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EDITOR'S NOTE

V.K. Kanjlia
Secretary & Treasurer
CIGRE India

CIGRE the International Council on Large Electric Systems founded in 1921, is leading worldwide Organization on Electric Power Systems, covering technical, economic, environmental, organisational and regulatory aspects. It deals with all the main themes of electricity. CIGRE is the unique worldwide organization of its kind - 14,000 equivalent members in around 90 countries. CIGRE is focused on practical technical applications. The main aim of CIGRE is to facilitate and develop the exchange of engineering knowledge and information, between engineering personnel and technical specialists in all countries as regards generation and high voltage transmission of electricity. CIGRE achieves its objective through the 16 Study Committees, each consisting of about 24 members from different countries. It is a matter of pride for India that we are representing in all the 16 Study Committee of CIGRE.

Besides National Committees in about 60 Countries CIGRE has also constituted its regional chapters in the world. The chapter created for Asia is named as CIGRE-AORC (Asia Oceans Regional Council). CIGRE-AORC is a forum for sharing experience and knowledge regarding pertinent technical issues particularly those affecting power systems in the Asia-Oceana Region. The countries from Asia Oceana Region, who are associated with the forum are Australia, China, Cambodia, Gulf Cooperative Council, Hong Kong, India, Indonesia, Iran, Jordan, Japan, Korea, Malaysia, New Zealand, Taiwan and Thailand.

It is a matter of great honor for India that CIGRE AORC has approved the name of India for the Chairman ship of CIGRE AORC for 2016-18. Dr. Subir Sen, ED, POWERGRID has taken over as Chairman and Shri P.P. Wahi, as Secretary of CIGRE AORC for two year during the last meeting of CIGRE AORC held at Paris on 24th August 2016.

CIGRE (India) has been in the administrative Council of CIGRE since 1970. The HQ of CIGRE India is Central Board of Irrigation & Power (CBI&P), Malcha Marg, Chanakyapuri, New Delhi. It functions as the National Committee, i.e., CIGRE (India) for CIGRE HQ (Paris). The CIGRE (India) coordinates interest of Indian members; organises National Study Committee (NSC) meetings. It recommends appropriate persons for CIGRE Study Committees. The National representatives are instrumental in providing feed back to CIGRE Study Committees at Paris.

The aims and objectives for which the committee, i.e., CIGRE (India), is constituted, is to implement and promote objectives of the International Council on Large Electric Systems (CIGRE) and accelerate its activities, which include the interchange of technical knowledge and information between all countries in the general fields of electricity generation transmission at high voltage and distribution etc.

All-out efforts are being made to increase the CIGRE membership and activities in India. There was excellent participation from India in CIGRE session 2016 at Paris. Total 18 papers were presented and more than 100 officers from India including CEOs & Sr. Officers from various PSUs, State Electricity Corporation and various Regulatory commissions participated in CIGRE session 2016. For CIGRE Session 2018 also 140 synopsis were scrutinized by the Technical Committee of CIGRE-India and out of 30 synopsis recommended for consideration of CIGRE HQ. 22 Synopsis have been approved.

The Membership of CIGRE from India is also on the rise and we are expecting a membership of about 800 in the year 2017 as against 600 in the year 2016.

This issue covers the informative and useful technical articles and statistical data on the subject.

We are bringout this Journal on half yearly basis. The last issue was published in the month of July 2017.

I am thankful to the Governing Council and the Technical Committee of CIGRE India for their valuable time and guidance, but for which, it would not have been possible to achieve the above significant progress, appreciated by CIGRE HQ Paris.

I am also thankful to all the senior experts from India and abroad and also to one and all who have supported in the past to realize the goal set forth for CIGRE India and expect the similar support in future too.

V.K. Kanjlia

Secretary & Treasurer CIGRE India

UNDERSTANDING GIS

Present Technologies & Future Expectations

Rajil Srivastava
POWERGRID

GIS INTRODUCTION

A Gas-insulated substation is a station in which no live part is exposed to human touch or environmental atmosphere, except from point of interfacing with overhead transmission lines.

All bus bars and other live parts of the system are enclosed in gas space enclosed in a metal enclosure.

GIS APPLICATIONS

- GIS perfectly match all surrounding conditions
- Air pollution
- Saline contamination
- Altitude above sea level
- Sand winds / storms
- High humidity in tropical / equatorial countries
- Earthquake areas
- Hazardous areas
- Installation under the ground level
- Installation in multi-storey buildings

GIS have minor environmental impact

- Low visual impact
- Low electromagnetic disturbances

DEFINATION

In IEEE C37.122

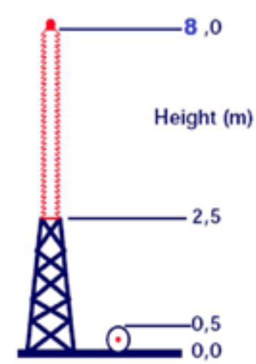
Gas Insulated Switchgear(GIS):
a compact multifunction assembly, enclosed in a grounded metallic housing in which the primary insulating medium is SF6 and normally includes buses, switches, circuit breakers, and other associated equipment.

In IEC 62271-203

Metal-enclosed switchgear and controlgear: switchgear and control gear assemblies with an external metal enclosure were intended to be earthed, and complete except for external connections.

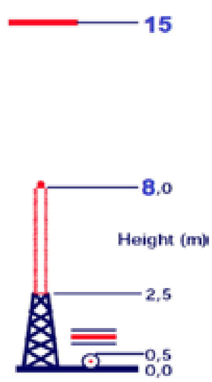
DIMENSIONAL DIFFERENCE AIS Vs. GIS

- Dimensional comparison, 400kV, of a support insulator on its frame, within an air-insulated substation (AIS) and a GIS element
- GIS technology enables to divide by 10 to 25 the area of a HV switchyard



DIMENSIONAL DIFFERENCE AIS Vs. GIS

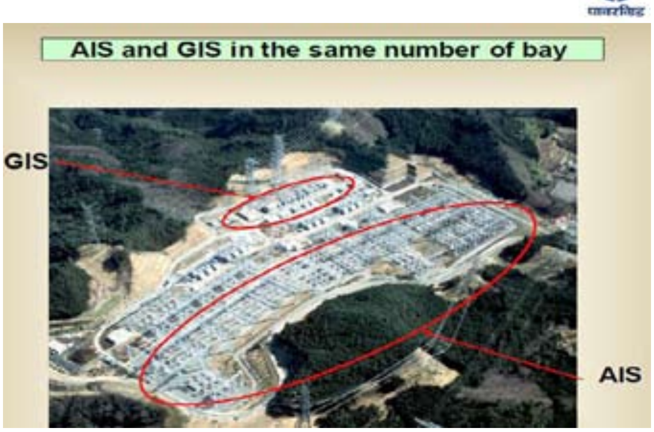
- Dimensional comparison, at **400** kV, of an AIS main busbar crossing, and a GIS busbar crossing
- GIS technology enables to divide by minimum 3 the height of a HV switchyard



ADVANTAGES OF GIS

SF6 GIS substations are compact compared to air-insulated substations. The switchgear is encapsulated by grounded metal enclosures and safe to touch as all active components such as busbars, disconnectors, circuit-breakers and cable terminations are contained inside the enclosures filled with insulating gas SF6.

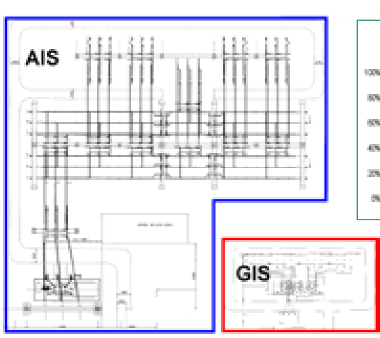
AIS Vs. GIS

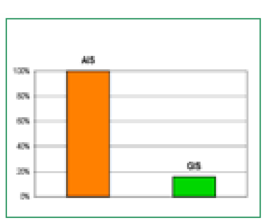


ADVANTAGES OF GIS

Safe	Operating personnel are protected by the earthed metal enclosures
Reliable	The complete enclosure of all live parts guards against any Impairment of the insulation system.
Space saving	SF6 Switchgear installations take up only 1/10 of the space Required for conventional installations.
Economical	High flexibility and application versatility provide novel, and economic overall concepts.
Maintenance free	An extremely careful selection of materials. an expedient design and a high standard of manufacturing quality assure Long service life with practically no maintenance requirement.
Low weight	Low weight due to aluminum enclosure, correspondingly Low cost foundations and buildings.
Shop assembled	Quick site assembly ensured by extensive preassembly and Testing of complete feeders or large units in the

AIS Vs. GIS





GIS CONSIDERATION

Configuration of GIS

- **Bus bar is extendable in both directions**
- **Modularised concept is used**
- **Feeder take-off direction can be oriented according**
- **Feeder take-off direction can be oriented according to the site need**

Types of Scheme

- **Single Main Bus**
- **Double Main bus**
- **Single Main and Transfer Bus**
- **Double Main and Bypass Bus**
- **Breaker & Half Scheme**

GIS CONSIDERATION

Bus Bars

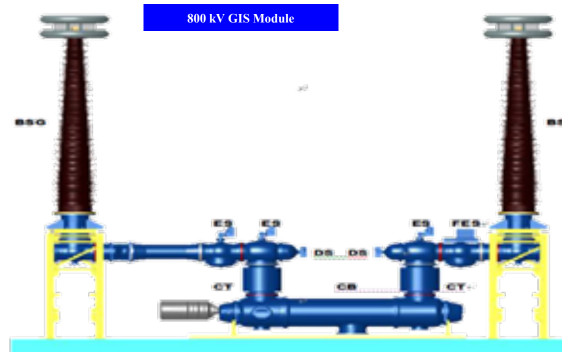
- Aluminium Alloy Bars / Copper Bars
- Sliding Contact of parts are made of Silver-coated copper
- Bus bar and connectors are fully modularised

GAS Compartment

- Through type/Transition type Compartment
- Gas system shall be designed to permit sections to be isolated.
- Gas volume of each gas compartment shall be limited so as to minimize the gas processing and filling.

GIS Modules

800 kV GIS Module



GIS CONSIDERATION

Seals

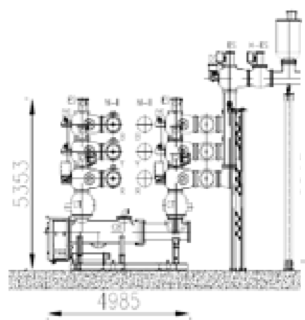
- Seals are vital devices to achieve gas leak proof system design in GIS
- EPDM (Ethylene Propylene Diene Monomer)

Support Insulators / Barrier Insulators

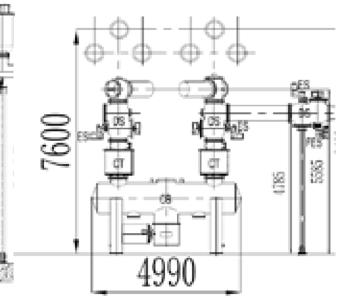
- Holding the conductor in the enclosure
- Hollow type insulator with communication port used as support in particular gas comportment
- Insulator placed at the end of the gas chamber acts as a barrier insulators.

GIS LAYOUTS

GIS Layout with Vertical Bus

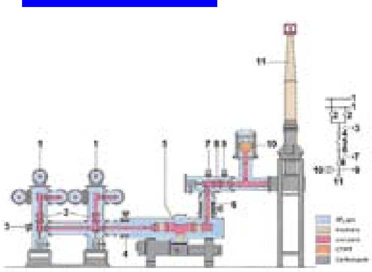


GIS Layout with Triangular Bus



GIS Modules

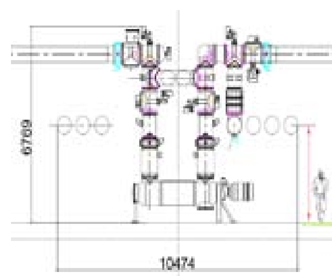
400 kV GIS Module



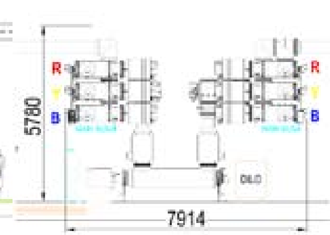
1: Busbar
2: Diconnector
3: Maintenance Earthing Switch
4: Current Transformer
5: Circuit Breaker
6: Current Transformer
7: Maintenance Earthing Switch
8: Diconnector
9: Earthing Switch
10: Voltage Transformer
11: Bushing

GIS LAYOUTS

GIS Layout with Horizontal Bus



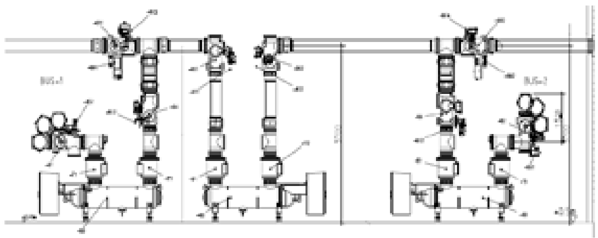
GIS Layout with Vertical Bus (outside)



GIS LAYOUT

GIS Layout of Different Manufactures

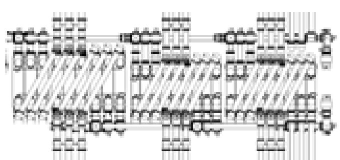
GIS Layout with Semi Circular Bus Arrangement



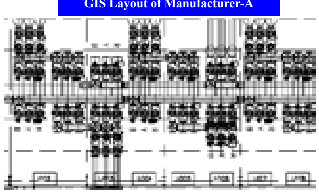
LIMITATIONS OF GIS

- Limited Technical knowhow in India.
- Limited Technical Expertise to handle Failure.
- Partial Energization of GIS Difficult.
- Limited On-site Testing Infrastructure in India.
- Extension of Half dia not Techno-economical at Later Stage by different Vendor.
- Layout Modification During Installation difficult.

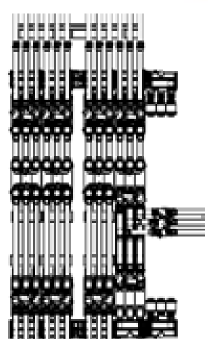
GIS Layouts



GIS Layout of Manufacturer-A

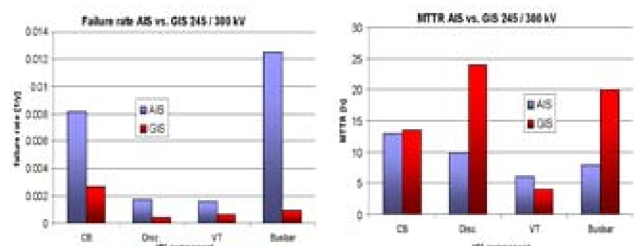


GIS Layout of Manufacturer-B



GIS Layout of Manufacturer-C

FAILURE IN GIS

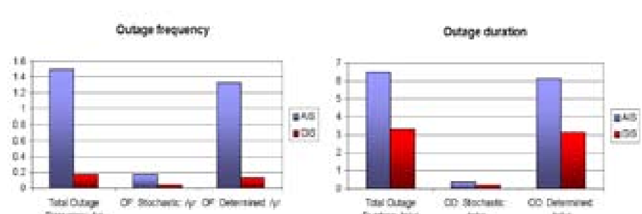


Failure rates and Mean Time To repair (MTTR)

LIMITATIONS OF GIS

- High cost compared to conventional outdoor substation.
- Excessive damage in case of internal fault.
- Long outage periods as Repair of damaged part at site difficult.
- Dust & Moisture Free Environment for GIS Assembly particularly at site.
- Handling of SF6 Gas
- Procurement of gas and supply of gas to site is problematic.

FAILURE IN GIS



Calculated outage frequency and failure rate

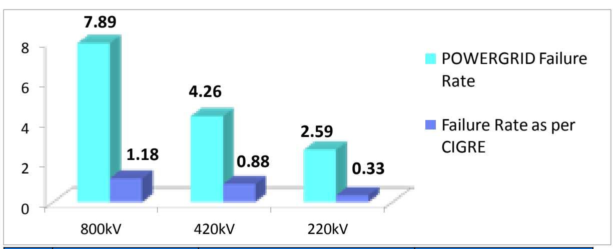
Types of defects affecting the dielectric performance of GIS

- Inadequate Precautions during assembly.
- Contamination by free moving metallic particles.
- Loose electrical and mechanical contact between conducting parts, including electrostatic shields and other floating components.
- Fixed defects such as metallic protrusions and particles attached to solid insulator (spacer) surfaces.
- Manufacturing insulator defects and surface tracks caused by testing flashovers.
- Contaminants which affect the quality of the SF6 gas (by-products, moisture content, erroneous gas filling).

Layout Finalization

- Requirement : Need to Adopt a universal layout for a particular switching Scheme.
- Similar Layout facilitate planning of Building optimally.
- Future Expansion less complex. BUT
- Every Manufacturer has a different layout.
- Need to work with every manufacturer to arrive at optimal solution.

GIS : Failure Rate (POWERGRID)



Sl	Voltage Class	POWERGRID Failure Rate	Failure Rate as per 3rd CIGRE Survey
1.	800kV	7.89	1.18
2.	420kV	4.26	0.88
3.	220kV	2.59	0.33

Failure Rate : Failures per 100 Bay Service Years

Interface/Extension of GIS

- Interface of two different GIS manufacturer equipment at the time of extension of GIS involve great amount of coordination efforts.
- Technical Data and information requisite to adopt the design of existing GIS equipment is not easily available due to intellectual property issue.
- Sharing on minimum data by GIS Manufacturer.
- Issues with Extensions:
  - Warranty Violation
  - Invalidated Module Design
  - Arranging supervision of existing GIS Manufacturer etc.

GIS Issues

1. Layout Finalization
2. Interface/Extension of GIS
3. Validation of type Test Reports
4. Site Installation
5. Partitioning of GIS
6. Know How of GIS to conduct Root Cause Analysis of fault
7. Compliance to the Technical Specification
8. Development of Indigenous Manufacturer for GIS
9. Spare finalization for GIS
10. Diagnostic Technique for GIS

Site Installation

- Ensuring Dust free & Moisture free Atmosphere.
- Availability of Trained and certified manpower.
- Extensive Material Planning.
- To be done mostly sequentially
- Very Limited Parallel installation.

Partitioning of GIS

- As we know GIS comes in Modular manner and these Module are connected with each other. GIS is broadly partitioned at the joint of these module and some time in between also.
- During repair and Maintenance taking out of affected module mainly depends on these partitioning further service continuity during repair and maintenance is also very much depends on the portioning of GIS.
- Both Mechanical and Electrical segregation of GIS Module are of great importance to handle repair and maintenance keeping service continuity requirement in view.

Spare finalization for GIS

- AS per concept, GIS requires less maintenance.
- But in case of failures the down time of GIS is very large.
- Need to have optimal level of spares
- Need to have at least similar equipment from one manufacturer.
- Need to have comprehensive spare policy for GIS addressing need for our installations and nor one specific sub-station.
- Need to Build spare reserve on long term techno commercial basis.

Know How of GIS to conduct Root Cause Analysis of fault

- A number of GIS failures in our Installations
- More than International Standards.
- NO specific reason established till now.
- Need to develop in-house expertise to analyse the behaviour
- Need to develop various study and simulation tools
- Need to have a dedicated focused expertise group for GIS.
- Need to work with Manufacturer for improvement.

Diagnostic Technique for GIS

- Mainly Two type of Diagnostic method are being used in GIS which confirms the healthy ness of GIS equipment.
  - Gas Leak Detections
  - Partial Discharge Monitoring
- In one complete 765/400 kV GIS substation there are expected to be more than 700 GIS compartment which need to be monitored.
- Online PD monitoring with UHF method has been implemented in POWERGRID since 2014 feedback of effective ness this technique needs to be establish

Development of Indigenous Manufacturer for GIS

- Assembly of GIS equipment started in India by Various manufacturer up to 800kV GIS.
- Mostly Parts are imported.
- Very Limited Fabrication and manufacturing of Module in India.
- Component Manufacturing yet to start in India.
- Design capability of GIS Component to be developed in India.

Future Trends IN GIS

- Mixed Technology Solution (Hybrid GIS)
  - GIS with AIS Bus Bars
  - GIS with Vacuum interrupters up to 220kV.
- Alternative Gas Solution for GIS.
  - Mix of Gases
  - New gas developed by certain manufacturers.
- GIL (Gas Insulated Line) which can be fabricated at site with site welding. It eliminates restriction of length of one section of GIL.
- GIS for HVDC Switch yard.

Complexities In GIS Interface

Bus Orientation:

Complexities In GIS Interface

Bus Orientation:

Complexities In GIS Interface

Bus Orientation:

Complexities In GIS Interface

1. Switchgear Height:

Complexities In GIS Interface

1. Custom Made Design is not Validated:

EXPECTATIONS FROM SMART METERS - A UTILITY PERSPECTIVE

Nilesh Kane, Subhadip Raychaudhuri and Anil Kumar
Tata Power Delhi Distribution Ltd.

ABSTRACT

Undoubtedly, the energy meters have the most important role in power distribution business. As entire revenue generation is coming out of energy recorded by an energy meter and it is essentially the cash box of energy distribution business. Smart electricity meters are a central module of the smart grid, facilitating automated assortment of periodic (usually every 15, 30 minutes or hourly) consumption data. This enables active electricity pricing stratagems, in which consumers can be charged greater rates during peak times to aid in reduction of peak load. In addition, smart meter data analytics, which targets to benefit utilities and consumers comprehend electricity consumption patterns, has become a dynamic space in exploration and industry. According to a latest report, utility data analytics is now a billion dollar marketplace and is anticipated to rise to almost 4 billion dollars by year 2020. A variety of smart meter analytics algorithms have been proposed, mainly in the smart grid literature, to predict electricity consumption and enable accurate planning and forecasting, extract consumption profiles and provide personalized feedback to consumers on how to adjust their habits and reduce their bills, and design targeted engagement programs to clusters of similar consumers.

INTRODUCTION

Smart meter investments originally were principally made out of a need to lessen operating costs for otherwise high cost undertakings of bill collection, field servicing costs (remote customers extended over huge service expanses and/or hard-to-access meters) where returns were evidently noticeable and instantaneous. Hence, between the times the first "automated meter" was perceived in the early 70's, and the dawn of deregulation in the mid to late 90's, it was reasonably quick Capex solution for reducing burdensome O&M costs that were otherwise difficult to displace. But it wasnot long before extra sources of value became readily apparent. Plummeting the cost of collections through automated disconnect and reconnect for example, sugarcoated the value proposition impressively. But for the most chunk, the major 30 years of the smart meter could be summed up as a wholesome monetary story, as the vast majority of the first dispositions were based on an unassuming operational value case. While there was a lot of talk and hype about the "value of the data", it wasnot until the crack of the millennium that companies were able to begin tapping into the value their AMI data streams were proficient of generating.

Smart grid is a generalized word, it includes diverse kind of sub-infrastructures. One of the important infrastructures is AMI. AMI is an infrastructure which has many function but it can also be used to control electricity theft. AMI is an infrastructure and smart meter is an entity which can be placed at each and every home/industry, replacing existing meters. AMI provides a new sensor based approach.

TYPES OF SMART METERS AND DATA ANALYTICS

There are mainly three categories of smart meters

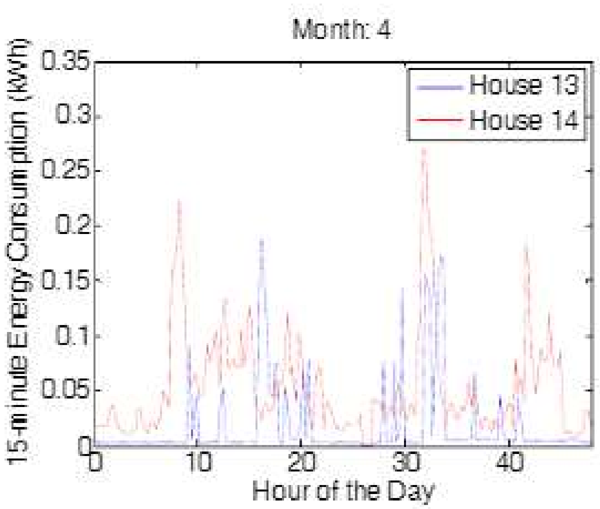
1. Simple : This basic type of smart meter was the first prototype and was basically facilitating two way communication between the meters and data accumulation and processing center.

These meter will be having no load switch and will not be able to disconnect he consumer load.

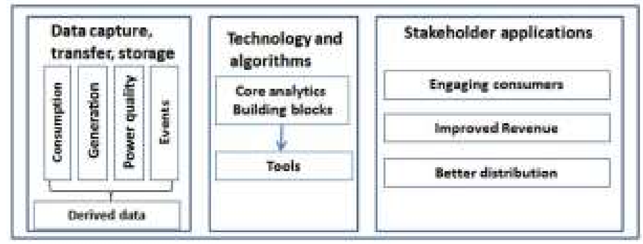
2. Semi : As a new idea of a dynamic system of two categories of loads was conceived which can help reduce complete blackouts by differentiating between critical and non-critical appliances and cutting off the load of noncritical ones. A need to remotely disconnect and connect such appliances was needed and in stepped the semi smart meters who provided exactly what was needed.

3. Full-Fledged : One of modern day marvels of smart electrical engineering is home automation that is complete control over home equipment e.g., A.C., refrigerator etc. So the most modern smart meters includes that together with its advanced metering infrastructure and are fully fledged smart meters to take care not just of non-critical load shedding but also facilitates home automation.

From the supplier-consumer affiliation standpoint, smart meters can redefine the supplier's role to that of an energy consultant. From an industry viewpoint, it can incorporate novel tools and innovations across the power grid. To the operators' gain, it can drive down charges, offer transparency and elastic pricing. And from a societal angle, it can increase energy saving, network consistency and outage supervision, as well incorporating the supply of renewable energy options. Much of the commercial case for smart meters axes on convincing customers to sincerely alter their energy usage. A constructive bias among most consumers toward energy conservation, for both economic and environmental reasons, is an encouraging start. What is needed is to create a positive experience, both during and after the rollout. Customer experience during the rollout needs to be driven by timely and personalized information dissemination on schedules, status updates, tariff options, potential benefits and concerns of privacy and health. Post the rollout, it shifts more toward an advisory engagement. Analytics, coupled with the Internet of Things (IoT), can enable companies to provide smart solutions that help customers efficiently manage their energy requirements. In-home displays can provide real-time feedback and empower customers to analyze their consumption patterns and maximize savings.



Two comprehensive extents of research in smart meter data analytics are those which use whole-house consumption readings accumulated by orthodox smart meters (e.g., every hour) and those which use highfrequency consumption readings (e.g., one per second) acquired using focused load-measuring hardware. We center on the former in this paper, as these are the statistics that are presently put together by utilities. For wholehouse smart meter data, there are two categories of uses: consumer and producer-oriented. Consumer-oriented applications deliver feedback to end-users on reducing power consumption and saving cash.



Smart meter data outline

Producer focused applications are geared in the direction of utilities, system operators and offer information about consumers such as their dayto-day routines for the determination of load estimation and bundling/ segmentation.

GAME CHANGING CONSUMER PROFILING USING SMART METER DATA

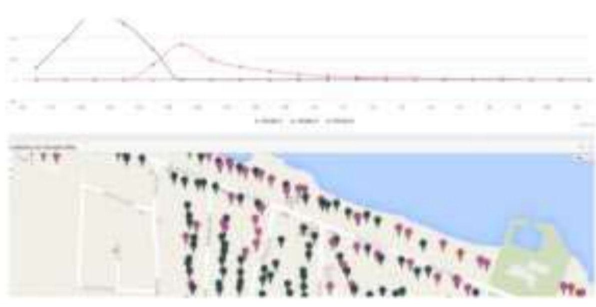
Case Study : Facebook has become one of the biggest company of world in very less time. Unlike its competitors, which enables advertisers to serve up ads based on keyword searches, Facebook's value proposition is targeted advertising. Advertisers can use the wealth of personal data about users from it and make the data anonymous and serves the information to advertisers in custom demographic buckets. Advertisers can further slice and dice the buckets based on their branding goals.

Similarly, energy meter data can be used for consumer profiling and mapping. Hence be potentially a business of huge opportunity. For example, advertisers can serve up custom ads to our smart meter users from specific income groups or regions. They can also target users based on other categories, such as gender, religion or political affiliation. E.g. Facebook has developed a broad variety of ad products for different stages of the branding lifecycle and its Dynamic ads product enables advertisers to upload their entire product catalog and target customers at specific income levels. Similarly, Lead ads help advertisers in lead generation and we can do the same for our consumers.

REVENUE GENERATION USING CONSUMER PROFILING AND CONSUMER MAPPING USING SMART METER DATA

From a technical stance, both of the above classes of applications i.e. High Frequency and whole-house consumption smart meters accomplish two styles of jobs: mining illustrative features and discovering similar consumers based on the extracted features. Domestic energy consumption can be broadly disintegrated into the temperature-sensitive element (i.e., the heating and cooling load) and the temperature-insensitive component (additional appliances). Thus, characteristic features comprise those which ration the magnitude of outdoor temperature on consumption and those which recognize consumers' everyday routines regardless of temperature, as well as those which measure the complete capriciousness (e.g., consumption histograms). Smart meter analytics can include four representative algorithms for characterizing consumption changeability, temperate sensitivity, daily activity and likeness to other consumers.

This mapping of Signatures of Monthly Household Energy Consumption is explained below. Traditionally, energy meters record household electricity usage by real power consumption only. A number is read at the end of each month to record the energy usage. Because the meter may not be read at the same time interval, the monthly electricity consumption data provide few details on consumption. A smart meter can record voltage (V), real (watt), and apparent (VA) power consumptions at 15-minute intervals. The monthly data can be collected and reported rigorously from selected start and end dates.



Consumer Segmentation using High frequency load profiling

Even the energy theft can be found out from such profiling. Energy use in opposite seasonal patterns can be signaled out for investigation. Abnormally low or flat energy consumption may indicate energy theft. Therefore, it is important to monitor the monthly data for abnormal energy consumption patterns that may cause utilities to lose revenue in energy sales or potential load characteristic changes for distribution system planning.

CONCLUSION

The paper has offered a broad assessment of smart metering and smart meter data analytics. Even though there has been much resistance to smart meters due to confidentiality and health concerns, it is evident that smart meters are here to stay and that the Smart Grid and smart metering will be a keystone in entire utility business and will be a "way of life" in the near future. A number of unalike scopes to smart meters have been underlined together with the smart meter technology and the process, the various stakeholders, existing analytics technologies and tools, and the current technological revolutions such as big data etc.

The paper has also presented the current smartmetering space as the smart-metering landscape, and then, a framework has been established to relate smart meter data to stakeholders and applications created by their needs and the analytics tools and techniques required to achieve the stakeholder needs. Another input from this paper is the proof of identity of smart meter analytics building blocks which enable to link the wide range of tools used for smart metering and identify the main analytics activities. The Smart Grid and smart meters will be part of a much wider Internet of Things (IoT) in the future integrating multiple aspects of human needs and services to satisfy such needs, and the analytics requirements discussed, such as big data, real time analytics, stream analytics, will need to be built into the processes and workflows for diagnostics in real time.

LEVERAGING SMART GRIDS ASSETS FOR BUILDING SMART CITIES AT MARGINAL COST

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ABSTRACT

The Smart Cities Mission has triggered the planning and designing of 100 Smart Cities in the country and it is expected that by 2030 more that 40% of India's population will live in urban areas. Using Smart Grids as anchor infrastructure to build Smart Cities in India makes sense given the need for modernizing the electricity distribution system to provide 24x7 supply of quality power to all. Compelling business cases are available for investment in smart grid technologies to improve operational efficiency and reduce system losses. Smart Grid is essential to integrate renewable energy resources on to the grid and green energy is a key element for Smart Cities and their sustainable future. This paper describes how Smart Grid assets can be leveraged to build Smarter Cities at marginal cost by extending the automation, IT and communication infrastructure of the Smart Grids to other infrastructure and services domains in a city.

***Keywords** : Smart Cities Mission-Smart Grid-Quality Power-Integrate Renewable Energy-Automation-IT-Communication*

INTRODUCTION

1. Smart Grid: A Paradigm Shift

The 21st Century electric grid is witnessing several disruptive changes. After 100 years of centralized power generation and creation of massive electric grids, the shift is now towards de-centralized generation. For the past five years we are witnessing an increasing share of new generation resources being added at the low voltage or distribution segment of the grid which is a major transformational change to the electric grid. The traditional model of electricity being generated at large power plants and transported to millions of consumers through long transmission and distribution lines is changing. The traditional boundaries between Generation, Transmission and Distribution are fast disappearing and the grid is evolving as an integrated grid. This change is primarily driven by distributed generation from renewables which have already achieved grid price parity to most customer classes in many geographies. Electric Vehicles are going to make the electric grid even more complex to manage as there will be less predictability of the loads!

Smart Grids have emerged as the critical enabling infrastructure for all flagship programs for Government of India (GoI) such as 24x7 Power for All, 100 Smart Cities, 175 GW of Renewable Energy by 2022, National Mission on Electric Mobility with a target of 6-7 million Electric Vehicles by 2020 etc. In order to bring efficiency and sustainability in the electricity distribution sector in India, introduction of Smart Grid technologies started with Restructured-Accelerated Power Development and Reforms Program (R-APDRP) and is continued with Integrated Power Development Scheme (IPDS). To take this on fast track a National Smart Grid Mission (NSGM) has been approved by GoI. NSGM is envisages to launch projects in conjunction with other ongoing programs of GoI and State Governments to build smart grids in the country in a phased manner starting with urban areas and regions with huge transmission and distribution losses.

2. Urbanization and India

The rise of cities has grown over millennia, and have evolved over time as places where the entirety of human activities and services concentrate, spanning multiple modes of transportation, water supply, electricity, telecommunication and internet, schools and colleges, hospitals, markets and businesses, other resources and services across people with varied skills. As cities evolved with more and more facilities and services, they became more and more attractive to people from rural areas leading to even faster urbanization. Rapid growth of cities has led to the creation of metropolitan regions - clusters of cities in a region.

Urbanization accompanies economic development. Rapid urbanization followed as India transformed from an agrarian economy to industrial cum services economy during the past three decades. While the urban population is currently around 31% of the total population, it contributes to over 60% of India's GDP. It is projected that urban India will contribute nearly 75% of the national GDP in the next 15 years. It is for this reason that cities are referred to as the “engines of economic growth” and ensuring that they function as efficient engines is critical to our economic development. This trend of urbanization that is seen in India over the last few decades is expected to continue for few more decades. Hence we need to plan our growing urban areas as sustainable cities. The relatively low technology penetration in cities allows us to plan our urbanization strategy in the right direction by taking advantage of the latest developments in technology.

Comprehensive planning and development of physical, institutional, social and economic infrastructure is the right approach to develop smart cities. Government of India is accelerating the development of cities in India with the Smart Cities Mission. The 100 Smart Cities are to make their infrastructure ready to take on the population growth, supply 24x7 reliable electricity supply, secure every citizen’s life with good health, education and employment facilities and make the city more liveable, workable and sustainable.

Increasing energy demand makes all these targets challenging as energy consumption from fossil fuel will lead to more carbon emission and environmental issues. Energy is the key driver for cities and non-polluting energy essential in smart cities. To ensure 24x7 sustainable supply of electricity and energy security, the efficient management of the electricity distribution network in real time through use of intelligent devices and applications has become necessary.

3. Smart Grids For Smart Cities

Smart grid is an electricity grid with communication, automation and IT systems that enable real time monitoring and control of power flows from points of generation to points of consumption at the appliances level. It is an evolving grid system that manages electricity demand in a sustainable, reliable and economic manner built on advanced digital infrastructure and tuned to facilitate the integration of both demand and supply. Smart Grid can implement basic building blocks for Smart Cities which can be utilised by other utilities like water, sewerage, piped gas, streetlights, etc., to integrate other solutions of Smart Cities and create a holistic eco-system with common command and control centre. Preliminary studies by India Smart Grid Forum (ISGF), indicate that in towns with AT&C losses above 25%, Smart Grid projects can bring it down to 10% with the payback period of 3-4 years. There are compelling business cases for Smart Grids which makes it an anchor infrastructure for Smart Cities and once Smart Grid infrastructure is in place, extending it to other domains and services to build Smart Cities can be achieved at marginal cost.

In the Indian context where cities do not have a single owner for all their services, it would be a herculean task to integrate all infrastructure and services on a common platform. However, a beginning can be made by extending the available digital platform of one domain (say power) to offer services in other domains (say water, gas, internet, transport, security etc). The smart cities in India can be in two categories – existing cities that should be made smarter by integrating all services on digital platforms; and new cities that would be built as smart cities with integrated communication, IT and Automation architecture.

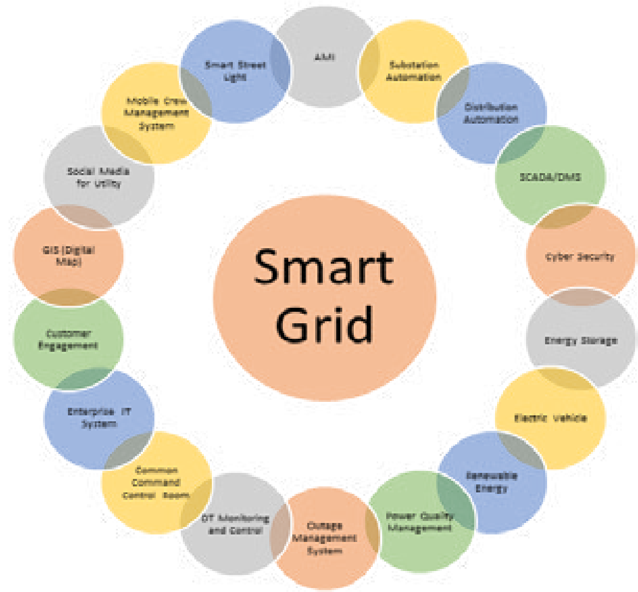

Fig. 1 : Smart Grid Components

This would essentially cover the following:

1. Building GIS data of all infrastructure and services in an integrated fashion by one designated agency (with rules for sharing, security, etc.)
2. Smart electricity grids that ensure 24x7 stable electricity to all citizens
3. High levels of renewable energy mix that is integrated with the power grid
4. EV charging infrastructure and ability to operate large fleet of grid-connected EVs as virtual power plants (VPPs)
5. Efficient water distribution network with leakage detection systems and safe gas distribution networks
6. Integrated billing systems for a variety of services (electricity, water, gas, internet, house tax etc.); common consumer care centers and user friendly payment platforms
7. Intelligent transportation systems - coordinated operation of traffic lights, alerts on congested routes in advance, common cards for toll payments etc. which also extends to improved public transportation.

8. Digital security systems integrated with emergency services (police, fire, ambulance, municipality etc.)
9. Electrification of mobility, with fleet operations being the low hanging fruit, permit creation of virtual power plants (leveraging grid connected EVs)
10. Intelligent buildings with rooftop PV and EV Charging facilities integrated with automation systems of the electric utility participating in the demand response market
11. Demand Response would strengthen negawatt market and IT infrastructure permit its aggregation for meaningful dispatch.
12. Energy independence in long term and "intelligent energy harvesting" that would recyle incoming energy flows.
13. Sharing of data between various domains and building smart analytical tools
14. Seamless payment system for all services

While building new cities and new neighbourhoods, it is possible to build all these in an integrated fashion, it is a tougher task to integrate the same in existing cities with different owners for different domains. The silver lining is that there are hardly any IT and Automation systems in most infrastructure domains in Indian cities which eliminates the risk of legacy systems with proprietary databases and protocols that cannot readily be integrated with one another.

LEVERAGING THE SMART GRID ASSETS FOR SMART CITIES

All state owned electricity distribution companies (Discoms) in India are implementing a set of basic IT and Automation solutions under the ongoing R-APDRP scheme of the Ministry of Power. Some of the digital assets created under this program that covers 1411 towns can be leveraged to build smarter cities at marginal cost. The IT and Automation Systems of the DISCOMS that can be leveraged by other infrastructure services providers is briefly explained below:

1. GIS Map of the Towns: All electrical assets (33 kV, 11 kV and Low Voltage lines and substations) and consumers are mapped on a digital map and the Discoms are updating this system on a regular basis to capture changes/addition to the electrical network as well as new consumers/buildings. This digital map can be effectively used by other infrastructure services providers for planning as well as operation and maintenance of their systems. This will be very useful for planning the laying of water supply and sewerage lines, telecom cables, gas pipe lines etc. It can also be used for planning of road network. As the simplest example of how a good GIS system can help beyond a single domain – if one knows the routing of underground power cables, then the same can be synergized to other utilities that would need to dig up roads (like water, sewage, telecom, etc. – thus one should, in the future, never interrupt other services for adding new connections/lines/pipes).
2. Billing and Customer Relationship Management (CRM) Systems: State of the art Billing and CRM systems have been implemented in all these towns and the consumers have multiple options to make their payments. There are also Consumer Care Centers at strategic locations and interactive consumer portals. Discoms have regular interactions with their customers on – meter reading, bill distribution, payment collection, attending to complaints, information on planned outages etc. Large number of consumers are already using the consumer portals. All water and gas consumers are electricity consumers also. The Billing and CRM systems of Discoms can be used for collection of water and gas bills, house taxes and other municipal dues, and can even be extended to private utilities such as cable TV, internet, telephone, etc. This not only reduces the overall collection cost, but also facilitates higher compliance in timely payment. If the consumer wishes, he/she could even opt for a consolidated bill across all such services.
3. SCADA/DMS System: For larger towns with population of 4 lakhs and above (about 78 towns), Discoms are implementing SCADA/DMS systems for monitoring and controlling the real-time power flows. The field infrastructure and dedicated communication bandwidth for SCADA/DMS can be leveraged to automate the water and gas supply networks as well.
4. Common Command and Control Center: A common command and control center that can handle the complaints from consumers for all their grievances related to electricity, water, gas, internet etc can be created. The incoming calls (on single number) can be diverted to the respective teams responsible for each domain and their crew. The IT and communication infrastructure and cost can be optimized to a great extent. It will boost customer satisfaction to a great extent as they do not have to knock at different doors for each service.
5. Outage Management Systems (OMS) and Mobile Workforce Management (MWFM): OMS and MWFM can be shared by electricity, water, gas and internet/ other services providers.
6. Application Integration: All the applications of all interconnected domains can be integrated and the data can be shared and dashboards can be made available to operators, managers and policy makers to effectively plan and manage the city.

NATIONAL SMART GRID MISSION (NSGM)

Ministry of Power issued a Smart Grid Vision and Roadmap for India in August 2013 which envisages transformation of the entire Indian power system to a smarter grid by 2027. In order to achieve the goals envisaged in this roadmap a National Smart Grid Mission (NSGM) has been approved by Government of India in 2015. Under the NSGM it is proposed to build about 30 smart cities in the country leveraging the existing R-APDRP infrastructure and new systems that would essentially be implemented for first building smart grids and then extending the systems to other domains.

The NSGM initiatives will be coordinated with other programs such as Smart Cities Mission, Digital India, 24x7 Power for All, 175 GW Renewable Energy, Solar Cities Program, National Mission on Electric Mobility, National Mission on Enhanced Energy Efficiency, etc. for improved efficacy and asset/cost optimization.

NSGM has a three tier structure:

- At the apex level, NSGM has a Governing Council headed by the Minister of Power. Members of the Governing Council are Secretary level officers of concerned Ministries and Departments. Role of Governing Council is to approve all policies and programs for smart grid implementation.
- At the second level, the NSGM has an Empowered Committee headed by Secretary (Power). Members of the Empowered Committee are Joint Secretary level officers of concerned Ministries and Departments. Role of Empowered Committee is to provide policy input to Governing Council and approve, monitor, review specific smart grid projects, guidelines / procedures, etc.
- In a supportive role, NSGM has a Technical Committee headed by Chairperson (CEA). Members of the Technical Committee are Director level officers of concerned Ministries & Departments, representatives from industries and academia. Role of Technical Committee is to support the Empowered Committee on technical aspect, standards development, technology selection guidelines, etc.
- For day-to-day operations, NSGM has a NSGM Project Management Unit (NPMU) headed by the Director NPMU. Director NPMU is a Member of the Governing Council and Empowered Committee, and Member Secretary of Technical Committee. NPMU is the implementing agency for operationalizing the Smart Grid activities in the country under the guidance of Governing Council and Empowered Committee.
- Grant up-to 30% of the project cost is available from NSGM budget. For selected components such as training & capacity building, customer engagement, etc. 100% grant is available.

SMART CITIES STANDARD FRAMEWORK

ISGF has studied various domains and sub domains of Smart Cities and designed an exhaustive matrix depicting the interdependency of each of these domains on other domains. Each domain can achieve its described features with the help of technology enablers available as a solution to the problem. Four main Smart Cities Pillars are:

A. Physical Infrastructure
B. Institutional Infrastructure
C. Social Infrastructure
D. Economical Infrastructure

Each pillar is then divided into domains and sub-domains.

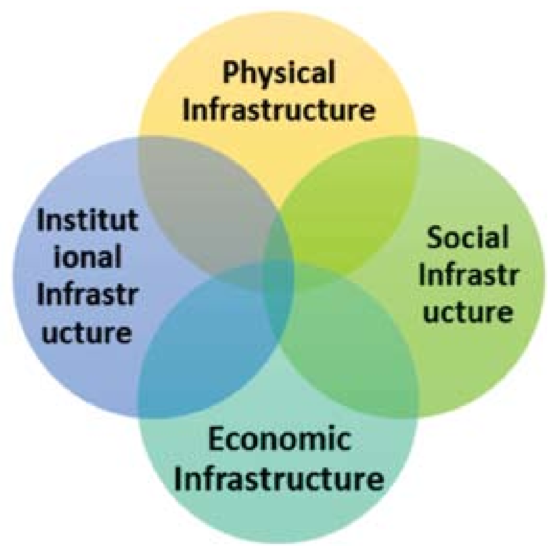

Fig. 2 : Smart City Pillars

Key technology enablers for the infrastructure are:

1. GIS (Digital Map)
2. Instrumentation and Control
3. ICT
4. Interoperability
5. Cyber-Physical Security
6. Data Management
7. Analytics
8. Planning and Modelling Tools
9. Environment Friendliness
10. Citizen Engagement and Participation
11. Governance

Sample of the Interdependency Matrix is as follow:

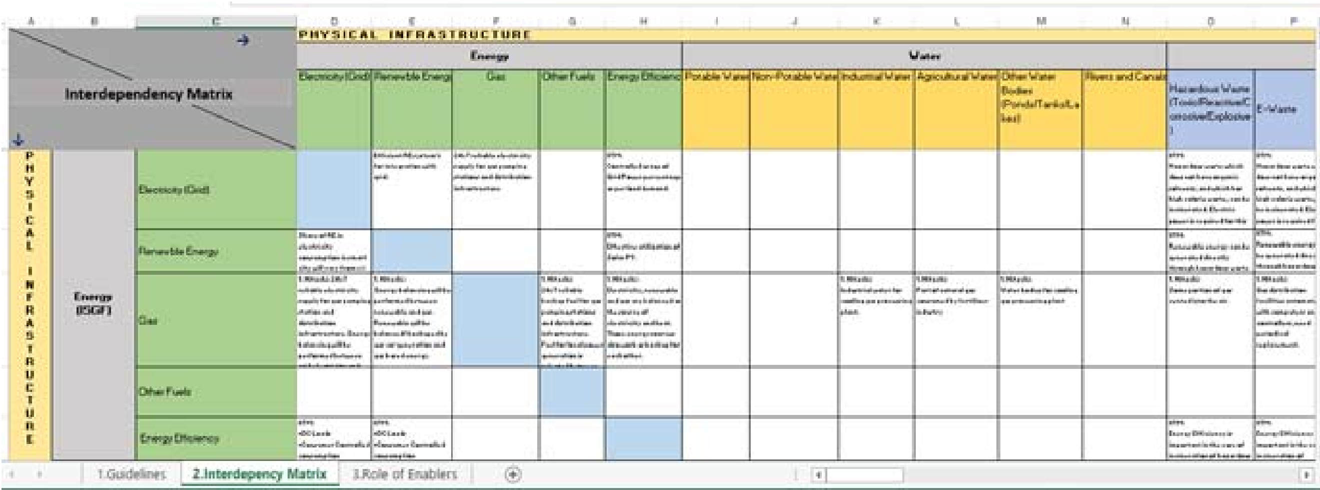

Fig. 3 : Smart City Domain's Interdependency Matrix

Each cell of the matrix describes "what is the interdependency of respective domain with other domains". For example a smart city with 24x7 water supply would require reliable electricity supply; and what the electricity grid should do to achieve reliable supply to all water pumping stations will be described. Certain technology enablers can be common to multiple domains.

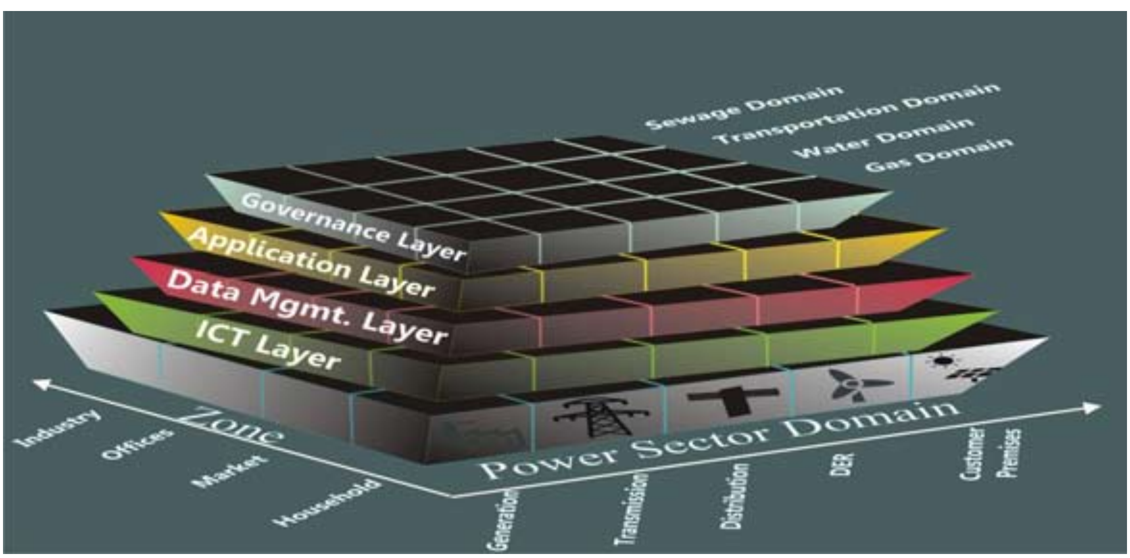

Fig. 4 : Interdependency of Domains

Detailed list of Infrastructure Pillars/Domains/Sub-domains are:

Sl. No.	Infrastructure Pillar	Domain Name	Sub-domain Name
A.	Physical Infrastructure	Energy	1. Electricity 2. Renewable Energy 3. Gas 4. Other Fuels (cooking, heating, manufacturing) 5. Energy Efficiency

		Water	6. Potable Water 7. Non-Potable Water 8. Industrial Water 9. Agricultural Water 10. Other Water Bodies (Ponds/Tanks/Lakes) 11. Rivers and Canals
		Waste	12. Hazardous Waste (Toxic/Reactive/Corrosive/Explosive) 13. E-Waste 14. Medical/Bio-medical Waste 15. Sanitation & Sewage 16. Radioactive Waste 17. Rain Water/Storm Water/Drainage 18. Municipal Solid Waste (Incl. Religious Waste)
		Transportation	19. Road/Rail/Metro/Tram/Multimodal 20. Water 21. Air 22. Electric Vehicles
		Buildings and Market	23. Residential 24. Commercial 25. Industrial 26. Shopping Malls 27. Market Places/Mandis 28. E-Commerce Infrastructure 29. EV charging stations 30. Parking Lots
		Communication	31. Voice 32. Data (Incl. M2M & IoT) 33. Video 34. Post & Courier
		City Control Centre	35. Common Command and Control Room 36. Weather & Events Forecasting
B.	Institutional Infrastructure	Governance Transparency & Accountability	37. E-Governance 38. Service Delivery
		Security	39. Physical Security 40. Cyber Security 41. Policing 42. Surveillance
		Emergency Services	43. Fire 44. Ambulance 45. Disaster Management
		Enforcement	46. Policing

		Planning	47. GIS 48. Modelling Tools 49. Data Collection and Analytics
		Legal	50. Court 51. Legal Cells 52. Prison/Juvenile Centres
		Environment	53. Environmental Sustainability
C.	Social Infrastructure	Education	54. Primary Education 55. Higher Education 56. UGs/PGs/PHDs 57. Research Institution 58. E-learning 59. Adult Literacy Centres 60. Vocational Training
		Health	61. Primary Healthcare Centers 62. Super Specialty hospitals 63. Mobile Health care services 64. Emergency Health care services 65. Preventive Vaccination 66. Child Mortality rate 67. E-Healthcare
		Religious And Culture	68. Public Parks 69. Recreation Clubs 70. Theatre and Auditoriums 71. Places of Worship
		Sports Recreation & Entertainment	72. Playgrounds/Gardens 73. Sports Academies/Training Centres 74. Training Centres
		Innovation	75. Culture inspiring Innovation, Development of Clusters
		Peoples participation in decision making	76. RWAs 77. Complaint/Suggestion Review 78. Feedback Collection
		Citizen Advisory Committees	79. Women/Children Welfare Bodies
D.	Economic Infrastructure	Economy	80. GDP 81. Job Creation 82. Incubation Centers 83. Government Institutions 84. Livelihood Activities 85. Market Growth
		Finance	86. Banking 87. Micro Finance 88. FDI & FII Investors

SMART CITY MATURITY MODEL (SCMM)

ISGF studied the ISO 37120 standard which specifies the benchmarking points for various themes/domains and designed a Standard benchmarking Framework for Smart Cities called the Smart City Maturity Model (SCMM). In the SCMM, the levels of maturity of a city in each of the above city domains/sub-domains will be defined in clearly measurable characteristics. This can be an effective tool for assessing the "AS-IS" state of a city in each of the domains. Once the "AS-IS" state is surveyed/evaluated, the stakeholders can decide where the city should focus on improving its infrastructure and services based on the long term vision for the city. Once the "TO-BE" state is defined for the city in each of the infrastructure domains and services, it will be possible to prepare a transformation roadmap for the city and plan projects in each domain in a phased manner and also undertake cost-benefit analysis for each of those projects. SCMM is being developed on the basis of Smart Grid Maturity Model (SGMM) being maintained by the Software Engineering Institute at Carnegie Melon University. This tool would help in order to prioritize and plan activities and develop a roadmap for building smarter cities and it would bring the competitiveness, sustainability and better quality of life in these Smart Cities.

CONCLUSION

The concept of a Smart City is gaining popularity, but the main challenge becomes how to start the process, and coordinate it. Instead of treating this as an IT project, it makes sense to anchor this around Energy and Power, for the below reasons:

1. IT is an enabler, a means to an end. The services and outcomes are really the end-goal
2. Power is a critical human need, and spans the entire multitude of operational, logistical, and philosophical needs for public utilities and services. It is neither as profitable as telecom, nor as loss-making as water/ sewerage. It is neither entirely a public good (basic human right) like water, nor a purely commercial commodity
3. The scale and scope of both power and underlying efforts (from R-APDRP to Smart Grids) make this utility a logical anchor for all other functionalities

Smart Grid can become the anchor of Smart Cities to accelerate the development of liveable, workable and sustainable eco system in Indian Cities. Renewable energy is the key to build sustainable future which will enable green energy consumption in Smart Cities. Standard Framework for Smart Cities would help in understanding the interdependencies of various domains and better planning. Smart City Maturity Model would map and benchmark various domains in the City and offer framework to develop the roadmap for transformation from AS-IS stage to TO-BE stage in a phased manner.

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FACTORY INSPECTION OF U.H.V. TRANSFORMERS

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1. INTRODUCTION

A very precise & planned factory inspection at various stages during manufacturing is most essential process to ensure reliability, efficiency & hassle free long term performance of UHV power transformer. Thus it becomes necessary to carry out factory inspection at various stages like winding, coil assembly, core building, core coil assembly, drying of active part, Repacking (Servicing), Tanking, Processing post tanking, Final components assembly check, Dismantling & dispatch etc. Even small omissions in design, material defect, manufacturing defect, processing defect has been directly associated with failure in FAT or failure of power transformer during its operation.

In preparing the paper reference have been made to manufacturers instruction manual, work standards, CBIP manual for power transformer manufacturing.

2. INFRASTRUCTURE

As the voltage level of transmission is getting continuously being upgraded, to the present level of 1200 kV, the manufacturing conditions and the infrastructure required calls for facility like positive pressurized clean room in winding shop, insulation shop, the active part and where the insulation components are stored prior to manufacturing activity. Also the infrastructure requirement like jerk free & smooth movement of for active part, clamping structures suitable to apply force ranging up to 250 tons in order to stabilize the winding height to design value . Special oil processing systems to achieve moisture content to the tune of 2.0 ppm and particle count of the order of size 4 microns less than 800, Dry air of dew point less -60 °C are pre requisites to manufacture a reliable product. The most important of all the above the management has to ensure the availability of stable, skilled man power.

3. STAGE INSPECTION PROCESS.

Well-structured and defined factory inspection stages need to be implemented at the appropriate stages. Any mistakes which are missed shall be very costly at a later stage to correct. The success of the organization to a great extent depends on to what micro level the process are defined, the parameters are set and the documents are prepared in advance so that the process are driven by a documented system and not depended on the competency, culture or behaviour of the individuals themselves.

Hence the strength, soundness of the unit is based on the establishment of rigorous quality inspection / manufacturing inspection at different stages.

The paper discusses on the important inspections that shall be carried out at various manufacturing stages, instrument required, interpretation of results, precautions during manufacturing, environmental requirement. Also an attempt made to share various quality problems during power transformer manufacturing, special processing requirement for high voltage component at various stages, handling precautions etc.

Many Inspections are concurrent with the production process and ''progressive''. One cannot arrive at the end of operation and spare time for checking alone.

4. ENVIRONMENT

As it is well known dust and humidity are the biggest enemies for insulation and hence for a high voltage transformer manufacturer.

The UHV Power transformer winding must be made in Temperature, Humidity & Dust controlled environment.

There is no formal bench marking done guideline for a clean room in a power transformer industry. However other clean room specifications like ISO 14644-01 control environment can be referred till such time. Practically a level of ISO Class 9 can be maintained and improved upon with in the wider range.

The standard defines cleanroom as "The room in which the concentration of airborne particles is controlled, and which is constructed and used in a manner to minimize the introduction, generation, and retention of particles inside the room, and in which other relevant parameters e.g. temperature, humidity, and pressure, are controlled as necessary".

The Airborne particle in controlled environment should be limited in range given in below table.

The data for Dust level in all manufacturing areas need to be collected on different manufacturing location on regular interval & trend analysis to be made. It can be monitored in 0.5 μm (i.e. 3,520,000 μm for ISO Class 9).

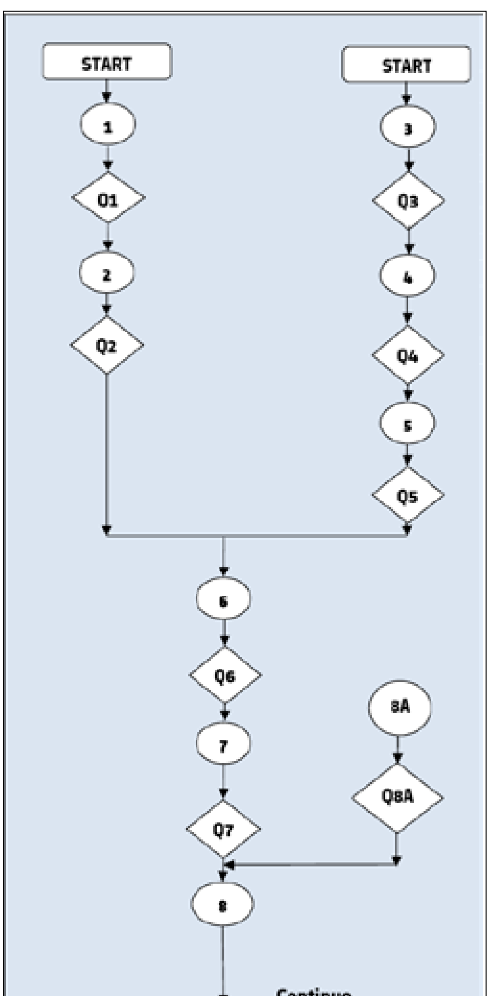
Table 1 — Selected airborne particulate cleanliness classes for cleanrooms and clean zones

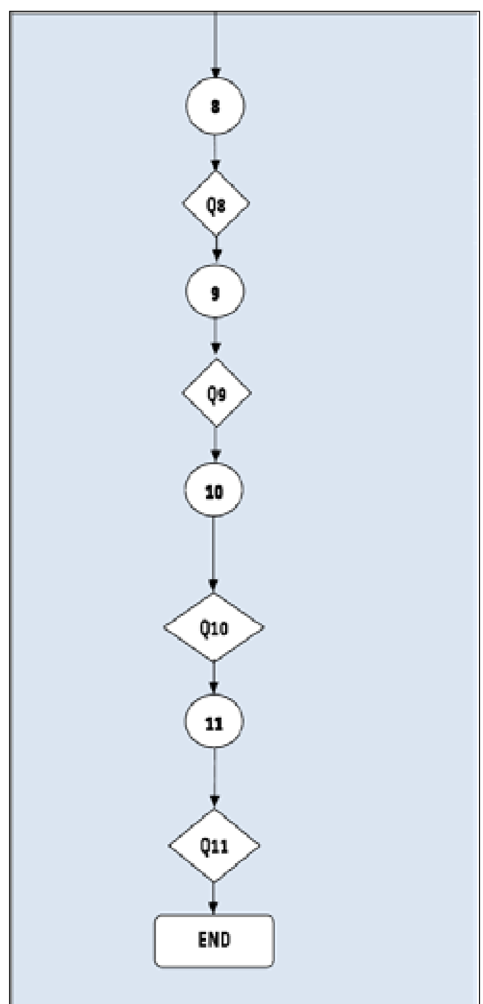
ISO classification number (N)	Maximum concentration limits (particles/m³ of air) for particles equal to and larger than the considered sizes shown below (concentration limits are calculated in accordance with equation (1) in 3.2)					
	0,1 µm	0,2 µm	0,3 µm	0,5 µm	1 µm	5 µm
ISO Class 1	10	2				
ISO Class 2	100	24	10	4		
ISO Class 3	1 000	237	102	35	8	
ISO Class 4	10 000	2 370	1 020	352	83	
ISO Class 5	100 000	23 700	10 200	3 520	832	29
ISO Class 6	1 000 000	237 000	102 000	35 200	8 320	293
ISO Class 7				352 000	83 200	2 930
ISO Class 8				3 520 000	832 000	29 300
ISO Class 9				35 200 000	8 320 000	293 000

NOTE Uncertainties related to the measurement process require that concentration data with no more than three significant figures be used in determining the classification level

5. PROCESS FLOW OF TRANSFORMER MANUFACTURING

Manufacturing Stages		Quality control In-process
Process		Inspection
1	Core Slitting & Cutting	Q1
2	Core Building	Q2
3	Winding	Q3
4	Winding Drying	Q4
5	Nesting & CS Drying	Q5
6	CCA	Q6
7	Drying of Active part	Q7
8A	Preparation for tanking	Q8A
8	Repacking & Tanking	Q8
9	Preparation for FAT	Q9
10	Final Testing	Q10
11	Dispatch	Q11





5.1 Core Slitting & Cutting

5.1.0 The correctness of Lamination is directly affecting performance of transformer in No load loss & noise level of transformer

5.1.1 ***Following activities are carried out during inspection***

- Width & dimension verification
- Burr level maintenance at C.R.G.O. Slitting & cutting stages.
- No surface defect, no damage in Carlite layer
- No Waviness in material
- Straightness of material
- Maintenance & preservation of cut lamination
- Storage of C.R.G.O. coils in controlled environment

5.1.2 ***Instruments used for inspection***

- Measuring tape
- Vernier caliper
- Micrometer
- Continuity tester

5.1.3 ***Tolerance***

– Thickness :
  - 0 mm to 0.23 mm :- + / - 0.02 mm
  - 0.27 mm & 0.30 mm :- + / -0.03 mm

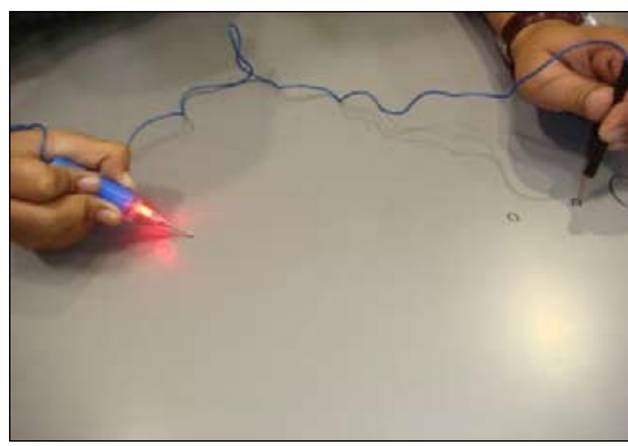
– Length :
  - Upto 315 mm +0/-0.3 mm
  - 315 mm-1000 mm +0/-0.6 mm
  - Above1000 mm +0/-1.0 mm

– Width:
  - Upto 150 mm +0/-0.2 mm
  - 150 -500 mm +0/-0.3mm
  - Above 500mm +0/-0.5mm

– Burr level:-
  - Upto 15 Microns (Maximum)

5.1.4 ***Impact***

- Increase in noise level
- Increase in No load losses
- Circulating magnetizing current



5.2 Core building

5.2.0 Core is manufactured from lamination of Cold Rolled Grain Oriented Silicon Steel, which gives very low specific loss at operating flux densities. Joints of the laminations are designed such that the electro-magnetic flux is always in the direction of grain orientation. The core clamping structure is designed such that it takes care of all the forces produced in the windings in the event of any short circuit

5.2.1 ***Following activities are carried out during inspection***

5.2.1.1 *Inspection at core stacking stages*

- Yoke Clamp leveling check
- Diagonals Measurement
- Window height measurement
- Window width measurement
- Core frame insulation checks
- Stack height
- Gaps, Overlaps and Burrs checks
- Cooling duct arrangement as per DRG.

5.2.1.2 *Inspection at full completion of core assembly*

- Core Diameter measurement
- Final Core clamping
- Total summed depth, dimensions check
- Torque on all hardware as per Table 5.2.1.2.1

5.2.1.3 *Isolation test between built core & yoke clamp*

- AC voltage withstand test (2 kV AC)
- Insulation resistance test (2.5 kV DC)

5.2.2 ***Instruments used for inspection***

- Measuring tape
- Digital Sprit level
- Outside Caliper / Pie tape
- High Voltage Tester (2kV)
- kV Insulation Resistance meter

5.2.3 ***Tolerance***

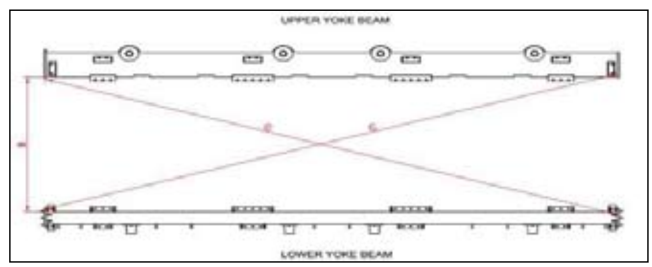
- Diagonals Measurement (+/- 1 mm)
- Window Height & Width Measurement (+/- 1 mm)
- Diameter measurement (+/- 2 mm)

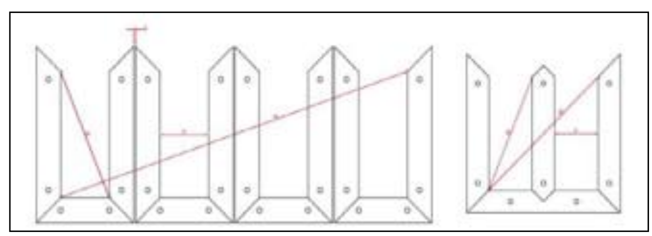
5.2.4 ***Impact***

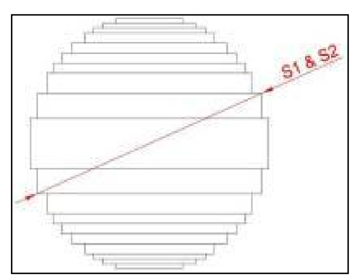
- Increase in humming & noise level
- Increase in No load losses
- Circulating current

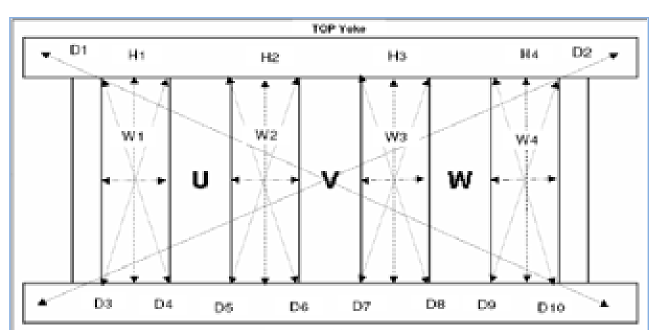
Table 5.2.1.2.1

Torque Values			
Hardware Type	**Mild Steel (M.S.)**		**Stainless Steel (S.S.)**
Thread Size	PC 8.8 (Nm)	PC 10.9 (Nm)	A4-70
M6	9	13	7.2
M8	22	32	17.6
M10	44	63	35
M12	77	109	61
M16	190	270	152
M20	370	528	296
M24	640	915	512
M30	1310	1820	



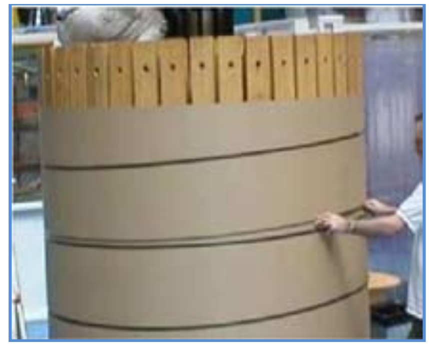






5.3 Winding

5.3.0 Windings are made from Continuous Transposed Conductor (CTC) or Paper Insulated Copper Conductors (PICC) which are transposed at regular intervals throughout the winding for ensuring equal flux linkage and current distribution between strands. Interleaved or shielded construction is adopted for the high voltage windings to ensure uniform distribution of impulse voltages. Insulation spacers in the winding are arranged such that oil is directed through the entire windings for ensuring proper cooling.



5.3.1 ***Following are the important criteria for UHV Power transformer winding manufacturing.***

5.3.1.1 *Inspection at initial winding stage*

- Cylinder Outer Diameter
- Lead length
- Lead start bay
- Radial depth of Winding disc
- Component assembly as per DRG.
- Conductor Transposition & 'S' bend
- Lead positioning

5.3.1.2 *Inspection at conductor brazing stage*

- Ensure brazier's qualification
- Location of joint
- No sharp edges
- No Porosity
- No carbonization / cleanliness of joint
- Correct Filling of WELD filler

5.3.1.3 *Inspection and test at coil completion stage*

- Interstrand Continuity check
- Spacer Block alignment
- Arrangement of DOF washer (Outer Diameter & Inner Diameter) between disc / turn
- Angle ring & SER fixing with winding

5.3.2 ***Instruments used for inspection***

- Measuring tape
- Steel tape
- Vernier Caliper

5.3.3 *Tolerance*

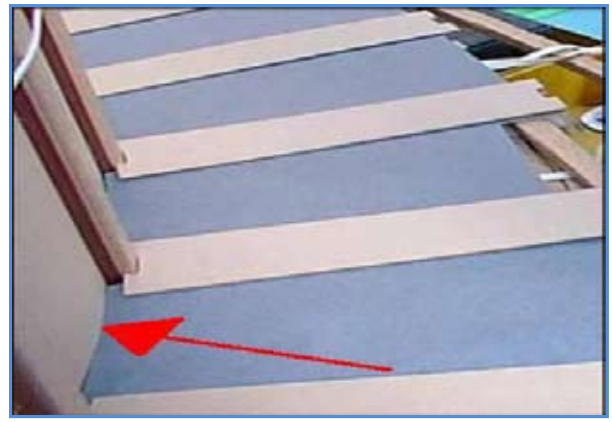
- Former diameter (+2/-0 mm)
- Cylinder O.D. (-0 to +3 mm)
- Radial Depth (+/-2 mm)
- Lead length(-0,+100 mm)

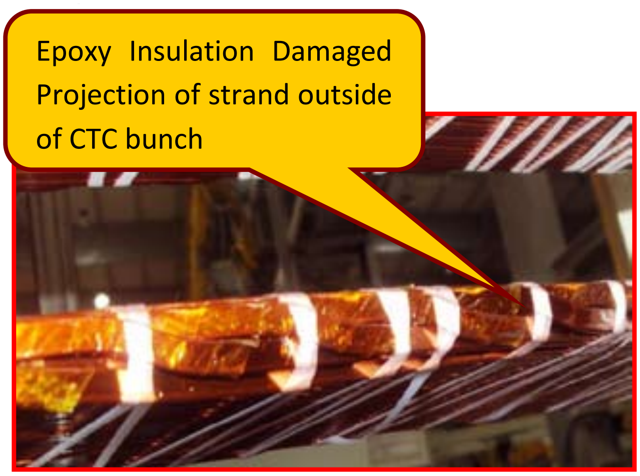
5.3.4 *Impact*

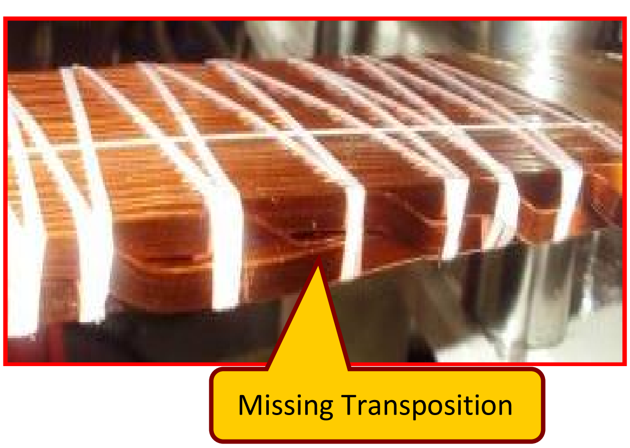
- Impedance voltage variation
- Dielectric failure
- Circulating current

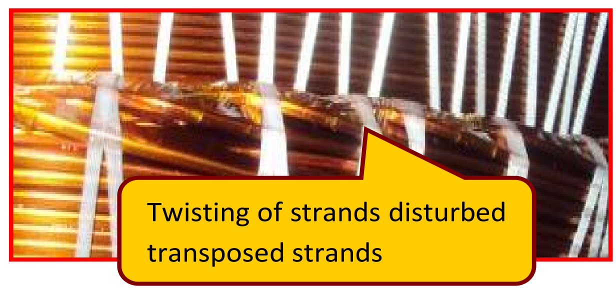
5.3.5 *Importance of Correct Material usage*

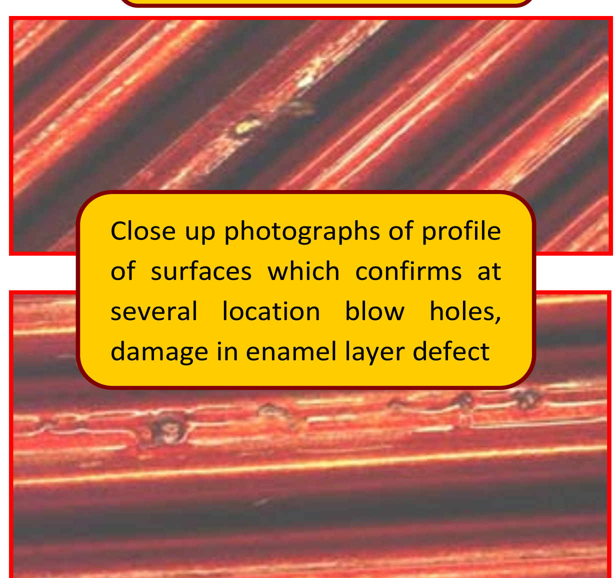
- The material quality should be ensured before usage in various manufacturing stages.
- Interstrand shorting can fail the transformer in PD test during FAT.
- Below are some photographs of various types of material defect of CTC which can fail / effect performance of transformer

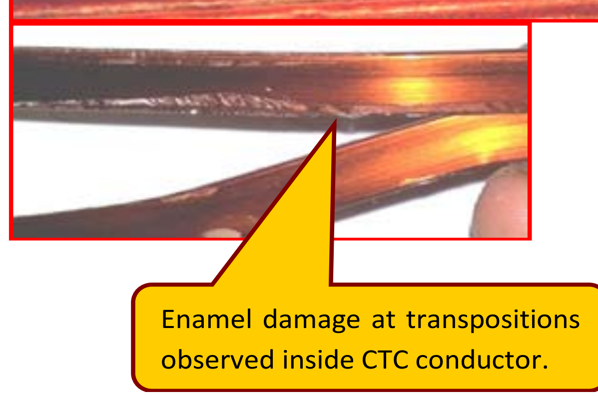










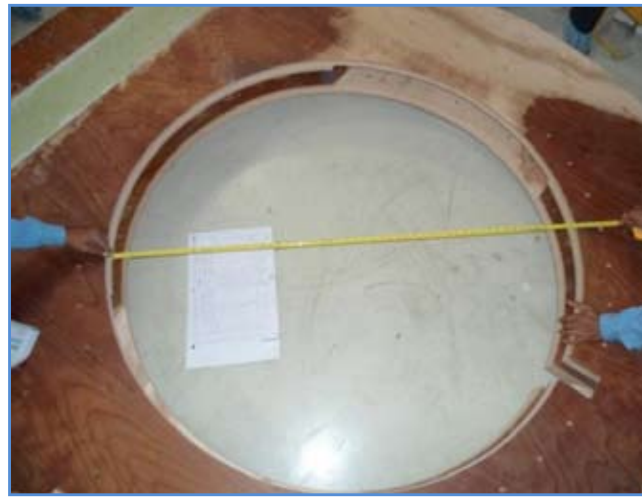


5.3.6 *Insulation Material*

5.3.6.0 Insulation material is very hygroscopic and processing of these materials is very necessary for UHV transformer before usage.

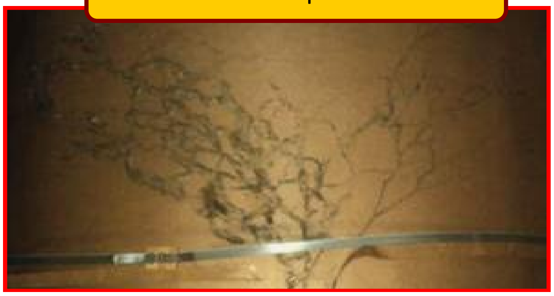
5.3.6.1 Following are the important criteria for UHV Power transformer Insulation material used in manufacturing process.

- The dimensional check of insulation component
- The Burr on surface can be a potential risk as the loose particle will cause PD problem & Die-electric failure during HV test.
- As the PBD material is hygroscopic & any impurities inside insulation will cause discharge & break down of voltage in HV test.
- Proper storage & handling of UHV Power transformer insulation component is very much important to avoid any failures in FAT.



5.3.6.2 Below are some typical examples of insulation material failure

Flash over on Paper insulation.



Tree formation crepage path due to dust particle on Paper Insulation.

5.4 Winding Drying

5.4.0 Winding Drying, stabilization & sizing is very important and mandatory activity for UHV transformers. Hot air oven and Isostatic clamping system are used for this activity.

5.4.1 Following are the important criteria for UHV Power transformer winding drying.

5.4.1.1 *Inspection before drying*

- Un-shrunk winding height
- OD rider fixing & block alignment
- Visual inspection of pressing Block arrangement
- Pressure application as per DRG.

5.4.1.2 *Inspection during drying and processing*

- Verification of oven parameters
- Isostatic pressure monitoring during winding processing

5.4.1.3 *Inspection after drying and processing*

- Height measurement
- Visual inspection for winding cylinder & strip arrangement
- Continuity test for conductor in pressed condition.
- Height adjustment if any variation.
- Compliance with current Drawings, Standards and Specifications

5.4.2 Instruments used for inspection

- Measuring tape
- Digital laser range finder
- Digital Sprit level
- Plumb

5.4.3 Tolerance

- Final height after drying (Tolerance:-±3mm) in a height of around 2 meters.

5.4.4 Impact

- Impedance voltage variation
- Dielectric failure
- Circulating current

5.5 Nesting & Winding Coil Stack Drying

5.5.0 ***Nesting is also known as separate phase Assembly.***

5.5.1 *Following are the important criteria for UHV Power transformer Nesting & Winding Coil Stack drying.*

5.5.1.1 Inspection at initial Nesting stage

- Cleanliness of Insulation.
- Bottom platform leveling.
- Insulation arrangement as per drawing
- Alignment of strip & blocks.
- Ensuring lead position.
- Position of top platform with respect to bottom plate form.
- Un-shrunk winding height measurement
- Damage checks
- Storage of materials prior to build
- Axial height of wraps
- Monitor the buildup of top/bottom insulation
- DOF paths clearness

5.5.1.2 Inspection during drying and processing

- Verification of oven / VPD parameters
- Isostatic pressure monitoring during Nested Winding coil stack processing

5.5.1.3 Inspection after drying and processing

- Height measurement
- Interstrand continuity test.
- Visual inspection after top ring removal
- Height adjustment if any variation.

5.5.1.4 Inspection at coil stacks completion stage

- Lead Numbering.
- Final height between top & bottom platform.
- Final cleanliness of Coil-stack assembly
- Oil Sealing arrangement at top, bottom
- Centre lead height & slot position for lead take out
- Compliance with current Drawings, SEI's, Standards and Specifications

5.5.2 *Instruments used for inspection*

- Measuring tape
- Digital laser range finder
- Digital Sprit level
- Plumb

5.5.3 *Tolerance*

- Final height after drying (Tolerance: ±3 mm)

5.5.4 Impact

- Impedance voltage variation

5.6 Core Coil Assembly

5.6.0 After the nested winding and core are ready both are assembled with one another to make the active part of a transformer.

5.6.1 Following activities are carried out during inspection

5.6.1.1 *Inspection coil lowering & yoke filling*

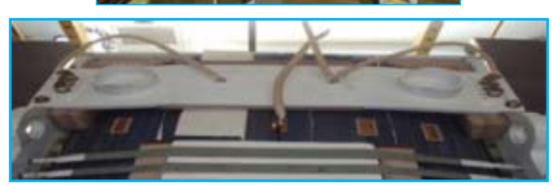
- Bottom Coil Support blocks leveling & insulation arrangement
- Measurement of core diameter & winding ID
- Lead position
- Pressure application
- Air gap during top yoke filling

5.6.1.2 *Earthing arrangement, Isolation test between core & yoke clamp*

- Layout as per DRG.
- AC voltage withstand test (2 kV AC)
- Insulation resistance test (2.5 kV DC)

5.6.1.3 *Crimping of connections*

- Correct size of sockets & connectors
- Packing as per Drawing
- Visual
- No sharp edges
- Checking of crimped area



5.6.1.4 *Inspection of support fittings, accessories fittings, connections.*

- Visual & Esthetic
- Dimensional
- Centre lead height & slot position for lead take out
- Torque application on all hardware
- Verification & Compliance with current Drawings, Standards and Specifications

5.6.1.5 *Connection of OCTC / OLTC & Electrical clearances*

- Torque application as per Table 5.6.1.5.1
- Shaft alignment
- Clearance check
- Dimensional checks as per DRG.

5.6.1.6 *In-process test conformity for Routine test*

- Winding Turns & Turns between Tap leads.
- Ratio Testing
- Ratio Test
- Winding 2 kV test.
- Magnetic balance test

5.6.1.7 *Isolation test between built core & yoke clamp*

- AC voltage withstand test (2 kV AC)
- Insulation resistance test (2.5 kV DC)

5.6.2 Instruments used for inspection

- Measuring tape
- Digital Sprit level
- Pie tape
- High Voltage Tester (2 kV)
- 2.5 kV Insulation Resistance meter

5.6.3 Tolerance

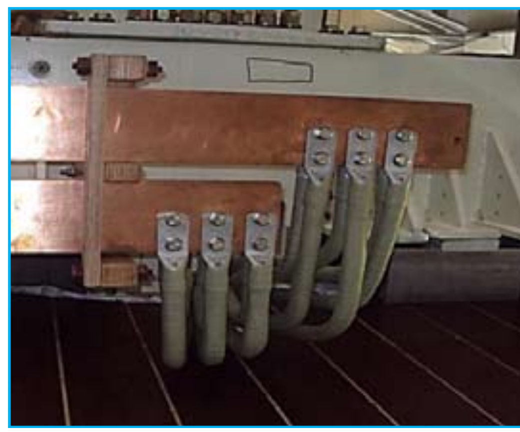
- Leveling (-0, + 2 mm)
- OCTC/OLTC Shaft alignment .(+/- 2 mm)

5.6.4 Impact

- DGA
- Flash over

Table 5.6.1.5.1

Torque Values			
Hardware Type	Mild Steel (M.S.)		Stainless Steel (S.S.)
Thread Size	PC 8.8 (Nm)	PC 10.9 (Nm)	A4-70
M6	9	13	7.2
M8	22	32	17.6
M10	44	63	35
M12	77	109	61
M16	190	270	152
M20	370	528	296
M24	640	915	512
M30	1310	1820	
M36	2300	3170	
M42	3670	4110	

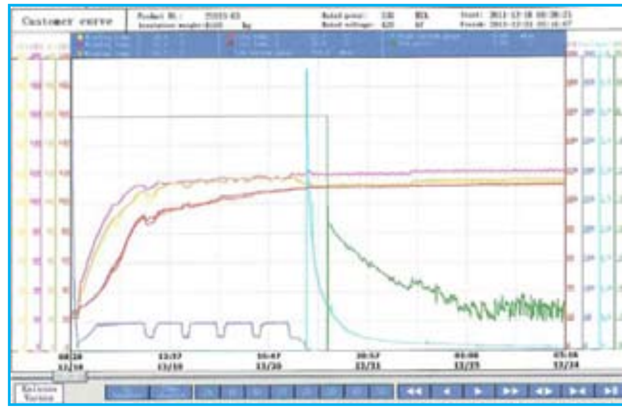


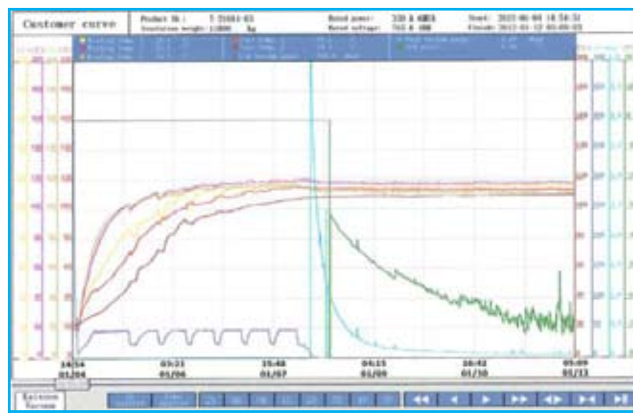
5.7 Final Drying

5.7.0 This process is very important process for healthy life of a transformer. After completion of Connections and a joint review between Quality, Design & Production before active part is sent to Vapor Phase Drying chamber.

5.7.1 *Following activities are carried out during inspection*

- Monitoring Temperature of Oven
- Fine vacuum & duration to be monitoring
- No. of IPRs & its duration
- Dew Point monitoring
- Total duration of drying cycle as per specification
- Compliance with current Drawings, Standard Engineering Instructions and Specifications





5.7.2 *Specified Values to be achieved*

- As per Manufacturer's Specifications

5.7.3 *Tolerance*

- As per Manufacturer's Specifications

5.7.4 *Impact*

- Low Tan delta value
- Low Megger value
- Dielectric failures
- Reduced life of a transformer

5.8A Tank Preparation

5.8A.1 *Following activities are carried out during inspection*

5.8A.1.1 Preparation of tank for tanking

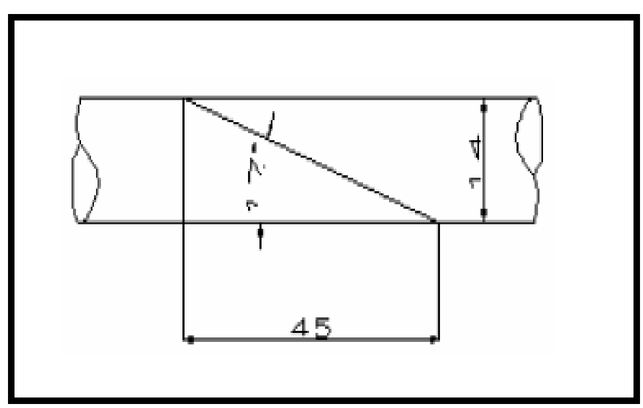
- Cleanliness of tank and accessories inside and outside.
- The gasket placing surface and grooves for o- rings are free from dust, paint granules. Match marking to be verified in turret fixing on top cover, bushing flange etc.

5.8A.1.2 *O - ring and gasket preparation*

- The joint for gasket must be dovetail and not very near to holes.
- The overlapping of o- ring to be lateral

5.8A.1.3 *Shunt and barrier fixing in top and bottom tank*

- Nuts/studs for barriers are fixed as per drawing.
- Megger test is to be conducted for all fixed shunts



5.8 Repacking & Tanking

5.8.0 ***After complete drying of active part stabilization of winding is very necessary before tanking and oil filling.***

5.8.1 ***Following activities are carried out during inspection***

5.8.1.1 *Inspection at Repacking stage*

- T.G Supports & hardware tightening.
- Clamping force for Winding as per DRG.
- Ensure all windings are under pressure
- Final height after pressing
- Cleaning of active part
- Isolation test
- Directed oil flow exit gaps above windings are clear
- Directed Oil flow Paths are leak free

5.8.1.2 ***Inspection at Tanking stage***

- Insulation Resistance Test after putting active part in bottom tank
- Check D.O.F. pipe isolation
- Bushing connections verification
- Tank inside clearances
- Isolation Test before vacuum application
- Monitoring of Vacuum after closing of all openings of Tank

5.8.2 ***Instruments used for inspection***

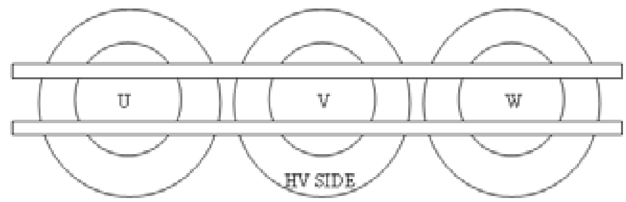
- Measuring tape
- Digital Sprit level
- Digital laser range finder
- High Voltage Tester (2 kV)
- 2.5 kV Insulation Resistance meter

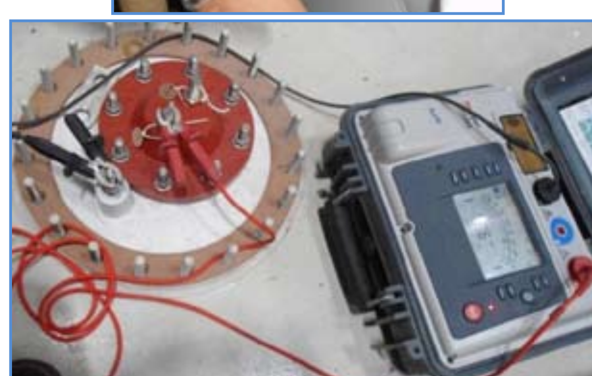
5.8.3 ***Tolerance***

- There is no negative tolerance in Electrical clearances it should be as per the specified Drawing.

5.8.4 ***Impact***

- Flash over failure





5.9 Preparation for Final Acceptance Test

5.9.0 *After tanking and vacuum application job is made ready for testing*

5.9.1 *Following activities are carried out during inspection*

5.9.1.1 *OIL Quality Check before filling*

- BDV
- PPM

5.9.1.2 *Vacuum Monitoring*

- Duration of fine vacuum hold

5.9.1.3 *Hot Oil circulation monitoring*

- Rate of oil flow during filling

o HOC with No. of passes circulated

5.9.1.4 *Measurement & achievement of Oil parameters*

5.9.1.5 *Shaft alignment and fitment of OCTC/OLTC*

5.9.1.6 *Readiness and verification of accessories as per General Arrangement Drawing & CWPM drawing*

- Dimensional checks
- Item wise fitment verification.
- Serial Numbers as per BOC index.
- Any functional fouling
- Match marking and Part marking numbers on fabricated items
- Direction of Flow indicators of Buchhloz relay to be verified
- Label & plates fixing

5.9.1.7 *Oil Leakage test with accessories*

5.9.1.8 *Air release from main unit and fitted accessories.*

5.9.1.9 *Earthing bridge fixing at all man-hole windows, turret, etc.*

5.9.1.10 *Marshaling box & RTCC readiness*

5.9.2 *Instruments used for inspection*

- Measuring tape
- Oil particle count measuring instrument
- PPM instrument
- BDV tester
- Tan-Delta and resistivity instrument for Oil

5.9.3 *Tolerance / Acceptance criteria as per Table 5.9.3.1*

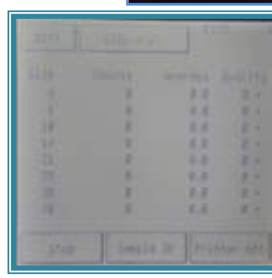


Table 5.9.3.1

	400 KV Class	765 KV Class
BDV	> 70 KV	> 70 KV
PPM	< 3	< 2
Tan Delta	Max. 0.01	Max. 0.01
Resistivity	Min. 6 x 10e12	Min. 6 x 10e12
Particle Count	4 microns <1470 38 microns < 0 70 microns < 0	4 microns <780 38 microns < 0 70 microns < 0

5.10 Final Testing

This is discussed separately.

5.11 Dispatch

5.11.1 Following activities are carried out during inspection

5.11.1.1 *Inspection at Dispatch stage of main unit.*

- Measurement of Dew Point of Dry air/Nitrogen.
- Megger for core – frame – tank to be checked after loading on trailer.
- Leakage & Hold test for Dry air for 24 hours min
- Monitoring of Dry air/Nitrogen after loading on trailer
- Verification of Lashing & covering of job on trailer

5.11.1.2 *Inspection of transformer accessories*

- Verification of all accessories as per Packing cum shipping list
- Proper blanking for pipes, accessories are to be verified

5.11.2 *Instruments used for inspection*

- 2.5 kV Insulation Resistance meter
- Paint thickness meter

AN ALTERNATIVE PROPOSAL FOR CABLE FAULT LOCATION IN THE HIGH VOLTAGE

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ABSTRACT

This paper deals with an alternative method for monitoring of long and very long HVAC and HVDC cable systems concerning the detection and localization of fatal breakdown errors during routine and commissioning tests as well as under service conditions. The presented principle is based on the Time Domain Reflectometry (TDR), but differs fundamentally from the well-known and established methods. It is applicable to land and submarine cables. The operation of the measuring system should be completely invisible and long-term reliable until the cable system fails. Measurements at installed cable systems have already proved the practical suitability.

This paper describes the theoretical concept of the proposed fault location. Necessary measurement systems are described. Furthermore, measurements at installed and stored cables are introduced and evaluated. A special focus is the influence of the high voltage components to the measurement. An automated evaluation procedure is used for the evaluation.

The proposed method can be used for a very fast fault location with high accuracy. The required conditions are worked out.

1. INTRODUCTION

Recent years have seen the installation of more and more high voltage cables. This applies to both land cables which are increasingly replacing overhead cables, and to submarine cables which serve as important links between different countries and to offshore wind farms.

If a link fails, the fault must be found and corrected as quickly as possible to minimize the economic and business damage.

This is particularly true of long and very long high voltage cables (AC and DC). Access to these types of cables is usually limited and hence visual fault finding is extremely difficult, if not impossible.

Moreover, the established fault finding methods for medium voltage cables have often reached their limits.

The method presented here should overcome these difficulties and facilitate straight forward, fast and reliable cable fault finding following breakdown.

It is important to mention here that the relevant rules and regulations (e.g. [1], [2], [3]) shall be complied with at all times during the testing of high voltage cables. Fault location does not replace the stipulated tests. Rather, it supplements them.

2. COMPARISON OF ONLINE FAULT LOCATION AND CLASSICAL TDR

The method described here distinguishes itself from the established TDR in its application. Established TDR is used where a fault is known to exist in the cable. It requires an additional voltage generator to locate the fault, but the energy of this generator's impulses is limited which can lead to problems during fault location.

Online fault location, on the other hand, works on the principle of continuous cable monitoring during testing or normal operation.

As soon as a fault is detected, a measurement is triggered and the result is stored. This means that, when breakdown occurs, all of the energy in the cable can be used for the measurement which leads to meaningful results, even over long distances. The measurement is analysed immediately so that, in the ideal case, the fault is reported together with its location very shortly after detection.

During cable testing, measurements can be repeated with a stepwise increment in test voltage until breakdown occurs. This can also improve the accuracy of the fault location.

Another benefit of the method is the absence of reflections from the distant cable end as the cable impedance is very low at the point of the fault when breakdown occurs. Figure 1 shows the basic measurement configuration for online fault location.

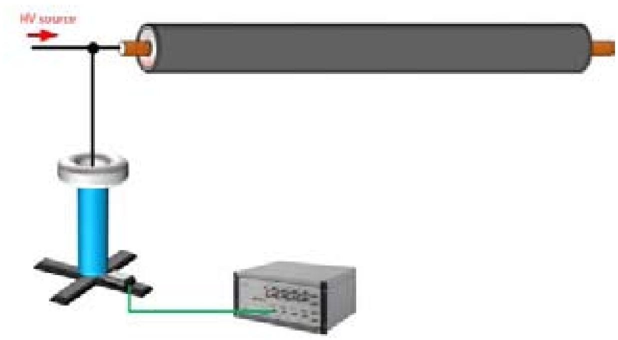

Fig. 1 : Basic measurement configuration for online fault location

Table 1 compares online fault location with established TDR.

Table 1 : Comparison of fault location methods

	Classical, established TDR	Online fault location
Type of application	Offline, after fault has occurred	Online, when breakdown occurs
Artificial impulse required	Yes in order to measure the reflections	No records when breakdown occurs
Reflections from distant cable end	Depends on type of fault	None
Maximum distance to point of fault	Several 10s of km, exact distance depends on fault	>100 km expected distance based on earlier measurements

3. THEORY AND CALCULATION

Of all the equations describing the behaviour and characteristics of cables, only two are relevant here:

$$v = \frac{1}{\sqrt{L' \cdot C'}} \quad ...(1)$$

$$v = \frac{2 \cdot l}{T} \quad ...(2)$$

If TDR is used to determine the fault location, exact knowledge of the propagation velocity is crucial. The more precisely this can be determined, the more accurately the fault can be located.

The propagation velocity v can be calculated from the cable's C' and L' parameters (1), assuming these are known. The equation does not take into account potential deviations arising from, for example, manufacturing tolerances or the way the cable is installed.

This is why, if possible, the propagation velocity should be measured during testing of the installed cable. It can be calculated by applying the cable length l and the measured reflection time T to equation (2). This equation however requires exact knowledge of the total cable length.

If measurements can be made at each end of the cable, the propagation velocity is no longer relevant. With equation (3), the distance to the fault lx can be easily calculated from the reflection times, T_x and T_y measured at both ends and the total cable length l_{cable}.

$$l_x = \frac{T_x}{T_x + T_y} l_{cable} \quad ...(3)$$

If the propagation velocity is known, equation (2) can be used to verify the result.

4. SIMULATION OF THE CABLE

To test the observations made above, a 100 km length of cable was simulated using OrCAD PSpice and a suitable cable model[4]. This distributed model can be used to simulate signal propagation and distortion along the total cable length. It takes into account the measurement configuration and allows viewing of specific fault points in the cable.

A propagation velocity of 171.25 m/µs was used in the simulation. A fault was triggered 83 km from the end of the cable by a short circuit.

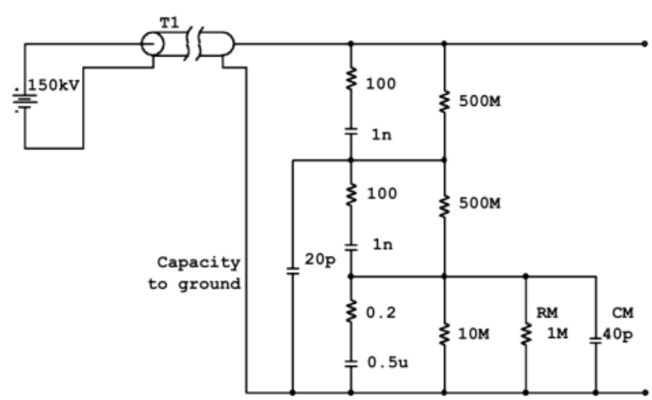

Fig. 2 : Simulated cable

The simulation resulted in a reflection time T of 970 µs. If this value is applied to equation 2, the distance to the fault l_x = 83,06 km.

5 SELECTION OF THE MEASURING SYSTEM

5.1 The Transient Recorder and Voltage Divider

At the heart of the online fault location measuring system is the transient recorder. In principle, the same type of transient recorder can always be used. The configuration is influenced by the number of (cable) systems being monitored and the use situation. The recorder must be capable of detecting breakdown and recording the voltage curve. Figure 4 shows examples of single and multi-channel transient recorders for this purpose.

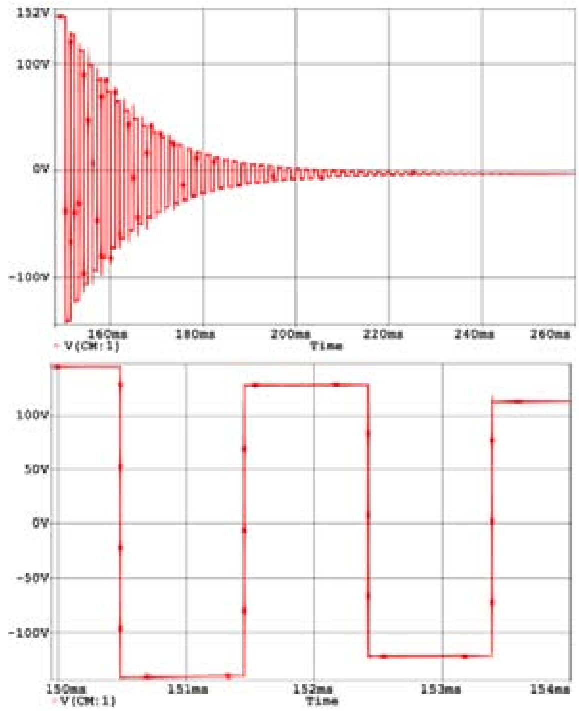

Fig. 3 : Simulation results

Fig. 4 : Transient recorders for online fault location

In addition, a voltage divider suitable for the required voltage class and voltage type is needed.

As breakdown occurs rapidly in high voltage cables, the voltage divider should also be able to make fast measurements. The best piece of equipment for this is a broadband resistive-capacitive divider with a fast settling time. In practice though, this type of divider isn't always available.

As test facilities and stations often have their own voltage dividers, these should be used, if possible, for the fault finding.

5.2 Measuring Systems for Testing Purposes

Unfortunately, purely resistive dividers are not suitable for transient measurements in DC voltage test systems. This case shall not be further considered here.

In contrast, AC cable test facilities normally use purely capacitive voltage dividers. These normally undamped dividers are not optimally suited either to measuring transient processes. However, in certain circumstances, their frequency characteristics can be modified to allow them to be used to measure the breakdown and locate the cable fault.

5.3 Measuring Systems for Online Monitoring

Voltage dividers in both off-short and on-shore switching stations must conform to specific operational safety standards. They must be able to tolerate a continually applied voltage and comply with the rules and regulations for use in public power grids. In comparison, the demands on broadband transient measurements are usually small. For online fault location monitoring in the case of breakdown, the use of these voltage dividers is imperative though.

This paper therefore goes on to discuss measurements on different cable configurations aimed at investigating the suitability of the voltage dividers for fault location. Finally, a description is given of a measurement on an installed cable with a real fault.

6. PRACTICAL MEASUREMENTS

6.1 Recorder Configuration and Analysis Software

Different measurement hardware was used for the various measurements. All hardware complied with the requirements for transient process measurements.

A modified version of the software was used to evaluate the measurement curves which facilitated automated analysis of the fault location and propagation velocity.

6.2 Measurements on an Installed 10 kV AC Cable

To validate the suitability of AC voltage dividers for recording transient processes, measurements were made on an installed 3 phase AC voltage XLPE cable using a WMCF type voltage divider[5] in different configurations. The cable was disconnected from the power supply system during measurements. The test voltage was generated by a resonance test system. The voltage was increased until breakdown occurred on the transmission line.

Measurements were made with different damping resistances. The results are shown in Figure 6.

This figure clearly illustrates how the transient oscillations vary with the damping resistance which started at zero with an undamped divider (Ch1) and was then incremented in steps of 50 Ω. Although the undamped divider (Ch1) suffers from large oscillations, making it potentially more difficult to determine the point of the fault, the solution is not to dampen the signal too much as this reduces the bandwidth of measurement signal. Rather, the aim is to find the optimum for each divider.

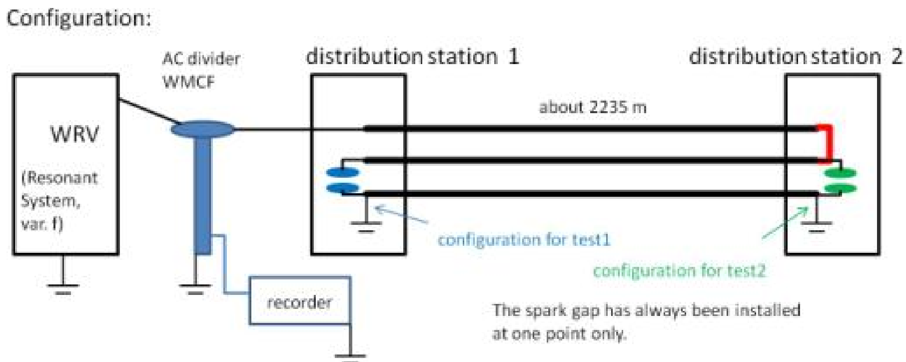

Fig. 5 : Test set-up

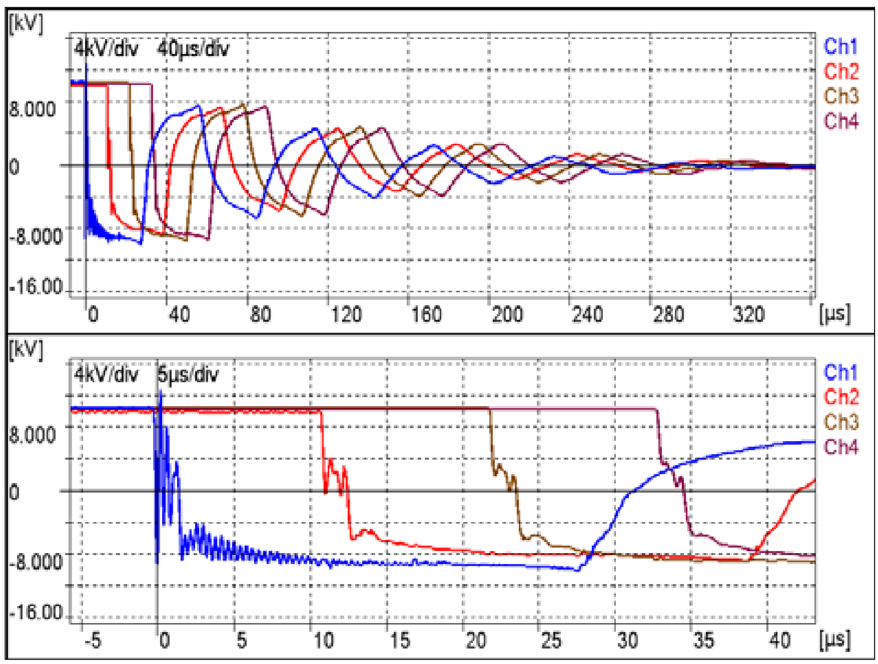

Fig. 6 : Measurements with different divider configurations

Additional measurements were subsequently made on different cable lengths (Figure 5) to investigate the accuracy of the fault location.

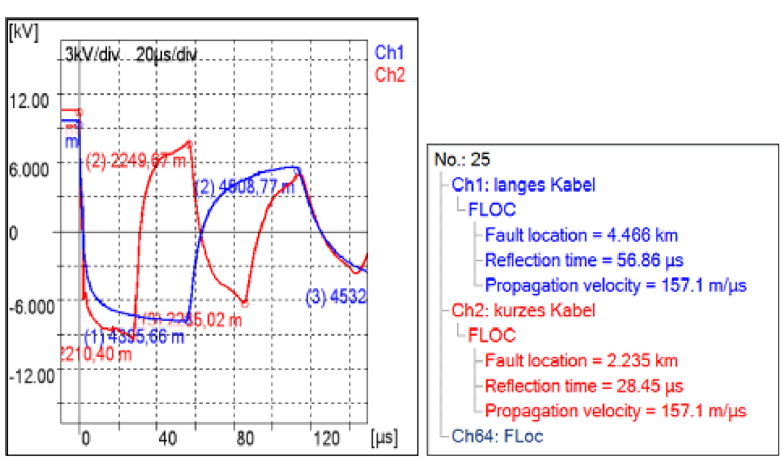

Fig. 7 : Measurements on single- and double-length cables

Assuming that the cables have the same length and the known length is correct, the measurement shows a deviation < 0.1 % over the maximum length of 4470 m.

6.3 Measurements on an Installed 320 kV DC Cable

To investigate the suitability of using voltage dividers in public power grids during online fault location, reference measurements were made on a DC cable approximately 4 km long.

The investigated dividers are hereafter referred to as divider A and divider B. The broadband divider R serves as the reference.

First, step response measurements were made on the dividers to determine their frequency characteristics.

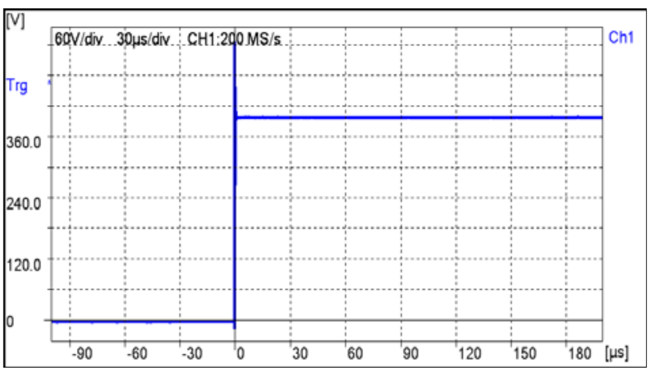

Fig. 8 : Step response of divider R, t_s = 180 ns

It was concluded that the characteristics of both divider A and divider B in their default configuration made them unsuitable for fault location. For this reason, the damper tests were halted here as well. Nevertheless, a significant improvement in the step response was achievable. The periodic oscillations around the zero line were due to a noise source near the test site and can be ignored here.

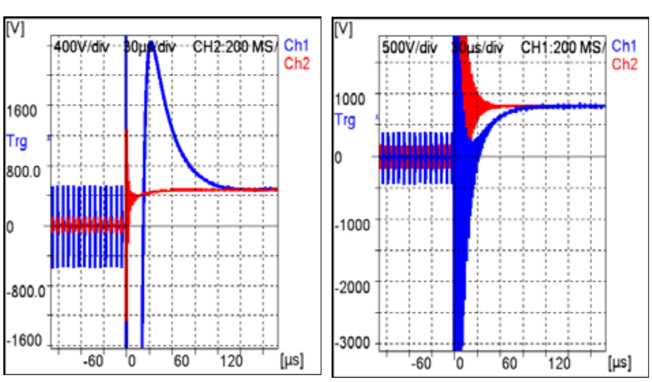

Fig. 9 : Step response of divider A (left) and divider B (right), undamped (Ch1) and damped (Ch2)

It was subsequently possible to measure cable breakdown using these configurations. A number of +6 kV and -6 kV measurements were made on each divider.

The measurement curve in Figure 10 shows that strong oscillations still occur in the modified divider configurations. The analysis software was nevertheless able to reproducibly analyse the measurement curves to a high standard.

For both divider A and divider B, the calculated fault location deviation was < 0.2%, relative to divider R. For a cable approximately 4 km long, the deviation is then < 10 m. The stronger oscillations of divider B probably mean that the further divider B is from a fault, the less accurately the fault location can be determined.

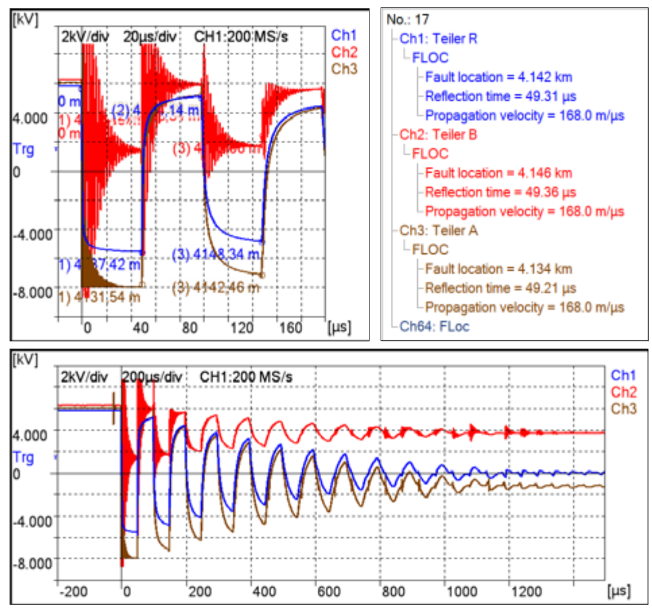

Fig. 10 : Sample measurements on divider A, divider B and divider R

6.4 Measurements on an Installed 115 kV AC Cable

It was possible to perform measurements on an installed 3 phase AC voltage XLPE cable more than 8 km long using a broadband resistive-capacitive divider AC. The cable was known to have a fault. Until then, though, its exact location could not be determined. DC voltage was applied to the cable until breakdown occurred.

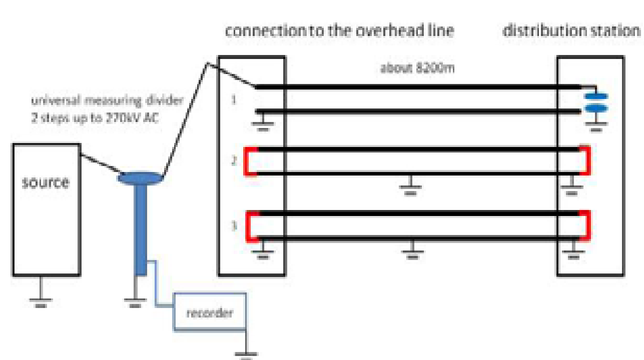

Fig. 11 : Cable configuration

As no precise cable data was available, first a reference measurement was performed over the total length of the cable. This allowed the propagation velocity in the cable to be determined for use in further measurements.

After determining the propagation velocity, the input voltage to the cable was increased until breakdown occurred. The tests were repeated a number of times. The first breakdown occurred at 95 kV, the second at 25 kV. During the third test, the breakdown voltage increased again to 65 kV. All measurements are shown in Figure 12.

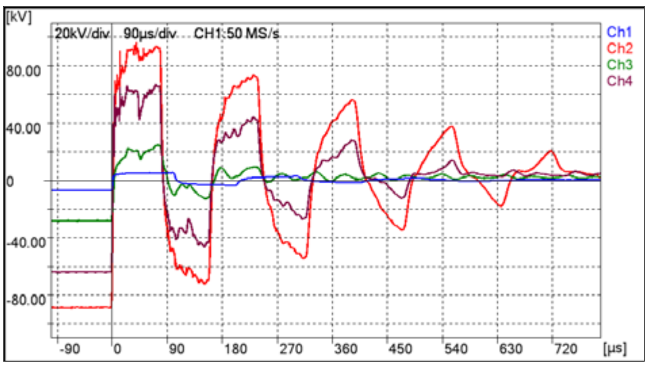

Fig. 12 : Three breakdowns at different voltages (Ch1 is the reference measurements)

The analysis software processed the data and determined a fault at 6429 m.

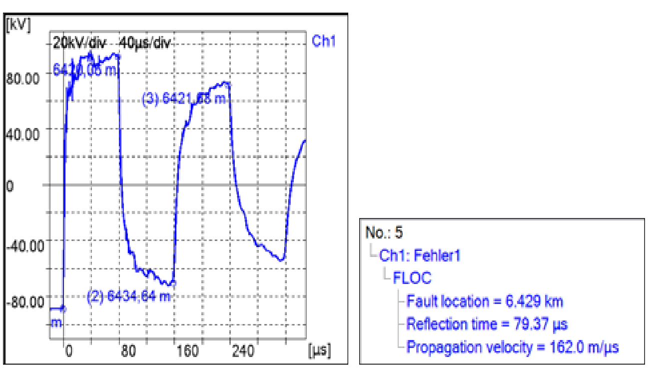

Fig. 13 : Analysis of the reflection measurement

With this information, the corresponding section of cable was investigated and a faulty cable sleeve was discovered at 6400 m.

Fig. 14 : Faulty cable sleeve

Assuming the known cable length is correct, this corresponds to a deviation of < 0.4 % with respect to the total cable length.

7. SUMMARY

This paper summarises the results of investigations which build on the investigations of[6].

The validity of the presented method could be confirmed for cables up to 10 km long. As a result of the performed calculations and simulations, it is expected that the method can be applied to cable lengths > 100 km. This can also be deduced from the measurements presented here.

It could be shown that, if correctly configured, high voltage dividers are suitable for recording transient processes, even though this might not be their intended purpose. Hence, already available measurement equipment can be used for the online fault location. However, not all types of voltage dividers are equally suitable.

Moreover, for the first time, the ability of the presented fault location method to locate the point of failure could be tested. The measurement deviation was < 0.4 %

LITERATURE

1. CIGRÉ 490. Recommendations for Testing of Long AC Submarine Cables with Extruded Insulation for System Voltage above 30 (36) to 500 (550) kV
2. CIGRÉ 496. Recommendations for Testing DC Extruded Cable Systems for Power Transmission at a Rated Voltage up to 500 kV
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4. Leißner, Sebastian, Untersuchungen zur Fehlerortung an langen HVDC-Kabeln, Diplomarbeit, 2013
5. HIGHVOLT data sheet 1.31/4, AC Capacitor, Type WC
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MONITORING AND UP-GRADATION OF UNDERGROUND CABLE NETWORK BY VARIOUS METHODS

Narayan Sirdesai and Dilip M. Mirashi
The Tata Power Co. Ltd. Mumbai

ABSTRACT

The company was founded by Mr. Jamshedji Tata and has established a strong foot print in Generation, Transmission & Distribution. Power is bring supplied to Mumbai City and the Year 2015 was celebrated as the Centenary Year.

The total cable network including High voltage and Extra High Voltage is about 2300 circuit km.

The first 6.6 kV power cable was laid in Mumbai in the year 1915 and 110 kV BICC make Gas Filled cable was commissioned in 1955, Oil filled cables of Hitachi, BICC & Pirelli were laid from 1961. To cater the increasing load growth, 22 kV, 33 kV and 11 kV network established from 1964 to 2010.

There are 20 Receiving Stations of 110 kV and 220 kV. Distribution Substations of 22 kV and 33 kV are 27 and Consumer Substations of 22 kV and 11 kV are around 740.

MAINTENANCE OF UNDERGROUND CABLES

Maintaining underground cable network in Mumbai City is a challenging task.as there are Gas filled, Oil filled and XLPE cables, maintenance practices are different for each type of cable.

Following are the maintenance practices for XLPE cables :

1. Visual Inspections of installations
2. Thermo scanning of terminations
3. Ultrasonic sound detection
4. Measurement of sheath currents
5. Cleaning of porcelain insulators by water spray
6. Checking of grounding connections
7. Topping up of 220 kv GIS sealing end oil levels in reservoirs when required.

For Oil filled and Gas filled cable :

1. Daily monitoring of Oil and Gas pressure
2. Maintenance of Pressure Gausses
3. Pumping of oil if the pressure drops below the level
4. Replacement of Nitrogen Gas Cylinder to maintain gas pressure in Gas filled cable.

CONDITION MONITORING

Following methods have been used for Condition monitoring of underground cable.

1. Ultrasonic Sound Detection

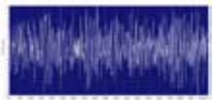
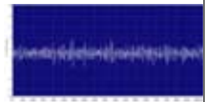
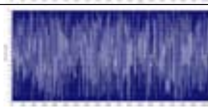
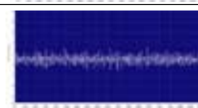
Majority of equipment at Distribution stations is enclosed type. No method was available for identifying developing ionisation inside enclosed metal clad equipment. With the help of Ultrasonic sound detector developing ionisation inside enclosed metal clad switchgear can be identified. It provides for safe inspections, Audio – Visual impact with the help of sound recordings by portable instrument. With the samples collected and patterning them with the ideal waveforms, problem in the equipment can be analysed and outage of the feeder is taken for attending the problem. Early detection of ionization activity and attending it helps in preventing arc flash thus safeguarding equipment & human being and maintaining power supply.

At 14 locations with the help of Ultrasonic sound detector ionisation was identified at very early stage (when the discharge sound was not audible to bare human ears). Data base is prepared based on the samples collected for different types of abnormalities and its corresponding waveform. With the experience gained, by analysing the sound file, abnormality can be judged and corrective action can be planned. Abnormalities identified through Ultrasonic condition monitoring have been attended and following corrective actions are taken:

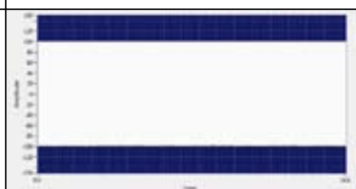
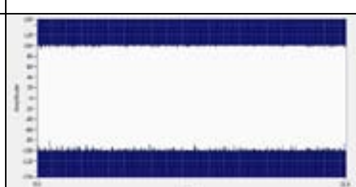
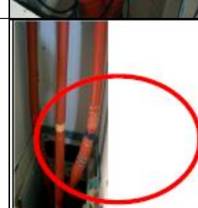
(1) providing additional heaters, exhaust fans, louvres (2) correcting grounding connections (3) replacing existing terminations with touch proof terminations (4) Replacing HVTM (5) cleaning moisture condensation (6) rerouting control cables in close proximity of live terminations (7) cores in close proximity are separated.

By providing the above solutions discharge sound was attended and thus arc flash was avoided at these 14 locations.

Case Study 1

Sr.no.	Abnormality reported at	Db value reported	Graph Before	Db Recoded	Graph After attending
1	Goldmohur Mill Sub-station RMU Iso-1074	17		14	
2	Goldmohur Mill Sub-station RMU Iso-1073	22		18	

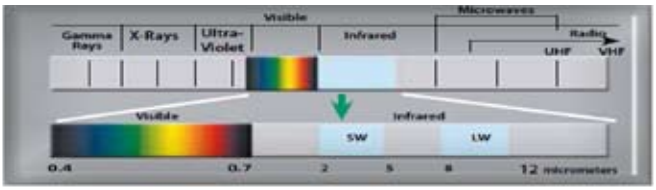
Case Study 2

Date	Case Stud	dB leve	Waveform	Photograph	Remarks
12 Apr' 1 4	22KV RMU Goldmohur Mill CSS iso 1073	22dB			**Problem:** Dark spot was observed where control cable was coming in close proximity of HT cable. **Action taken:** Control cable was re- routed
12 Apr' 1 4	22KV RMU Goldmohur Mill CSS iso 1074	17dB			**Problem:** Dark spot was observed where control cable was coming in close proximity of HT cable. **Action taken:** Control cable was re- routed
23 Apr' 1 4	22KV RMU Genext CSS iso 2441	20db			**Problem:** Dark spot was observed where control cable was coming in close proximity of HT cable. **Action taken:** Control cable was re- routed
23 Apr' 1 4	22KV RMU Genext CSS iso 2442	20db			**Problem:** White pit marks observed on cable. **Action taken:** Cable cleaned
23 Apr' 1 4	22KV RMU Genext CSS iso 2443	18db			**Problem:** White pit marks observed on cable. **Action taken:** Cable cleaned

2. Thermography of Cable Terminations –

Thermography (Thermovision) is the measurement of a certain temperature field by recording the infrared radiation and visualizing the temperature distribution over the screened surface.

Wave length of Thermography: 2 to 12 micrometer



Advantage of thermography:

It is non-contact – uses remote sensing.

It is two dimensional – produces images.

It is accomplished in real time.

It senses heat losses.

Thermovision scanning of EHV cable terminations is done once a month and for HT cable terminations once a quarter. The termination is kept under observation when temperature exceeds ambient by 20 deg C and immediate action is taken when the temperature exceeds ambient by 40 deg C. Care is taken to see that thermoscanning is done during peak loads. Hot spots have been detected on nut/bolts, clamps, loose connections and connectors and conductor strands.

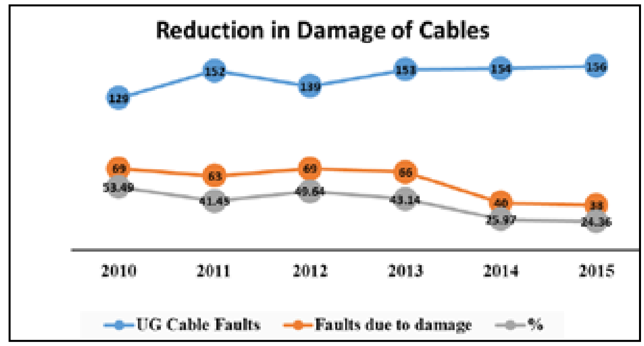
3. Prevention of cable from External Damage

Every year there are many infrastructure activities are being taken by the various authorities in the Mumbai City. While developing roads, footpath etc. mechanized tools are being used extensively. This results in to damage of underground cables. Cable faults due to external damage contributed to nearly 48% in FY 12. This triggers many innovative ideas to save the cables from external damage.

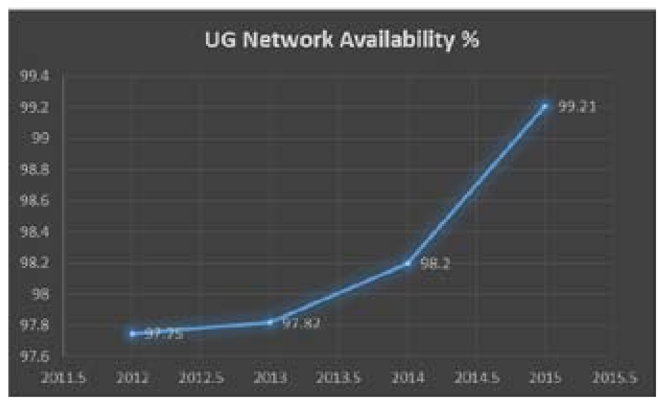
- Placing of cable markers on the cable route inside private premises.
- Sensitizing JCB operators.
- Sharing of cable route drawings with the authorities.
- Consistent dialogue with the officials of the authorities to know their development plan in advance.

As most of the external damage to the cable were caused due to the use of JCB's in infrastructural activities it was concluded during the multilevel brainstorming and discussions with the managerial focus-group to sensitize the JCB operators to minimize damage to underground utilities with special reference to power cables.

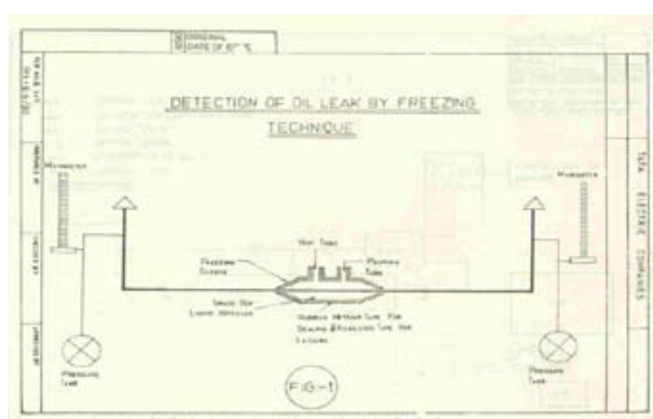
The consistent efforts to educate the JCB operators, resulted in huge success and external damage has been reduced from 53.49% in FY 10 to 24.36% in FY 15.



The optimum utilization and close monitoring of underground cables, resulted in increase of network availability from 97% in FY 12 To 99% in FY 15.



4. Freezing Process to Detect Oil Leak



5. Pumping of Oil if the Pressure Drops Below the Level

Oil needs to be pumped into the cable to top up oil, during oil leaks and cable faults.

Oil is pumped at a temperature of 65 deg C and after obtaining a vacuum of less than 0.1 torr.

6. Fire protective coating for cables

WAY AHEAD

- Daily bike patrolling on cable routes.
- Regular interaction with JCB operators & Municipal officials
- Protection / diversion of cables to avoid damage
- Painting of exposed cables in receiving stations with fire protective coating
- Daily monitoring of oil and gas pressure
- Use of TR-XLPE for HT cables
- Residual Life Assessment for cables
- Replacement of aged cables

(L-R) Mr. P P Wahi, Director, CBIP; Mr B Venkateshwar, VP, Reliance; Mr.V K Kanjlia, Secretary, CBIP; Mr. R K Verma, Chairperson, CEA; Mr A K Gupta, Director, NTPC; Mr R K Tyagi, AGM, PGCIL; and Mr Dipal Shah, Chairman, NSC B1, during inaugural session

THE TUTORIALS

and

The International Colloquium on
HIGH VOLTAGE INSULATED CABLES

Under the aegis of CIGRE SC B1 on HV Insulated Cables & CIGRE India

12-14 October 2017, New Delhi, India

A Report

GENERAL

A two day International Colloquium on "High Voltage Insulated Cables" was organised jointly by CIGRE SC B1, CIGRE India and Central Board of Irrigation and Power at Hotel Vivanta by Taj, Dwarka, New Delhi on 13th & 14th October 2017.

The colloquium was preceded by a very informative set of tutorials on the subject, conducted by eminent experts from CIGRE SC B1, on the12th October 2017 at the same venue.

The International Council on Large Electric Systems (CIGRE), with its Headquarters at Paris deals in the field ofTransmission and Generation. It functions through 16 Study Committees formed for various disciplines of Power Systems. Each Study Committee comprises about 24 experts drawn from various countries. In addition, some more experts are members of the Working Groups/Task Forces formed by these Study Committees. It is a matter of pride that India is represented in all the 16 CIGRE Study Committees as regular/observer member.

CIGRE-India is an affiliate of Central Board of Irrigation and Power. It is the Indian National Committee of CIGRE and is a registered society. It co-ordinates the activities of CIGRE in India, through a number of National Study Committees and disseminates the information about the activities of the CIGRE Study Committees and Working Groups to various organization in India.

Mr R P Sasmal, Chairman (Tech.), CIGRE India & Director, Power Grid, during inaugural session

The activities of CIGRE Study Committee B1 concern all types of AC and DC insulated cable systems for land and submarine connections and are focused mainly on high voltage applications. Whenever appropriate, however, lower voltage applications are also considered. Within this field, the scope of work of the Study Committee covers design, manufacture, installation, service, quality assurance, tests and testing technology, behaviour in and interaction with the network, reliability, asset management, maintenance and diagnostic techniques in service. The objective of CIGRE SC B1 is to facilitate and promote the progress of engineering and the international exchange of information and knowledge in the field of insulated cables. Its aim is to add value to this information and knowledge by means of synthesizing state-of-the-art practices and developing recommendations.

CIGRE-India had the honour to host the meeting of CIGRE Study Committee B1 and its Working Groups in India on 9, 10 &11 October 2017. To take advantage of the presence of the international experts, associated with CIGRE Study Committee B1, in India, CIGRE-India and Central Board of Irrigation and Power, in conjunction with the meeting of CIGRE Study Committee B1 and its working groups, organized the International Tutorials and Colloquium on HV Insulated Cables on 12, 13 & 14 October, 2017 at Hotel VIVANTA by Taj, Dwarka, New Delhi, India.

The highlights for the participants were:

- The opportunity to interact with the renowned experts from the participating countries including the Chairman & the Members of CIGRE SC B1 & it's working Group from the various countries.
- The Tutorials by Senior Experts on the Subject
- The views expressed by the International experts, as the Chairman of the various sessions
- The quality presentations by the National & International experts during the Colloquium.

Thursday, 12th October 2017

TUTORIALS

There were six very informative Tutorials conducted during the course of the day, preceded by a brief Inaugural Session.

INAUGURAL SESSION

Present on the dais were:

- Mr N N Misra, Vice Chairman (Tech.), CIGRE India
- Mr R P Sasmal, Chairman (Tech.), CIGRE India & Director, POWERGRID
- Mr Geir Clasen, Norway
- Mr Dipal Shah, Member from India on CIGRE SC B1
- Mr P P Wahi, Director, CBIP

Mr R P Sasmal, Chairman (Tech.), CIGRE India & Director, Power Grid, during Tutorial

Mr N N Misra, Vice Chairman (Tech.), CIGRE India, during Tutorial

Mr Wahi gave the Welcome Address. He welcomed both the participants, as well as, the CIGRE SC B1 experts. He explained the circumstances around the CIGRE SC B1 meeting in Delhi and the opportunity presented thereby to take advantage of the great pool of knowledge, in the form of the technical Experts present there, both on and off dais. He exhorted the participant to take full advantage of their presence and gain from the tutorials. Further, he referred to the colloquium, which was to take place over the next two days, and hoped that everyone would consider participating there, as well.

Mr Dipal Shah, as the Indian representative on CIGRE SC B1, welcomed the participants. He showed optimism, given the rising number of CIGRE members from India in the recent past, and appealed to the participants to join the organisation in ever greater numbers. Afterwards, he advised everyone to take full advantage of the tutorials and turn it in to an interactive session. He even went on to describe the benefits of the membership of CIGRE.

Mr Geir Clasen chose to be brief in his address. He gave a very brief overview of the Sessions to come. Later he welcomed the participants and hoped that they would make it an interactive session.

Mr Misra also pointed out the great opportunity presented by the tutorials, and advised the audience to get the maximum out of the sessions. Further, he welcomed everyone.

Mr Sasmal greeted the audience. Even he referred to the many advantages of the tutorials for the participants. He referred to the massive transmission network in the country, and the associated Right of Way issues. He felt that HV cables were the right solution in the urban areas. He referred to the jointing problems and the shortage of expert manpower, and hoped that the Make in India would address this issue as well. He felt that the younger people should take more interest in this area. Finally, he wished the tutorials and the participants all the best.

With this, the Inaugural session ended.

Mr Geir Clasen, Norway , during Tutorial

Mr Dipal Shah, Member from India on CIGRE SC B1, during Tutorial

Mr Ken Barber, Australia, during Tutorial Session

Mr Harry Ortan, Canada, during Tutorial Session

TUTORIAL SESSION 1

The first tutorial ‘Fault Location on Land and Submarine Links (AC & DC)’ was conducted by Mr Robert Donaghy, Ireland.

Mr Donaghy gave an elaborate discourse on fault location in cables. Therein, he first explained the types of faults, and then the fault location techniques available. He even explained the design factors affecting this process, both for land and for submarine cables. Then came the planning required. Finally, he talked of the training, etc. needed.

To summarise, there are many well established techniques available for fault location in cables, particularly for buried underground cables. Successful cable fault location depends to a great extent on applying the appropriate technique or combination of techniques. Methods for locating cable faults require competent engineers and service providers.

TUTORIAL SESSION 2

The second tutorial ‘A Guide for Rating Calculations of Insulated Cables’ was conducted by Mr De Wild, Netherland.

The aim of the guide is that companies worldwide shall use similar approaches when dealing with similar problems, so thatin the longer run, even solutions to the most difficult problems become available.

Although cables rarely fail from overloading, this may bedue to the often moderate loading of cables. This may change in future. As rating evaluation studies come with a certain limited accuracy, there is a need for margin in cable rating calculations.This margin needs to be discussed and agreed between parties in any cable project. The most important starting points seem often to be assumed rather than measured or investigated. This leads to large uncertainties. It is advised to pay attention to measuring / investigating starting points and to evenly balance the accuracy in the starting points, the calculations and the tools.

Mr Robert Donaghy, Ireland, during Tutorial Session

Mr De Wild, Netherland, during Tutorial Session

Group Photo

TUTORIAL SESSION 3

The third tutorial 'Maintenance of HVAC Cable Systems/ Accessories' was conducted by Mr Geir Clasen, Norway.

Mr Clasen talked about the Maintenance strategies for HVAC Cable Systems & Accessories. He started with a Survey of the presently used maintenance programs. Then he elaborated the Failure modes and the related detection methods/Maintenance actions.The available diagnostic tools were taken up next. Then came some Maintenance case studies, followed by some recommendations. Lastly, he pointed out the future developments in this area.

TUTORIAL SESSION 4

The fourth tutorial 'Implementation of long length HV & EHV cable systems' was conducted by Mr Ken Barber, Australia.

Mr Barber described the challenges that might be faced while implementing such cable systems. These included the system design issues, issues with installation & commissioning – including the right of way, monitoring, and finally the maintenance, which includes the fault location and also the route information.

TUTORIAL SESSION 5

The fifth tutorial 'Impact of EMF on Power Cable System' was conducted by Mr Harry Ortan, Canada.

This tutorial presented the guidelines for managing (de)rating of an HV underground power cable electric system with magnetic field mitigation techniques.The presence of mitigation devices might modify the ambient conditions surrounding the cables.The examples provided gave good technical solutions leadingto practical installations. A Summary Table was provided to assist with the most judicious selection of the shielding method. Economical evaluation of investment costs, the cost of additional losses and maintenance of the mitigation device was presented. The overall conclusion is that magnetic fields from cable systems can be effectively shielded, with minimal influence on the rating of the whole link.

TUTORIAL SESSION 6

The sixth tutorial 'DGA (dissolved-gas analysis) on Oil-Paper Transmission Cable Systems, including Extruded Cable Terminations and Transformers' was conducted by Mr Nirmal Singh, USA.

Mr Singh stated that DGA is an economical & effective diagnostic test for taped cables and transformers, as shown by its growing worldwide application. Generally better understood, users can readily relate to DGA data. Acetylene is the single, most important DGA gas for all equipment, so is its increase over time. However, its upper limit, like other gases, cannot be accurately given. A 25 ppm level of acetylene poses concern for a power transformer, 150 for HPFF termination, 50 for a SCFF termination, and 20 ppm for an HPFF splice. DGA success critically depends on proper sampling, analysis and interpretation. Field sampling is under full control of the user; it is here that most mistakes are made. DGA behaviour of the terminations is markedly different from that of the splices, cables per se and risers; it significantly varies amongst cable types, and DGA offers the most value for all types cable terminations

Dignitaries on the dais

–the limited fluid volume renders this test quite sensitive and quite decisive. Cable DGA should not be confused with that of transformers. Due to the much higher viscosity of HPFF fluids, sampling can present a challenge, all the more in winter, which may be readily overcome by the EPRI method(s). Small sample requirement of EDOSS is valuable in many applications. A keen understanding of the cable's operational history (and construction) is essential for realizing maximum value from DGA; this also holds for transformers. DGA trending is invaluable to monitor the dormant, stable and deteriorating nature of the problem. DGA can be equipment-specific. While guidelines are useful, the user should develop his/her own DGA expertise on properly generated-data, as many results can defy accepted norms.

All the six tutorials were not just full of subject knowledge, but also, brought out the practical experience of the speakers to fore. The lively interaction with the audience led to sharing of in-depth knowledge.

The tutorials were followed by closing remarks by Mr P P Wahi, Director, CBIP.He appreciated the vast amount of targeted information and good practices shared by the presenters for the benefit of the participants. These were all based on their long and deep practical experience. He was all praise for the CIGRE experts, and exhorted all to consider joining the organisation for the benefits it provides to the working engineers.

Mr Wahi invited all the participants to consider attending the colloquium on the same subject scheduled over the next two days.

Thereafter, the Tutorials were declared ended.

Friday, 13th October 2017

CONFERENCE INAUGURAL SESSION

Present on the dais were:

- Mr. P.P. Wahi, Director, CBIP
- Mr. B. Venkateshwar, VP, Reliance
- Mr. V.K. Kanjlia, Secretary, CBIP
- Mr. R.K. Verma, Chairperson, CEA
- Mr. A.K. Gupta, Director, NTPC
- Mr. R.K. Tyagi, GM, POWERGRID
- Mr. Dipal Shah, Chairman, CIGRE NSC B1

Mr. R.K. Verma, Chairperson, CEA, during Inaugural Session

Mr. A.K. Gupta, Director, NTPC, during Inaugural Session

Mr Kanjlia presented the welcome address. He welcomed everyone on the dais by name, starting with Mr R.K. Verma. Thereafter, he referred to the officers of CBIP and their efforts, which resulted in this colloquium. He then welcomed the CIGRE SC B1 members. Then came the turn of the speakers and the delegates participating in the colloquium, to be welcomed. To end his address, he once again welcomed everyone and requested them to take full advantage of the opportunity presented by the event to enrich their own knowledge of the field.

Mr Dipal Shah welcomed the participants and thanked them for their presence. He felt that the underground cable system is the requisite background for reliable power. In this context, he referred to some of the papers being presented in the forthcoming technical sessions. He also announced a panel discussion in the last session of the day, providing the audience the opportunity to get their queries answered by the experts. Thereafter, he thanked everyone and asked them to whole-heartedly participate in the proceedings.

Mr R K Tyagi also welcomed everyone. He referred to his previous visit to Canada in connection with VSC Technology. He was in touch with a cable manufacturer of 11 kV and 33 kV level. Currently 220 kV and 400 kV is being talked about. He did not doubt that there were challenges, which would be taken up in the technical sessions. In the end, he shared that cable was a useful topic for everyone present.

Mr B Venkateshwar welcomed the international experts. From his experience, he informed that a failed cable joint takes upto four months for restoration. The reasons for this were non availability of spares and expert manpower. His advice to the cable manufacturers was to keep adequate stock of spare parts locally. To end, he stated that he was looking forward to finding suitable solutions in this colloquium.

Mr A K Gupta complimented Mr Dipal Shah for organising this colloquium, which was not only a event of pride for India, but also an opportunity for everyone present. Further, he congratulated CBIP/ CIGRE India and all the stakeholders for the CIGRE membership crossing the 800 mark. Then, he talked of a shift from overhead lines to cable based systems, especially in urban and congested areas. He advised manufacture of cables in India, as also the accessories and installation services. The reduction in cost would be a result. Among the desirables, he talked of longer cable lengths. Finally, he hoped for the colloquium to enrich everyone with knowledge.

Mr R K Verma started off by greeting all present. He quoted some statistics to indicate good growth in the sector. The power availability is good, whereby, around 330 GW is the installed capacity. The target is 1600 billion units of power. He expected the demand to grow further. Among the challenges, he listed, financial needs of the Discoms, which affects fresh capacity. Schemes had been devised to improve distribution infrastructure. Another challenge was the huge RE induction, 175 GW bu 2022, which would form around 20% of the total. This leads to problems as infirm supply, needing balancing sources. He referred to the huge transmission infrastructure created by POWERGRID, including 765 kV AC lines. Then, he stated that in locations with high population density, cables aught to be used. However, cost is a major issue. He advised increased local development. Finally, he expressed happiness at being present there. He appreciated the great work being done by CBIP. In this connection, he even referred to the significant growth in CIGRE membership. Even he felt that the colloquium provided a great opportunity to everyone to gain sector-specific knowledge.

GLIMPSES OF THE CONFERENCE

Mr. B. Venkateshwar, VP, Reliance, during Inaugural Session

Mr. R.K. Tyagi, AGM, PGCIL during Inaugural Session

Mr P P Wahi gave the Vote of Thanks. He was pleased to do so. He praised and thanked each dignitary on the dais individually for their presence and their contribution to the sector. He also thanked the other experts, the officers and the staff of CBIP and the Hotel, and also the sponsors of the event, for the help and support extended by them towards the success of the event. Further, he thanked the participants of the Tutorials held the previous day.

He again exhorted the participants to consider joining CIGRE and increasing its membership even further, recounting the advantages thereof.

This was the end of the Inaugural Session.

The conference was divided into seven technical sessions, followed by the closing remarks by Mr Dipal Shah and Mr Wahi. The sessions 1 & 2 were merged, and the session 5 was the Panel Discussion.

TECHNICAL SESSION 1& 2

The session was chaired by Mr Dipal Shah, Chairman, CIGRE NSC B1.

The session included the following papers:

1. Evolution of HV Cable Systems – *Mr Walter Zenger*

   The message conveyed by Mr Zenger was that the Cable Systems are evolving in their technologies and applications. The growing availability of the Renewable sources of Energy has a significant influence on this trend, as many wind farms are located off-shore and depend on HV/ EHV cables to transfer power to land. CIGRE is monitoring this, and evolving guidelines as appropriate.

2. Activities of B1 – *Mr Dipal Shah*

   Mr Shah described the activities being undertaken by SC B1. Specifically, the confabulations held since the 9th October 2017 and including the Colloquium being conducted, was covered. Even the tutorials held on the previous day were included. Towards the end, he shared a set of queries, which he hoped, would be deliberated during the colloquium. He also announced the additional unplanned inclusion of the panel discussion as the last item of the day.

3. Trends and Challenges of HV Cable Systems – *Mr Bruno Arnald*

   This was mainly a company presentation by M/s Pfisterer. Mr Arnald presented some important issues in connection with the HV cable system, and its solution from his organisation, including the requisite hardware accessories. The issues touched on space constraints, installation, reliability, etc.

Mr Dipal Shah, Chairman, CIGRE NSC B1, during Inaugural Session

Mr. V K Kanjlia, Secretary, CBIP, during Inaugural Session

4. HV/ EHV Extruded Cable Systems - *Mr. Xabier*

   Even this one was a company/ product presentation from M/s General Cable. Mr Xabier presented the product portfolio and explained how it solved certain issues. Towards the end, he shared a few case examples of the products in use.

TECHNICAL SESSION 3

The session was chaired by Mr Harry Ortan, Canada.

The following papers were presented in this session:

1. Challenges in Planning and Design of Cable Transmission System of Pugalur NorthTrichur HVDC System- Users Perspective - *Mr. Puneet Tyagi, POWERGRID*

   Mr Tyagi described the journey of POWERGRID in executing the above named work of the 32 km XLPE cable system design. It starts with the challenge of the route design, considering the RoW issues and a pipeline along the way. The other challenges were in the domain of Voltage Stresses, Cable system thermal design, Cable Screen Current Stresses & Environmental Aspects of the Analysis for HVDC Cable Route.

2. New MVDC Technology for Remote Area Electrification – *Mr Ken Barber, Australia*

   Mr Barber took the case of the multiple remote islands in the Chuuk Lagoon area. One of the islands had enough power generation, and the issue was to supply power from there to the other islands. AC cables were considered, but dropped for various reasons, including the bulk and the shorter cable drum lengths. Instead DC cables with converters were found more appropriate. The paper described the process and the steps undertaken.

3. Fully Qualified Low Loss 525 and 640 kV extruded DC Cable System - *Mr. M Jeroense*

   The paper described the difference between HVDC and HVAC cable lines. The advantages/ dis advantages were taken up. The remaining paper was on installation and testing of HVDC cable system, including some practical aspects, e.g., trenching. Finally, a brief case study was taken up, as an example.

4. Cable Overvoltage for MMC based VSC HVDC System: Interaction with Converters – *Mr M Saltzer, ABB*

   This paper was on overvoltages in HVDC cables. It described the results of a study undertaken on the subject. To summarise the results: For extruded cables pole to ground fault the healthy polemidpoint is expected to see highest overvoltage due to the longest distance from the station arresters. The overvoltage magnitude is expected to increase with decreased load. The DC fault occurring in the middle of the line gives the highest over voltage on the healthy pole. For TOV due to a pole to ground fault in a symmetrical monopolar HVDC system, consideration of the mid point voltage of a fault in the middle of the line with low loading is sufficient.

TECHNICAL SESSION 4

The session was chaired by Mr Harry Ortan.

The following papers were presented in this session:

1. 220 kV EHV Networkat Reliance Jamnagar Refinery Complex - *Mr. B Venkatashwar, Reliance*

   Mr Venkateshwar described the installation of 220 kV EHV cable network in the Reliance Refinery Complex with 400 sq mm and 1000 sq mm cables. Under case studies he described some issues faced in relation to these cables. The analysis process and the solutions were also shared.

2. Failure of Transformer Cable box: A case study – *Mr S K Mishra, NHPC*

   The case was of Dhauliganga Power Station of NHPC. In August 2016, unit 4 tripped on XLPE cable differential protection of R-phase. The paper described the events and analysis of this failure. The paper recommends that the transformer having oil filled HVCB must be type tested and installation/commissioning should be done as per approved drawing. Also, suitable alternative solution should be explored to minimise the use of oil filled High Voltage Cable Box for high voltage transformer to minimise such type of faults.

3. Next Generation XLPE Insulation Reaching Extra High Voltage DC Performance - *Ms. Wandy Loyens*

   This paper was also a product description. Ms Loyens described the requisite properties of a novel XLPE insulation. She described even its comparison on multiple parameters. The property profile focussed on balance between electrical, mechanical and crosslinking.The ultimate verification resulted in successful type and prequalification testing at the record level of 640 kV according to CIGRÉ TB496.

TECHNICAL SESSION 5: PANEL DISCUSSION

The session was fully devoted to a Panel Discussion, whereby many technical experts from CIGRE SC B1 formed the panel, and fielded queries from the participants.

The following constituted the panel:

- Mr Robert Donaghy
- Mr N N Misra
- Mr Ken Barber
- Mr Eugen Bergin
- Mr Gair Clasen
- Mr Walter Zenger
- Mr Dipal Shah

Mr Bergin was the convener of the panel.

The panel started the session with brief initial comments by the panel members, to set the tone. Mr Donaghy pointed out that in respect of the HV Cables, functional requirement is not enough, but other aspects need also be considered. Mr Misra saw the colloquium as a platform to review our knowledge, and hoped that people learnt from the tutorials. Mr Barber referred to the expertise available. Mr Clasen talked of Submarine Cables. Mr Zenger emphasised diagnostics and fault log. Mr Shah stressed on local manufacturing.

This was followed by the questions and answers.

Someone from the Sterlite team expressed that 3 core cables were not in favour. Mr Barber responded that lots of 3 core AC cables were in use, and gave the example of Japan. He did caution though that drum length is a problem.

Again the Sterlite team wanted to know the recommended device test methods. Mr Bergin advised the person to take the discussion offline with Mr Clasen.

Mr Talande wanted expert comments on the use of extruded vs welded corrugated tubes; and if any tests were advised. Mr Barber shared his experience with a manufacturer. He talked of a problem from a designer's point of view in the case of the extruded tube. As per him, water penetration does create issues. Mr Talande acknowledged that the corrugated sheet may have manufacturing defect due to water ingress. Mr Barber informed of a new type of welding process to avoid this problem.

Mr Raj Kumar pointed out that converters introduced harmonics. Mr Jeroense informed that SC B4 has a working group on this.

Mr Gaikwad wanted to know if forced ventilation is required for a trench based 66 kV cable on cable tray. Mr Barber advised that the temperature should be known for this. Mr Shah advised to consult a Singapore study of 2010 on this. Mr Barber referred to a CIGRE paper on water cooling system.

Mr Shrivastava of CEA wanted to know how PQ and type test are related to the thickness, etc. Mr. Bergin, Clasen and Zenger responded that there is no need to repeat the test if the stress is lesser. Also, if there is no change in any manufacturing issue, no type test is needed, even beyond 5 years. There was a lot of commentary on what constituted 'no change'. No clear answer came out.

Mr Deshpande, COI, wanted to know the effect of cathodic protection on cables. Mr Bergin shared that there was a CIGRE paper on the topic.

A delegate from China wanted to know the details on corrosion on welded Aluminium cables. Mr Barber pointed out that quality of welding needs to be assured.

Mr Mohanty wanted to know the optimum thickness of the metal sheet. Mr Barber shared that it is around 3 mm for aluminium, but would be different for other cases. There are no CIGRE guidelines on this.

Mr Dhiren, Tata Power, wanted advice on the type of tests. Mr Barber advised Partial Discharge for the extruded cables and Tan-delta for the others.

Mr Jay wanted the opinion of the panel on the life of the cable, if it could be taken as 35 years. Mr Zenger concurred, but added that it could even be taken as 40 years. Mr Jay also wanted to know of any recommended test laboratory for this. This query remained unanswered. Mr Donaghy instead referred to the many CIGRE papers touching life of a cable, including even HVDC cables.

Saturday, 14th October 2017

TECHNICAL SESSION 6

The session was chaired by Mr Hideo Tanaka, Japan

The following papers were presented in this session:

1. A case study on laying of 132 kV UG Cable in LMRC – *Mr Mahendra Kumar, Director, Lucknow Metro*

   Lucknow Metro has planned to commission two lines in the city of Lucknow. Of this around 8.5 km is ready. Mr Kumar described the story of Lucknow Metro Rail Corporation and the plans of the two lines. Thereafter, he described the 132 kV cable installation as a part of the project. In this regard, he shared a few challenging situations encountered in the process. These included difficult road crossings, gas pipeline crossing, work during rains, etc. Also described was the details of the cable laying process.

2. Challenges Faced by Utility in High Voltage Cables and Solutions Derived – *Kapil Kumar, Tata Power*

   Tata Power has extensive experience of using cables in iis power network. Over the period of time, it has faced many challenges. Mr Kumar shared the experience of the organisation in this area, describing the various challenges and the solutions devised. He concluded that theusage of more & more trenchless technology & HDPE pipe for laying of the cable is resulting in de-rating of the cable system capacity. The uneven depth of cable laying and the usage of HDPE pipe is resulting in problems of pin-pointing faults.These problems are increasing day by day and need holistic solutions in terms of more advanced monitoring systems andrugged cables, which eliminate the usage of any external duct forlaying of these cables.

3. EHVCable Safeguarding-An Augmented Reality – *Paresh Khamkar, Reliance Infra.*

   Reliance Infra is another organisation with a significant population of power cables in urban areas. Consequently, even Reliance has faced many challenges in this regard. Mr Khamkar shared his experience. He started off by acquainting us with the Reliance Infra and its network in Mumbai. Then he described the multiple challenges faced by the 'cables' due to the essential works undertaken by the other city utilities, which has a possible detrimental effect of the cable due to the proximity. We also learnt of the technological solutions used to monitor the cable network. One of these is the embedded fibre to monitor the cable temperature. The other one is the 'Augmented Reality', which an IT based method of combining the real location graphics with an overlay of the cable routes. Mr Khamkar described the solution and its uses.

TECHNICAL SESSION 7

The session was chaired by Mr Marc Jeroense.

The session included the following papers:

1. Case Study – *Mr Dhiren Pandya & Mr Vivek Tidke, Tata Power, Mumbai*

   Mumbai, as a major Metropolis, presents its own challenges. One major such challenge is getting suitable RoW for laying of power cables, whereby all the other utilities also clamour for space. This case study described one such situation. RoW issues led to two cables being put on the same side of the road. The paper described a case of a cable failure needing rectification. However, due to the location, permission for digging was not available. The paper described the novel alternate method adopted for resolution.

2. Design Modifications for 11 kV Transition Joints - *Mr. Prasanjit Karmakar, CESC, Kolkatta*

   The CESC cable network has both XLPE and PILC cables. Both types need to be joined at places. Mr Karmakar described the joint and the joining process. Further, he informed that these joints fail at times. The paper described the failures and the analysis thereof. The failures were categorised as XLPE failures, PILC failures and Ferrule failures. Apart from the statistics, Mr Karmakar also shared the reason for the failures and the design changes incorporated for its mitigation.

3. Best practices for MV cable commissioning and condition monitoring - *Mr. S C Narayana, Megger.*

   Mr Narayana's message was that unlike DC testing, VLF testing will find major workmanship problems. So from a safety point of view it would be safe to energize the cable after successfully passing the VLF test.

For commissioning testing, it is not enough to withstand testing only as a commissioning test. PD diagnostics are strongly recommended and widely applied. However, excitation voltage should be comparable to operating frequency. For condition monitoring, additionally a tan-Delta diagnosis is needed. A tan-Delta diagnosis can also identify local problems.

At the end of the session, Mr Jeroense pointed out the advantages of taking up the membership of CIGRE, whereby, a lot of relevant information would be available to the member with a simple click. He advised the participants to consider taking up membership.

Group Photo

CONCLUDING REMARKS

Mr Dipal Shah thanked all the participants for taking active interest in the proceedings. He pointed out the vast amount of knowledge available with CIGRE, which is easily available to the members. Thus, the membership of CIGRE helps the working engineer in multiple ways. He invited the participants to take membership of CIGRE for continued benefits.

Mr Wahi gave his concluding remarks, whereby even he advised everyone to seriously consider joining CIGRE for professional progress.

He concluded that the colloquium had been a great success. He appreciated the presence of the stalwarts of the field, who had contributed immensely to the proceedings.

He particularly referred to the Tutorials conducted on the12th, a day prior to the colloquium. He was impressed by the depth of knowledge shared thereby. All the presenters took great pains to share their wide and deep experience of the subject.

Coming back to the colloquium, he thanked each one of the contributors for their contribution.

Mr Wahi described the role and the aim of CBIP, which is knowledge dissemination in the field of Power, Water Resources and Renewable Energy. For this, CBIP conducts Trainings and conferences, and also publishes books and periodicals. He appealed to the participants to take full advantage of the offerings.

He appreciated the excellent contribution by one and all to the success of the event. Lastly, he thanked Mr Kanjlia, Mr Batra and the staff of CBIP for their support.

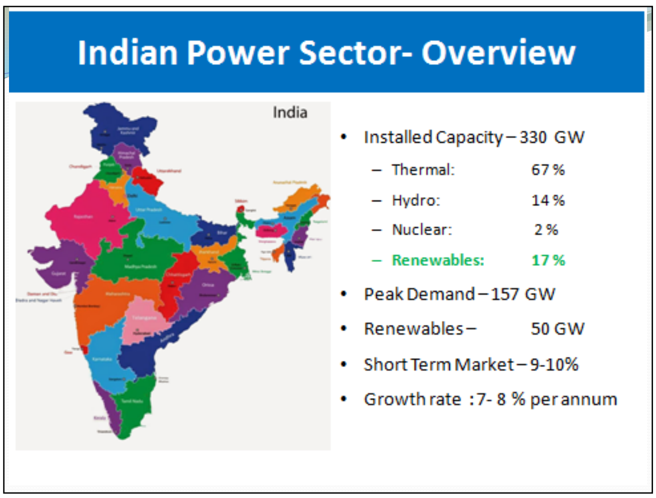
With this the conference concluded.

GLIMPSES OF THE CONFERENCE

GLIMPSES OF CIGRE SC B1 MEETING

GLIMPSES OF THE CONFERENCE

CIGRE-INDIA


Indian Power Sector- Overview
India
Installed Capacity – 330 GW
– Thermal: 67 %
– Hydro: 14 %
– Nuclear: 2 %
– Renewables: 17 %
Peak Demand – 157 GW
Renewables – 50 GW
Short Term Market – 9-10%
Growth rate : 7- 8 % per annum


CIGRE India – Governing Body
Mr. I.S. Jha, President, CIGRE-India and CMD, POWERGRID India.
He is a well known Power System Professional having more than 35 years of rich experience.
Mr. R.P. Sasmal, Chairman, Technical Council, CIGRE-India & Director (Operations), POWERGRID, India.
He is instrumental in introducing the ±800 kV multi-terminal HVDC transmission system which is First of its kind.
He has more than 34 years of experience in power sector.


ABOUT CIGRE INDIA
Functions as National Committee for CIGRE and coordinates CIGRE activities in India.
It Organizes National Study Committee (NSC) meetings and Events at National Level.
Affairs of CIGRE-India are administered by the General Body / Governing Council
3


Vice Presidents of CIGRE-India
Mr. N.N. Misra
Vice Chairman
Technical Council
Mr. Amitabh Mathur
Director, BHEL
A.K. Gupta
Director, NTPC

Chairman, AORC & Secretary, CIGRE India

Dr. Subir Sen
Chairman,
CIGRE AORC &
ED, POWERGRID

Mr. V.K. Kanjlia
Secretary
CIGRE India

Mr. P.P. Wahi
Secretary
CIGRE AORC

Membership Growth

Category	2016		2017	
Collective 1	69X6	414	91X6	546
Collective 2	11X3	33	19X3	57
Individual	152	152	151	150
Young	24X0.5	12	28X0.5	14
Total				768
In process of Renewal				18
Total		611		786

Technical Committee – CIGRE India

Plan for participation in CIGRE Session 2018

- 136 synopsis have been scrutinized by the Tech. Committee under Chairmanship of Mr. R.P. Sasmal, Tech. Chair, CIGRE India.
- 30 papers have been recommended to CIGRE for their consideration.

Major activities of CIGRE India

I. Membership

II. Participation at international level

III. CIGRE National Level activities

CIGRE SC Meeting Organized and Planned in India

CIGRE Meetings already organised

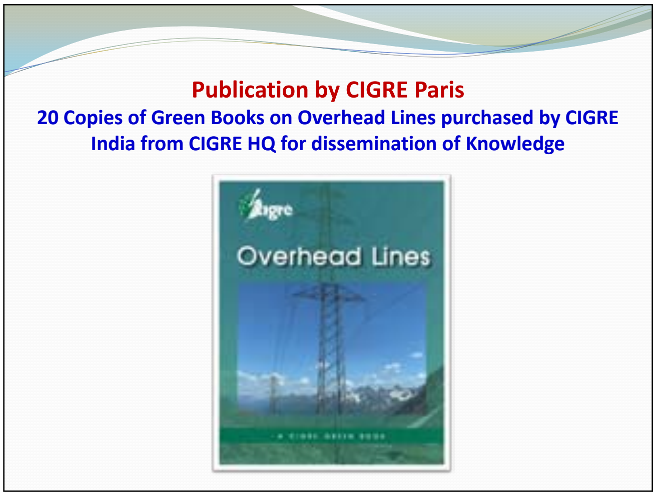
- CIGRE SC D2 in Sept. 2014 at Mysore,
- CIGRE SC B4 in 2015 at Agra, under chairmanship of Mr. R.P. Sasmal, Tech. Chair, CIGRE India

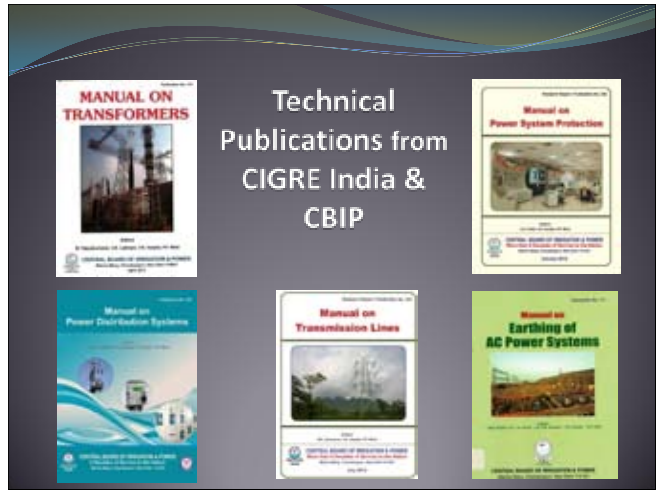
CIGRE Meeting being held

- CIGRE SC B1 on "HV Insulated Cables" – 9 -13 Oct. 2017 in New Delhi
- SC A1 Meeting & Intl. Conf. on Rotating Machines - 23 - 28 Sept. 2019 at New Delhi.
- Meeting of SC A2; SC B2 & SC D1and Joint Colloquium of Three Study Committee i.e. SC A2 (Transformers)/ B2 (Overhead Lines) / D1(Materials) – in Nov. 2019 in New Delhi.

Meetings Planned to be hosted in

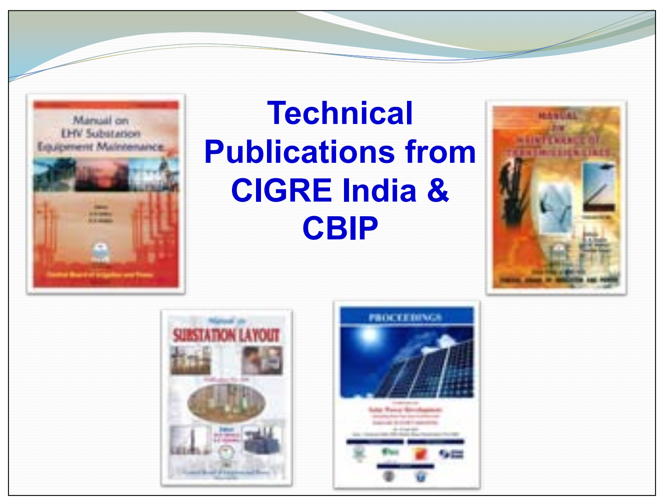
- SC A3; B3; C1; and C2; ---- in 2021
- SC B5, C4; C5; & C3 ---- in 2023





Publications by CIGRE India and CBIP

- CIGRE-INDIA with the support of Central Board of Irrigation & Power brings out several Technical Books based on practical experience of experts in the field for dissemination of knowledge.
- These technical documents remain in great demand by professionals, utilities and other stake holders.
- These are referred for design, Construction & O&M activities by the professionals.
- These are also in great demand in countries like Bhutan, Nepal, Nigeria etc



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Institutional Members

1. Electricity Regulatory Commission, Andhera Pradesh
2. Electricity Regulatory Commission, Bihar
3. Electricity Regulatory Commission, Delhi
4. Electricity Regulatory Commission, Gujarat
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6. Electricity Regulatory Commission, Maharashtra
7. Electricity Regulatory Commission, Odisha
8. Electricity Regulatory Commission, Sikkim
9. Electricity Regulatory Commission, Uttar Pradesh
10. Electricity Regulatory Commission, Uttarakhand
11. Electricity Regulatory Commission, West Bengal
12. Eastern Regional Power Committee
13. Electrical Research & Development Association
14. IEEMA
15. Indian Institute of Technology Bombay
16. Indian Institute of Technology Hyderabad
17. National Institute of Technology, Cailcut
18. Ramelex Testing & Research Institute
19. Centre of Excellence, CBIP & CIGRE (I)

Individual Members

S. No.	Name	Organisation
1	Amit Kumar	Antarriksh, INC
2	Abhay Kumar Agrawal	ABB India Ltd.
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5	Urmil Parikh	ABB India Ltd.
6	Sachin Srivastava	ABB Global Indst. & Services ltd.
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9	Gopal Ji	Angelique International Ltd.
10	Arvind Gupta	Adani Power Ltd.
11	Bipin B. Shah	Adani Transmission Ltd.
12	Srimanta Kumar Jana	Apar Industries Ltd.
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15	Manoj Santani	BHEL
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21	Balasubramanian Krishnan S.	Consultant
22	Sanjay Patki	Consultant
23	Pramod Rao	Consultant
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26	Vijaykumar Wakchaure	CTR Manuf. Industries Ltd.
27	Nageshwar Rao Burjupati	CPRI
28	Nitin Dhamale	Cee Dee Vaccum Equipment Pvt. Ltd.
29	V.K. Kanjila	CBIP
30	Vikrant Joshi	Crompton Greaves Ltd.
31	Sameer Gaikwad	Doble Engineering Pvt. Ltd.
32	Aditya Korde	Diagnostic Techno-logies India Pvt. Ltd.
33	Anil Kumar Jha	DVC
34	Ravi Kumar Puzhankara	DNV-KEMA
35	Madhuryya Prosad Chakravorty	Energy Infratech Pvt. Ltd.
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37	Singaram Christian Johnson	Excel Engineering College
38	Anagha Dixit	EMCO Ltd.
39	Mary Mody	EMCO Ltd.
40	Rahul Banerjee	GDF Suez Energy Pvt. Ltd.
41	Jayesh Gandhi	GETCO
42	Asha M Agravatt	GETCO
43	Manishkumar K. Jani	GETCO
44	Yogesh Vishnu Joshi	GETCO
45	Bhadreshkumar B. Mehta	GETCO
46	Nikunjkumar Makwana	GETCO
47	Parind Munsif	GETCO
48	Dipakkumar Patel	GETCO

49	Rameshchandra P. Satani	GETCO
50	Ankur Shah	GETCO
51	Nilesh Sheth	GETCO
52	Bankim Pravinchandra Soni	GETCO
53	Praful K. Varsada	GETCO
54	Pankajbhai Suthar	GETCO
55	Bhadresh B. Chauhan	GETCO
56	Ashokkumar J. Chavda	GETCO
57	Rajesh Suri	GE T&D India Ltd.
58	Madhu Sudhan	GE T&D India Ltd.
59	Amit Kothari	GE T&D India Ltd.
60	Vijayakumaran Moorkath	GE T&D India Ltd.
61	Purshottam Kalky	GE T&D India Ltd.
62	Subhasis Jhampati	GE T&D India Ltd.
63	Sukhbir Kapoor	GE Grid
64	Firoz Ahmed	GE Grid Solution
65	Narendra Sharma	General Electric T&D India
66	Sanjib Mishra	General Electric
67	Udaya Kumar	IIS- Bangalore
68	Joy Thomas Meledath	IIS- Bangalore
69	Himanshu Bahiorat	IIT, Mumbai
70	Habib Chowdhary	J & K Power Development Department
71	Sunil Bhanot	KEC International ltd.
72	Sarveshkumar Virendrakumar	KEC International ltd.
73	E.V. Rao	KEC-RPG
74	Arvind Shrowty	KEI Industries Ltd.
75	Pervinder Singh Chowdhary	Kalpataru Power Trans. Ltd.
76	Nene Milind	Kalpataru Power Trans. Ltd.
77	Nitin Kumar Patel	Kalpataru Power Trans. Ltd.
78	Muthuraj Ramaswamy	Kanohar Electricals Ltd.
79	Rupesh Rajhans	Larsen & Toubro Ltd.
80	Puneet Sharma	Larsen & Toubro Ltd.
81	Aradhana Ray	Laxmi Associates
82	Monal Patel	Map Power LLP
83	Dipti Saxena	MNIT Jaipur
84	Udaybabu Ratanchand Shah	Mahati Industries Pvt. Ltd.
85	Dhananjay Kumar Chaturvedi	NTPC Ltd.
86	Narendra Nath Misra	NTPC Ltd.
87	Subhash Thakur	NTPC Ltd.
88	Bishnu Prasanna Nanda	NTPC Ltd.
89	Dr. Tukaram Moger	NIT-Karnataka
90	I. R. Rao	NIT-Karnataka
91	Venkaiah Chintham	NIT- Warangal
92	Subrata Karmakar	NIT- Rourkela
93	Jora Gonda	NIT- Karnataka
94	Sarasij Das	Organistion Indian Institute of Science
95	Satyajit Ganguly	ONGC Tripura Power Co. Ltd.
96	Pravinchandra Mehta	Persotech Solutions
97	Prakash Nayak	Pena Power Engg. & Automation (P) ltd.
98	Deepal Shah	PFISTERER
99	Pradeep Kumar Gangadharan	Protection Engg. & Research Laboratories
100	Chandan Kumar	POSOCO
101	K V S Baba	POSOCO
102	Manoj Kumar Agrawal	POSOCO
103	S.R. Narasimham	POSOCO
104	Vivek Pandey	POSOCO
105	Rajiv Kumar Porwal	POSOCO
106	Sushil Kumar Soonee	POSOCO
107	Samir Chandra Saxena	POSOCO
108	N.S. Sodha	Powergrid
109	Subir Sen	Powergrid
110	Rajendra Prasad Sasmal	Powergrid
111	Avinash Madhav Pavgi	Powergrid
112	Arun Kumar Mishra	Powergrid
113	Anantha Sarma Boppudi	Powergrid
114	Sunita Chohan	Powergrid
115	Seema Gupta	Powergrid
116	Rajesh Kumar	Powergrid
117	Barindra Narayan De Bhowmick	Powergrid
118	R.K. Tyagi	Powergird
119	I.S. Jha	Powergird
120	Manish Kumar Jha	Powergrid
121	Vinod Kumar Agrawal	Regen Powertech Pvt. Ltd.
122	Sushil Chaudhari	Raj Petro Specialities Pvt. Ltd.
123	Nalin Nanavati	Raj Petro Specialities Pvt. Ltd.

124	Baburao Keshawatkar	Raj Petro Specialities Pvt. Ltd.
125	Alok Roy	Reliance Power Transmission Ltd.
126	Naveen Nagpal	Reliance Power Transmission Ltd.
127	Arvind Kumar Sharma	Reliance Infrastructure Ltd.
128	Bhashyam Hosalli	Sifang Automation India Pvt. Ltd.
129	Vikas Shahaji Jagadale	Shreeram Electric Ltd.
130	Sanjay Gulabrao Jagdale	Savita Polymers Ltd.
131	Santosh K. Kumar Patro	Siemens Ltd.
	Hrushaabh Prashaant Mishra	Syselec Technologie Pvt. Ltd.
132	Deepak Lakhapati	Sterlite Power
133	Anil Rawal	Sterlite Power
134	Sanil Namboodiripad	Sterlite Powergrid Ventures Ltd.
135	Parantap Krishna Raha	Sterlite Powergrid Ventures Ltd.
136	Umesh Maharaja	Tata Power Co.
137	Rajendra Vinayak Saraf	Tata Power Co., Mumbai
138	Murali Krishna Tallamraju	Tata Power Co., Mumbai
139	Vivek Thiruvenkatachari	TAG Corporation
140	Subhash Chandra Takalkar	Takalkar Power Engineers & Consult. Pvt Ltd.
141	Avanish Shrivastava	TAMCO
142	Arogya Raju Pudhota	TSTRANCO
143	Narasimhan Ravinarayan M	Taurus Powertronics Pvt. Ltd.
144	Vishnu Agarwal	Technical Assosiates
145	Jaywant Thorat	Vision Vidyut Engineer Pvt. Ltd.
146	Hillol Biswas	WAPCOS Ltd.
147	Venkata Satya Narsimha Raju	WAPCOS Ltd.
148	Manoj Kumar Muthyala	WAPCOS Ltd.
149	Balwant Singh Mehta	WAPCOS Ltd.
150	Deepak Kumar Saxena	Welspun Energy Ltd.

Young Members

S.No.	Name	Organistaion
1	Hari Om Baboo	Ayesa India Pvt. Ltd.
2	Suresh Maturu	ABB Global Industries & Services Pvt. Ltd.
3	Ravi Chandran Sharon	ABB Global Industries & Services Pvt. Ltd.
4	Sundaramoorthy Gopinath	ABB Limited, UK
5	Aayush Anand	BSNL
6	Harshit Suratu	Consultant
7	Sudalai Shunmugam Sundaram	Central Power Research Institute
8	Ramautar	DHBVN
9	Kaustuv Mohapatra	Ernst & Young PPL
10	Saurabh Waghulde	Energo Project Intel Ltd. Doha
11	Ahir Bhavesh Bachubhai	GETCO
12	Amit Kumar	GE T&D India Ltd.
13	Rajat Misra	General Electric Grid Solution
14	Siddhesh Chavan	JSW Energy Ltd.
15	Shridhar Ghodasara	Jonam Tech Impex
16	Nilesh Bareyya	LPGCL
17	Naveen Kumar Basva	L & T MHPS Turbine Generators
18	Adithya Kumar Woppuloori	L & T Construction
19	Sheri Abhishek Reddy	Mahatma Gandhi Institute of Technology
20	Amresh Kumar	NERIST
21	Vaibhav Parganiha	Powergrid
22	Abhigyan Tiwari	Powergrid
23	Sivaji Burada	Sterlite Power Transmission Ltd.
24	Jitendra Kumar	Shell India Market Pvt. Ltd.
25	Nerayanoor Venkat Bhargav	Sifang Automation India Pvt. Ltd.
26	Venkata Jagadeesh Yarramsetty	WAPCOS Ltd.
27	Dinesh Raja Ponamalli	WAPCOS Ltd.
28	Anil Kumar Singh	Tesla Transformers Ltd.

CIGRE MEMBERS FROM INDIA IN 2017

Organizational Members

1 ABB India Limited
2 Adani Transmission Limited
3 Amitasha Enterprises Pvt. Ltd.
4 Associated Power Structures Pvt. Ltd.
5 Atlanta Electricals Pvt.Ltd.
6 Bajaj Electricals Ltd.
7 Bhakra Beas Management Board(BBMB)
8 Bharat Heavy Electricals Ltd. H.Q.
9 EDN, Bharat Heavy Electricals Ltd.
10 Hardwar(HEEP), Bharat Heavy Electricals Ltd.
11 R&D, Hyderabad, Bharat Heavy Electricals Ltd.
12 Bhopal, Bharat Heavy Electricals Ltd.
13 Cargill India Private Limited
14 Central Power Research Institute (CPRI)
15 Central Electricity Authority (CEA)
16 CG Power and Industrial Solutions Ltd.
17 CESC Limited
18 Deccan Enterprises Limited
19 Delhi Metro Rail Corporation Ltd.
20 EMC Ltd.
21 Grasim Industries Ltd.
22 Gupta Power Infrastructure Limited
23 HYOSUNG T&D India Pvt. Ltd.
24 India Smart Grid Forum
25 JSK Industries Pvt. Ltd.
26 KEI Industries Ltd.
27 Larsen & Toubro Limited- Construction
28 Maharashtra State Electricity Trans. Co. Ltd.
29 North Eastern Electric Power Corp. Ltd.
30 NTPC Limited, H.Q.
31 Auraiya TPS, NTPC
32 Anta GPS, NTPC
33 Badarpur TPS, NTPC
34 Bongaigaon TPP, NTPC
35 Dadri SSTP, NTPC
36 Faridabad TPP, NTPC
37 Farakka STP, NTPC
38 Kahalgaon STPS, NTPC
39 Kayamkulam STPS, NTPC
40 Kawas GPP, NTPC
41 Korba STPS, NTPC
42 Koldam HPP, NTPC
43 Mouda STPP, NTPC
44 Rihand STPP, NTPC
45 Simhadri STPP, NTPC
46 Singrauli STPS, NTPC
47 Talcher STPS, NTPC
48 Talcher TPS, NTPC
49 Tanda TPS, NTPC
50 Unchahar TPP, NTPC
51 Vindhyachal STPS, NTPC
52 NTPC Sail Power Company Pvt. Ltd.
53 OMICRON Energy Solutions Pvt. Ltd.
54 POSOCO H. Q.
55 Eastern Regional Load Despatch Centre, POSOCO
56 Northern Regional Load Despatch Centre, POSOCO
57 South Regional Load Despatch Centre, POSOCO
58 Western Regional Load Despatch Centre, POSOCO
59 Powergrid Corporation of India H.Q.
60 Western Regional-II, Powergrid
61 North Eastern Regional, Powergrid
62 North Regional Transmission System-I, Powergrid
63 HVDC Champa Kurukshetra, Powergrid
64 Southern Regional Transmission System-I, Powergrid
65 Eastern Regional Transmission System-I, Powergrid
66 Northern Regional Transmission System-3, Powergrid
67 Southern Regional Transmission System-2, Powergrid
68 Western Regional Transmission System-I, Powergrid
69 Northern Regional Transmission System-2, Powergrid
70 Odisha Project, Powergrid
71 R'grh-P'glur Project, Powergrid
72 Eastern Region-2, Powergrid
73 NERSIP & Comprehensive Scheme, Powergrid
74 Reliance Infrastructure Ltd. M.T.B.
75 Savita Oil Technologies Ltd.
76 Scope T&M Pvt Ltd
77 Siemens Ltd, EM TS
78 Sterlite Power Grid Ventures Limited
79 Sterlite Power Transmission Limited
80 Supreme & Co. Pvt. Ltd.
81 Switchgears & Structurals (I) Pvt. Ltd.
82 Tata Power Delhi Distribution Limited
83 Taurus Powertronics Pvt. Ltd
84 The India Fruits Private Ltd.
85 The Motwane Manufacturing Co. Pvt Ltd
86 The Tata Power Company Ltd.
87 Toshiba Trans.& Dist. Systems (I) Pvt Ltd
88 Transformers & Rectifier (India) Ltd.
89 Transrail Lighting Limited
90 Universal Cables Limited

INTERNATIONAL COUNCIL ON LARGE ELECTRIC SYSTEMS

TO BE SENT TO NATIONAL COMMITTEE (i.e Central Board of Irrigation and Power)

MEMBERSHIP APPLICATION FORM – for the year 2018

Please fill in the column of the relevant MEMBER CATEGORY.

MEMBERSHIP RENEWAL ☐ **NEW MEMBERSHIP** ☐ **Membership Number** ☐

☐ ***INDIVIDUAL MEMBER I*** ☐ ***INDIVIDUAL MEMBER II*** *(Young Member under 35 years)*	***COLLECTIVE MEMBER I*** *Administrative bodies, scientific and technical organisations, research institutes, public or private Companies industrial and/or commercial.*	***COLLECTIVE MEMBER II*** *Universities, Educational Bodies only.*
Family Name ………… *Forename* ………… *Position, Dept.* ………… *Company, Organisation* ………… *Full Address* ………… ………… ………… TEL ………… Mobile no. ………… FAX ………… E-Mail………… *Year of Birth* …………	*NAME of COMPANY* ………… ………… *Person or Department to receive ELECTRA journal.* ………… ………… *Full Address* ………… ………… ………… TEL ………… Mobile no. ………… FAX ………… E-Mail…………	*NAME of UNIVERSITY* ………… ………… *Person or Department to receive ELECTRA journal .* ………… ………… *Full Address* ………… ………… ………… TEL ………… Mobile no. ………… FAX ………… E-Mail…………

Membership fee in India in Rs. is as below :

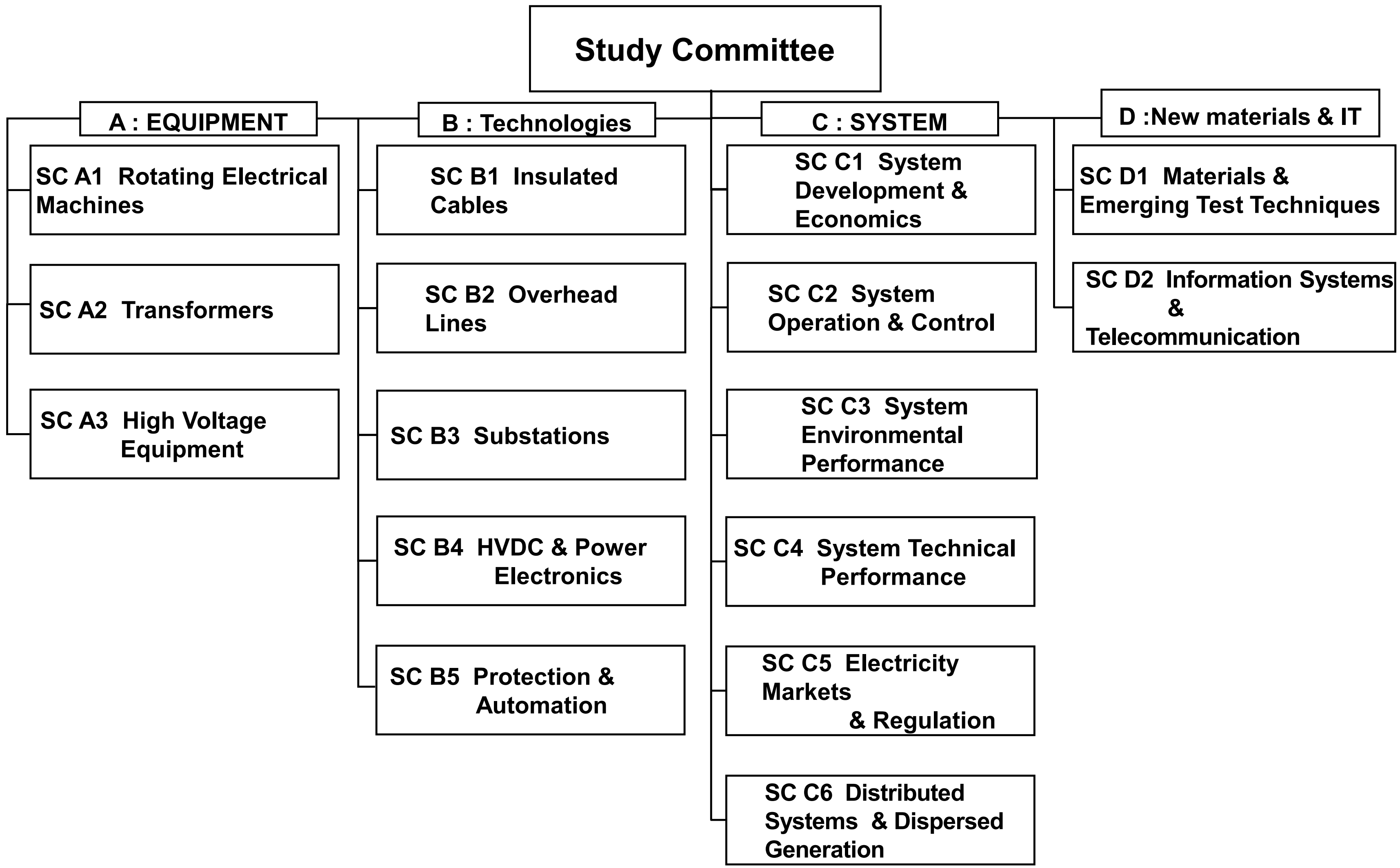
1	Collective I	Rs. 65,000/-
2	Collective II (Universities & Regulatory Commission)	Rs. 25,000/-
3	Individual	Rs. 7,500/-
4	Young - below 35 years of age	Rs. 3,750/-

Fee can be paid through cheque/ DD in favour of CIGRE India or through bank transfer

The details for bank transfer

Vender Name	The Committee for International Conference on Large High Voltage Electric Systems (CIGRE) India		
Bank Name & Branch	ICICI Bank Limited/ Malcha Marg Shopping Centre		
Branch Address	16/48, Malcha Marg Shopping Centre, Chankyapuri, New Delhi -110021. Ph.No.41680133-34-35		
IFSC code of branch	ICIC0000346	**MICR No.** : 110229052	**Account No.** : 034601001054
Type of account	Special Saving Account		**PAN No.** : AAAAZ0260A

Four Group of CIGRE Study Committees



FIELDS OF ACTIVITY OF CIGRE STUDY COMMITTEES

Study Committees No.	Scope
A1	**Rotating Electrical Machines** : Economics, design, construction, test, behaviour and materials for turbine generators, hydro-generators, non conventional machines and large motors.
A2	**Transformers :** Design, construction, manufacture and operation for all kinds of power transformers including industrial,DC converters and phase-shift transformers and for all types of reactors and transformer components (bushing, tap-changer…)
A3	**High Voltage Equipment :** Theory, design, construction and operation for all devices for switching, interrupting and limiting currents, surges arresters, capacitors, busbars and equipment insulators and instrument transformers.
B1	**Insulated Cables :** Theory, design, applications, manufacture, installation, testing, operation, maintenance and diagnostic techniques for land and submarine AC and DC insulated cables systems.
B2	**Overhead Lines :** Design, study of electrical and mechanical characteristics and performance, route selection, construction, operation, service life, maintenance, refurbishment uprating and upgrading of overhead lines and their components including : conductors, earth wires, insulators, towers, foundation and earthing systems.
B3	**Substations :** Design, construction, maintenance and ongoing management of substations and electrical installations in power stations, excluding generators.
B4	**HVDC and Power Electronics :** Economics, application, planning aspects, design, protection, control, construction and testing of HVDC links and the associated equipment. Power Electronics for AC systems and Power Quality Improvement and Advanced Power Electronics.
B5	**Protection and Automation :** Principles, design, application and management of power system protection, substation control, automation, monitoring and recording – including associated internal and external communications, substation metering systems and interfacing for remote control and monitoring.
C1	**System Development and Economics :** Economics and system analysis methods for the development of power systems : methods and tools for static and dynamic analysis, planning issues and methods in various context, assets management strategies.
C2	**System Operation and Control :** Technical and human resource aspects of operation of power systems : methods and tools for frequency, voltage and equipment control, operational planning and real time security assessment, fault and restoration management, performance evaluation, control centre functionalities and operators training.
C3	**System Environmental Performance :** Identification and assessment of the impacts on environment of electric power systems and methods used for assessing and managing the environmental impact of system equipment.
C4	**System Technical Performance :** Methods and tools for power system analysis in the following fields: power quality performance, electromagnetic compatibility, lightning characteristics and system interaction, insulation coordination, analytical assessment of system security.
C5	**Electricity Markets and Regulation :** Analysis of different approaches in the organisation of the Electric Supply Industry : different market structures and products, related techniques and tools, regulations aspects.
C6	**Distribution Systems and Dispersed Generation :** Assessment of technical impact and requirements which new distribution features impose on the structure and operation of the system : widespread development of dispersed generation, application of energy storage devices, demand side management; rural electrification.
D1	**Materials and Emerging Test Techniques :** Monitoring and evaluation of new and existing materials for electrotechnology, diagnostic techniques and related knowledge rules, and emerging test techniques with expected impact in medium to long term.
D2	**Information Systems and Telecommunications :** Principles, economics, design, engineering, performance, operation and maintenance of telecommunication and information networks and services for Electric Power Industry; monitoring of related technologies.

HIGHLIGHTS OF POWER SECTOR IN INDIA

GROWTH OF INSTALLED CAPACITY

(Figures in MW)

	At the end of 11th Plan (March 2012)	As on 30.11.2017	Planned for 12th Plan	Planned for 13th Plan
THERMAL	131603.18	218959.51	72340.00	56400.00
HYDRO	38990.40	44963.42	10897.00	12000.00
NUCLEAR	4780.00	6780.00	5300.00	18000.00
RENEWABLE ENERGY SOURCES	24503.45	60157.66	30000.00	30500.00
TOTAL	**199877.03**	**330860.58**	**118537.00**	**116900.00**

Source : CEA

ALL INDIA REGION WISE INSTALLED CAPACITY

As on 30-11-2017

(Figures in MW)

Region	Thermal	Hydro	Nuclear	RES	Total
Northern	58270.46	1620	19423.77	12279.15	91593.38
Western	79968.03	1840	7447.50	18825.36	108080.89
Southern	51617.26	3320	11808.03	27728.32	94473.61
Eastern	26771.64	0	4942.12	1027.32	32741.08
N. Eastern	2292.07	0	1342.00	285.41	3919.48
Islands	40.05	0	0.00	12.10	52.15
All India	**218959.51**	**6780**	**44963.42**	**60157.66**	**330860.58**
Percentage	**66.18**	**2.05**	**13.59**	**18.18**	**100**

Source : CEA

SECTOR WISE INSTALLED CAPACITY AND GENERATION

As on 30-11-2017

Sector	Installed Capacity (MW)					Percentage Share	Net Capacity added
	Thermal	Nuclear	Hydro	RES	Total		During November 2017
STATE	71223.38	0.00	29858.00	1976.90	103058.27	31.15	-257 MW
PRIVATE	85550.30	0.00	3394.00	58180.76	147125.06	44.47	
CENTRAL	62185.83	6780.00	11711.42	0.00	80677.25	24.38	
TOTAL	**218959.51**	**6780.00**	**44963.42**	**60157.66**	**330860.58**	**100**	

Source : CEA

GROWTH OF TRANSMISSION SECTOR

	Unit	At the end of 11th Plan (March 2012)	Addition During November, 2017	As on 30.11.2017	Addition during 12th Plan	Addition during 13th Plan (up to November 2017)
TRANSMISSION LINES						
HVDC	ckm	9432	0	15556	110370	13820
765 kV	ckm	5250	0	33286		
400 kV	ckm	106819	303	167013		
220 kV	ckm	135980	397	165816		
Total Transmission Lines	**ckm**	**257481**	**700**	**381671**	**110370**	**13820**
SUBSTATIONS						
HVDC	MW	9750	0	22500	331214	50805
765 kV	MVA	25000	0	177500		
400 kV	MVA	151027	4105	267932		
220 kV	MVA	223774	1035	323638		
TOTAL	**MW/MVA**	**409551**	**5140**	**791570**	**331214**	**50805**

RURAL ELECTRIFICATION / PER CAPITA CONSUMPTION

(As on 30-11-2017)

Total no. of Villages	597464
No. of Villages Electrified	594599
% of Villages Electrified	99.25
No. of Pump-sets Energized as on 31-10-17	21191474
Per Capita Consumption during 2015-16	*1075 kWh

*Provisional

RE SECTOR IN INDIA: POTENTIAL AND ACHIEVEMENTS

(up to October 2017)

GRID-INTERACTIVE POWER Sector	FY 2017-18 Target (MW)	Cumulative Achievements (MW) (as on 31-10-2017)
Wind	4000.00	32715.37
Solar Power (SPV)	10000.00	15574.71
Small Hydro (up to 25 MW)	200.00	4399.35
Bio Power (Biomass & Gasification and Bagasse Cogeneration)	340.00	8181.70
Waste to Power	10.00	114.08
Total (Approx)	**14550.00**	**60985.21**
OFF GRID/CAPTIVE POWER	**183**	**1542.65**

Source : MNRE

GOVERNMENT TO PUSH PREPAID, SMART METERS IN UNIVERSAL ELECTRIFICATION DRIVE

Prepaid and smart meters are going to get greater thrust from the government as India moves towards the target of achieving universal household electrification as part of the Saubhagya scheme by end of next year.

"The government is planning to provide prepaid facility for electricity where the consumer can recharge for as small an amount as Rs 50," minister for power and new and renewable energy RK Singh told reporters at the launch of an online portal for Saubhagya scheme.

Prime Minister Narendra Modi in September launched the Saubhagya scheme to electrify four crore un-electrified households in the country by December 2018. The scheme has an outlay of Rs 16,320 crore, including budgetary allocation of Rs 12,320 crore. Singh said the government is promoting smart and prepaid meters as a move to change the electricity ecosystem. A major constraint, however, remains the limited capacity of smart meters being manufactured in India.

"The ecosystem will be something like, you don't have to wait for the bill. Just like you recharge your mobile, you will be able to recharge electricity. This will make it viable for the poor. With this prepaid facility, he will not get disconnected," Singh said.

"There is assured demand for smart meters. The households which will be electrified in future will be connected through smart meters..we are encouraging manufacturing of smart meters in the country.. the government is willing to procure," he added.

Source : ET Bureau, November 17, 2017

BID TO FIGHT AIR POLLUTION: NTPC TO USE CROP STUBBLE IN FUEL MIX

In an initiative to help curb increasing air pollution in Delhi and neighbouring states, the Centre has told NTPCBSE 0.42% to procure farm stubble from states like Punjab and Haryana to be used in its fuel mix, power minister R K Singh has said.

The state-run electricity producer will use 10% of straw pellets in their energy mix, Singh said.

"This will create a market for stubble for the farmers," he said. "NTPC will soon float a tender for procurement of these pellets."

The move comes even as a study by Centre for Science and Environment (CSE) said coal-based power plants continue to flout emission norms.

NTPC is the largest thermal power generator in the country with coal-based installed capacity of 38,755 MW.

The national capital region is fighting a pollution emergency due to smog and extremely poor air quality for more than week now, and one of the major causes for this is widespread burning of rice stubbles by farmers in Haryana, Punjab and Uttar Pradesh to quickly get their fields ready for sowing wheat.

The government hopes to dissuade farmers from burning stubbles by creating a market for crop residue. State-owned Indian Renewable Energy Development Agency (IREDA) will finance pellet manufacturing units, which will then bid for NTPC tender, Singh said. He said farmers will get Rs 11,000 for stubble from one acre of farm land.

NTPC will offer average price of Rs 5,500 per tonne for pellets and the average produce is two tonnes in one acre, the minister said.

"We are writing to all the states and discoms that a similar obligation will be placed on the thermal generating units of the states as well," Singh said. Power secretary A K Bhalla, however, said using stubble pellets for power generation may not be possible this season "because infrastructure will have to be set up for the manufacture of these pellets (and) it will take some time". The government is trying to set up a system anyway, Bhalla said.

THERMAL PLANTS FLOUTING EMISSION NORMS

A study by Centre for Science and Environment (CSE) has said coal-based power generating units continue to flout emission norms and are yet to install pollution control equipment. Most plants have done very little to even assess their technology needs or the investment required, the study said.

"With active help from the ministry of power (MoP) and the Central Electricity Authority, power units are all set to avoid complying with the new emission norms that will come into effect shortly," Chandra Bhushan, deputy director general at CSE, has alleged.

Source : ET Bureau, November 17, 2017

REC TO PROVIDE RS 14K CR LOAN FOR 2,400 MW PATRATU POWER PLANT

Rural Electrification BSE 3.18 % Corp (REC) will provide Rs 14,000 crore debt to set up 2,400 MW thermal power plant of power giant NTPCBSE 0.42 %'s arm PatratuVidyut Utpadan Nigam Ltd. (PVUNL) in Jharkhand.

"The REC and PVUNL signed a loan agreement for establishing 3x800 MW Patratu Super Thermal Power Project Phase-I in Jharkhand," a statement by REC said.

The project cost of Rs 18,668 crore is funded in debt:

equity ratio of 75:25 and Rs 14,000 crore (entire debt component of project) is sanctioned by REC as sole lender for the project. PVUNL is a subsidiary of NTPC holding 74 per cent stake in the company and 26 per cent of stake is held by Jharkhand BijliVitran Nigam Lid (JBVNL), the discom utility of Jharkhand.

The loan agreement was exchanged between Ajeet Agarwal, Director Finance, REC and Kulamani Biswal, Chairman, PVUNL. The CMD of REC, P V Ramesh and the CMD of NTPC, Gurdeep Singh, along with senior management of both the organisations were also present at the event.

Source : PTI, November 15, 2017

POLLUTION BOARD LIFTS BAN ON 5 POWER UNITS TILL JAN 12:VEDANTA

Vedanta Ltd today said the State Pollution Control Board (SPCB) of Odisha has allowed it to resume operation at all the units of two power plants up to January 12.

The board had earlier ordered the company to close temporarily five units -- three 135 MW each of 1,215 mw plant and two 600 mw each of 2,400 mw plant -- for breaching pollution norms.

“The SPCB has allowed operation of all the units of 1,215 mw and 2,400 MW plants up to January 12, 2018 after which further extension of operation will be considered with a review of progress,” Vedanta said in a filing to BSE. With this order, the company said, the closure order has been revoked on all five power units that were directed by SPCB to be temporarily closed.

“The company had earlier announced on September 14, 2017 that consequent to a breach in the ash dyke wall at Jharsuguda, the SPCB had served a direction resulting in temporary closure of three units of 135 MW each of the 1215 MW power plant, two units of 600 mw of the 2400 mw power plant,” the company said.

Source : PTI, November 15, 2017

INTERNATIONAL SOLAR ALLIANCE TO SUPPORT SETTING UP 1000 GW OF SOLAR ENERGY CAPACITY

As US touts coal, Prime Minister Narendra Modi’s sunshine club gets ambitious. Just weeks before it is recognized as a United Nations treaty organization, the International Solar Alliance announces a target to support setting up 1000 GW of solar energy capacity by 2030 across its member countries.

This initiative by India to harness the untapped resource of sunshine-rich countries between the Tropics of Cancer and Capricorn was backed by the France, and was launched at the Paris climate talks in 2015. Sixteen countries have ratified the framework agreement of the International Solar Alliance (ISA) and it will come into force on December 6, when it will recognized as a UN treaty body.

The ambitious target that will help move countries, especially developing countries, on a low carbon energy path was announced on the day that the United States touted the value of coal as a energy source at an official programme organized by the US government at the UN-sponsored climate talks. The bulk of the 121 countries that are located within the tropics are rich in solar resources despite which large sections of their populations have little or no access to energy. The Alliance aims to remedy this situation by offering cooperation for better technology diffusion, faster costs reductions, and sound policy lessons to partners of the coalition.

“The 1000 GW target has been set by the ISA. It will be met through projects that ISA will support under its various work programmes. This target does not take into account renewable energy targets or projects that countries are pursuing on their own as part of their national efforts,” said Anand Kumar, Secretary, Ministry of New and Renewable Energy The ISA is focused on identifying solutions that are locally appropriate and for difficult conditions, while remaining affordable.

The alliance is “bold global initiative” on which “our hope for a sustainable planet rests” as developing world works to life billions of its people into prosperity. In an effort to ensure faster difussion of solar energy especially in the poorest countries, India has called on the industrialised countries to earmark a percentage of Overseas Development Assistance towards solar energy projects in developing countries.

At the heart of ISA’s manadate is ensuring the successful take of efforts on the ground that furthering the adoption of solar energy. To this end, India which the brainchild behind the alliance suggested that Multilateral Development Banks and other financial institutions support solar projects through low-cost finance, and research & technology institutions worldwide try their utmost to bring the cost of solar power and storage within reach of all.

Source : ET Bureau, Nov 14, 2017

International Council on Large Electric Systems (CIGRE)

International Headquarters:

International Council on Large Electric Systems (CIGRE), 21 Rue d'Artois, 75008 Paris, France
Tel: **+33 1 53 89 12 90;** Fax: **+33 1 53 89 12 99**
Email of Secretary General: philippe.adam@cigre.org

Date of inception : CIGRE was founded in 1921 with its HQ at PARIS

Aims and Objectives:

CIGRE (International Council on Large Electric Systems) is one of the leading worldwide Organizations on Electric Power Systems, covering their technical, economic, environmental, organisational and regulatory aspects.

A permanent, non-governmental and non-profit International Association, based in France, CIGRE was founded in 1921 and aims to:

- Facilitate the exchange of information between engineering personnel and specialists in all countries and develop knowledge in power systems.
- Add value to the knowledge and information exchanged by synthesizing state-of-the-art world practices.
- Make managers, decision-makers and regulators aware of the synthesis of CIGRE's work, in the area of electric power.

More specifically, issues related to planning and operation of power systems, as well as design, construction, maintenance and disposal of HV equipment and plants are at the core of CIGRE's mission. Problems related to protection of power systems, telecontrol, telecommunication equipment and information systems are also part of CIGRE's area of concern.

Establishment of Indian Chapters:

CIGRE India was set up as society on 24.07.91 with CBIP as secretariat.

Membership:

(I) Collective Members (I) - (companies of industrial and commercial nature)

(II) Collective Members (II) - (Universities, Engineering Colleges,Technical Institutes and regulatory commission)

(III) Individual Members -

(In the engineering, teaching or research professions as well as of other professions involved in the industry (Lawyers, economists, regulators...)

(IV) Young Members (Below 35 Years of Age) -

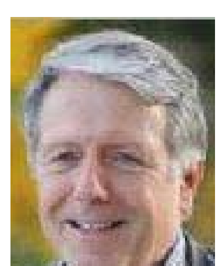
(In the engineering, teaching or research professions as well as of other professions involved in the industry (Lawyers, economists, regulators...)

CIGRE - HQ

President
Rob STEPHEN (SA)

Chairman TC
Mark WALDRON (UK)

Treasurer
Michel AUGONNET (FR)



Secretary General
Philippe ADAM (FR)

Distribution of Smiles

Irrigation

Healthcare facilities

Drinking water

Size: 17cm X 24cm Interpub