Study Committees Capabilities and Resources

Part of the four-year dissemination plan of CIGRE's state-of-the-art power system know-how for Africa, in cooperation with the World Bank

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Introduction

CIGRE's 2017-2021 Strategic Plan slogan is "Sustainable Electricity for All". CIGRE has decided that effective dissemination of know-how in Africa deserves special attention for the following reasons:

- Sub-Saharan Africa contains the largest number and largest percentage of people globally who still do not have access to electricity.
- Africa is developing rapidly economically and with the highest population growth worldwide, which means electricity system growth will be especially strong. It is in the interest of Africa and the entire world that this growth be sustainable.
- Different from other parts of the world still with large numbers of people without electricity access, African people without electricity are spread over many different countries whose central institutions often struggle with resource and skill deficits.
- Different from other parts of the world, current population densities in Sub-Saharan Africa are low and make grid-based electrification expensive under many scenarios.
- Sub-Saharan Africa can benefit particularly strongly from the ongoing energy system paradigm shifts of cheaper renewable energy, digitalization including viable microgrid control, and ever better understanding of the role of markets vs. monopolies in electricity systems. African system planning accounts for remote villages with near-term microgrid supply and longer-term grid connection as population density and electric load increase, and in parallel for application of microgrid market-based approaches to manage generation deficits in rapidly growing metropolises. Learnings from this dual use of micro-grids in Africa can in turn benefit the whole world
- The huge hydro and solar natural resources in Africa make international or even intercontinental interconnections seem especially attractive – they could help achieve reliable energy supply with very high renewable energy penetration affordably. This could positively affect renewable energy integration also in Europe and the Middle East.

Because all the above reasons affect which infrastructure investments have the best multicriteria benefit/cost ratios, the World Bank also has a strong focus on African electricity system developments. Thus, World Bank staff can benefit for its African investment prioritization from the best possible understanding of CIGRE's power system state-of-the-art resources.

But at least equally important is know-how transfer to the managers, engineers and planners in Sub-Saharan countries' energy ministries and legislators, nascent regulators, grid and system operators, generators, industrial customers, city administrations, and microgrid installation and maintenance companies. Universities – including centres of excellence – are additional very promising target partners for know-how transfer to pursue all-important "self-empowerment". For this, the dissemination of CIGRE work results in Africa itself is crucial and needs to be systematically stepped up.

This project involves systematic effort to improve dissemination of information and resources for Africa in cooperation between CIGRE and the World Bank (WB), focusing on assisting African countries to develop internal expertise by providing access to unbiased, upto-date technical experience in several innovative ways.

One of the first steps in this project was to determine what CIGRE considered to be the most useful resources available to assist in the development of knowledge and ultimately, the future African power sector. This was assessed by a survey of our study committees, each focused on different aspects of the power system. This document contains a summary of the information that was assembled and should serve as a guide to African stakeholders in the development of the African power system. But first some basic question are addressed.

Who is CIGRE?

CIGRE (International Council on Large Electric Systems) is a permanent, non-governmental and non-profit International Association. Based in France, CIGRE was founded in 1921.

CIGRE is an international organisation dedicated to the development of the power supply sector through the identification and the development of solutions to industry issues.

With members in more than 80 countries, it is the leading worldwide organization on electric power systems, including technical, economic, environmental, operational, organisational and regulatory aspects.

Key Statistics (2016 to be updated):

- Individual Members: 7817 Regular, 1545 Stud ents, 665 Young members,
- Collective members: 1083 companies and 161 universities

Currently there are 243 working groups comprised of 3766 experts from 67 countries.

How is CIGRE Organised?

CIGRE counts more than 3 500 experts from all around the world, working actively together in structured work programmes, coordinated by 16 CIGRE Study Committees, overseen by the Technical Council. Their main objectives of CIGRE are to design and deploy the power system of the future, optimize existing equipment and power systems, respect the environment and facilitate access to information.

What types of Resources are available now?

CIGRE provides arrange of resources and reference material for the power sector including Technical Brochures, Reference Books (Green Books), our magazine Electra and our CIGRE Science and Engineering (CSE) publication. These resources are all easily available from publication web site: *www.e-cigre.org*.

16 different Study Committees

Each Study Committee covers a specific technical domain dealing with Power Systems as shown below:

SC A1 – Rotating Electrical Machines

Study Committee A1 aims to facilitate and promote the progress of engineering and the international exchange of information and knowledge in the field of rotating electrical machines which include turbo-generators, hydro-generators, large motors, high efficiency motors and non-conventional machines which include wind turbine generators, bulb turbine generators and tidal wave generators. SCA1 deals with maintenance aspects, refurbishment, condition monitoring, new technology and future technologies.

SC A2 – Power transformers and Reactors

The technical field of activity of Study Committee A2 is:

- Power transformers, including industrial, dc converter, and phase-shifting transformers
- Reactors, including shunt, series, saturated, and smoothing
- Transformer components including bushings, tap changers and accessories

Study Committee A2 addresses topics throughout the asset management life-cycle phases; from conception; through research, design, production, deployment, operation, and end-oflife. 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.

Some additional specific areas of attention for SC A2 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.

SC A3 – Transmission and Distribution Equipment

SC A3 addresses topics related to transmission & distribution equipment throughout the asset management life-cycle phases; from conception, through research, development,design, production, deployment, operation, and end-of life. At all stages, technical, safety,economic, environmental and social aspects are addressed as well as interactions with, and integration into, the evolving power system and the environment. All aspects of equipment 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.

SC B1 – Insulated cables

Study Committee B1 work includes AC and DC insulated power cable systems for power transmission, distribution and generation connections on land and in submarine applications, as well as power cable systems associated with micro-grids and the integration of distributed resources.

Within its technical field of activity, Study Committee B1 addresses topics throughout the full range of asset management life-cycle phases. This includes consideration of technical, safety, economic, environmental and social aspects and all aspects of performance, specification, testing and the application of testing techniques, 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.

SC B2 – Overhead lines

Study Committee B2 covers design, construction and operation of overhead lines including the mechanical and electrical design of line components (conductors, ground wires, insulators, accessories, supports and their foundations), validation tests, the study of in service performance, the assessment of the state of line components and elements, the maintenance, the refurbishment and life extension as well as upgrading and uprating of overhead lines.

SC B3 – Substations and electrical installations

Study Committee B3 is responsible for study of the design, construction, maintenance and ongoing management of substations and for electrical installations in power stations excluding generators and this is directly applicable in developing the African power sector. The work is aimed to serve a broad range of target groups in the electric power industry whose needs include the technical, economic, environmental and social aspects of this scope in varying degrees. Major objectives of the work include increased reliability and availability, asset management, environmental impact containment, and the adoption of appropriate technological advances in equipment and systems to achieve these objectives. More recently the scope has included lower cost infrastructure and safe working in substations.

SC B4 – DC systems and power electronics

Study Committee B4 is involves the study of DC systems and power electronics, addressing topics throughout the asset management life-cycle phases; including technical, safety, economic, environmental and social aspects. 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 the study committee considers:

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

SC B5 – Protection and control

Study Committee B5 covers the principles, design, application and management of power system protection, substation control, automation, monitoring, recording and metering – including associated internal and external communications and interfacing for remote control and monitoring. SC B5 has as main areas of interest: Improved concepts of Substation Automation Systems, New requirements and concepts for metering and monitoring, Technical recommendations and applications for standard IEC 61850, Methods to improve the performance of protection systems, Protection implications of new generation technologies and system requirements, Wide-Area Protection, Metering and Monitoring.

SC C1 – Power system development and economics

SC C1's vision and focus is to anticipate and plan a system that best fits the paradigm shift brought about by rapid evolution in generation patterns and economics, demand response, ICT, and in social, environmental, regulatory frameworks and expectations. We describe best practice in planning the system to deal with these changes (system development), building infrastructure despite economic and acceptance difficulties (business environment & investment), maintaining the system well (asset management), and dealing with international (horizontal) and transmission-distribution (vertical) interconnectivity.

SC C2 – Power system operation and control

Study Committee C2 studies requirements, methods, tools and performance indicators for Control Centres and training of System Operators. Further focus areas include control, monitoring and switching of equipment, voltage control, frequency control, monitoring of operational limits and actions to maintain network security and to avoid congestion (e.g. congestion management). Topics related to reserves and emergency strategies, management of disturbances and restoration strategies, and interaction between the system players also play an important role in SC C2.

SC C3 – Power system environmental performance

Study Committee C3 deals with environmental issues, sustainability and stakeholder engagement. It is the only one non-technical study committee of CIGRE.

SC C4 – Power system technical performance

Study Committee C4 deals with methods and tools for analysis related to the technical performance of power networks, with particular reference to dynamic and transient conditions and to the interactions within the network and between equipment.

SC C4 has wide system modelling and study knowledge in all areas of power system modelling and analysis (steady-state, frequency domain, electromechanical and electromagnetic time domain), studies that usually identify any shortfalls at the planning stage of a development.

Principal areas of interest are: Power Quality, Electromagnetic Compatibility and Electromagnetic Interference (EMC/EMI), Lightning, Electromagnetic Transients and Insulation Coordination, Power System Dynamics Performance and Numerical Analysis.

SC C5 – Electricity markets and regulation

The scope of Study Committee C5 is the Analysis of the impacts on the planning and operation of electric power systems of different market approaches and solutions; and of new structures, institutions, actors and stakeholders. The role of competition and regulation in improving end- to-end efficiency of the electric power system.

Areas of attention include:

- Physical and financial market structures contracts and internationally integrated markets.
- Regulation and legislation, price regulation, transmission/distribution coordination,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 behaviors.
- 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.

Generally, the topic area of SC C5 is more applicable to mature networks that are stable, physically and financially developed.

SC C6 – Active distribution systems and dispersed energy resources

Study Committee scope includes: Rural Electrification, islanded power systems and individual customer off-grid systems and solutions. In addition, the following parts of C6 scope could be relevant for Africa:

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

SC D1 – Materials and emerging test techniques

The activities of Study Committee D1 include the evaluation and monitoring of:

- Fundamental aspects of new and existing materials for electro-technology (conducting and insulating materials for electrical use)
- Multi-component insulating arrangements with one or more electrical insulating materials used in conjunction with associated conducting parts
- Diagnostic techniques and related knowledge rules
- Emerging test techniques. Provision of timely information on new developments and trends in the field of materials and emerging test techniques to other Study Committees and support for their analysis of the introduction and application of these materials and techniques

SC D2 – Information systems and telecommunications

Study Committee D2 covers the specification, design, engineering, performance, operation, maintenance, economic and management aspects of the Information and the Telecommunication systems in the EPU both for operational and business activities.

Resources Summary

Technical Brochures

Technical Brochures are booklets that summarise the outcome of working groups. These booklets are available for free download by all CIGRE members and available for purchase by others. There are currently 668 brochures available for download on a range of topics. Some of the key Technical Brochures are listed below:

SC A1 – Rotating Electrical Machines

TB 690	Vibration and Stability Problems in New, Old and Refurbished Hydro Generators, Root Causes and Consequences
TB 682	Survey on Hydro Generator Instrumentation and Monitoring
TB 665	Hydro-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 Hydro Generator Cleaning
TB 581	Guide - Corona Electromagnetic Probe Tests (TVA)
TB 573	Guide for Minimizing the Damage from Stator Winding Ground Faults on Hydro-generators
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 522	Generator Stator Winding Stress Grading Coating Problem

SC A2 – Power transformers and Reactors

TB 445	Maintenance Guide - Likely to be of special relevance for utilities setting-up or improving a maintenance programme
TB 528	Transformer Specifications - Likely to be of special relevance for utilities procuring large numbers of new transformers
TB 529	Transformer Design Review - Likely to be of special relevance for utilities procuring large numbers of new transformers
TB 530	Transformer Supplier Qualification and Development - Likely to be of special relevance for utilities procuring large numbers of new transformers, especially where these are sourced from new suppliers. Particularly relevant in Africa where the supplier base is weak.
TB 655	Shunt Reactors - Likely to be of special interest to utilities with sparse networks, of which there are many in Africa

SC A3 – Transmission and distribution equipment

TB xxx	Guide for Commissioning and Operation of Controlled Switching Projects
TB xxx	Non-intrusive methods for condition assessment of distribution and transmission switchgears
TB 725	Guide for ageing high voltage substation equipment and possible mitigation techniques
TB 716	Survey on System conditions for and probability of Out-of-Phase
TB 696	Guide for MO surge arresters for emerging system conditions
TB 683	Survey on Technical requirements of state-of-the-art HVDC switching equipment
TB 589	Survey on Vacuum Switchgears at transmission voltages
TB 570	Survey on Switching Phenomena for EHV and UHV Equipment
TB 511	Reliability survey on High Voltage Equipment - Part 3: Disconnectors and earthing switches
TB 510	Reliability survey on High Voltage Equipment - Part 2: SF6 Circuit Breakers
TB 497	Applications and Feasibility study on Fault Current Limiters in Power Systems
TB 455	Application guide for composite insulators to high voltage apparatus
TB 394	Guide for state of the art of instrument transformer

SC B1 – Insulated cables

TB 189	Insulation co-ordination for HV AC underground cable system
TB 194	Construction, laying and installation techniques for extruded and self-contained fluid filled cable systems
TB 268	Transient voltages affecting long cables
TB 283	Special Bonding of High Voltage Cables
TB 303	Revision of qualification procedures for HV and EHV AC extruded underground cable systems
TB 347	Earth potential rises in specially bonded screen systems
TB 398	Third-party damage to underground and submarine cables
TB 403	Cable systems in multi-purpose or shared structures
TB 556	Power system technical performance issues related to the application of Long HVAC Cables
TB 559	Impact of EMF on Current Ratings and Cable Systems
TB 640	A guide for rating calculations of insulated cables
TB 714	Long term performance of soil and backfill systems
TB 720	Fire issues for insulated cables
ELT 258-4, TB 476.	**Cable Accessory Workmanship** Africa needs to ensure it is not the dumping ground of inferior products or workmanship. This TB is a useful guide to the Project Managers of aspects to be sensitive about.
TB 110	**Report and Guidelines on the comparison of Overhead Lines and Underground Cables** Africa is no different from the rest of the world in that projects should be assessed for suitability with respect to legislation, planning and public interest. This TB may be old (1996) but gives good guidance on the matter.
TB 177	**Accessories for HV cables** The Glossary of Terms section is particularly useful for new customers to understand the terminology.
TB 194	**Laying and Installation Techniques** The wide range of potential installation techniques should be understood by new customers to help assist assessing offers.
TB 250	**Integration of Underground Cable Systems into Networks** Amongst other important topics, this TB covers Life Cycle Assessment; Environmental Impact. Assessment as well as an Appendix giving a guide to input data

SC B2 – Overhead lines

TB 353	**GUIDELINES FOR INCREASED UTILIZATION OF EXISTING OVERHEAD TRANSMISSION LINES** This brochure provides executives and asset managers guidelines for the economic and technical considerations for transmission line asset renewal and any combination of uprating, upgrading, refurbishment and asset expansion.
TB 583	**GUIDE TO THE CONVERSION OF EXISTING AC LINES TO DC OPERATION** Conversion of existing AC lines to DC is generally considered the most effective way for major increases in capacity. The aim of the brochure is to discuss possibilities and constraints associated with AC to DC line conversion, such as DC insulator dimensioning, DC corona and field effects.
TB 598	**GUIDELINES FOR THE MANAGEMENT OF RISK ASSOCIATED WITH SEVERE CLIMATIC EVENTS AND CLIMATE CHANGE ON OVERHEAD LINES** This technical brochure is aimed at providing a reasonable basis for the evaluation of the vulnerability of networks to the risks and consequences of these severe events and to provide a basis for management of resources to minimise potential network outages.
TB 695	**EXPERIENCE WITH THE MECHANICAL PERFORMANCE OF NON-CONVENTIONAL CONDUCTORS** Non-conventional conductors considered are mainly aimed at increasing capacity of existing overhead lines although other benefits are also considered. This brochure presents such conductors and gathers all available data on their mechanical performance as well as field experience.
TB 708	**GUIDE ON REPAIR OF CONDUCTORS AND CONDUCTOR-FITTING SYSTEMS** Line reliability is addressed by reviewing experience with conductor & fitting systems, the different modes of failure of these systems and the best practice to restore the integrity of damaged conductors. The different types of conductor and fitting damage are described and strategies used by utilities to maintain their network integrity.
TB 731	**THE USE OF ROBOTICS IN ASSESSMENT AND MAINTENANCE OF OVERHEAD LINES** To maintain or increase the reliability of ageing overhead transmission lines, new maintenance techniques are becoming available to assess and diagnose the condition of line components. Mobile robotics can reduce the potential risk to maintenance crews (e.g. live work), reach hardly accessible spans (e.g. river crossings), perform faster, and decrease costs

SC B3 – Substations and electrical installations

TB 161	**General Guidelines for the design of outdoor AC substations** The purpose of this document is to provide a simple guide for designing an outdoor AC substation, considering the systems requirements, the most suitable site, and design of the equipment to be installed. It provides advice on the general principles, relevant IEC standards and CIGRE reports, as appropriate, and also takes the economic factors involved.
TB 439	**Turnkey Substations** This is relevant for considering the procurement of new substations. This TB presents the full turnkey process from conception to completion and enables the reader to adapt the process to his particular project, from single bay extension to building of a complete new substation. It also covers the issues arising from conversion from the traditional process of completing the project in-house to the turnkey process.
TB 585	**Circuit Configuration Optimisation** Substation designers have always had to consider the optimization of the substation layout to achieve operational needs with appropriate levels of security. The objective of this joint working group was to investigate the factors influencing Circuit Configurations and to elaborate criteria and technical guidance for the selection and comparison of Circuit Configurations to support the choice of an optimized solution. The material brought forward can also be used as material for a tutorial.
TB 607	**Contracts for outsourcing utility maintenance work** This TB reviews the practical aspects of managing outsourced maintenance contracts. It describes the content and approaches that may be adopted, including request for proposals (RFP), the statement of work (SOW), contractor selection, contractor qualification and performance evaluation, tender assessment, contract preparation and subsequent monitoring of performance.

TB 614	**Air Insulated Substation design for severe climatic conditions** This TB provides information to support the design and life management of electrical installations exposed to severe weather conditions. The document includes consideration of a wide range of severe climatic conditions from around the world, its effect on AIS equipment, typical support systems and substation infrastructure employed by those electrical installation owners, operators and equipment providers. Consideration is given to the short, medium, future and reactive measures that can be implemented, to ensure resilience to future severe weather events, along with associated human performance under such conditions. Case studies for a number of weather types are included.
TB 576	**IT Strategies for Asset Management of Substations - General principles** The TB establishes general principles for the information strategy [named the 'hourglass model'] for substation level asset management; however, the discussed strategy can also be seen in a broader context. Basically, the hourglass model shows that there is a need to link information requirements with data requirements. In order to obtain such a link, it is necessary to have integrated data containing technical, economic, sociological information, and a well-defined enterprise-wide data model.
TB 354	Guidelines for cost reduction of air insulated substations
TB 660	Saving through optimised maintenance of air insulated substations

SC B4 – DC systems and power electronics

TB 684	Recommended-voltages-for-HVDC-grids
TB 269	VSC transmission
TB 492	Voltage-Source-Converter-VSC-HVDC-for-Power-Transmission-Economic-Aspects-and- Comparison-with-other-AC-and-DC-Technologies
TB 280	HVDC and FACTS for distribution systems
TB 417	Technological Assessment of 800kV HVDC Applications
TB 649	GUIDELINES FOR LIFE-EXTENSION OF EXISTING HVDC SYSTEMS

SC B5 – Protection and control

TB 711	**Control and automation systems for Electricity Distribution Networks (EDN) of the future:** explains the new requirements for controlling future distribution grids
TB 687	**Experience concerning availability and reliability of DSAS -** offers a description of different techniques for maintenance of digital substations
TB 637	**Acceptance, Commissioning and Field Testing Techniques for Protection and Automation Systems:** describes many techniques for field works related to PAC 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 584	Standardised protection schemes
TB 540	**Applications of IEC 61850 Standard to Protection Schemes:** explains the different ways this standard can be used to automate substations
TB 687	Experience concerning availability and reliability of DSAS
TB 464	**Maintenance Strategies for Digital SAS Systems:** offers a description of different aspects of maintenance of digital substations
TB 539	Lifetime Management of Relay Settings

SC C1 – Power system development and economics

TB 666	**TECHNICAL RISKS AND SOLUTIONS FROM PERIODIC, LARGE SURPLUSES OR DEFICITS OF AVAILABLE RENEWABLE GENERATION:** Relevant for any region where variable renewable energy sources will grow to significant penetration rates, as can be expected for Africa.
TB 715	**THE FUTURE OF RELIABILITY – DEFINITION OF RELIABILITY IN LIGHT OF NEW DEVELOPMENTS IN VARIOUS DEVICES AND SERVICES WHICH OFFER CUSTOMERS AND SYSTEM OPERATORS NEW LEVELS OF FLEXIBILITY:** Explains how not only in developing but also in industrialized countries, electricity systems will need be able to deal with temporary surpluses and scarcities, e.g. from fluctuating renewable resources, partly through customer choice and price elasticity. This could have relevance to African microgrid-based electrification, to metro area energy scarcities and curtailments, and to the later connection of microgrids to the national or even international grid.
TB 670	Establishing best practice approaches for developing credible electricity demand and energy forecasts for network planning: Relevant where data from distributed systems is not perfectly available, or where data collection and use for planning is being built up, and especially where variable and distributed energy sources are important, as is the case for Africa.
TB 527	Coping with Limits for Very High Penetrations of Renewable Energy: Relevant for any region where variable renewable energy sources will grow to significant penetration rates, as can be expected for Africa.
TB 547	Planning Issues for newly industrialized and developing countries (Africa). For obvious reasons, albeit a few years old and more an overview than a prescription.
TB 684	Recommended voltages for HVDC grids: Relevant to international interconnection planning in Africa.
TB 681	Planning criteria for future transmission networks in the presence of a greater variability of power exchange with distribution systems: Relevant for any region where variable renewable energy sources will grow to significant penetration rates, as can be expected for Africa.

SC C2 – Power system operation and control

TB 712	**System restoration procedure and practices** Presents findings of the C2.23 WG on the general procedure and practices adopted by 18 transmission system operators (TSOs) over 5 continents, namely: Europe, Asia, Australia, North America and South America. It also presents the major challenges encountered and the key lessons learnt during restoration of the disrupted power grid in recent major disturbances. . From these findings, a set of recommendations for follow-up work is made.
TB 700	Challenges in the control center (EMS) due to distributed generation and renewables Discusses challenges, both current and future which have to be managed by the system operator when controlling the power system in the presence of distributed and variable generation. The traditional power system with predictable flows and loads centered on synchronous generators with predictable outputs is evolving into a more dynamic system. Solutions to these system operational challenges are discussed in the Brochure
TB 677	Power system operator performance: corporate, operations and training goals and KPI's used This brochure is related with Power System Operator performance, with its goals and key performance indicators (KPI's), used from organisation corporate level to operations and finally training level. The term Power System Operator is used as generic that accommodates all different organisational/functional forms like TSO, ISO, etc. Analysis performed on data acquired through the international survey has revealed, among other things presented in the TB, that performance goals and KPI's exist, but normally for the narrow domain segments, like reliability but rarely for the whole operations and training domains. This enabled authors to propose several recommendations to organisations/utilities in this domain. Additional practical examples (as case studies) are also presented.
TB 608	Lessons Learnt from Recent Emergencies and Blackout Incidents The result of work by the C2.21 Working Group: «Lessons Learnt from Recent Emergencies and Blackout Incidents «. This TB provides details of the findings, and recommendations for follow-up activities in this area. A summary of the key findings by the working group was presented at the Large Disturbance Workshop during the 2012 Session in Paris.

TB 524	Voltage and VAr Support in System Operation Expands on previous work carried out in the field of operator training to produce a comprehensive and usable guide for utilities attempting to create an operator training program or to enhance their existing approach to training. Each chapter covers a relevant topic, from capturing operator knowledge and skills requirements and analysing human performance in the control centre, to operator selection, a training program design/development and program accreditation/operator certification. As an integral part of any state of the art training program, training tools (like OTS/DTS) are included as well as issues of training organization and justification. Finally, by way of illustration there are some very interesting case studies detailing the approach to training of nine different countries.

SC C3 – Power system environmental performance

TB 548	Stakeholder engagement strategies in sustainable development, the result of working group C3.04 This TB set out 8 key principles which should apply for all stakeholder engagement on electricity projects. The risk of ignoring these is that a population or a community may get an electrical supply "solution" imposed on them which isn't what they actually want or need
EMF	SC C3.01 doesn't have a TB, but every 2 year presents an update on worldwide literature concerning EMF. This working group published last year a reference paper and a scientific paper about EMF.

SC C4 – Power system technical performance

TB 569	RESONANCE AND FERRORESONANCE IN POWER NETWORKS The TB provides an overview of the fundamental frequency resonance and ferroresonance in power networks starting with a thorough description. It then covers various network topologies that may lead to each phenomenon. Particular attention is given to shunt compensated transmission lines that can result in resonance. Ferroresonance in electromagnetic voltage transformers and power transformers are treated separately. Mitigation measures that can be employed to overcome resonance and ferroresonance are given in the form of active or passive measures. Guidance in modelling both phenomena and case studies are also provided.
TB 568	TRANSFORMER ENERGIZATION IN POWER SYSTEMS: A STUDY GUIDE The TB provides a generic guidance on transformer energization studies in power systems. It covers the description of inrush currents in transformer energization and the various scenarios where they may be observed. The brochure suggests tools and methodologies for practising engineers in order to study and analyse voltage-related problems (RMS voltage drop and temporary overvoltages) created by the inrush currents during transformer energization. Recommendations on modelling the various components within the study zone and possible mitigation measures that can be employed to overcome the technical issues associated with transformer energization phenomenon along with case studies are given.
TB 577	ELECTRICAL TRANSIENT INTERACTION BETWEEN TRANSFORMERS AND THE POWER SYSTEM A number of transformer dielectric failures have been attributed to transient overvoltages, even when good practices for insulation design and insulation coordination have been followed. The analysis of these failures and their future prevention requires an in-depth knowledge of the transient interaction between the transformer and the power system. Although previous IEEE and CIGRE working groups have reported important findings on this subject, additional evaluations with a wider scope was found necessary to improve transformer reliability regarding transients. This technical brochure was prepared with this goal and presents different topics in the context of high-frequency transients.
TB 648	ANALYTICAL TECHNIQUES AND TOOLS FOR POWER BALANCING ASSESSMENTS The aim of this working group has been to perform a critical assessment of existing modelling methods and tools for analysing power balancing issues in order to provide recommendations for future developments. The overall scope of work is related to frequency control and inertia, management of reserves and balancing markets.
TB 672	POWER QUALITY ASPECTS OF SOLAR POWER There has recently been a huge increase in the amount of solar power connected to the grid and this trend is expected to continue and even grow during the coming years. A possible concern with the connection of solar-power installations is their potential impact on the voltage and current quality in the grid. The principle aim of this TB is a mapping and quantification of that impact where it concerns power quality disturbances. As part of this effort, an industry survey is also performed gathering experiences from around the world.

TB 719	POWER QUALITY AND EMC ISSUES WITH FUTURE ELECTRICITY NETWORKS The TB "Power Quality and EMC Issues Associated with Future Electricity Networks" gives an overview of the expected unintended consequences for PQ of several on-going developments in the power system. Four developments directly related to smart-grid technology are covered: microgrids; advanced voltage control; feeder reconfiguration; and demand-side management. Four developments indirectly related are also covered: new sources of electricity production; increased used of active power-electronic converters; shift from overhead lines to cables; and new types of lighting. The TB also summarizes the discussions related to new measurement techniques and new mitigation methods and presents the main findings, recommendations and open issues.
TB 707	EMC IN WIND ENERGY SYSTEMS The TB focuses on the extremely harsh electromagnetic environment faced by electronic and electrical systems in wind turbine generators and wind farms. The high levels of electromagnetic disturbance may originate from lightning; turbine-blade charging; wind-turbine-converters; wind farm interconnections; other high power electromagnetic disturbances (including HEMP IEMI and nearby transmitters); and wind-turbine emissions. Each source of electromagnetic disturbance is considered on its own as a chapter of the TB and mitigation techniques for these disturbances are also included. In summary, the TB provides a good introduction to engineers working in wind energy systems and highlights the important aspects to be considered when designing, planning and, indeed, maintaining electromagnetic compatibility for wind energy systems.
TB 727	MODELLING OF INVERTER-BASED GENERATION FOR POWER SYSTEM DYNAMIC STUDIES This Technical Brochure provides a guidance on inverter-based generator models with associated functions that should be used for specific phenomena such as frequency deviation, large voltage deviation and long-term voltage deviation. This guideline helps to reduce the computational burden when performing simulations as well as to represent more accurate power system dynamic behaviour with inverter-based generators following faults.

SC C5 – Electricity markets and regulation

Nil

SC C6 – Active distribution systems and dispersed energy resources

TB 721	**The impact of battery energy storage systems on distribution networks** Provides business cases with balancing RES generation and lessons learnt for this technology. This brochure focuses on the following topics: 1). Planning and design considerations for BESS in distribution systems; 2) Operational considerations for BESS in distribution systems; 3). Use-cases and business cases for BESS in distribution systems; 4). Standards and Grid Codes for BESS in distribution systems; 5) Practical international experiences with BESS in distribution systems.
TB 635	**MICROGRIDS EVOLUTION ROADMAP** This the first TB covers the definition of microgrid, and describes the necessary equipment and methods needed to implement one. Technology and business case development are described in detail and benefits analysis conducted for two example microgrids
TB 586	**Capacity of Distribution Feeders for Hosting DER** The scope of the CIGRE WG C6-24 was to study the limits of distribution feeders for hosting DER and the derivation of practical guidelines for the connection of DER. For this purpose, the WG studied the technical evaluation practices adopted by DNOs all over the world. Main results of this investigation are summarized in the Technical Brochure, including a review of the main technical issues limiting hosting capacity of distribution feeders, the evaluation practices and methodologies applied by several DNOs, the means currently available to increase the hosting capacity, as well as a concentration of simplified, practical rules of thumb, currently adopted in DG interconnection studies.
TB 711	**Control and Automation Systems for Electricity Distribution Networks (EDN) of the future** The objective of the CIGRE/CIRED C6.25/B5 Joint Working Group (JWG) is the control and automation systems for the future electric networks with particular reference to the TSO/DSO interface. The TB written by JWG is mainly focused to evaluate the level of automation and control necessary to better manage distribution networks with large penetrations of Distributed Energy Resources (DERs), as seen from both the TSO and DSO perspectives, and to provide services and information about the two level of management (i.e., at TSO and DSO level).

TB 678	**SMART METERING, REGULATORY ASPECTS, STANDARDS AND DEVELOPMENT STATUS** Smart Metering is positioning as a first step for the establishment of the Active Distribution Networks because of its capability of being an Advanced Metering Infrastructure (AMI) and of creating values for different stakeholders within the energy sector, i.e. from network operators, retailers to energy consumers. This report summarises the metering stakeholders in different regions/continents, the regulatory approaches (future plans, implementing or no plans) of each region and their development status of Smarting Metering through questionnaire analyses. In addition, as the grid structure and national requirements have critical impacts on the development of Smart Metering in different areas, the worldwide regulatory framework, technical aspects, the environmental impacts and strategy of Smart Metering are discussed.
Other	Other brochures to be published soon including: Hybrid Systems for Off-grid Power Supply

SC D1 – Materials and emerging test techniques

Nil

SC D2 – Information systems and telecommunications

TB 685	**COMMUNICATION SOLUTIONS FOR INFORMATION EXCHANGE IN THE SMART DELIVERY OF ELECTRICAL ENERGY** This TB provides a comparison of experiences, assessments, implementation scenarios and migration plans for the communication infrastructure in order to prepare guidelines for the electrical power utilities who are planning the deployment and/or evolution of their telecom infrastructures for information exchange in the smart delivery of electrical energy.
TB 615	**SECURITY ARCHITECTURE PRINCIPLES FOR DIGITAL SYSTEMS IN ELECTRIC POWER UTILITIES -** This TB gives basis of general Security Architecture principles for digital systems in Electric Power Utilities (EPUs). This is in response an increasing dependency of EPUs on digital systems, which can introduce new vulnerabilities. The group's work focused on 'Classification methods for security zone/level definition', the 'Characterization, categorization and modelling of threats' and 'Remote services'.
TB 452	**EMS FOR THE 21st CENTURY - SYSTEM REQUIREMENTS** The TB provides a common, world-wide system architectural vision for the next generation of Energy Management Systems (EMS) and related real-time grid and market systems. The architecture is based on SOA principles and is comprised of the following sub-architectures: Information Architecture, Integration Architecture, User Interface Architecture, Security & Network Architecture, and Platform & Business Continuity Architecture
TB 618	**SOLUTIONS OVER OPTICAL NETWORKS** The document draws upon experiences of EPU's globally and analyses trends in the use of networks and network technologies based on comparative methodology and technical appraisal of EPU applications/ technology characteristics. The document also covers: - General considerations for replacing, refurbishing or extending networks - An assessment of available physical technologies and transport protocols - Recommendations for future works in the area of classification and requirement definition.

Tutorials

CIGRE Study Committees provide a number of Tutorials on key topics, with expert presenters. The following is a list of some of the most relevant Tutorials available in each SC. Some of these tutorials are available as web-based tutorials.

SC A1 – Rotating Electrical Machines

Tutorial 1	New Generator-Grid Interaction Requirements
Tutorial 2	The use of premium efficiency IE3 (IEC 60034-30) motors & determining benefits of greenhouse gas emission reductions
Tutorial 3	Technological Feasibility Studies for Super and ultra-premium Efficient Motors
Tutorial 4	Magnetic core dimensioning limits in Hydro-Generators
Tutorial 5	MINIMIZING THE DAMAGE FROM STATOR WINDING GROUND FAULTS IN HYDROGENERATORS

SC A2 – Power transformers and Reactors

Tutorial 1	Transformer Maintenance - accompanies TB 445
Tutorial 2	Transformer Procurement - accompanies TBs 528-529-530
Tutorial 3	Shunt Reactors - accompanies TB 655

SC A3 – Transmission and distribution equipment

Tutorial 1	Non-intrusive methods for condition assessment of distribution and transmission switchgears
Tutorial 2	Guide for ageing high voltage equipment and possible mitigation techniques (TB 725)
Tutorial 3	Survey on System conditions for and probability of Out-of-Phase (TB 716)
Tutorial 4	Survey on Technical requirements of state-of-the-art HVDC switching equipment (TB 683)
Tutorial 5	Survey on Vacuum Switchgears at transmission voltages (TB 589)

SC B1 – Insulated cables

Tutorial 1	Third Party Damage to Underground and Submarine Cables (TB 398) How to minimise risk of cable damage from third party. What are the most common damages to cable systems
Tutorial 2	Cable accessory workmanship of extruded HV cables (TB 476) Guidelines for focus on workmanship when installing cable accessories. Cable Characteristics Methods for deriving cable impedances that will affect system stability (TB 531) Calculation examples, how OHL and cables will react to transients. Guidelines for maintaining the integrity of XLPE cable accessories (TB 560) To ensure long life of cable accessories by preventing failures from poor workmanship, design and lack of maintenance.
Tutorial 3	Guide for rating calculations of HV cables (TB 640) Methods to perform ratings calculations. Examples, calculation tools. All types of cable installations covered. Long term performance of soil and backfill systems (TB 714) To ensure long life of installed cable systems to prevent overheating of cables. Design and performance of soil and backfill for cable installations.

SC B2 – Overhead lines

Tutorial 1	**GUIDE TO THE CONVERSION OF EXISTING AC LINES TO DC OPERATION** Conversion of existing AC lines to DC is generally considered the most effective way for major increases in capacity. The aim of the brochure is to discuss possibilities and constraints associated with AC to DC line conversion, such as DC insulator dimensioning, DC corona and field effects.
Tutorial 2	**GUIDELINES FOR THE MANAGEMENT OF RISK ASSOCIATED WITH SEVERE CLIMATIC EVENTS AND CLIMATE CHANGE ON OVERHEAD LINES** This technical brochure is aimed at providing a reasonable basis for the evaluation of the vulnerability of networks to the risks and consequences of these severe events and to provide a basis for management of resources to minimise potential network outages.
Tutorial 3	**EXPERIENCE WITH THE MECHANICAL PERFORMANCE OF NON-CONVENTIONAL CONDUCTORS** Non-conventional conductors considered are mainly aimed at increasing capacity of existing overhead lines although other benefits are also considered. This brochure presents such conductors and gathers all available data on their mechanical performance as well as field experience.
Tutorial 4	**GUIDE ON REPAIR OF CONDUCTORS AND CONDUCTOR-FITTING SYSTEMS** Line reliability is addressed by reviewing experience with conductor & fitting systems, the different modes of failure of these systems and the best practice to restore the integrity of damaged conductors. The different types of conductor and fitting damage are described and strategies used by utilities to maintain their network integrity.
Tutorial 5	**THE USE OF ROBOTICS IN ASSESSMENT AND MAINTENANCE OF OVERHEAD LINES** To maintain or increase the reliability of ageing overhead transmission lines, new maintenance techniques are becoming available to assess and diagnose the condition of line components. Mobile robotics can reduce the potential risk to maintenance crews (e.g. live work), reach hardly accessible spans (e.g. river crossings), perform faster, and decrease costs.

SC B3 – Substations and electrical installations

Tutorial 1	**Contemporary Design for Low-cost Substations for Developing Countries** This tutorial provides a definitive guide on the process of design, focusing on modern methods and systems to optimise design to achieve required asset management outcomes. This work was focused on the needs of Sub-Saharan Africa
Tutorial 2	Circuit Configuration Optimisation
Tutorial 3	The Design of Air insulated substations for severe climatic conditions
Tutorial 4	Application Guidelines for Turnkey Projects
Tutorial 5	Innovation vs Standardisation in Substation Design

SC B4 – DC systems and power electronics

Tutorial 1	Interconnecting weak networks using VSC technologies and renewable energy sources
Tutorial 2	VSC / STATCOM technology and applications
Tutorial 3	Upgrading AC transmission systems with HVDC
Tutorial 4	Economic assessment and justifications of HVDC / VSC technology projects
Tutorial 5	DC Grids

SC B5 – Protection and control

Tutorial 1	**Reliability-Centred Maintenance of Digital Substations -** teaches how to apply the RCM methodology to digital substations
Tutorial 2	**Workshop on Electricity Supply System of the Future -** shows the main evolution of electrical power systems and the challenges for protection and automation
Tutorial 3	**Functional Testing of Digital Substations -** introduces the main techniques for testing fully digital substations
Tutorial 4	**Trends in Protection and Automation of Future Electrical Grids -** shows the main tendencies and technologies applied to future digital installations
Tutorial 5	**Cyber Security of Electrical Networks -** teaches how to plan and deploy a cyber security solution for utilities

SC C1 – Power system development and economics

Tutorial 1	**Wind Generation: Issues for Investment and System Operation** In 2009, CIGRE Study Committee (SC) C1 organised a tutorial in collaboration with C2 (System Operation) and C5 (Electricity Markets and Regulation) the subject of "Wind Generation: Issues for Investment and System Operation". In common with most of the rest of the world, many countries on the continent of Africa are seeking to decarbonise their electricity supply. In many locations, wind energy holds great potential. However, it also presents operational challenges.
Tutorial 2	**Integration of renewable and storage energy to deliver optimum system performance** In 2011, SC C1 organised a tutorial in collaboration with C2 (System Operation) and C4 (System Technical) on "Integration of renewable and storage energy to deliver optimum system performance".
Tutorial 3	**Grid integration of renewables** In 2013, similar topics to 2009 were re-visited, updated and expanded on Generic wind turbine modelling, Facilitation of renewables and ensuring a Secure, Reliable and Efficient Power System, Integration of Market design with Renewables 4. Potential market/regulatory mechanisms to ensure investment in 'reliable' resources.
Tutorial 4	**High voltage DC** In 2015, SC C1 contributed to a tutorial led by SC B4 (HVDC) with further contributions from B1 (Cables) and C5 (Electricity markets and regulation)
Tutorial 5	**Alternatives to development of new overhead line routes.** The tutorial concerns different technology options and how to evaluate them. This was of particular interest in Europe where, primarily, changes to the generation mix lead to changed power flows and the need for some network reinforcement including the development of new routes. However, there is strong opposition to new overhead lines from a public that is used to a very reliable supply of electricity and often tries to insist that any new electricity networks (and, often, existing ones) are undergrounded. Although, on the face of it, this might seem of less immediate importance in the very different circumstances often to be found on the continent of Africa, some elements of the tutorial are likely to still be of interest.

SC C2 – Power system operation and control

Nil

SC C3 – Power system environmental performance

Tutorial 1	**EMF, «time to reassure».** This tutorial lectures about the development on policies and science on EMF. It gives the most recent state of the art and tries to give an unbiased view about the health risks of EMF.

SC C4 – Power system technical performance

Tutorial 1	Modelling and Dynamic Performance of Renewable Energy Systems
Tutorial 2	Resonance & Ferroresonance

SC C5 – Electricity markets and regulation

Nil

SC C6 – Active distribution systems and dispersed energy resources

Tutorial 1	Battery Energy Storage Systems in Distribution Networks
Tutorial 2	Planning of active distribution networks
Tutorial 3	Control and Automation Systems for Electricity Distribution Networks (EDN) of the future
Tutorial 4	Microgrids

SC D1 – Materials and emerging test techniques

Nil

SC D2 – Information systems and telecommunications

Tutorial 1	Cyber-Security - gives a overview on the topic of Cybersecurity, what does it cover, the standards, best practices, guidelines to face it and Cigré's role.
Tutorial 2	Framework for EPU operators to manage the response to a cyber-initiated threat e –Presents a framework for tools that EPU operators can use to automate their response to a cyber- initiated threat. to their critical infrastructure.

Working Groups: Planned or Current

Working groups consisting of experts representing different countries are formed to carry out studies and produce brochures and Tutorials. The following working groups are relevant to the development of the African power sector and are currently formed and working in each Study Committee:

SC A1 – Rotating Electrical Machines

WG A1.60	Guide on economic evaluation for refurbishment or replacement decisions on hydro generators
WG A1.59	Survey on Industry Practices and Effects associated with the Cutting Out of Stator Coils in Hydro-generators.
WG A1.58	Selection of Copper Versus Aluminium Rotors for Induction Motors
WG A1.56	Survey on Lap and Wave Winding and their Consequences on Maintenance and Performance
WG A1.55	Survey on Split Core Stators
WG A1.54	Impact of Flexible Operation on Large Motors

SC A2 – Power transformers and Reactors

WG A2.49	Transformer Asset Health Index - Likely to be of special relevance for utilities setting-up or improving an asset management programme.
WG A2.55	Transformer Life Extension - Likely to be of special relevance for utilities setting-up or improving a life extension programme.
WG A2.56	Transformer Losses and Efficiency - Likely to be of special interest for utilities or government regulators setting-up or improving energy efficiency standards.

SC A3 – Transmission and distribution equipment

WG A3.42	Failure analysis and risk mitigation for recent incidents of AIS instrument transformers
WG A3.41	Interrupting and switching performance with SF6 free switching equipment
WG A3.40	Technical Requirements and Testing Recommendations for MV DC switching equipment at distribution levels
WG A3.39	Application and field experience with Metal Oxide Surge Arresters
WG A3.38	Shunt capacitor switching in distribution and transmission systems
WG A3.36	Application and Benchmark of Multi Physic Simulations and Engineering Tools for Temperature Rise Calculation
WG A3.35	Guidelines and Best Practices for Commissioning and Operation of Controlled Switching Projects
JWG A3.32/ CIRED	Non-intrusive methods for condition assessment of distribution and transmission switchgears
WG A3.30	Overstressing of HV substation equipment

SC B1 – Insulated cables

WG B1.38	New testing technologies
WG B1.44	Working under induced voltages
WG B1.50	Bonding and SVLs for cable systems
WG B1.58	Asset management of MV cable systems
WG B1.60	Maintenance of HV cable systems
WG B1.61	Cable system design and installation
TF B1.69	Insulation co-ordination

SC B2 – Overhead lines

WG B2.60	**AFFORDABLE OVERHEAD TRANSMISSION LINES FOR SUB-SAHARAN COUNTRIES.** Electric infrastructures are vital in every country. They are capital intensive and, in what concerns the energy grid, sometimes require specialized manpower. Because many of developing countries don't have national standards, infrastructure design follows international standards, leading to, sometimes, more expensive infrastructures and somewhat out of the local context. This work will explore the possibility to optimize Overhead Transmission Lines, with specific emphasis for Sub-Saharan Countries, in terms of cost and reliability.
WG B2.45	**BUSHFIRE CHARACTERISTICS AND THE POTENTIAL IMPACTS ON OVERHEAD LINE PERFORMANCE.** Fire related trips is a major concern for the performance of high voltage transmission industry in a number of countries. Major bushfires following prolonged heat wave conditions caused people to perish; major loss of property over thousands of square kilometres; numerous major transmission line fire trips and load loss; and loss of major interregional transmission interconnection. Vegetation types and their management on overhead line corridors may vary around the world, but there are very distinct similarities in the characteristics of severe wild fire and associated climatology.
WG B2.55	Conductors for uprating of existing Overhead Lines
WG B2.59	Forecasting Dynamic Line Ratings
WG B2.67	Assessment and Testing of Wood and Alternative Material Type Poles
Other plans	Condition Monitoring of Overhead Lines in Inhabited Areas

SC B3 – Substations and electrical installations

WG B3.41	**Mobile substations incorporating HV GIS design aspects.** This WG is examining ways that substations can be designed with fast connection, pre- assembly and other aspects can be achieved.
WG B3.46	**Guidelines for safe work in substations.** Safety is paramount and this WG is examining practices around the globe.
WG B3.43	**Contemporary solutions for low cost substations in developing countries.** This WG is specifically aimed at developing low cost solutions for sub-Saharan Africa and similar regions.
WG B3.35	**Substation earthing system design optimisation through the application of quantified risk analysis.** This work is aimed at developing low cost earthing solutions with a systematic approach to risk management. In other words, lowest risk vs cost outcomes.

SC B4 – DC systems and power electronics

WG B4.60	Designing-HVDC-Grids-for-Optimal-Reliability-and-Availability-Performance
WG B4.71	Application-guide-for-the-insulation-coordination-of-Voltage-Source-Converter-HVDC-VSC- HVDC-stations
WG B4.59	Control-and-Protection-of-HVDC-Grids
WG B4.64	Impact-of-AC-System-Characteristics-on-the-Performance-of-HVDC-schemes
WG B4.74	Guide-to-Develop-Real-Time-Simulation-Models-RTSM-for-HVDC-Operational-Studies
WG AG4	HVDC-System-Performance

SC B5 – Protection and control

WG B5.63	**Protection, Automation and Control System Asset Management** The aim of the WG is to assess and describe the different internal and external drivers having an impact on the Asset Management of PACS. Based on this assessment, the WG shall give recommendations for the implementation, working flow and organization of the Asset Management of PACS, by providing: a state of the art of PACS Asset Management; guidelines and recommendations for seamless Asset Management workflow; guidelines and recommendations for the migration from conventional to integrated PACS Asset Management; asset management requirements related to IED and PACS component replacement and maintenance; asset management requirements related to upgrading maintenance; asset management strategies related to PACS life cycle management and extensions; recommendations for the specification of configuration tools to be used along the whole system life cycle; PACS specification requirements related to the system asset management; PACS life cycle management; remote access to PACS for asset management; cloud-based PACS asset management and services; a discussion of secondary system items to be monitored for asset management; PACS Asset Management and dependence from Manufacturers; and the impact on staff training and organization.
WG B5.64	**Methods for Specification of Functional Requirements of Protection, Automation, and Control** This Working Group shall survey the currently available methods and formats for specification of functional requirements of PAC systems used by the industry, analyze their advantages and disadvantages, and/or propose new methods for requirement definitions. A questionnaire, under development by TF B5.02, shall be used to collect the utilities, researchers, academia, designers, integrators and suppliers experience and proposals for new methods. A set of examples shall be used in the survey to exemplify the application of the selected methods to typical protection, automation and control configurations of power system substation and their control centers. The automatic or manual compilation of requirements to a target technology will not be addressed but can be exemplified for demonstration purposes. Based on the results of this survey, the Working Group shall propose the requisites of a Domain-Specific Language (DSL) oriented for the specification of functional requirements of PAC solutions for the Electricity Supply Systems of the Future. Using a formal syntax and precise semantics, the language shall help users to describe and exchange the structure and desired logic of PAC systems, without delving into the technological details of its implementation. Complex Temporal Logic (TL) should be possible to be described using simple linguistic constructs near the natural language used by PAC users and planners. A set of examples shall be used in the project to exemplify the language application to typical protection, automation and control configurations of future power system substation and control centers.
WG B5.57	**New challenges for frequency protection** In this WG, Load Shedding Schemes (LSS) are being revisited in the context of past blackouts and diminishing system margins. Major areas of focus are: frequency measurement accuracy, measurement range, scheme response time and maximum load shed (disconnection) time. This includes the definition of frequency under dynamic system conditions, frequency measurement accuracy, frequency element response time and total scheme operating time.
WG B5.58	**Faster protection and network automation systems: implications and requirements** This Working Group was commissioned to produce guidelines for optimized and coordinated PAC systems with the objective to improve the speed of fault clearing systems. The WG will review available PAC technologies and suggest the best practice for main and backup protection, recommend settings, discuss applications guidelines and identify limitations related to primary network components.
WG B5.59	**Requirements for Near-Process Intelligent Electronic Devices** This WG was commissioned to produce guidelines and propose requirements for the specification and configuration of Near-Process IED(s) and to elaborate recommendations for their design and installation.

SC C1 – Power system development and economics

WG C1/ C4.36	Review of Large City & Metropolitan Area power system development trends taking into account new generation, grid and information technologies)
WG	Integration of renewable and storage energy to deliver optimum system performance In 2011, SC C1 organised a tutorial in collaboration with C2 (System Operation) and C4 (System Technical) on “Integration of renewable and storage energy to deliver optimum system performance”.
C1/C6.37/ CIRED	Optimal transmission and distribution investment decisions under increasing energy
scenario uncertainty	High voltage DC In 2015, SC C1 contributed to a tutorial led by SC B4 (HVDC) with further contributions from B1 (Cables) and C5 (Electricity markets and regulation)
WG C1.38	Valuation as a comprehensive approach to asset management in view of emerging developments
WG C1.39	Optimal power system planning under growing uncertainty
WG C1.34	ISO Series 55000 Standards: General Process Assessment Steps and Information Requirements for Utilities
WG C1.33	Interface and allocation Issues in multi-party and/or cross-jurisdiction power infrastructures projects
WG C1.23	Transmission investment decision points and trees

SC C2 – Power system operation and control

WG C2.24	**System Operations impact of Fire and Weather Risk for Transmission and Distribution Systems** History shows that on high fire-risk days, electricity networks can start bushfires/wildfires. The risk of this can be mitigated if utilities shut down power pre-emptively. However, electricity is vital to the safety of the community and its absence increases the risk to public safety and public health. This WG, approved in November 2017, aims to collate the decision-making frameworks used by utilities to address this dilemma. It will address the impact of the risk of bushfires on system operations in relation to operational decision-making, and methods to guarantee network security.

SC C3 – Power system environmental performance

WG C3.16	I**nteractions between electrical infrastructure and wildlife -** started 2 years ago. This working group will identify various different technologies and how such can be installed in different scenarios and different environments. Across Africa the impact of utility structures on wildlife will be a constant threat, as well as the technical performance of networks being impacted negatively by wildlife. Sharing this information will assist African utilities.
WG C3.18	**Eco-friendly Design**, started also 2 years ago. Grid activities are driven by a range of external influences including legislation, regulation and community expectations. Often the concern of regulatory bodies is to balance reliability of the service, market facilitation and costs for the customer. In that framework, environmental issues are mainly considered as extra costs, but as added value for the society.
WG C3.19	**Responsible management of the electric and magnetic field issue** - The first meeting will be held in Paris 2018. The scope of this working group applies to both public and occupational situations associated with electrical networks. It covers e.g. science of EMF and health, EMF exposure guidelines, measuring and calculation of EMF, methods to reduce magnetic fields, social aspects of EMF.

SC C4 – Power system technical performance

WG C4.49	Wideband stability of grid-tied converter-based modern power systems
WG C4.48	Overvoltage Withstand Characteristics of Power System Equipment 35-1200 kV
WG C4.47	Power System Resilience
WG C4.46	Evaluation of Temporary Overvoltages in Power Systems due to Low Order Harmonic Resonances
WG C4.44	EMC for Large Photovoltaic Systems
WG B5/C4.61	Impact of Low Inertia Network on Protection and Control
WG A1/C4.52	Wind generators and frequency-active power control of power systems

SC C5 – Electricity markets and regulation

Nil

SC C6 – Active distribution systems and dispersed energy resources

WG 1	Rural electrification
WG 2	MVDC systems
WG 3	Customer empowerment

SC D1 – Materials and emerging test techniques

Nil

SC D2 – Information systems and telecommunications

WG D2.44	Usage of Public or Private Wireless Communication Infrastructures for Monitoring and Maintenance of Grid Assets and Facilities
WG D2.43	Enabling software-defined networking for Electric Power Utilities' telecom applications - Software Defined Network (SDN) is an extension to the growing adoption of virtualization within the EPU in solving new challenges such as distributed energy resources (DER) which benefit from an agile infrastructure and network.

Lectures and Workshops

In addition to tutorials, study committees may have additional resources including workshops and lectures. The following lectures and workshops are available from each study committee.

SC A1 – Rotating Electrical Machines

Nil

SC A2 – Power transformers and Reactors

Item 1	CIGRE India - CBIP have prepared some interesting tutorials which may be of relevance, e.g. on Transformer End-of-Life Management

SC A3 – Transmission and distribution equipment

Item 1	Substation equipment in power system, History of circuit breakers (GB)
Item 2	Switching phenomena (GB, TB570)
Item 3	CIGRE Reliability surveys on equipment (TB 510-TB 514, TB 319, TB 165, TB 083)
Item 4	Controlled switching (TB 262-264)

SC B1 – Insulated cables

Item 1	South Africa has a very active institute for Electrical engineers (The SAIEE). The SAIEE is very active in scheduling engineering training and knowledge sharing events in South Africa, and recently proposed to assist in scheduling also Cigre related training sessions. The Cigre SA national committee requested SC B1 members to assist in performing such an event, a two-day Cigre Tutorial event for South Africa in November 2018 was proposed and in principle supported. This event can then be repeated in all parts of South Africa and other interested Southern Africa / African countries and updated accordingly for new available tutorials.
Item 2	South Africa also host a Cigre combined symposium/conference every two years and the annual African power Utility week where several engineers from other Southern African countries attend.

SC B2 – Overhead lines

Item 1	"OHL day" workshop where new developments in the field of OHL are presented with relevance for Africa
Item 2	Web tutorial, but I do not have any experience with this.

SC B3 – Substations and electrical installations

Item 1	Guidelines for Safe Work in Substations
Item 2	Targeted tutorials or workshops can be arranged to assist in education regarding safety

SC B4 – DC systems and power electronics

Nil

SC B5 – Protection and control

Item 1	Reliability-Centered Maintenance of IEC 61850 Based Systems
Item 2	Workshop on Electricity Supply System of the Future
Item 3	Trends in Protection and Automation of Future Electrical Grids
Item 4	Cyber Security of Electrical Networks
Item 5	Automation and Security of Electrical Networks

SC C1 – Power system development and economics

Item 1	The Study Committee per se has not produced or delivered lectures, workshops or other educational materials aside from the tutorials described in the answer to Question 3. However, individual members of the SC have done so, e.g. on transcontinental grid development, investment appraisal, transmission and distribution interaction, interconnectors, integration of renewables, flexible demand and asset management. And of course, discussions and tutorials in

SC C2 – Power system operation and control

Nil

SC C3 – Power system environmental performance

Nil

SC C4 – Power system technical performance

Item 1	Short series of tutorials can be put together to demonstrate how a planning engineer runs certain planning studies. For example, load flow analysis, fault calculations, basic dynamic analysis etc.

SC C5 – Electricity markets and regulation

Nil

SC C6 – Active distribution systems and dispersed energy resources

Nil

SC D1 – Materials and emerging test techniques

Nil

SC D2 – Information systems and telecommunications

Nil

Experts

A number of experts are available from a number of study committees to provide specific advice and training.

SC A1 – Rotating Electrical Machines

David Tarrant, South African (English)	Hydro and Turbo generator expert for more than 25 years. Independant Consultant
Rémi Tremblay, Canada (French)	Hydrogenerator expert for more than 35 years. Full time employee of Hydro Quebec
Johnny Rocha, Brazil (Portuguese)	Hydrogenerator expert, more than 35 years design and manufacturing experience on Hydrogenerators and Bulb turbine generators. Independant Consultant
Peter Wiehe, Australia (English)	Hydrogenerator expert, more than 35 years experience on Hydrogenerators, independent consultant with fixed time contract with Hydro Tasmania
Sun Yutian, China (Chinese)	Hydrogenerator and bulb turbine design engineer full time employed by Harbin Research Institute
Marcio Sinischalchi, Brazil (Portuguese)	Hydro and bulb turbine generator expert for more than 35 years. Independant Consultant

SC A2 – Power transformers and Reactors

Simon Ryder [*sryder@doble.com*] and **Luw Moodley** [*lmoodley@doble.com*]	Doble Engineering have been involved in consulting and training in Africa for some years.
Adesh Singh [singhai@eskom.co.za] and **Khayakazi Dioka** [*diokak@eskom.co.za*].	ESKOM are the largest utility in the region and have developed a good specification for a rugged and low-maintenance transformer, which they may be willing to share.
Johan Jordaan [*johan.jordaan@pttransformers.co.za*]	PowerTech transformers, the largest manufacturer in the region and have good experience.
South Africa NC	There are a number of good universities in South Africa, esp. Stellenbosch, Witts and UKZN.
Mr SK Batra [*batra@cbip.org*]	CBIP in India have relevant experience and may be willing to assist.
South African NC	CONCO have strength in Africa

SC A3 – Transmission and distribution equipment

Nenad Uzelac [*nuzelac@gwelec.com*]	Incoming SC A3 chair will advise the future projects in Africa
Kevin Kleinhans [*KleinHK@eskom.co.za*]	ESKOM experts will support the African projects

SC B1 – Insulated cables

Mr. Thinus du Plessis	10 years experience in Cable system design, maintenance and operation within Eskom]
Mr. Kieron Leeburn	30 year experience in Cable systems design, manufacturing and maintenance within CBi-electric African cables
Ms. Queeneth Khumalo	4 years experience in Cable system design, maintenance and
operation within Eskom	There are a number of good universities in South Africa, esp. Stellenbosch, Witts and UKZN.
Mr. Michael Barnes	4 years experience in Cable systems design, manufacturing and maintenance within CBi-electric African cables
Mr. Pravesh Haripersad	15 years experience in Cable systems design, manufacturing and maintenance within CBi-electric African cables

Mr. Deon-Louis Visagie	9 years experience in Cable system design, maintenance and operation within Eskom
Mr. Peet Schutte	4 years experience in Cable system design and insulation co-ordination within Eskom
Bongani Mofu	10 years experience in overhead line and LV services design, maintenance and operations within Eskom
Mr. Siyanda Biyela	5 years experience in Cable system research activities within Eskom

SC B2 – Overhead lines

Herbert Lugschitz	Can be provided on request

SC B3 – Substations and electrical installations

Terry Krieg	Independent consultant with over 40 years industry and consulting experience in all aspects of substations including asset and life cycle management. Experience with development of standards to meet new challenges including modularisation and the design of substations to meet rapid load growth scenarios, with diagnostics and monitoring of HV equipment.
Peter Glaubitz	Peter is an expert in the field GIS equipment technologies with over 50 years experience with Siemens.
Peregrine Tonking	Convenor of Working Group B3.43 – Contemporary Solution for Low Cost Substations in Developing Countries. Facilitator and Lead Engineer for Utilities with industry experience spanning over 20 years. Undertaken roles across both government and private sector in Africa, Europe, Australasia and Middle East. Has experience in the asset management cycles of electricity and water networks.
Robert J. Slebodnik	BSEE; Retired with extensive 43 year experience in substation design from 12kV to 765kV for two major US utilities Allegheny Power and FirstEnergy. Licensed Professional Engineer since 1986; IEEE since 1989, Senior Member 2007; CIGRE since 2011, Full Member CIGRE WG B3.43. Instructor for Substation Design in university-based continuing education program 2008 to 2015.
Philip König	Independent consultant based in South Africa
Sergio Feitoza Costa	Available for consultancy on design and implantation of large and medium sized testing laboratories for high power substations equipment. Apply consultancy for developing cubicles, panels, busbar systems. Author of the software SwitchgearDesign. Experience in IEC Standards preparation and in practices of developing countries. Full Member of CIGRE WG B3.43
Dr. Wallace Vosloo	Has been with Eskom, South Africa for over 36 years. Currently working as Corporate Specialist: High-Voltage Engineering. Main task is assisting to find practical solutions and give advice on all high-voltage-related problems in Southern Africa and across the globe. This typically involves standards, failure investigations, research, writing of technical publications/books, innovative solutions to problems, technology transfer, and mentoring of engineers.
Charles Chibambo	S.I.T.E Engineering: 10-years-experience with a Power Utility in Malawi; Full Member CIGRE WG B3.43; Active Expert in Energy Trilemma Project (Energy Security, Energy Equity & Environmental Sustainability); Member of World Energy Council's Future Energy Leaders Program; Alumni of A.U's Infrastructure Skills for Development Program and U.S. Government's Program on Energy Security; available for consulting especially on developing Energy Systems in Emerging Markets
Robert Adams	Expertise extends to Power System Technical performance covering such areas as Power Quality, EMC, Earthing and Insulation Co-ordination. Committee member for Standards making bodies that deal with HV Installations, Power Quality and EMC. Australian member of IEC 77 concerning EMC.
Piet Knol	SC B3 Tutorial Advisory Group Convenor can select and advise the most appropriate experts on request

SC B4 – DC systems and power electronics

Marcio Szechtman	Independent Consultant, expertise in HVDC system studies, technical, economic and regulatory studies
Mojtaba Mohaddes	TGS: expert in VSC technology
Nigel Shore	ABB: HVDC AC Filter expert

B4 is full of well experienced and knowledgeable experts, any expert that may be nominated by the SC based on the needs and skills required.

SC B5 – Protection and control

Iony Patriota de Siqueira	Tecnix Engineering and Architecture Ltd. Iony holds a D.Sc. and B.Sc. in Electrical Engineering, an M.Sc. (honors) in Operations Research, and an MBA in Information Systems, and more than 35 years of experience in operation and maintenance management for infrastructure sectors. He is a Distinguished Member and Chairman of CIGRE Study Committee on Protection and Automation, Chairman of Brazilian Technical Committee of IEC TC 57 and ABNT, an adviser for the Brazilian Maintenance Association, President and CEO of Tecnix Engineering and Architecture, Director of Brazilian Maintenance Institute, and a post-graduation teacher at two Brazilian universities. A recipient of CIGRE Technical Committee Award, Brazilian Engineering Premium, CIGRE-Brazil best Paper Award, Vote of Praise from the Brazilian Chamber of Deputies and CIER Special Award. He has authored four books about Automation, Maintenance, Management Science, and Critical Infrastructure Networks, and co-authored one book on Operations Research.

SC C1 – Power system development and economics

Ronald Marais	Eskom - Ronald is an experienced Planning Engineer and had previously participated in a number of Study Committee C1 working groups as an ordinary member and a convener. He provides valuable support to the Southern African power system fraternity on power systems, particularly long-term planning, dynamic stability, generation integration and economic evaluation of infrastructure investments. Ronald also serves in the South African Power Pool, as the representative for South Africa and formed chairperson its Planning Subcommittee.
Kevin Leask	KFW - Kevin is an experienced Planning Engineer and had previously participated in a number of Study Committee C1 working groups as an ordinary member and a convener. He provides support to the Southern African power system fraternity on power systems, particularly long-term transmission development planning and economic evaluation of infrastructure investments.
Sidwell Mtetwa	Eskom - Sidwell is an experienced High Voltage Plant Engineer specialising in Transformers & Reactors. He previously participated in a number of Study Committee A3 working groups. He is currently a Cooperate Specialist in Eskom, providing wide ranging support in substation hardware and instrument transformers in South Africa.
Robert Koch	Eskom - Robert is an experienced Power System engineer specialising in quality of supply and organisation resilience. He previously participated in a number of Study Committee C4 working groups. He is currently a Senior Manage: Enterprise Resilience in Eskom, providing leadership on power utility risk management initiatives in South Africa.
Konstantin Staschus	Ecofys/Navigant: Chair of SC C1 2014-20; ENTSO-E Secretary- General 2009-2017; Chair of CIGRE Africa WG; available for consulting especially on institutional and cooperation issues in international interconnections or power pools, for RES integration, for market design and the evolution from monopoly structures of electricity supply in a measured and location-specific way towards market structures.

SC C2 – Power system operation and control

Franco Crisci	Franco Crisci is the Convenor of WG C2.24. He is an electrical engineer with over 35 years in the electricity industry. He has worked in roles ranging from distribution engineer, through to establishing the state Network Operations Centre. He is now the Manager of Emergency Management for local DSO, SA Power Networks, coordinating the response to emergency events affecting the Distribution Network.

SC C3 – Power system environmental performance

Henk Sanders	Chair of SC C3, working with TenneT (Netherlands national TSO)
Mercedes Vazquez	Secretary of SC C3, working with REE (Spain TSO)
Michel Plante	Convenor of WG C3.01, lecturer of tutorial EMF, working with Hydro Quebec Canada

SC C4 – Power system technical performance

Marta Val Escudero (Ireland)	Transmission planning engineer with extensive experience in power system modelling and analysis from consultancy and system operator sides. Convener of JWG C4/B4.38 on Network Modelling for Harmonic Studies
Shijun Xie (China)	Convenor of WG C4.45, Ph.D, Senior Engineer, from State Grid Corporation of China. Research field includes the overvoltages and insulation coordination of power system (including UHVDC transmission system), the lightning attachment process, the high-voltage measuring techniques.
Ertugrul Partal (Turkey)	Expertise in earthing system assessments for power installations exceeding 1kV and UGC/OHL exceeding 45kV.
Zia Emin (United Kingdom)	Chair of SC C4. Transmission planning engineer with extensive experience from consultancy and system operator perspective.

SC C5 – Electricity markets and regulation

Nil

SC C6 – Active distribution systems and dispersed energy resources

Nil

SC D1 – Materials and emerging test techniques

Nil

SC D2 – Information systems and telecommunications

Nil

Reference books

CIGRE publishes a range of technical reference books that are called the "Greenbook series". These books are reference works designed to present topics in reference book format often summarising the work of several years of CIGRE work in a more readable format. The current books available or planned are listed below:

Title	Study Committee	Status
Switching Equipment	A3	Available
Accessories for Extruded High Voltage and EHV Cable Systems	B1	Planned
Overhead Lines	B2	Available
Aesthetic Overhead Line Towers	B2	Planned
The Modelling of Conductor Vibrations	B2	In production
Substations	B3	Available
SF6 Guidebook	B3	In production
Flexible AC Transmission Systems	B4	Planned
Transmission System Assets	C1	In production
Utility Communication Networks and Services	D2	Available
Network of the future	TC	Planned
Transformer and Reactor Procurement	A2	Planned

Books are available for purchase from the publisher Springer or via *www.e-cigre.org*

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SC D2 – Information systems and telecommunications	Philippe QUENAUDON	*philippe.quenaudon@RTE-FRANCE.COM*

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