

Workshop on low cost substation and transmission solutions

Johannesburg, South Africa

13-17 March 2017



A Workshop on Low Cost Substation and Transmission Solutions was held during the week of March 13 to 17, 2017 at the Eskom Research and Innovation Center in Johannesburg, South Africa. The workshop was part of the efforts of CIGRE's Working Group B3.43 "Contemporary Substation Design for Developing Countries", which started its endeavor on 5 November 2015 in Baden, Switzerland to provide technical guidance to support developing countries in securing access to an affordable, reliable and sustainable energy supply that is vital to end extreme poverty and promote economic prosperity.

Introduction

As background for reporting on this event, according to the National Academy of Engineering, a survey of the Greatest Engineering Achievements of the 20th Century revealed that the number one accomplishment that changed the world is "Electrification", the basic electrical service we all take for granted. Yet according to the World Bank, around one in seven, or 1.1 billion people in the world (roughly the population of India), mostly concentrated in Africa and Asia, live without access to electricity. To support the efforts to electrify these regions where significant challenges exist regarding development of infrastructure, CIGRE commissioned Working Group B3.43. They were given the objective to identify opportunities to lower the cost and risk, while improving the efficacy, of new greenfield substation assets for deployment in developing and under-developed countries, as well as remote locations in these countries. Once identified, the group will provide guidance to ease the design of cost-effective practical substations utilizing currently available equipment. This will be done with consideration to the construction, operation and maintenance of these substations with respect to currently available technologies, practices and the limited resources locally available in these developing areas. Sustainability of the facilities and electrical service for these regions will be a key consideration.

To accomplish its objectives, the Working Group's main deliverables will be a Technical Brochure and a Tutorial. Both are targeted for release in 2018 and both will provide guidance for designing cost-effective and fit-for-purpose substations in the targeted regions. In addition, WG B3.43 will present technical papers at CIGRE colloquia, symposia and sessions. A Technical Poster was presented at the 2016 Paris Session.

To accomplish its deliverables, one of the Working Group's main tasks is to seek engagement from organizations with the expertise in deploying electric infrastructure in underserved regions. One method employed was to conduct a survey of practices around the world to identify and assess currently available technologies and challenges relevant to designing low cost substations in remote areas. Emphasis is on high voltage equipment with consideration for the balance of plant impact (auxiliary systems, communications and others) necessary to support a sustainable low cost operation. Another method, unforeseen and innovative, soon developed. Due to the limited input received from the survey, the group determined that it may be better to go to the subject matter experts rather than seek them out via a questionnaire. This is where the alternative approach, that of conducting a workshop, was conceived. It is also worth mentioning that other innovative methods were successfully used by the group. One is the use of Confluence, CIGRE's Knowledge Management System (KMS) for the creation, storage, and communication of WG material – in other words – easier collaboration. The other is the use of Skype (soon to be WebEx) for monthly WG meetings – in other words – to repeat again, easier collaboration.

The Workshop

The main purpose of the workshop was to create a venue where WG B3.43 could interact face-to-face with utilities tasked with expanding electrification into underserved areas. Sub-Saharan African utilities were selected since they were identified by CIGRE as one of the targeted regions; the others being South America and Asia. The WG and African utilities have a common objective – Electrification – so this mutual need would help us both accomplish our goals. The WG received a better understanding of the needs, risks, practices and opportunities of the African utilities to aid in finalizing a Technical Brochure by 2018. The African utilities received three tutorials (one related to substations, one to transmission lines and one to distribution lines), which accomplishes part of the WG's objective to provide technical guidance to support electrification in developing countries. The WG received an opportunity to visit three Eskom substations to observe design practices deployed along with seeing overhead lines while travelling the area. Both the WG and African utilities delegates had sufficient time to network together to personally share knowledge and experience regarding the subject and to establish contacts within the industry. And both will take new learnings and concepts back home to colleagues to provide support for their endeavors from this valuable exchange of ideas and information. Finally, the awareness and promotion of CIGRE and The World Bank were also woven into the workshop.

The Presentations

The Workshop started with a cheerful welcome from WG B3.43 Convener Perry Tonking followed by an introduction of the CIGRE organization and Working Group B3.34 to the audience. Many of the participants are new to the workings of CIGRE as the leading global organization for all aspects of electric power systems and its mission to be world's foremost collaborative technical reference organization for these systems. This established a good, basic understanding of CIGRE. This was followed by an overview of the Survey Questionnaire by WG Member Robert Slebodnik, and an overview of the proposed Technical Brochure by WG Convener Perry Tonking. The main presentations followed. A summary of each is provided below.

The World Bank Kwawu Gaba, Lead Energy Specialist and Global Lead - Power Systems Solution Group for the Energy and Extraction Industries Global Practices spoke about the organization's activities in general such as their visions and goals, their portfolio of projects, global emerging trends, and key areas for focus. He also spoke of their collaborations with industry organizations such as CIGRE and The World Bank clients in adopting cost effective T&D solutions.

CIGRE Terry Krieg, Chairman of Study Committee SC B3 "Substations" gave presentation on global challenges, key drivers, and industry trends in electrification. He then spoke on how CIGRE and Study Committee B3 are facilitating and promoting the progress of engineering to meet these challenges through Working Groups, technical brochures, tutorials, the Green Books, and symposiums. He concluded with information on how workshop participants can join and get involved.

Eskom's General Manager, Power Delivery Engineering, Prince Moyo, made a presentation about Eskom's organization, infrastructure and electrification history. Their remarkable first in the world electrification program started in 1994 to electrify 1.75 million houses by the year 2000 was exceeded by a year, and by end of 1999 more than 42% of rural households were electrified. In 1996 Eskom received the electricity industry's highest award, the Edison Award for its contribution to electrification. By 2016, 5.6 million connections out of a target of 6 million ...

... were achieved. He described Eskom's design standardization and practices, which contributed to their successful electrification program. This serves as an excellent example to workshop participants to emulate.



Tutorial on Substation Design Optimization

CIGRE Tutorials In keeping with the theme of the WG B3.43 desired design outcomes, which are low-cost, value-engineered, design-optimized substations, tutorials were selected to this meet criteria.

"Substation Design Optimization" - Colm Twomey, Manager, Substation Design with ESB International presented a tutorial on various configurations developed for substation bus bars to optimize performance in meeting the various required functionalities. It is based on CIGRE Technical Brochure 585 (June 2014) "Circuit Configuration Optimization". A case study was presented as an example of how to provide a more efficient solution than the classical arrangements.

"Overhead Lines General Concepts" - Riaz Vajeth, Sharon Mushabe, Lebo Maphumulo, Arthur Burger, Dr. Rob Stephen, and Bertie Jacobs, all of Eskom's Lines Engineering Services, presented a group tutorial on based on CIGRE Technical Brochure on "Overhead Lines" (December 2015) focused on the unique aspect of power lines in that they are dependent on terrain and ambient conditions to a far greater extent than other devices such as transformers. This yields benefits for a utility in that the lines can be specifically designed for their location on the grid to a far greater extent than other devices. The parameters were described that effect the electrical aspects of the line such as conductor and tower configuration as well as methods to utilize them to achieve the best design optimization.

"The Shield Wire Scheme (SWS) on Transmission Lines for Rural Electrification" - Franklin Gbedey, Power Engineer and Senior Energy Specialist at the World Bank, presented a tutorial based on The World Bank (ESMAP) Manual titled "Grid-Based Rural Electrification with Shield Wire Scheme in Low-Income Countries - Manual for Planning, Engineering, Design, Specification, Construction and Operation". The isolated Shield Wire Scheme supplies power over an insulated energized shield wire using an earth return. SWS is practical as a low-cost power supply from the grid to residential and industrial customers such as villages, farms, factories and pumping stations located along or at a reasonable distance from transmission lines. It is a solution for rural electrification when separate conventional long medium voltage lines are not justifiable.

African Utilities Delegates from the 15 attending utilities listed below made a 15 minute presentations on their organizations, infrastructure, current projects and how they are meeting the challenges of electrification. Each one provided valuable information for WG B3.43 to use.

- ◆ CEB Electricity of Benin-Togo
- ◆ TCN Transmission Company of Nigeria
- ◆ ZESCO Zambian National Electric Utility
- ◆ TRANSCO Cote d'Ivoire Liberia Sierra Leone Guinee
- ◆ EDM-SA Energy of Mali
- ◆ SNEL/RDC National Electricity Company of the Democratic Republic of the Congo
- ◆ NIGELEC Niger Electric
- ◆ KPLC Kenya Power & Lighting Company
- ◆ SONABEL National Electricity Company of Burkina Faso
- ◆ ESCOM Electricity Supply Corporation of Malawi
- ◆ CI-ENERGIES Cote d'Ivoire Energy

- ♦ EDG Electricity of Guinea
- ♦ RWG Rwanda Energy Group
- ♦ TANESCO Tanzania Electric Supply Company Ltd.
- ♦ WAPP West Africa Power Pool

Each day's sessions began with the course of action from Theunus Marais, Chief Engineer (Substations) in Group Technology Division of Eskom and member of WG B3.43 who planned coordinated its efforts with Eskom. And each day's sessions ended with a recap by WG B3.43 Secretary Jose Visquert, Principal Engineer Power & Energy at AECOM.

Eskom Substation Tours Eskom conducted a tour of local substations for the members of WG B3.43. The purpose was to observe standard designs and practices as well as the environmental conditions and challenges faced in implementing electrification projects. The group traveled to visit an older substation (Corobrick), a newer station (Barcelona), and future one (Impophoma) still under construction. All were of the 88kV primary and 11kV secondary voltage levels utilizing AIS construction. Everyone provided valuable input for the Working Group's future discussion and consideration. ...



Impophoma Substation



Corobrick Substation



Barcelona Substation

The Real Workshop

And now for the real summary of the workshop. Quite often the language of such workshops is spoken in terms of volts, amps, watts and vars. This is to enable discussions that revolve around such topics as substation bus voltage, transformer MVA, conductors and insulators, cables, IED's and the like. The discussions result in a Technical Brochure on better bus configurations, more efficient transformers, comparisons of GIS and AIS, and the like. But this workshop was very different. Here the language transcended into that of basic light, heat, water, food and energy. These enabled discussions critical to improving the well-being of the poor who need light to study for better education; heat to cook for healthier nutrition; pumps and purifiers for easier access to safe drinking water; motors for machines for efficient production of goods and services; and medical equipment to provide basic health care. These discussions ought to result in a Technical Brochure for guidance in electrification to support developing countries in securing access to affordable, reliable and sustainable energy. This is vital to promote rural welfare on a scale equal to urban areas to end extreme poverty and promote economic prosperity of people by increasing productivity and sustainable livelihoods.



Word of Appreciation

A successful workshop of this magnitude does not happen easily. Recognition and gratitude must go to The World Bank for funding the participation of the African utilities, transportation, and translators for the English and French participants; and to Eskom for hosting the workshop and providing training facilities, lunch, tea/coffee breaks, security, substation tour guides and presenting tutorials; and to the CIGRE officers who attended to provide support for this cause and to promote its organization; and to the CIGRE Working Group B3.43 members that planned and conducted the workshop, presented tutorials, recorded minutes, and all the many activities that made this workshop possible; and finally to the African utility delegates who actively participated in and contributed to the transactions. For these organizations and people, and anyone we may have missed, we are grateful for all who made this meeting of the minds and valuable exchange of ideas possible ... and very successful! ■

Bob Slobodnik
On behalf of WG B3.43