TB 911	Power system restoration accounting for a rapidly changing power system and generation mix – WG C2.26
TB 917	Wide Area Monitoring Protection and Control Systems – Decision Support for System Operators – WG C2.18

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



C3

POWER SYSTEM SUSTAINABILITY AND 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.



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C3 • SYSTEM ENVIRONMENTAL PERFORMANCE

PRINCIPLE 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 INTEREST

- 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

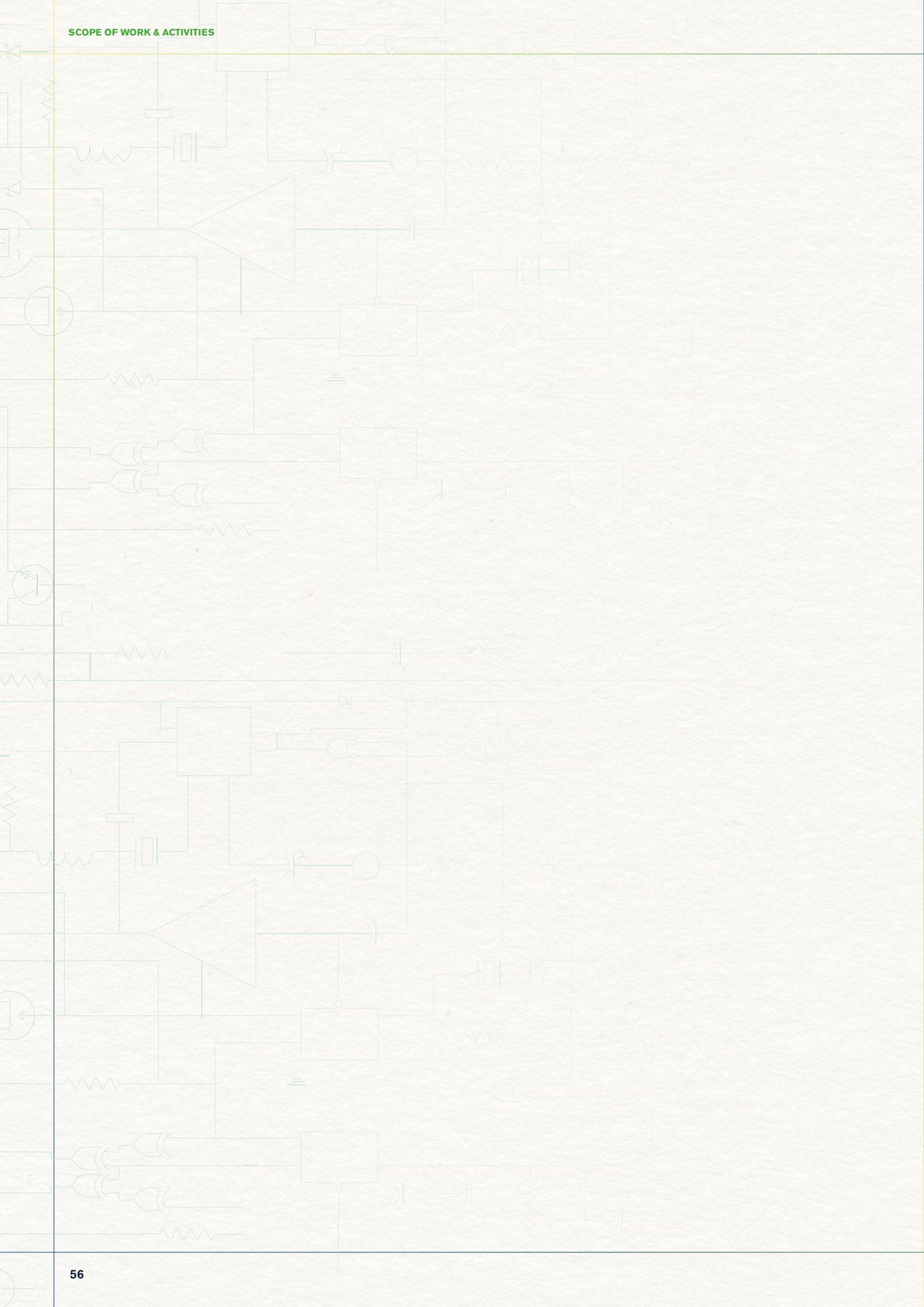
The scope of the SC C3 covers the identification, assessment, and management of the interactions between the natural and social environments, and the end-to-end electric power system, recognising the importance and influence of a wide range of stakeholders and communities. Recommendations for appropriate 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

ONGOING 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 C3-20	Sustainability goals in the electric power sector	Lou Cecere (USA)
WG C3-22:	Vegetation management in substations	Vincent Du Four (BE)
JWG B1/C85	Environmental impact of decommissioning of underground and submarine cables	Kieron Leeburn (SA)
FINISHED WORK		
WG C3-16	Interactions between electrical infrastructure (overhead lines and substations) and wildlife (TB finished and tutorial presented in Paris 2022)	Cécile Saint-Simon (FR) Anaëlle Brand (FR)
NEW WG		
JWG C3/B2.24	Methods of reducing electrocution of birds from power lines	Frode Johansen (NO)
JWG B3/A2 A3/C3/D1.66	Guidelines for Life Cycle Assessment in Substations considering the carbon footprint evaluation	Akshaya Prabakar (NL)
JWG A2/C3.70	Life Cycle Assessment (LCA) of Transformers	Myles Margot (DE)
DISBANDED		
WG C3-14	Impact of Environmental liability on transmission and distribution activities (disbanded with no publication)	Vincent Du Four (BE)
WG C3-15	Best environmental and socio-economic practices for improving public acceptance of high voltage substations (disbanded. A publication is being prepared)	Marijke Wassens (NL)
WG C3-18	Eco-friendly approaches in transmission and distribution (disbanded with no publication)	Anne-Sophie Desaleux (FR)
WG C3-21	Including stakeholders in the investment planning process (disbanded with no publication) To be relaunched (TOR to be reviewed and need of convenor)	Susana Batel (PT)
WG C3-12 A.	Greenhouse Gas Emissions inventory and report for transmission	
SYSTEM OPERATORS		
WG C3-17	Interactions between wildlife and emerging renewable energy sources and submarine cables	
WG C3-23	Eco-design methods for TSOs/DSOs under environmental transition	



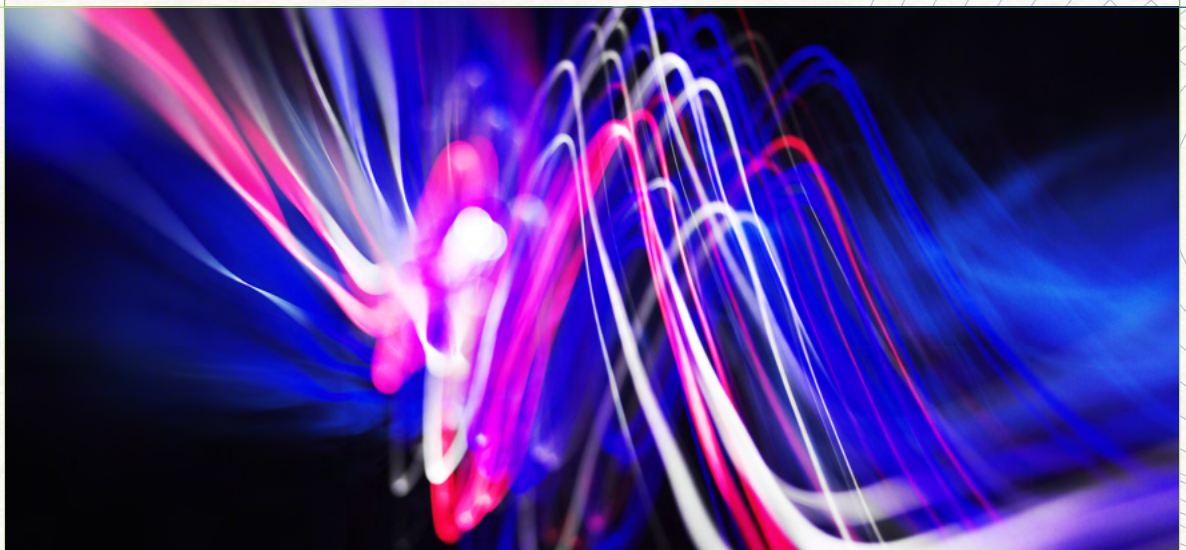


C4

POWER SYSTEM TECHNICAL PERFORMANCE

Study Committee C4 is responsible for advanced methods and tools for analysis related to end-to-end power systems, with particular reference to dynamic and transient conditions and to the interaction between the power system and its apparatus/sub-systems (including external causes of stress, other installations and non-standardised waveforms).

This scope includes the development of tools, models and methods of analysis for identification of power system needs, scarcities, technical envelope and design requirements, and new power system phenomena caused or accelerated by the energy transition. Key drivers, from the system perspective, include increased penetration of non-synchronous generation technologies such as wind, solar and storage into the power system, and the resultant changes in transmission and distribution networks. Accurate modelling of the controls of new (IBR based) technologies has become increasingly important for both steady-state and transient power system studies, as well as inter-stability issues and harmonics. The Study Committee also addresses modelling and performance issues related to demand and integration into bulk power systems. Demand types considered include, but are not limited to, traditional industrial plants (e.g., arc furnaces, traction systems, etc) and their decarbonisation, and new energy consumers (e.g., data centres, electrolyzers, and crypto mining farms).



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C4 • POWER SYSTEM TECHNICAL PERFORMANCE

PRINCIPAL AREAS OF INTEREST

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

OTHER SPECIFIC INTERESTS

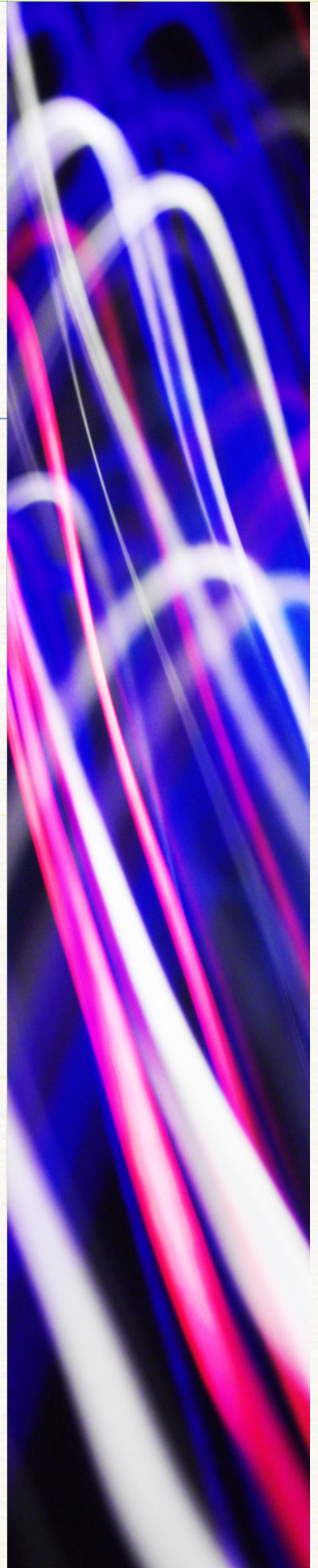
- Evaluation of System Technical Performance of Traditional Power Systems.
- Development of Advanced System Analysis Tools for Smart Grids.
- Wind, Solar and Storage Technologies: Modelling and Performance Analysis.

CURRENT ACTIVITIES

- Advanced Modelling and Analysis Techniques to facilitate energy transition.
- Grid Forming Controls.
- Phasor Measurement Unit Applications.
- EMT Modelling and Simulation.
- Stability Analysis in Converter-Based Modern Power Systems.
- Power Quality and EMC: Modelling, Assessment and Standardization.
- Power System Resilience.
- Evaluation of Lightning Performance of Power Systems.
- Advanced Lightning Monitoring Systems.
- Evaluation of Over-voltages and their Withstand Characteristics.
- Pollution Maps for Insulation Co-Ordination Applications.

KEY PROJECTS FORTHCOMING EVENTS

CIGRE Session, 2024, Paris, France
 CIGRE Symposium, Trondheim, Norway, 2025
 CIGRE Green Book: Power system dynamic modelling
 and analysis in evolving networks



C4 • POWER SYSTEM TECHNICAL PERFORMANCE

MAIN AREAS OF ATTENTION

The scope of SC C4 covers power system technical performance phenomena that range from nanoseconds to many hours. Areas of attention include:

- **Power System Dynamics** : Development of processes and best practices for performing power system dynamic studies, in particular for grid connection studies. Development of advanced tools, models and new analytical techniques for the assessment of traditional and emerging new forms of power system dynamic/transient performance, security and stability. Design of controls, modelling of existing and new equipment, real time stability evaluation and control. Modelling of transient and unsymmetrical conditions of power systems. Black-start analysis using IBR.
- **Keywords** : Steady-State, Power System Dynamics, RMS, EMT, PDT, Voltage Stability, Frequency Stability, Transient Stability, Rotor Angle Stability, Resonance Stability, Converter-driven Stability, Control Interactions, Small Signal Stability, Sub-Synchronous Oscillations, Super-Synchronous Oscillations, Low Inertia, RoCoF, Grid Following, Grid Forming GFL, GFM, IBR, IBL, Storage, Wind and Solar, SPS, System Strength, PMU, Model Development, Model Validation, Power System Resilience.
- **Power Quality** : Continuity of end-to-end electric power supply and voltage waveform quality (magnitude, frequency, symmetry). Analysis covers emission assessments from contributing installations (e.g. HVDC, FACTS controllers, inverter-based resources, inverter-based loads, arc furnaces) in radial and meshed networks, measurement and simulation methods, identification of quality indices, monitoring techniques, immunity of sensitive installations, and mitigation techniques taking into account a co-ordinated approach across all voltage levels.
- **Keywords** : Power Quality, Voltage fluctuation, Voltage Dip, Flicker, Voltage Imbalance, Frequency Variation, Waveform Distortion, Harmonics, Sub-harmonics, Inter-harmonics, Emissions, PQ Compliance, PQ Monitoring, PQ mitigation.
- **Electromagnetic Compatibility and Interference (EMC/EMI)** : 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 including EM vulnerability, immunity of sensitive installations, EMC in the vicinity of power systems, effects of intentional EMI and HEMP on the power system, understanding geomagnetic phenomena and their impacts on the power system. SC C4 will support the evaluation of health effects related to low-frequency EMF with measurements, calculations, mitigation, etc.
- **Keywords** : EMC, EMI, HEMP, GMD, Supra-harmonics, Radiated Interference, Conducted Interference, Radio Interference, Communications Interference, Impulsive Transient, Oscillatory Transient, Digitalisation.
- **Lightning** : Analysis and modelling of lightning characteristics and interactions of lightning with electric power systems and equipment, including the evaluation of the lightning performance of power systems as well as lightning detection technologies. Design of protection measures against lightning effects and their standardisation in power transmission and distribution networks, power stations, sensitive infrastructures, industrial sites and tall structures.
- **Keywords** : Back-flashover, EMT analysis, FDTD, Ground Flash Density, Grounding, Induced overvoltages, Lightning, Lightning characteristics, Lightning data analysis, Lightning detection systems, Lightning induced overvoltages, Lightning measurements, Lightning monitoring, Lightning performance, Lightning protection, Shield wire, Surge arresters.
- **Insulation Co-ordination** : Methods and tools for insulation co-ordination and electromagnetic transient analysis (e.g. harmonic instability, ferroresonance, lightning, switching, transformer energization, IBR driven transients) in electric power systems and equipment, contributing to optimisation of their cost and reliability. Development of accurate models for network components and equipment, appropriate for the phenomena of interest, as well as modern sources for LF, HF, and VHF transients.
- **Keywords** : Insulation Co-Ordination, BIL, BSL, Low Frequency Oscillation, Temporary Overvoltage, Slow-Front Surges, Fast-Front Surges, Very-Fast-Front Surges, Harmonic Instability, Ferroresonance, Resonance, Inrush current, Transformer Energisation, EMT, Switching Transient, Black-start.

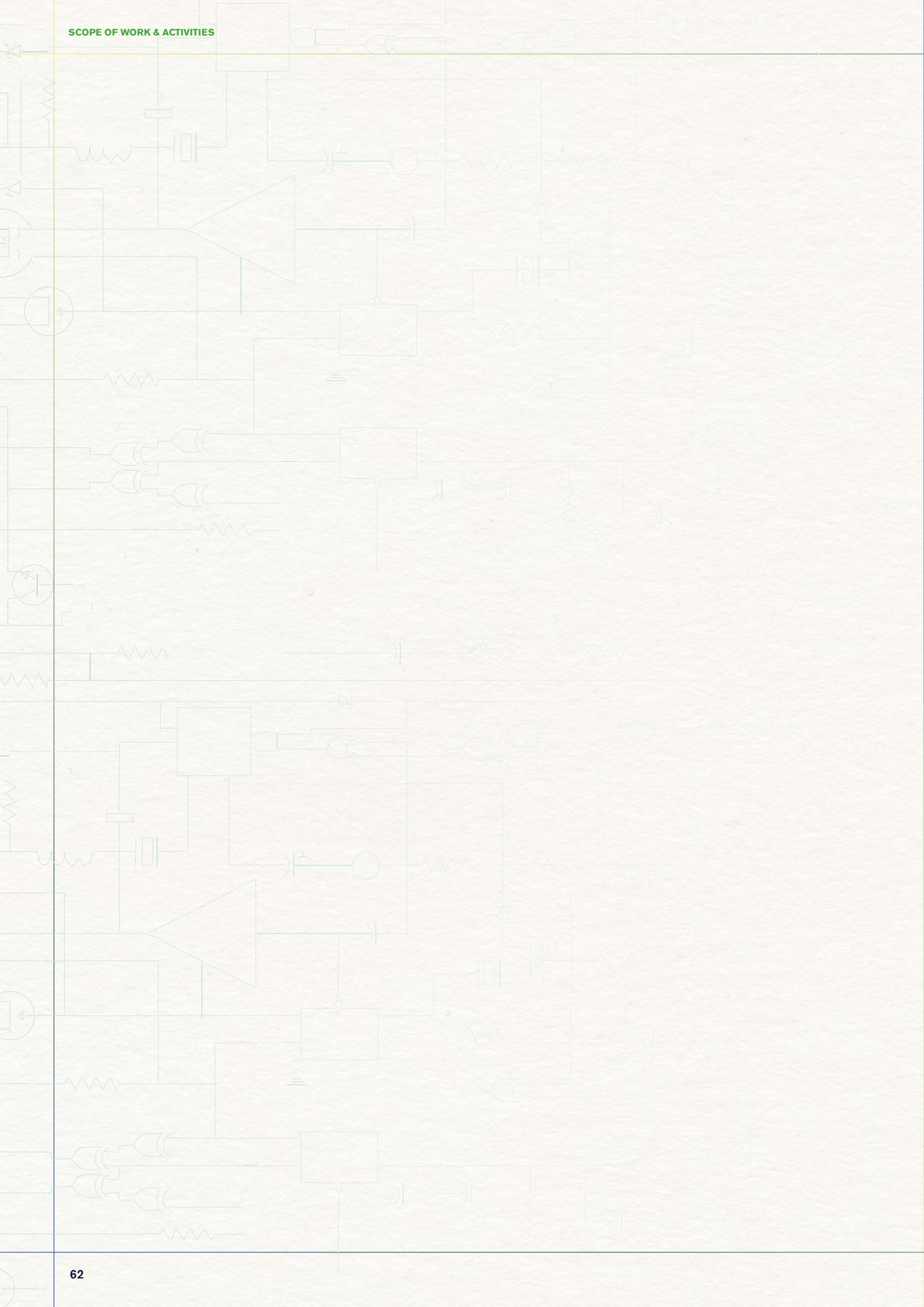
C4 - POWER SYSTEM TECHNICAL PERFORMANCE**TOPICS OF WORKING GROUPS**

WG C4.36SAG	Winter Lightning – Parameters and Engineering Consequences for Wind Turbines
JWG C4.40/CIRE	Revisions to IEC Technical Reports 61000-3-6, 61000-3-7, 61000-3-13, and 61000-3-14
JWG C4.42/CIRE	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 C4.47	Power System Resilience
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
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 C4.57	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
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
JWG C4/C2.62/IEEE	Review of Advancements in Synchrophasor Measurement Applications
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
WG C4.73	Insulation Coordination of HVDC Overhead Lines
WG C4.74	Accurate Line and Cable Models for Steady-State and Transient Studies
JWG C4/A3/B2/B4.75	Guide to procedures for the creation of contamination maps required for outdoor insulation coordination
WG C4.76	Overvoltage Protection in Switching Inductive Devices with Vacuum Circuit Breaker
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 B4/C4.93	Development of Grid Forming Converters for Secure and Reliable Operation of Future Electricity Systems
JWG B1/C4.69	Recommendations for the insulation coordination on AC cable systems
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
JWG B5/C4.79	Protection Roadmap for Low Inertia and Low Fault Current Networks
JWG B4/C4.97	Benchmarking of simulation models for control interaction in meshed AC networks with multiple conver

LATEST PUBLICATIONS

TB 922	Review of Large City & Metropolitan Area power system development trends taking into account new generation, grid and information technologies
TB 921	Applying Low-Residual-Voltage Surge Arresters to Suppress Overvoltages in UHV AC Systems
TB 913	Evaluation of Temporary Overvoltages in Power Systems due to Low Order Harmonic Resonances
TB 909	Guidelines for Subsynchronous Oscillation Studies in Power Electronics Dominated Power Systems
TB 900, TB 901,	High-frequency transformer and reactor models for network studies
TB 902, TB 903,	High-frequency transformer and reactor models for network studies
TB 904	
TB 885	Guide on the Assessment, Specification and Design of Synchronous Condensers for Power Systems with Predominance of Low or Zero Inertia Generators
TB 881	EMT simulation models for large-scale system impact studies in power systems having a high penetration of IBR

All of the TBs are available to download from <https://www.e-cigre.org>



C5

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 is important for the orderly transition of the power system as well as improvements to its end-to-end efficiency.



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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, energy community resources, and new technologies ;
 - wholesale market price formation, including emission pricing and the impact of non-wholesale market participants;
 - sector integration between gas (including renewable gases) and electricity, including EV integration
 - validation of low emission technologies.
- The impact of emerging technologies on market 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 to cater for the changes in the supply and demand for electricity:
 - generation and demand flexibility to manage intermittent supply,
 - integration of storage into ancillary services,
 - incentivising system strength and inertia in energy systems.

MAIN AREAS OF ATTENTION

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.

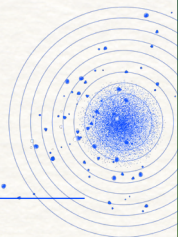
Evolution of markets and regulation from wholesale transmission focus to include retail distribution. The increasing interaction between regulation and markets throughout the electric power system value chain and the ability of markets and regulation to cater to rapid evolutions in dynamic / variable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

ACTIVITIES TOWARDS NEW CIGRE TOPICS

The activities of Study Committee that are related to the key new subject identified in the new CIGRE Strategic Plan are set out below :

New subject	Electricity markets and regulation aspects
Hydrogen	Integration of hydrogen into markets. Hydrolysers, use for storage, generation, etc. Regulation and certification of hydrogen.
Storage	Integration into markets, dispatch and pricing Regulatory aspects of network access
Wind and Solar	Integration into markets, dispatch and pricing Regulatory aspects of network access
Grids and microgrid integration	Regulation and operation of microgrids. Integration of connected microgrids and embedded network.
Consumers, prosumers and EVs	Flexible demand and distributed energy resources: market integration and access regulation
Climate change	Impacts of emission reduction on markets Regulation of pricing and subsidies
Sector integration	Regulation of related sectors that impacts electricity markets and regulation
Digitalisation	Integration of new digital approaches



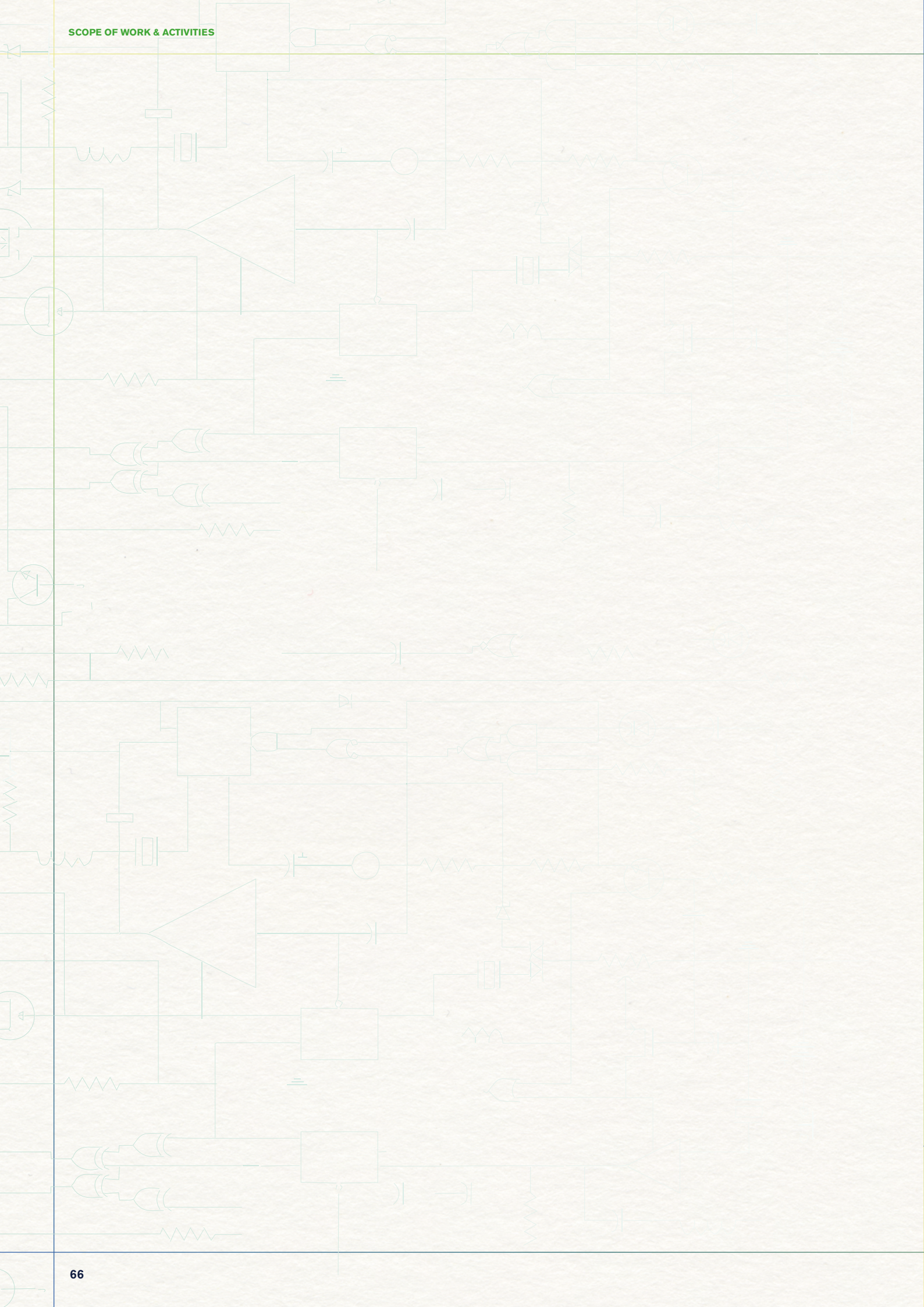
C5 • ELECTRICITY MARKETS AND REGULATION

TOPICS OF WORKING GROUPS

JWG C2/C5.06	The Impact of electricity market interventions by system operators during emergency situations (also listed under SC C2)
JWG C5/C6.29	New Electricity Markets, Local Energy Communities.
WG C5.31	Wholesale and Retail electricity cost impacts of flexible demand response.
WG C5.34	Summary of current uses of electric vehicle charge-discharge flexibility in wholesale energy markets and reliable grid operation.
JWG C5/C1.35	Integration of hydrogen into electricity markets and sector regulation.
JWG C5/C1.36	Certification of the electricity used to produce hydrogen
WG C5.37	Regulatory framework on modernization and extension of useful life of transmission & distribution assets

LATEST PUBLICATIONS

TB 874	"Auction Markets and Other Procurement Mechanisms for Demand Response Services"
TB 877	"Energy Price Formation in Wholesale Electricity Markets"
TB 893	"Trading Electricity with Blockchain systems"
TB 897	"Carbon Pricing in Wholesale Electricity Markets"



C6

ACTIVE DISTRIBUTION SYSTEMS AND DISTRIBUTED ENERGY RESOURCES

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). This would include the requirements associated with the variability associated with DER, flexibility requirements, congestion management, smart grid integration and the impacts of new disruptive technologies, such as Electric Vehicles.

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.



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C6 • POWER 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 distribution system planning and operation, 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, increased resilience and energy efficiency requirements within distribution systems, demand side integration and customer empowerment, multi-energy deployment in urban infrastructures including electric vehicles, electric railway distribution systems and rural electrification.

MEMBERSHIP PROFILE

The membership profile shall reflect the stakeholders' profile to make sure that the outcomes are relevant for the participants who have an interest in the SC C6 scope of activity.

- Distribution System Operators, - mainly engineers from asset management, system planning and system operations
- Power Engineering consultants
- Technology providers
- Electricity consumers and prosumers
- Countries with differing levels of renewables and DER integration
- Rural electrification experts
- Information and communication technology experts
- Academia on respective topics and relevant expertise
- "Non-traditional" professionals dealing in "edge markets" such as economics, legal matters and regulation.
- Increased liaison with like-minded industry bodies

OTHER SPECIFIC SPECIFIC TOPICS, ISSUES

and questions of interest to the SC, and to other SCs are :

- Battery Storage – focus on technical capability, choice of technology, operating costs and life cycle assessment, reliability.
- Integration of Hydrogen and Power to X in distribution systems
- Hydropower pumped storage, and other storage technologies
- Sector coupling and multi-energy systems
- Electric transportation systems – electric vehicles, trains, and other transportation
- Power system compensation and voltage regulation
- MV and LV DC systems

MAIN AREAS OF ATTENTION

The topics of recent interest, and those relevant for the coming years, as identified at SC C6 strategic meetings, include :

- DER equipment and systems – distributed generation, renewables (PV, wind), storage operation and impact on the distribution grid, integration and deployment in different applications, sizing issues, performance characteristics, modelling
- DER control – monitoring and control, operational strategies, locational value, reliability, and availability
- DER integration as a vehicle towards improved resilience of Distribution networks
- DER deployment – hosting capacity, grid compliance, codes and standards, aggregation (microgrids, VPP, DERMS)
- DER interfaces (enabling technologies) – Modelling the requirements of power electronic converters, smart inverters, sensing communication and information technologies into Distribution Systems
- Protection requirements for DER integration
- DER platforms for the provision of flexible services
- Managing DER integration – forecasting, data analytics, data mining (short (operational requirements) and long term (planning requirements))
- Microgrids – aggregation of DER, operation under islanded and grid connected modes
- Distribution system equipment – equipment for power flow control and power quality enhancement, low voltage STATCOM, transformers
- Distribution grid modernization – design, planning and operation of active distribution systems, state estimation, smart meters, asset management, and the provision of ancillary services – focus on technology functions and tools
- Customer integration – design of approach, controllability, visibility and metering, power quality
- Demand side integration – customer impact, trends in customer behaviour/expectations, customer point of view, new customer sectors including "behind the meter" generation, consumer empowerment and participation in electricity markets, demand response, load management, smart load, and smart home impact on distribution systems.
- Smart cities – DER deployment and management systems
- Rural electrification and off-grid distribution systems – microgrid deployment opportunities

FORTHCOMING EVENTS

Paris Conference 2024
International Symposium Trondheim, Norway, May 2025
International Symposium, Montreal, Canada, September 2025

C6 • POWER ACTIVE DISTRIBUTION SYSTEMS AND DISTRIBUTED ENERGY RESOURCES

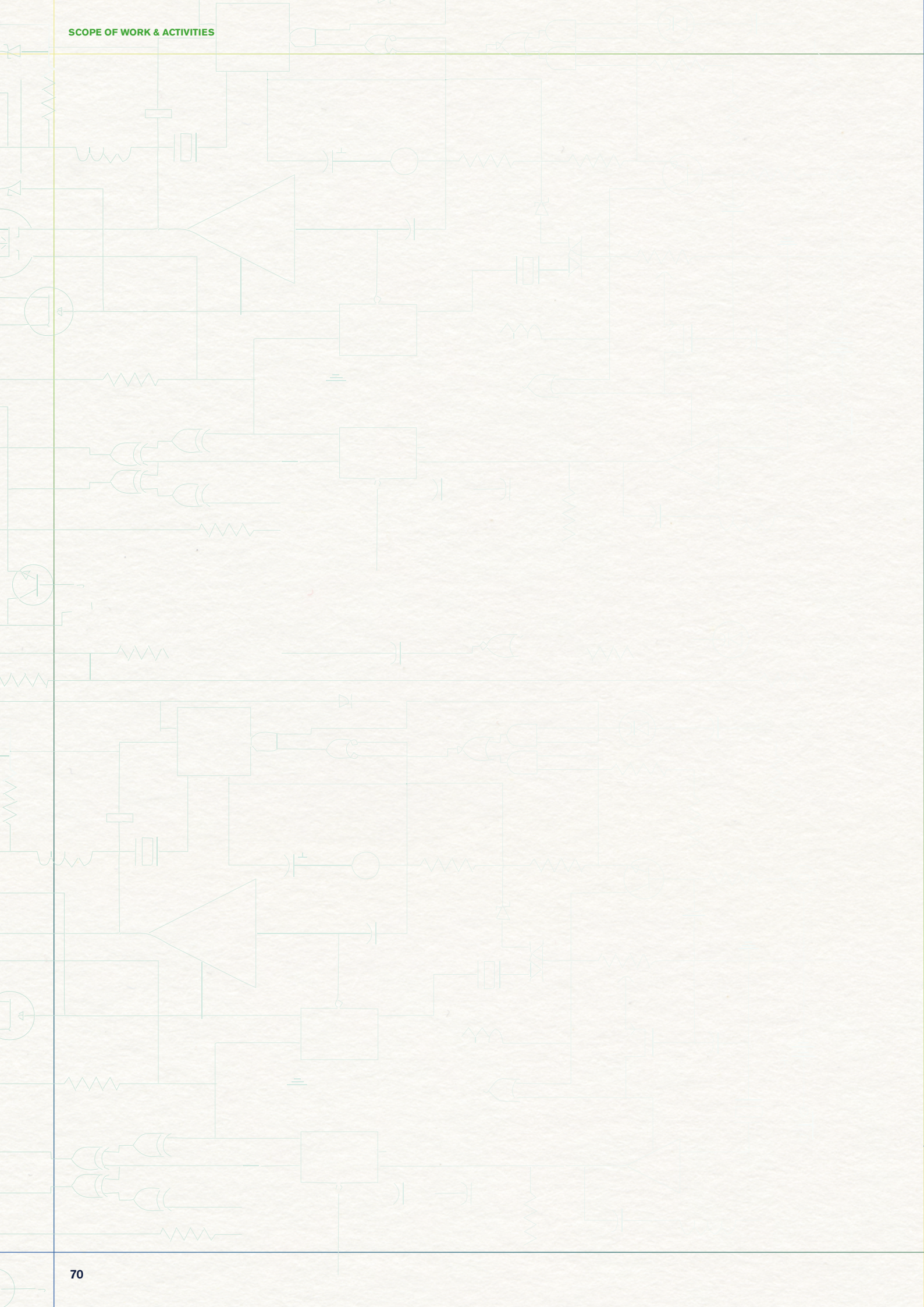
TOPICS OF WORKING GROUPS

WG C6/C2.34	Flexibility provision from distributed energy resources
WG C6.35	DER aggregation platforms for the provision of flexibility services
WG C6.39	Distribution customer empowerment
WG C6.40	Electric Vehicles as Distributed Energy Resource (DER) Systems
WG C6.42	Electric Transportation Energy Supply Systems
WG C6.43	Aggregation of battery energy storage and distributed renewable generation, including solar PV.
WG C6.44	Nodal Value of Distributed Renewable Energy Generation
WG C6.45	The impact of DER on the Resilience of Distribution Networks
WG C6.46	Energy Efficiency in Distribution Systems
WG C6.47	DSO – Customer interfaces for efficient system operation

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 733	System operation emphasizing DSO/TSO interaction and coordination
TB 782	Utilization of data from smart meter system
TB 793	Medium voltage direct current (MVDC) grid feasibility study
TB 826	Hybrid systems for Off-grid Power Supply
TB 835	Rural electrification
TB 863	Multi-energy system interactions in distribution grids
TB 875	Medium Voltage DC Distribution Systems
TB 906	Distributed Energy Resource Benchmark Models for Quasi-Static Time-Series Power Flow Simulations

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



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.

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D1 - MATERIALS AND EMERGING TEST TECHNIQUES

PRINCIPAL AREAS OF INTEREST

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

CURRENT ACTIVITIES

- Characterisation 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 Session 2024 in Paris
- SC D1 participating at CIGRE Colloquium, 2025 in South Korea

OTHER SPECIFIC INTERESTS

Materials to support the energy transition

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

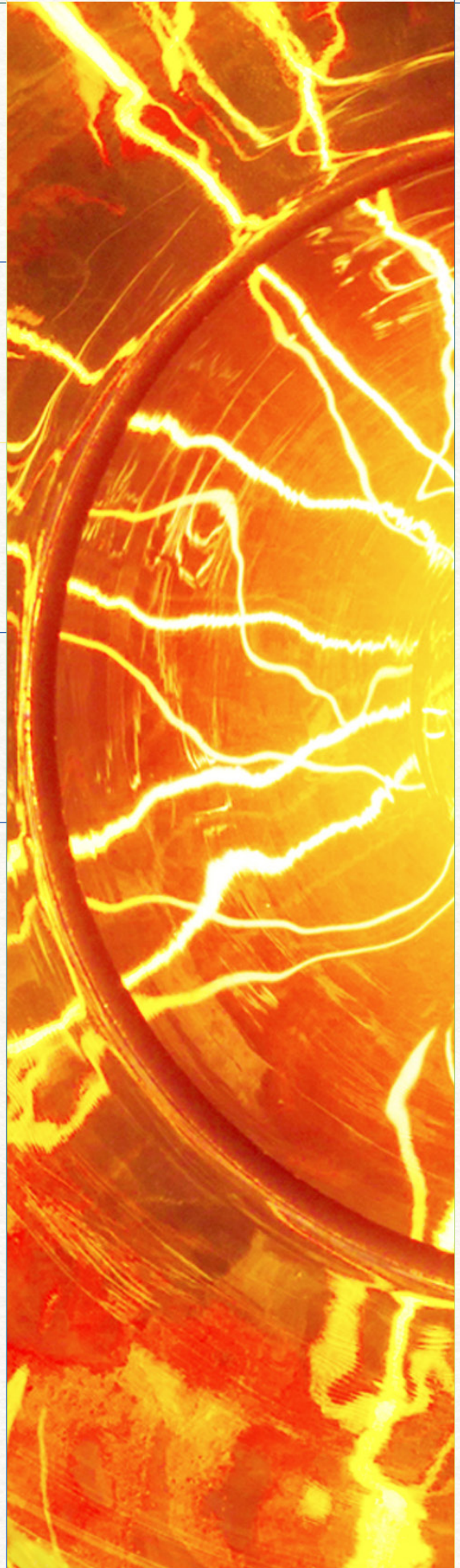
MAIN AREAS OF ATTENTION

The Study Committee deals with the performance of materials and electrical insulation systems (EIS) subjected to electrical, thermal, mechanical, chemical, and environmental stresses. Based on this knowledge, test and measurement procedures are evaluated and developed. These methods can be applied to generate new diagnostic tools for asset management of electrical apparatus to aid the work of the equipment, subsystem, and system committees.

Current hot topics include:

- Materials and testing methodologies to support the energy transition
- Performance of non-SF6 insulating gases
- Testing and performance of UHVAC and UHVDC technologies

The Study Committee facilitates and promotes the international exchange of information and knowledge through developing best practices, recommendations and guidelines. It also supports standardisation bodies by providing relevant technical and scientific background information to support the development of international standards.



D1 - MATERIALS AND EMERGING TEST TECHNIQUES

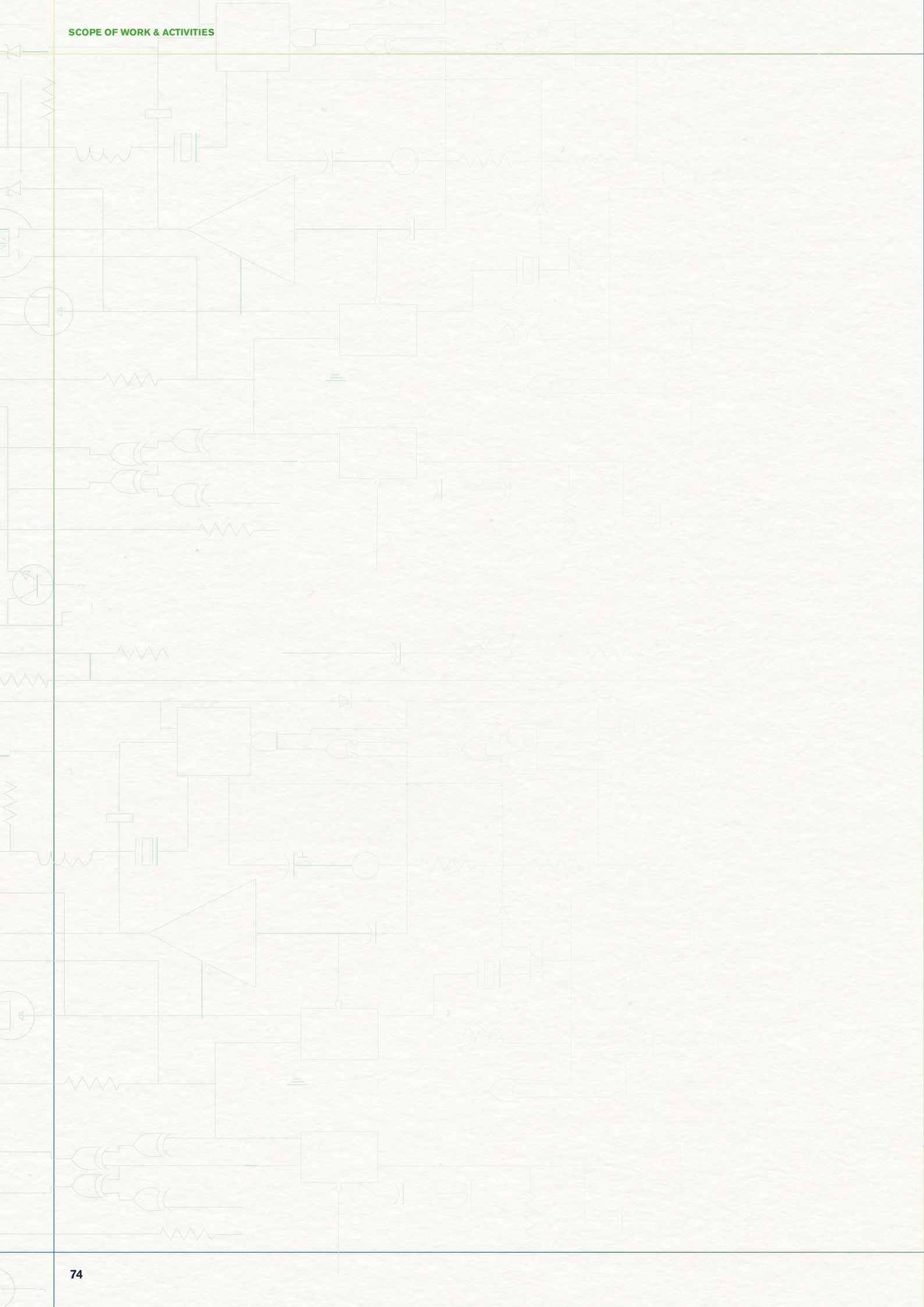
TOPICS OF ACTIVE WORKING GROUPS

WG D1.50	Atmospheric and altitude correction factors for air gaps and clean insulators
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 D1.66	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
JWG D1/B1.75	Strategies and tools for corrosion prevention for cable systems
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
WG D1.78	Partial discharge properties of non-SF ₆ insulating gases and gas mixtures
JWG D1/A2.79	Improved understanding of dynamic behaviour of winding insulating materials in liquid insulated power transformers
WG D1/A2.80	Functional properties of non-metallic solid materials for liquid filled transformers and reactors and their compatibility with insulating liquids
WG D1.81	Methods and common data file format for Time-Domain Reflectometry
JWG A2/D1.66	Breathing systems of liquid filled transformers and reactors
JWG A2/D1.67	Guideline for online dissolved gas analysis monitoring
JWG A2/D1.72	Retrofill of mineral oil in transformers – motivations, considerations and guidance
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
JWG B3/D1.63	Guideline for assessing the toxicity of used SF ₆ gas onsite and in the lab of T&D equipment above 1 kV in substations

LATEST PUBLICATIONS

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
TB 888	Atmospheric and altitude correction factors for air gaps and clean insulators
TB 894	Basic principles and practical methods to measure the AC and DC resistance of conductors of power cables

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



D2

INFORMATION SYSTEMS, TELECOMMUNICATIONS AND CYBERSECURITY

The scope of Study Committee D2 is to develop, facilitate collaboration and disseminate knowledge in the areas of information systems, telecommunications and cybersecurity for power systems.



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PRINCIPAL AREAS OF INTEREST

The current principal areas of interest are the methods and adoption of principles, methods and technologies in the rapidly changing landscape of energy transition and renewables.

- These are the areas we consider as crucial in enabling an increased global adoption of clean energy sources by integrating renewables to deliver reliable, sustainable electricity for all, in a sustainable way.

Our specific current focus areas include the use of machine learning, artificial intelligence, automation techniques and drones to enhance predictive and proactive asset lifecycle management; agile applications and resilient telecommunications systems to facilitate exchange of information between market participants in the end-to-end supply chain of power generation and distribution; and adoption of cybersecurity principles and techniques to strengthen the cybersecurity posture of power utilities.

MAIN AREAS OF INTEREST

- **Digitalisation** : Machine learning algorithms and drones to improve asset lifecycle management, use of artificial intelligence (AI) to enhance cybersecurity posture of critical systems.
- **Renewables Systems Connections** (Solar PV, Wind, Hydrogen, Storage): Agile and resilient telecommunications methods, including 5G and wireless technologies, in supporting diverse and distributed generation participants' connectivity into the grid securely.
- **Grids and Flexibility** : Edge computing and data storage at the edge to support the increasingly distributed grid; resilient telecommunications methods using packet based networks, advanced telecommunications methods such as SDN and cloud-based applications.
- **Consumers, Prosumers and EVs** : Secure information exchange between a diverse set of grid participants including IoT devices, infrastructure, hardware and software interfaces, APIs (Application Programming Interfaces), and telecommunications considerations for virtual power plants.
- **Interoperability and Data Exchange** : Methods in ensuring legacy and new applications to communicate between Electricity Network Grid Operators, System Operators, Market Operators, Generation

Companies, Industrial Product Manufacturers, Telco Operators, ICT services providers, Energy Regulators, and Certification Entities.

- **Telecommunications Technologies and Management** : Assessment of technologies and architecture to ensure resilience for power utility use cases; telecommunication network management systems for a resilient and agile utility telecommunications network.
- **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.
- **Cybersecurity** : Assessment of best practices, adoption of standards, tools and solutions of cybersecurity from the OT domain, for example, protection relays, SCADA control centres, to core corporate business systems such as asset management systems; development of recommendations for a resilient strategy in the system life cycle, from design, through to implementation, testing, operation and maintenance of solutions for power utilities; cybersecurity challenges related to emerging services, technologies and DER interconnection and the flexibility required to support increased data exchanges between market participants in a modern grid, including transmission system operators, distribution system operators, renewable resources operators, and consumers.

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.

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KEY PROJECTS FORTHCOMING EVENTS

CIGRE Session 2022 (August 28 – September 02), including the tutorial: “Artificial Intelligence Application and Technology in Power Industry” and the workshop “Standardization of cybersecurity in power utilities digital infrastructures – a joint vision from IEC, IEEE and CIGRE” to be held on 30th of August 2022, Paris.

The SEERC Colloquium 2022 in Vienna, Austria (May 30 - June 02) participation with tutorial “Cyber Security Management – a key player in the EPU resilience strategy” to be held on 24th of November, 2020, Vienna.

CIGRE Symposium 2023 in Cairns, Australia (04 - 07 September, 2023), SCs C2 & C5 (lead) with the participation of B1, B3, B5, C1, C4, C6, D1, D2.

TOPICS OF ACTIVE 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
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
WG D2.57	CIM (Common Information Model) Methodology
WG D2.58	Monitoring, Maintenance and Control of Packet Networks & Services – From Situational Awareness to Network Control

LATEST PUBLICATIONS

GREEN BOOKS

Utility Communication Networks and Services
Electricity Supply Systems of the Future

TECHNICAL BROCHURES

TB 840 Electric Power Utilities' Cybersecurity for Contingency Operations
TB 866 Enabling software defined networking for electric power utilities
TB 892 Impact of governance regulations and constraints on EPU sensitive data distribution and location of data storage

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



Credits pictures

P04 GV_Electra_2
 P09 Rotating Electrical Machines
 P.13-14 Power Transformers & Reactors
 P.17-18 Transmission & Distribution Equipment
 P.21-22 Insulated Cables
 P.25 Overhead Lines
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au fil de la prod



