CIGRÉ INDIA Journal

ISSN : 2250-0081 (Print)
ISSN : 2250-009X (Online)

Vol. 10, No. 2 - July 2021 (Half Yearly Journal)

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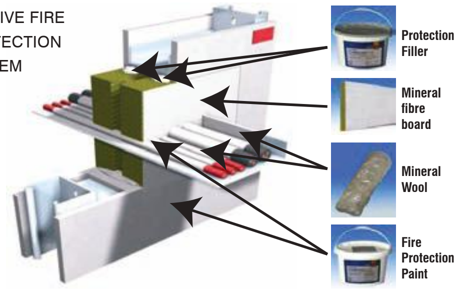

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CIGRE India Journal

Volume 10, No. 2 ***July 2021***

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Subscription Information 2021/ (2 issues)

Institutional subscription (Print & Online)	:	Rs. 900/US$75
Institutional subscription (Online only)	:	Rs. 600/US$50
Institutional subscription (Print only)	:	Rs. 600/US$50
Subscription for 10 Years (Print Only)	:	Rs. 5,000
Subscription for 10 Years (Online)	:	Rs. 5,000
Subscription for 10 Years (Print & Online)	:	Rs. 8,000

EDITOR'S NOTE

CIGRE the International Council on Large Electric Systems founded in 1921, is leading worldwide Organization on Electric Power Systems, covering technical, economic, environmental, organizational and regulatory aspects. It deals with all the main themes of electricity. CIGRE is the unique worldwide organization of its kind having 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. CIGRE achieves its objective through the 16 Study Committees, each consisting of about 30 members from different countries. India is 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. CIGRE AORC has been chaired by India during 2016-2018. Dr. Subir Sen, ED, POWERGRID was Chairman and Shri P.P. Wahi, Director, CIGRE India was Secretary of CIGRE AORC for two year during 2016-18. CIGRE (India) has been in the Administrative Council of CIGRE since 1970. It is a matter of pride that India recently in 2018 got seat in Steering Committee in 2018. CIGRE India functions as the National Committee, 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. CIGRE-India has regularly been making efforts to invite various CIGRE study committees and their working groups to hold their meeting in India. We in the recent past have already hosted SC D2 on Information and telecommunication in 2013; SC B4 on HVDC - in 2015 and SC B1 on HV Insulated cables in 2017 in India. In the Year 2019 we have hosted four Study Committees SC A1 on Rotating Electrical Machines in Sept. 2019 & SC A2; SC B2 & SC D1 on Transformers, Overhead Lines and Materials & test techniques respectively in Nov. 2019. This is done with the aim to provide opportunities to professional to exchange & share views / knowledge with international experts. We have already got approval from CIGRE to host Study Committee SC A3 on high voltage equipment's and B5 on Power System Protection in March 2021 and Oct. 2023 respectively.

CIGRE every two years holds its flagship event that CIGRE Session at Paris. There was excellent participation from India in CIGRE session 2018. For CIGRE Session 2020, CIGRE India forwarded 45 synopsis out of 240 received and 37 synopsis were approved by CIGRE. The Covid 2019 affected organisation of CIGRE session 2020, virtual session was organised by CIGRE, where these were 107 participants from India. For the session 2022 CIGRE India has forwarded 75 synopses from India for consideration.

The Membership of CIGRE from India is also on the rise and in the year 2018 we achieved membership count to 827 Nos. and the same was maintained for 2019. For 2020 total 800 members were registered as CIGRE Member from India.

In this present COVID-19 situation where skill enhancement and training of professional is emerged as an important aspect and a challenge, CIGRE- India held series of virtual Tutorials/ Workshops/ Webinars on the subject relevant to 16 CIGRE Study Committees, to further promote CIGRE in India and involve additional professional including New Generation / Young professionals with CIGRE. The reports of the virtual tutorials are included in this issue of journal.

We are bringing out this Journal on half yearly basis. The last issue was published in the month of January 2021.

This issue covers the useful statistical data and eight very informative and important technical articles on the subject of Cyber Security- Communication Infra in Power Utility; Manifestation Impact & Solution for Reliability, Stability & Flexibility of Rich Modern Power Grid; Experience on Improvement of Distribution Automation on 3G Mobile Network; Parametric Study of 500 MW subcritical Coal Power Plant with High Ash & Low Volatile Material; Enhancing Existing Transmission Line & Corridor capacities through Voltage Upgrade; Restricted Earth Fault Protection; Improving Specification of Transformers based on Operational Experience; and Challenges during replacement of Static Generator Relay Protection of Gas Turbine. I convey sincere thanks to the authors of these papers. On the demand of members, a Panel discussions was organized with the eminent Panel Members National & international, from Government; Industry\y and Academics on 28th July 2021 on the subject of "Tips for writing a Technical papers by Engineering professional for consideration at International Level. This Journal includes the Report & useful recommendations by Panel members.

I am also 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.

A.K. Dinkar
Secretary & Treasurer CIGRE India

Cyber Security -Communication Infra in Power Utility

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SUMMARY

Today's electric utilities are far more vulnerable to cyberattack than in the past. Their highly interconnected digital infrastructure enables real-time visibility in power system. Customer manage electricity consumption from their smartphones and deploys sophisticated tools for energy management. All this means that utilities are more and more exposed, to cyber-attacks /interventions as these features requires internet connectivity among utilities' and other stakeholders' IT networks.

Utilities must act definitively to minimize this risk, yet several challenges affect their ability to do so. Like continually evolving business and technology requirements, a widespread shortage of qualified personnel, additional risks associated with third-party connectivity, this becomes further critical as utility must ensure sensitisation & participation of the entire workforce in managing cybersecurity risks. The magnitude of these challenges is only amplified for small utilities, which lack the scale and resources of their larger peers.

Present Day scenario

Electric utilities are making a dramatic transition to intelligent digital networks. Today's Power business is complex with regulatory, and consumer requirements added with increasing trend of renewable and distributed energy generation, smart cities, and electric vehicles etc. As utilities introduce increasingly sophisticated technologies to their legacy systems to manage these complexities, they find themselves progressively more vulnerable to cyberattack.

Increasing Exposure

To make the transition, electric utilities are being compelled to allow data flow between IT and operational-technology (OT) networks. While IT systems are thought of as office systems, OT systems control the equipment that performs the utility's operation of generation transmission and distribution of power. These OT systems were once standalone, and their obscure proprietary protocols had made it difficult to access or control them from the outside world. Over the past two decades, the demand for integration of OT-generated data and IT data for various business and customer requirements is necessitated. Modern OT systems are built on software and hardware platforms that malicious actors know and understand. With so many devices linked to the network, its attack surface is exponentially greater as well: more devices mean more vulnerabilities – and more possible points of entry. Moreover, cyberwarfare is asymmetrical: attackers can succeed if they find even a single exploitable weakness, whereas defenders must protect all points of access from every possible attack.

Considering the all above factors the role of Cyber security is now not an allied but is one of the Key elements in automation systems of any Power Utility. This encompasses the entire business right from Generation (Conventional and non-conventional), Transmission and distribution. This Paper studies the challenges faced by Power utilities in different verticals of business. Paper also indicates how Tata Power is trying to overcome these challenges and mitigate the risks coming out of it. Thereby brings out striking out the balance between business needs and cyber security deployment.

Case Study:

We will also describe case study surfacing real life example at TATA POWER Mumbai implementation cyber security initiatives in following verticals.

(1) Transmission networks.

(2) Distribution networks.

(3) Renewables-Hydro.

1. INTRODUCTION

TATA Power is India's largest Integrated Power company. Tata Power Mumbai Operations area constitutes of transmission and distribution business. The Operations are centrally controlled using communication WAN spread across 35+ locations. In the present paper we will bring out the cyber security initiatives taken up by TATA POWER in Mumbai Transmission and Distribution communication networks. The Power system operations i.e. monitoring, and control of the power systems Transmission and distribution energy grids are done centrally from a central control room. These operations are done through SCADA (Supervisory Control and Data Acquisition) systems are based on Communication WAN which is based on own fibre optic network. These Communication WAN based on TCP/IP Layer 3 stack-based switches is spread across Mumbai and Hydro's.

The system is interconnected at different points to the following interconnections;

(a) Enterprise IT network.

(b) Other State Utilities like MSEB and BEST.

(c) Telecom Service Providers.

Till date firewall was the only solution deployed for achieving controlled access to devices across automation network.

2. TATA POWER AUTOMATION WAN WITH FIREWALLS

TATA Power Automation WAN is based on L3 switches spread across all Transmission and Generating substations. These Switches are interconnected on own fibre optic backbone through owned OPGW network.

Figure A shows the sample schematic of the TATA POWER Automation WAN. Here each of the node indicates the Transmission station spread across Mumbai. The interconnection points are shown to be interconnected via the Firewalls.

The interconnected points are shown through firewall mainly for the following applications.

(1) Exchange of Realtime operational parameters with other state utilities.

(2) Transfer of Operational data to Management Information Systems (MIS).

(3) Telecom service provider for connectivity to field devices where TATA Power own network is unavailable.

3. CYBER SECURITY ASPECTS IN EARLIER DEPLOYMENT

The network shown in Figure A is heavily dependent on quarantining of threats with the help of firewalls deployed across the network perimeter. Thus, these firewalls were the only line of defence any external intrusion happening on the automation WAN.

Drawbacks of existing Network:

(a) The existing network setup with firewalls depend for security only on the firewalls.

(b) Only external threats and know threats will be mitigated if detected in firewall.

(c) Internal threats are not easily detectable, and they can go ahead and create potential threat to the system.

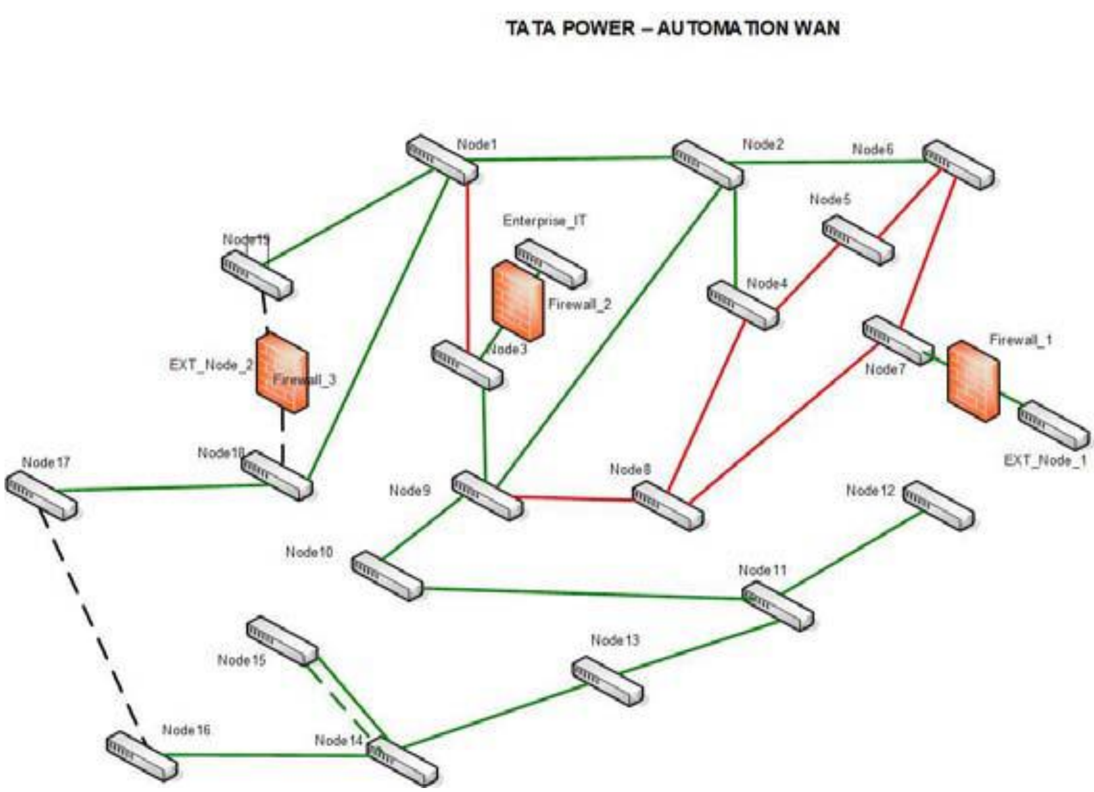

Fig. : A

(d) No monitoring of real time logs of the breach condition if any occurring in the overall network is available.

(e) No control on internal traffic as to any engineer /user could have network access even to other networks SCADA engineer could have access to Protection Devices or Distribution systems could access other networks.

(f) Access on network through open ports.

4. METHODOLOGY ADOPTED

A step approach was adopted to address issues related to cyber security through the below mentioned steps.

(A) Measures that can be internally adopted with no/ minimum investment.

- Identification of all the critical assets to be protected.
- Blocking of unused ports across all communication L3 switches.
- Data gathering from all stake holders for the authenticated and required access of networks as per business requirements.
- Patch upgrades on network switches.

(B) Measures that require extensive network modification and substantial CAPEX investment.

- These measures involved replacing of all existing firewalls with Next Generation Firewalls.
- Implementation of Network revamp with replacement of all non-supported equipment's.

5. ACCESS LIST

An ACL or Access control list is a common means by which access to and denial of services is controlled. On network devices such as Layer -3 Switches, Routers and firewalls, they act as filters for network traffic, packet storms, services and host access. Most of these devices come with standard or default ACL and allow for custom ACL's. In Tata Power stations, Access list technique involved configurations in L3 switches to define IP address and each IP address can be configured to have controlled access to another IP address / addresses Thus access control can be defined for the IP addresses which are routed through the Layer -3 switches. In simple terms source destination IPs will be specified for access and all others will be blocked. Detailed access list template was made and circulated to all stake holders including Transmission, Transmission SCADA, and Distribution SCADA and testing.

6. ACCESS LIST CATEGORIES IMPLEMENTED

(a) External access

External network access from network other than OT networks and relevant Enterprise IT network was blocked completely.

(b) DSS (Distribution Substation SCADA) to Transmission SCADA:

- Distribution station to Transmission station network access to be blocked i.e. no access from DSS SCADA to RSS (Receiving Sub Station) SCADA and vice-versa.
- Distribution station to Distribution station network access to be blocked i.e. no access from One DSS to Other DSS.
- Consumer Substation to other Consumer substation access to be blocked.
- Consumer Substation to other Distribution substation access to be blocked.

(c) Within Transmission SCADA

Access for remote maintenance for SCADA engineers will be given from identified machines through which only access will be permitted to all other nodes for maintenance.

- Access from one receiving station SCADA to other receiving station SCADA to be disallowed.
- Access from receiving station RTU's and IEDs to nodal server be blocked.
- Allow access from receiving station gateways to Nodal servers.
- Disallow access from receiving station protection IED's, RTU's to other station SCADA.
- Block access from CCR SCADA, PSCC (Power Systems Control Center) SCADA to station level protection IED, RTU at station.
- Allow access from nodal to CCR, PSCC and PSCC to CCR.

(d) Metering Services

- Disallow access from metering servers to transmission and distribution SCADA.
- Allow traffic from Metering MOXAS devices to metering servers.
- Disallow traffic from Metering Moxas to other networks.
- Disallow traffic from PQM meters, PQM server to Transmission SCADA network.
- Disallow traffic from PQM server to Distribution SCADA.

(e) Protection Services

- Disallow access from Protection IEDs from one Station to Protection IED's to another station protection IED.

- Allow access from DRPC machine to central relay setting machine.
- Disallow access from Protection IED to any machine in automation WAN.

7. CONCLUSION AND LEARNINGS:

- Cyber security is not a one day or period defined activity. It is a continuous journey.
- It is imperative that all stake holders should be taken in confidence and knowledge sharing sessions be taken before the deployment of such measures.
- Regular and time bound network audits to be carried out to have view into the network abnormalities and for any threats.
- Firmware upgrade and patch updates should be done on regular basis as and when new patches are released.
- No open port access should be allowed, and all open ports should be administratively blocked.
- Recovery plan in case of vulnerabilities to kept ready for utilisation.
- High tech solutions are not the only ones which can solve the cyber security problems, but the intent and behavioural modelling of all stake holders is required for any such initiative to be a success.

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(a) TATA POWER internal System Documentation: Access List concept note and Cyber security implementation across OT networks.

(b) Allied Telesis switching technical documentation.

(c) Internal study report on OT Cyber security.

(d) TATA POWER OT Network Architecture.

ABBREVIATIONS

Sr.No	Abbreviation	Expansion
1	IT	Information Technology
2	OT	Operational Technology
3	SCADA	Supervisory Control And Data Acquisition
4	RSS	Receiving Sub Station.
5	DSS	Distribution Sub Station.
6	PSCC	Power System Control Centre.
7	PQM	Power Quality Monitoring.
8	RTU	Remote Terminal Unit
9	IED	Intelligent Electronic Device
10	CCR	Centralised Control Room.
11	DRPC	Distribution Recorder PC.

System strength – Manifestations, Impacts and Solutions for Reliability, Stability and Flexibility of RE Rich Modern Power Grid

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N.M. SHETH[2]

INTRODUCTION

The term system strength has emerged in recent years due to significant impact on electrical power grid as a result of rapid uptake of inverter based generations. In broader definition, system strength is an "Umbrella of terms that refers to suite of interrelated factors which together contribute to power system stability. It reflects the sensitivity of power system variables to disturbance and indicate inherent local system robustness. System strength affects the stability and dynamics of generating system, control system and ability of power system to both remain stable under normal condition and return to steady state condition following disturbance." Thus, the term system strength encompasses a broad range of issues and their implications on Power system stability, Protection system operation and Quality of power supply.

C0ncerns regarding system strength, its manifestations and emerging solutions are evolving topics and area of focus across the RE rich countries. Lot of study and research are going on and as a result many new concepts and technology are coming out time to time. It is mandetory to keep pace with the technological developments, solutions to these challenges and implementation aspects for seamless transition towards RE rich modern grid. All these aspects need to be looked into for system evaluation, planning, operation and monitoring. In this context an attempt is made in continuation to our previous article regarding "Utility roadmap with respect to system strength aspect" (Jan-21 edition) to discuss further developments with insight to better practices.

Unlike previous article, which was much focused towards key indices, its monitoring & compliance, system strength parameters of the grid etc. this article is covers detailed insight to IBG characteristics and its interactions along with resultant manifestations and solutions as a leap forward in system strength domain.

1. TYPES OF GENERATING TECHNOLOGY

In interconnected scenario, to keep all plant in synchronism as well as to maintain stable control of voltage and frequency depends on interactions between characteristics of the network and that of connected plant. Thus, characteristics of power generating plant i.e. generating technology has significant impact on strength of the power system. Fundamentally generating technology can be classified into synchronous and asynchronous plant (Fig.1).

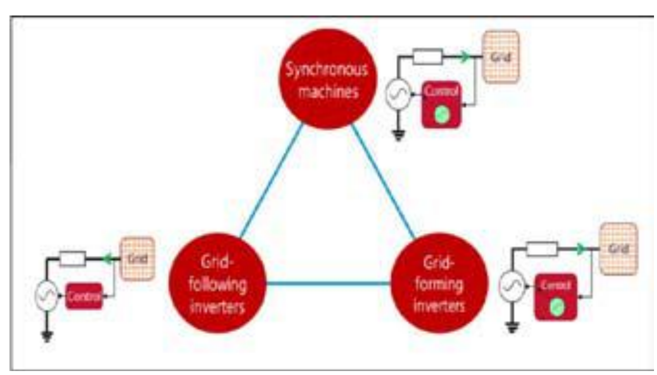

Fig. 1 : Classification of Generation technology from system strength perspective

1. I/C Superintending Engineer, Gujarat Energy Transmission Corporation Limited

2. Executive Engineer, Gujarat Energy Transmission Corporation Limited

Synchronous plants consist traditional synchronous machine as well as synchronous condensers. This technology has been around for many decades and generally offers simple and predictable response. The power system developed over the past century and still relied upon heavily today with this technology as base.

Asynchronous plant covers rest of the technologies generally termed as Inverter based generation (IBG). Another important difference between synchronous generation and inverter based generation is more tightly controlled, sophisticated non-linear response in IBGs which is further subdivided in to Grid-following (traditional) and emerging solutions which utilise Grid-forming concept within inverter control.

Unlike synchronous generators, IBG need sufficient system strength to operate in stable manner. Majority IBGs today are grid-following type. They are coupled with controlled inverters that typically relied on phased-locked loop (PLL) to stay synchronised to the fundamental component of voltage waveform and control the phase of output current to inject active and reactive power to the network. During system faults, the supressed voltage magnitude and distorted waveform can lead to these inverters loosing synchronism which presents challenges when attempting to rapidly recover after fault clearance.

Challenges are likely to be experienced as a function of Short Circuit Ratio (SCR) at point of interconnection. This is characterised as SCR POI Vs SCR Inverter (Fig.2) with its impact.

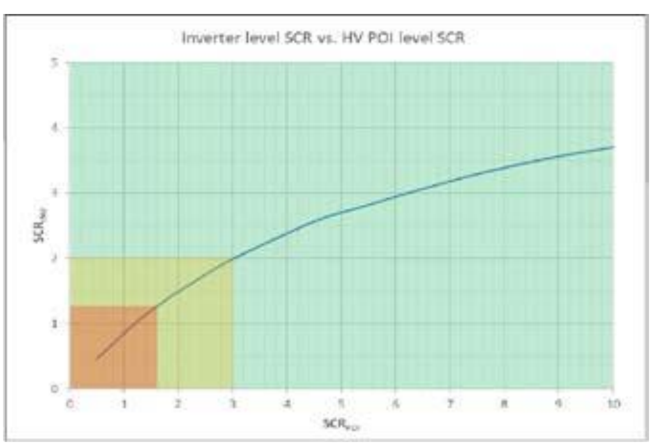

Fig. 2 : Impact of range of system strength on complexity of IBG connection

Challenges area characterised in three parts as under.

Green Zone :

1. Standalone tuning of IBG alone is sufficient to achieve satisfactory outcomes.
2. Standard control parameters are likely to work.

Yellow Zone :

1. Standalone tuning of IBG alone is not sufficient due to increased risk of interactions with other nearby IBGs.
2. Site specific control system tuning is likely to be required.

Orange zone:

1. Control system tuning by itself may not be sufficient.
2. Additional equipment such as Synchronous condensers, Grid forming inverters are likely to be required to achieve acceptable outcome.

This is a very good scanning tool for power grid and accordingly with due analysis IBG connected buses should be segregated in different zones to plan remedial measures instead of directly considering system upgrade of providing new equipments.

Thus, strength of the power system and the support provided by nearby synchronous machines and interconnecting lines is not the only factor that determines IBG stability. Design and tuning of control system in IBGs has equally important role to play.

It is general consideration that, synchronous generation and grid-forming inverters are often solutions for low system strength operating condition. But, it is not prudent to consider any of the technology type as solution for system strength problem without analysing symptoms of system strength and under laying cause. It is also misunderstood that, grid following inverters always adversely impact system strength. It is not the real scenario. Actually, inverter control system plays a significant part in achieving desired outcome and can also support the system strength case to case basis.

To address the issues faced by traditional IBGs under low system strength conditions, in recent years, emerging technology as "Grid-forming inverter" is being area of focus across the RE rich countries. The fundamental concept is to emulate the desirable characteristics of synchronous machine as close as possible using inverter based generation technology.

2. FACTORS INFLUENCING SYSTEM STRENGTH:

Three main factors influencing system strength includes Density, Scarcity and Sparsity (Fig.3) as covered hereunder.

a. Density of Inverter based generation:

The concentration of multiple IBGs in close electrical proximity of each other

b. Scarcity of Synchronous generation:

The lack of sufficient on line synchronous machine support due to either despatch scenario or retirement/ obsolesce.

c. Sparsity of the Network:

It reflects the electrical remoteness of the area in which IBGs are connected i.e. how far from major generation and load centres and how meshed the network area which interconnects them.

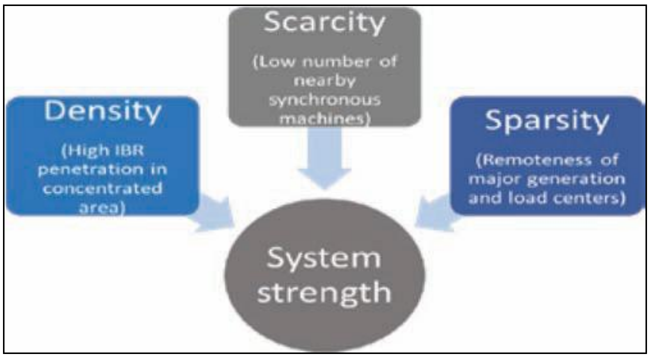

Fig. 3 : Factors influencing system strength

For density perspective, either total MW output or total MVA of on line inverters can be used. The materiality difference is shown with post disturbance voltage oscillation udder two different condition; (i) Reduced Nos of inverters, (ii) Reducing MW output of inverters with all inverter on line for same MW output (Fig.4).

Thus with reduced Nos of inverter on line results in a substantial reduction in levels of oscillations whereas reducing total MW output only helps marginally. This reveals that, inverter itself has its own susceptibility to low system strength conditions and having more Nos of inverters on line means less stable response. This is another very important operational condition consideration whenever situation demands to minimise the impact of low system strength aspects on the grid.

3. MANIFESTATION

The three aspects most closely related to system strength are stability, power quality and protection coordination. Out of these three aspects, stability issues are being widely discussed. However, impact of low system strength on power quality, protection and interrelationship between these aspects are less discussed. The interrelationship between these aspects becomes more pronounced when system strength declines.

Stability

The most common issue for IBGs under low system strength condition is inability to ride through the network faults. Another significance issue is unstable oscillations at point of interconnection of IBG which would have been classified as small signal oscillatory behaviour in normal condition. Area of lower system strength experiences further decline in system strength. The growing voltage oscillations due to this may result in disconnection of IBG (Fig. 5).

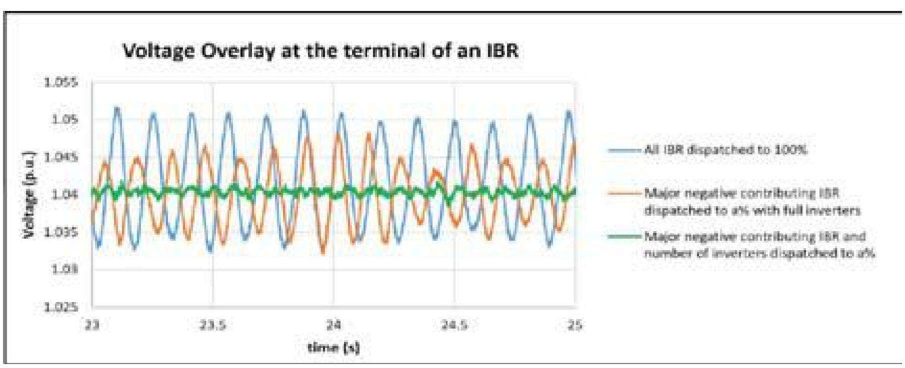

Fig. 4 : Reduced Nos of inverters Vs Reduced MW output with all inverter online

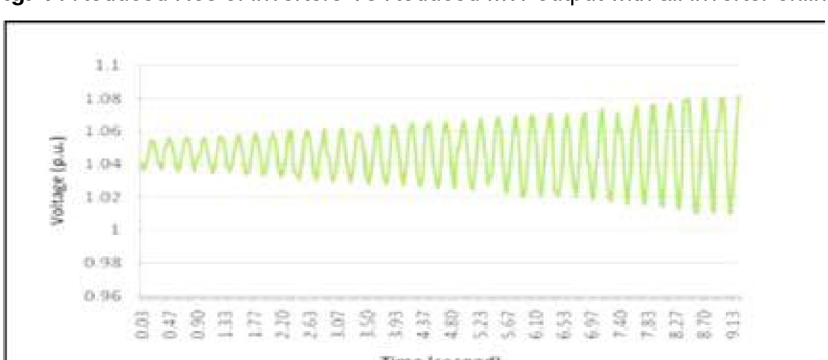

Fig. 5 : Unstable oscillations

Another common manifestation is sustained oscillations after a fault which would not have been there if system strength is sufficient and there are no IBGs. (Fig. 6).

Power Quality

Inverters can generate sub and super synchronous harmonics including harmonics of several KHz. This results in adverse interaction of undesirable current component. Such currents how small may excite "Network resonant frequencies" which further develops into permanent voltage distortion or excessive temporary over voltage. Here power quality and stability issues become intertwined and may lead to plant disconnection as a result of such interactions.

Another possibility of harmonic susceptibility in low system strength condition is generation of temporary over voltage due to transformer energization is represented (Fig.7).

Protection:

Increased penetration of IBGs is creating major impact on power system protection as the fundamental principles on which protection system is designed gets defeated. The key defeating attributes are;

(a) The fault current provided by SGs is of high magnitude and largely defined by electrical parameters of the source whereas in case of IBG fault current is around 1.0 to 1.2 p.u. and highly dependent on control

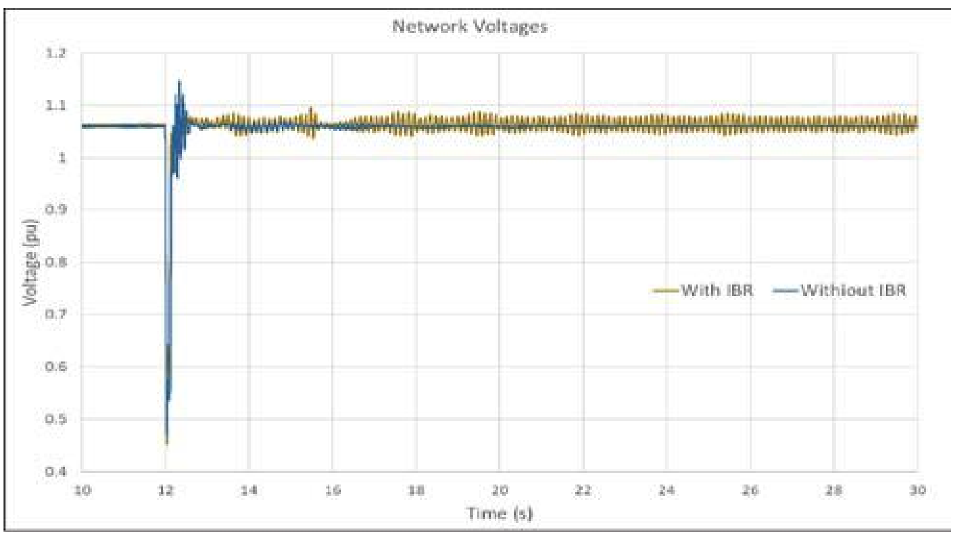

Fig. 6 : Voltage oscillations under low system strength condition with and without IBGs

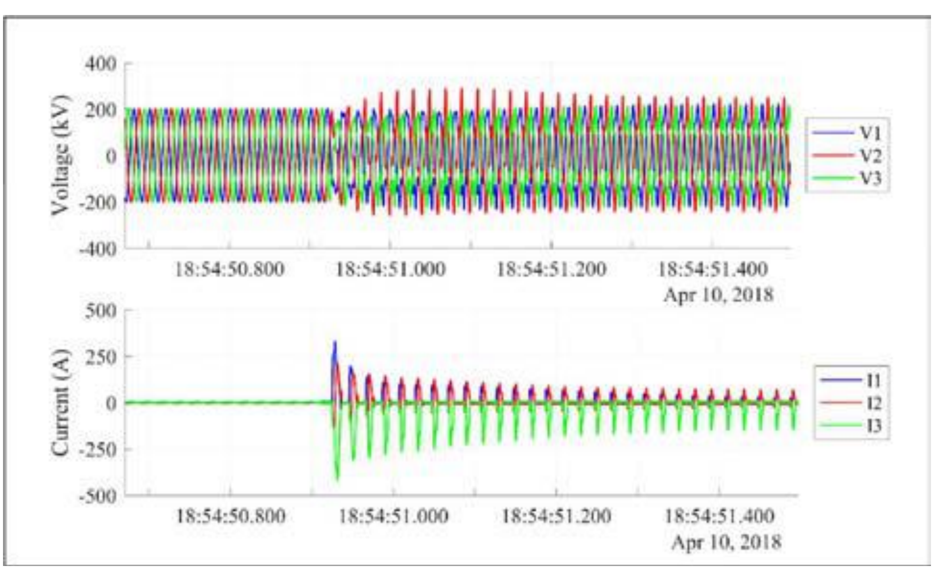

Fig. 7 : Transformer energization under low system strength condition

system design of IBGs (inverter / wind turbine), (Fig. 8).

(b) Negative sequence current characteristics of IBGs are quite different than that of synchronous generation. Negative sequence contribution from IBGs are significantly smaller and phase angle is also different than synchronous generation dominant system Even different wind turbines have different characteristics for V2 & I2 (Fig.9).

(c) The protection which could be adversely impacted due to low system strength is impedance based protection i.e. distance protection. Some of the adverse impact on distance protection are;

1. Reduced system inertia leads higher rate of change of swing impedance. This may mal operate power sing blocking and result in unintended tripping (Fig.10).
2. Out of step tripping detects unstable power swing using impedance trajectory, here again with increased rate of change of swing impedance, stable swing may be mistakenly considered as unstable swing and partitioning of power system (Fig.11).

d. Further complexities for Distance protection are like (i) Change in apparent impedance seen by relay – Fluctuation in wind speed causes variations in voltage level at local buses, ii) Reach issues – Crowbar protection offers different value of fault current or rather limits the fault current for certain period, iii) High impedance fault scenario – In case of 3-Ph fault with DFIG connected system, crowbar and rotor winding resistance in combine offer high impedance and make it difficult to detect, iv) Directionality detection – Most of the modern relays

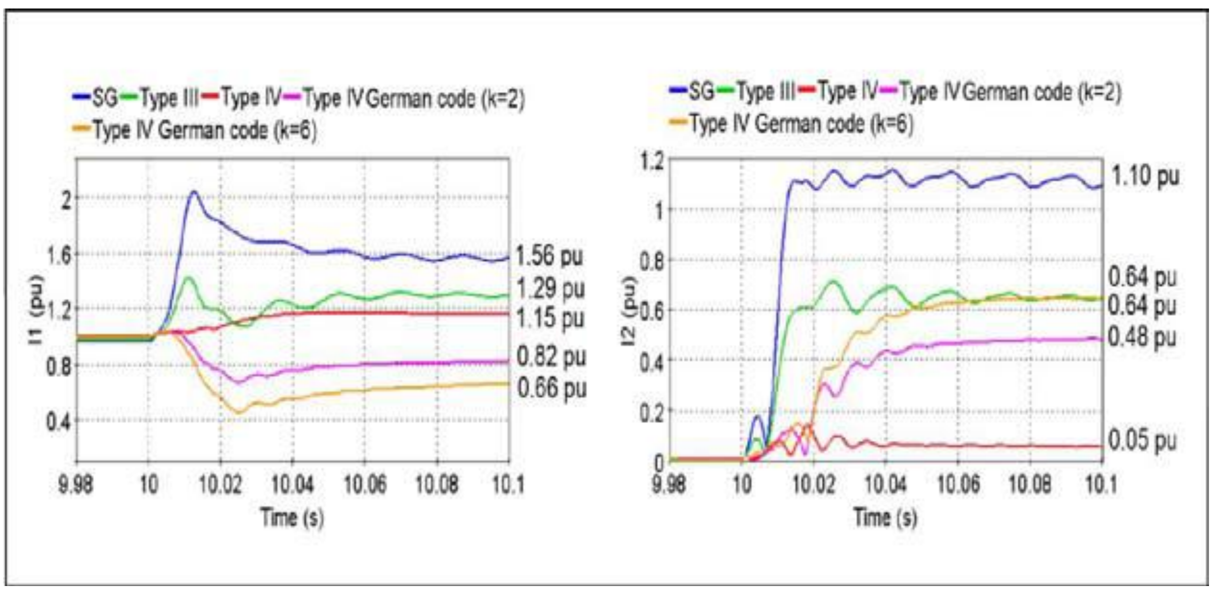

Fig. 8 : Comparison of I1 and I2 fault current contribution of different generator type

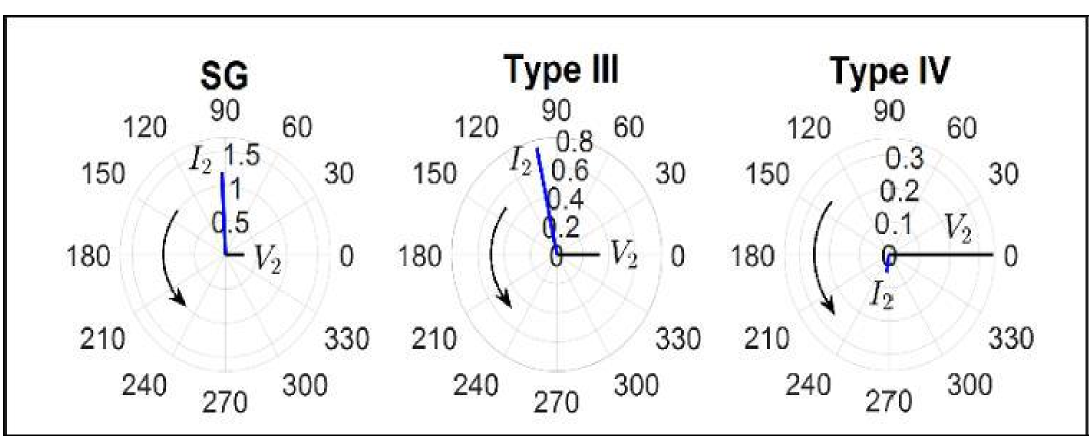

Fig. 9 : Comparison of negative sequence characteristics of different generator type

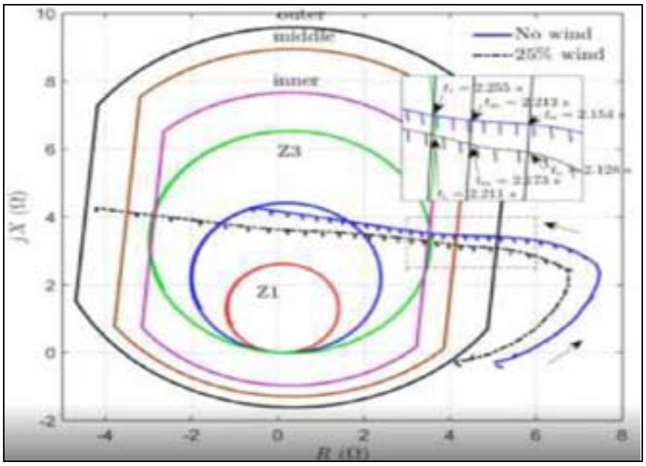

Fig. 10 : Low system strength and inertia impact on Power swing

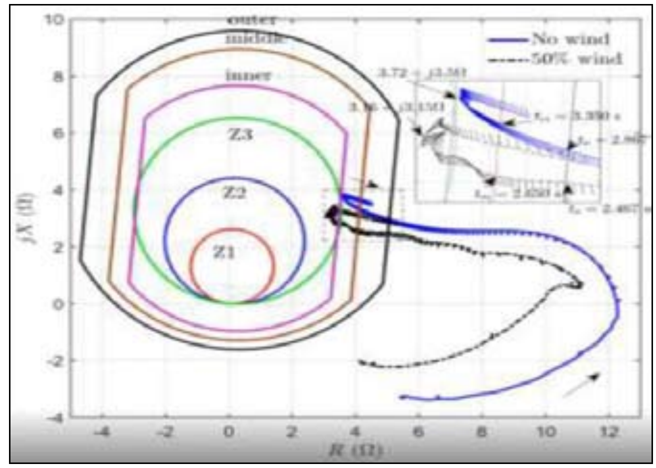

Fig. 11 : Low system strength and inertia impact on Out of step protection

use negative sequence components as I2 leads V2 @90 to 92 deg during fault in forward direction for synchronous generation dominant system. But, IBGs do not contribute for negative sequence and hence directionality detection may get hampered etc.

(e) In case of distribution system, protection is dominated by Non-Directional Over current protection considering radial network, leading to impacts like; (i) Blinding of protection – Due to reduced fault current in case of feeding through RE, (ii) False or Sympathetic tripping – Unwanted tripping in case of fault in adjacent feeder, (iii) Loss of coordination – Due to sequential false operation, (iv) Unwanted islanding of RE – Non coordinated tripping due to other element fault may lead to unstable operation etc.

4. SOLUTIONS

As system strength is a complex set of problems there is no one stop solution for the problem. Actually, as discussed earlier in this article that first symptoms and underlying cause needs to be distinguished to apply remediation activities and then optimum location of the remediation. However, some of the better practices by RE rich countries are discussed which seems important in either retaining available system strength or building sufficient system strength.

Synchronous condenser

Synchronous condenser are generally effective means of improving system strength due to inherent characteristics like; Inertia due to rotating heavy mass, Dynamic reactive power compensation, Ride through capabilities, Excellent short circuit support, Inherent stabilizing response etc.

There are many references worldwide for successful and effective implementation of synchronous condensers in RE rich grids.

Being effective solution, application of synchronous condenser is evaluated for highest IBG penetrated area of GETCO grid which is at the western coast and at extreme end of the grid (means weaker part of the grid) for improvement in SCR and inertial aspects. It is observed that, 135 MVAR synchronous condenser (with flywheel) is enhancing SCR to 8.69 from 3.69 (132kV Bhatia), CSCR to 8.9 from 6.04, and WSCR to 5.53 from 4.55 respectively (Fig. 12).

Also, addition of Inertia @ 1.2 GW*sec in the system. These are really encouraging results. Synchronous condensers generally provide necessary short circuit power for IBGs, however if not carefully designed they may introduce their own issue if small and low inertia synchronous condensers are used in remote part of the network.

Advanced grid following inverters

Along with higher cost, synchronous condensers need considerable lead time for design, installation and commissioning. In this regard, solution involving modifications in control system of existing assets e.g. tuning of inverter control system should also be considered by comparing relative technical and economical merits and solution to the problem.

Impact of advanced grid following inverter's tuning for inverter control system has significant impact on post disturbance oscillations (Fig.13).

Comparison demonstrates that design and tuning of inverter control system plays a key role on its performance in low system strength condition. Tuning according to grid condition is also very important in achieving desired supportive response (Fig.14)

Sr. No	Wind Farm	GETCO Grid Substation	SC MVA	Connected IBG (MW)	SCR
1	Lamba	132kV Bhatia	998	22.5	3.69
	Navdra			21.6	
	Bhogat			204.06	
	Gandhavi			22.10	
2	Patelka	66kV Kalyanpur	311	17.37	17.89
3	Vasai	66kV Varvala	475	30.78	15.44
4	Mota Gunda	132kV Bhomiyavadar	738	119.7	6.16
5	Kobavadar	66kV Goinj	173	70	2.47
6	Bhatel	132kV Khambhaliya	933	50.6	18.43
CSCR = 6.04			WSCR = 4.53		

(a) System strength parameters without Syn. condenser

Sr. No	Wind Farm	GETCO Grid Substation	SC MVA	Connected IBG (MW)	SCR
1	Lamba	132kV Bhatia	998+ 1350 (Syn. con)	22.5	8.69
	Navdra			21.6	
	Bhogat			204.06	
	Gandhavi			22.10	
2	Patelka	66kV Kalyanpur	311	17.37	17.89
3	Vasai	66kV Varvala	475	30.78	15.44
4	Mota Gunda	132kV Bhomiyavadar	738	119.7	6.16
5	Kobavadar	66kV Goinj	173	70	2.47
6	Bhatel	132kV Khambhaliya	933	50.6	18.43
CSCR = 8.9			WSCR = 5.53		

(b) System strength parameters with Syn. condenser

Fig.12 : Improvement in SCR Matrix in weaker part of the grid

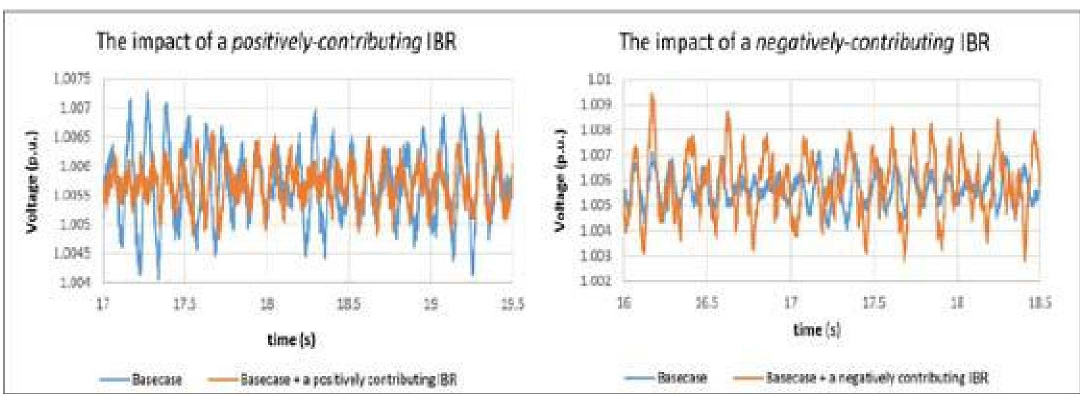

Fig.13 : Impact of tuning of inverter control

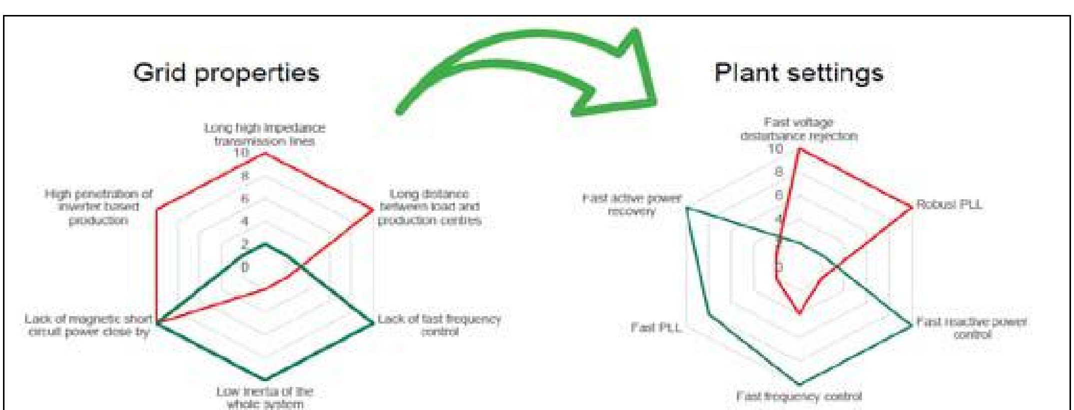

Fig.14 : Tuning of plant controller according to system condition

Modifications of controllers on existing network assets

Networks with FACT devices has another option of opting modification in control system tuning to minimize the impact of low system strength condition. Revised SVC control tuning practically eliminates post disturbance voltage oscillations (Fig.15).

Advanced grid forming inverters

Advanced grid forming inverters (in the form of virtual synchronous machine) can provide positive system strength contribution.

Early generation grid forming inverters are known as voltage source inverters or voltage controlled inverters. This type of inverter does not rely on PLL as they are capable of generating their own voltage waveform including during FRT operation. But, the challenge is that they do not operate effectively in parallel with other voltage source e.g. synchronous machines or a broader grid.

Current generation grid forming inverters generally follow one of the following design principles.

1. Droop
2. Virtual synchronous machine (VSM)
3. Virtual oscillator controllers (VOC)

VSM inverters exhibits characteristics like synchronous machines during both steady and dynamic condition. Also it enables advanced performance in stand-alone as well as parallel operations. Key attributes of VSM inverter are;

1. As it always operates as voltage source, which enables seamless transition into and out of islanded operation for delivering system security support.
2. Allows tuning and flexibility at POI for effective integration to grid.
3. Several services can be exhibited like;
   (a) Virtual inertia
   (b) System strength
   (c) Seamless islanding
   (d) Back start
   (e) Fast frequency response

However, as on date technology is evolving and not matured enough for detailed comparison of all three types.

Protection System

In case of distribution system, some of the solutions which seems adoptable in prevailing scenario are like; (i) Directional Over current protection, (ii) Voltage based protection scheme at PCC with relatively stronger buses, (iii) Distance protection at specific locations to overcome false tripping of over current protection etc.

In case of transmission system, some of the solutions with prevailing technology are like; (i) Adaptive distance protection scheme by utilizing phasor data of IBG end, (ii) Modifications in Power swing and Out of step setting philosophies – Reducing the PSB time delay or middle blinder closer to inner blinder etc. (based on system study), (iii) Line Differential scheme – To minimize the impact of impedance trajectory, (iv) Travelling wave based protection schemes - Being independent of phasor magnitudes etc.

Upgradation in protection system should be backed by thorough simulation study and analysis of real time challenges.

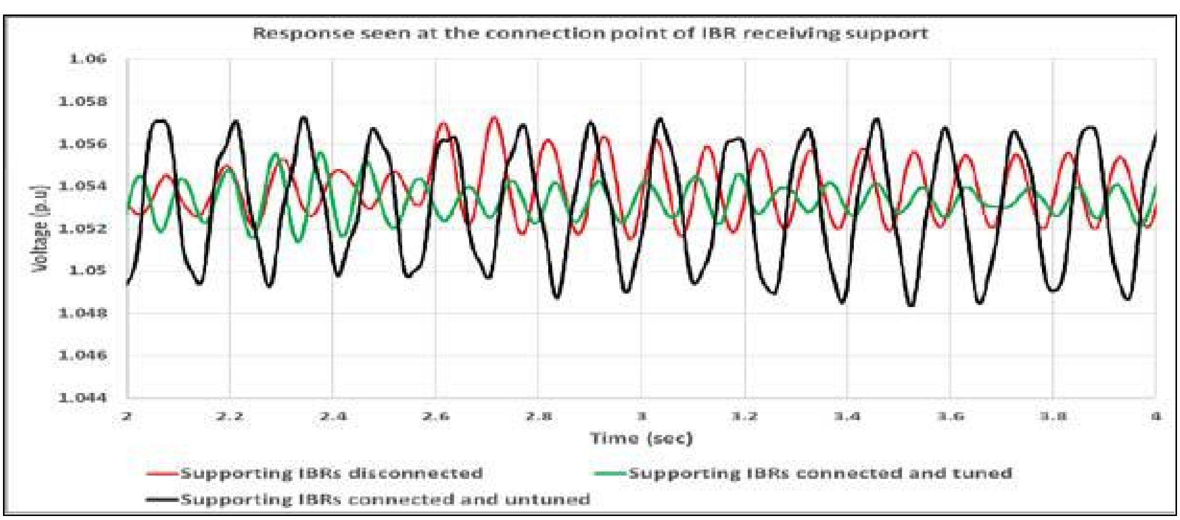

Fig.15 : Impact of SVC control system tuning on post fault voltage oscillations

Overview of some of the better practices

Low system strength may also cause wide area oscillation, deeper voltage dip, wide voltage sag propagation and slower voltage recovery following a contingency event which may increase the risk of cascade failure. To maintain sufficient system strength under new dynamics of power system, RE rich countries are adopting some better practices as discussed.

1. "Do not harm principle"

   The continuously changing generation mix necessitates the consideration of adverse system strength impact from any newly connected generator. The retirement/displacement of SGs and entry of new IBG reduces SCR or available fault level for adjacent IBG. Thus reducing the ability of IBG to ride through the disturbance. Hence, many countries have introduced a requirement of new generator via fault level rule to "Do not ham" the operational security of the power system and nearby generator.

2. Quantification of system strength by specifying synchronous fault level at important nodes of the network

   This another method of retaining fault level i.e. system strength. Fault level nodes are being determined by level of impact on global and local system strength. Likely locations for grid point of view should be; (i) Load centres, (ii) Synchronous generation centres, (iii) Areas with high IBGs, (iv) Area electrically remote from synchronous generator, (v) Some key nodes of the grid.

5. TAKEAWAY

Changing power system dynamics and generation mix compels utility to look power system in new way with respect to analysis, planning, monitoring and remedial measures. There is a need to have paradigm shift in present practices to really arrive at the system strength problems if exist and remedial measure case to case basis. Study and analysis of performance as well as behaviour of IBGs and their control interactions with nearby plants is key to plan remedial measures.

Before considering high cost system upgrade, first possible solution through modification in inverter control setting should be evaluated for various operating scenarios. Evolving concept of "Do not harm" principle as well as maintaining synchronous fault level at important nodes of the grid seems very much useful in context to maintaining required system strength.

In Indian grid context, analysis of the grid and thereby identifying critical areas with respect to system strength is the first and foremost requirement. On the basis of above analysis symptoms of undelaying cause should be identified to plan the remedial measures. The concepts presented in the article seems useful in paving the way forward.

It is evident that, there is no one stop solution to the system strength aspects. Continuous analysis and monitoring of power system is necessary for understanding emerging needs and related solutions. In this context, an attempt is made in continuation to our previous article (Jan-21 edition) to support the journey of Indian power system towards greener grid.

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(a) How lack of system strength can create issues

(b) Tools and techniques for analysing low system strength operating condition

(c) Design planning and Operational requirements under low system strength condition

(d) Current and prospective system strength solutions

(e) Advanced control strategies to better cope with weak grid situation

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Presently working in Engineering department and responsible for Design & Engineering of Control, Protection, Automation, schemes & Philosophies, Digital substation, Secondary engineering as well as RE integration related domains.

Presented several technical papers at various national and international conferences CIGRE, GRIDTECH, CBIP, POWERLINE etc. on Relay protection, Substation Automation, Digital Substation and RE Integration challenges related matter. One of the contributor from GETCO to review Draft Grid code standards and suggesting some of the additional Technical requirement in context to RE integration challenges.

Member of distinguished organization committees like; i) BIS Relay committee ETD 35, ii) 35 th RAC Committee ERDA, ii) Substation Automation Expert Group of CBIP and Cigre India iv) R&D consortium of National Institute of Wind Energy (NIWE).

Tata Power's Experience on Improvement of Distribution Automation on 3G Mobile Network

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SUMMARY

Public mobile network is widely used option for connecting field RTU devices located at Consumer Substation. However, maintaining the communication availability of FRTU connectivity through mobile network becomes a challenge as the availability of mobile data service depends on various factors such as network signal at CSS location, number of users sharing of cell site resource, reliability of backhaul link, application characteristic of traffic etc.

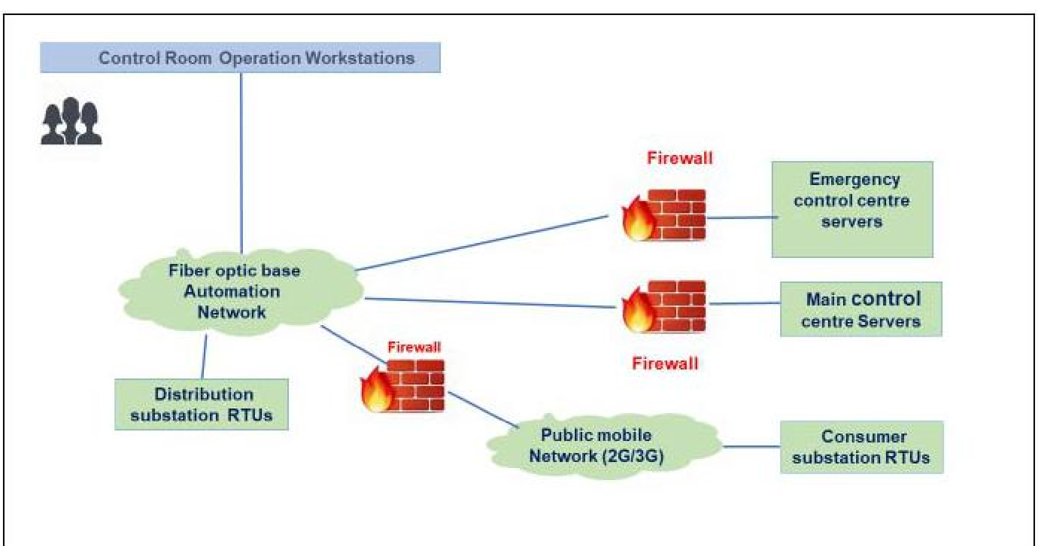
This Paper contains various technical solution used for improvement of communication availability from 92% to 97%. The technical solution included tuning of application protocol parameter to suit the latency and bandwidth constraint on 3G channel, Improvement of network signal strength using RF solutions, improve the performance of modem devices, backing up critical backhaul links. The Paper also covers practical experience on use of the data services of public mobile network for Distribution automation of electric operation at Consumer Substation which helps to improve reliability indices as per regulatory guidelines. It also discusses the problems of field devices and the probable solutions of the same.

***Keywords** : Distribution management System (DMS); Remote Terminal Unit (RTU); IEC 60870-5-104 protocol; Public Mobile Network*

1. INTRODUCTION

Distribution Automation System plays vital role as it is essential for any Power Distribution Utility to provide uninterrupted supply to consumers. However, it is highly inevitable to prevent electrical network from fault. Hence, it is a big challenge for any utility to minimize the downtime whenever the fault occurs thereby increasing the reliability and customer satisfaction.

The existing Distribution network of Tata Power in Mumbai area consist of 32 Nos. Of Distribution Station (DSS) and 980 Nos of consumer substations (CSS). This network is operated on 11kV, 22kV, 33 kV voltage level. Out of 980 consumer station, 480 substations are automated. These 480 nos consumer substation are automated through data services of public mobile network (2G/3G). The high level system architecture is as shown in below.



SYSTEM ARCHITECTURE

Since Consumer stations are spread across the Mumbai area it is not feasible to connect Consumer stations on wired connection such as fiber network. The public mobile network also offers advantage of having lowest initial investment and recurring cost. It also enabled faster deployment of distribution network automation.

However, mobile network has some inherent limitations on availability of data service connectivity as it is primarily designed for public service usage like voice communication and internet connectivity. It poses a technical challenge to improve and maintain the high availability of RTU connectivity.

This Paper discusses the limitations of mobile network-based connectivity for automation of substation. It shares analysis carried out on performance data of distribution automation system over a period and reasons of failure. It contains various technical solution such as tuning of application protocol parameters, improve the signal quality by RF solution, improving the performance of 3G/2G modem, deploying redundancy for critical component, providing reliable battery solution and following best maintenance practices. As experienced, these measures have significantly improved overall performance of distribution automation system availability and command success rate.

2. PUBLIC MOBILE NETWORK LIMITATIONS

The public mobile network, being a wireless network, the data connectivity performance depends very much on the signal strength at site. The network has strong signal strength in some area and weak coverage in other. The strength of the signal also depends very much on weather condition.

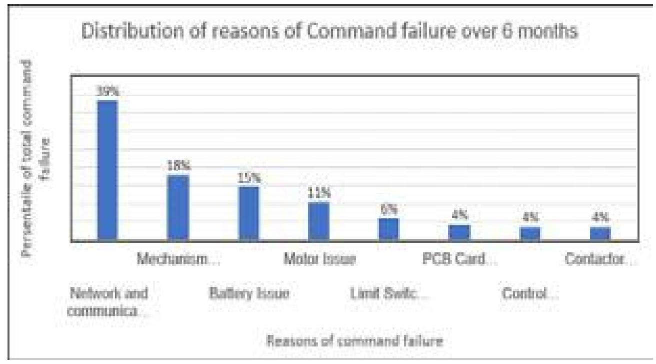
The data channel per cellular site is limited resource and hence bandwidth and latency time response of the data connectivity depends on the number of consumers connected to cellular site at that point of time. These two-performance parameters are dynamic and varies throughout the daytime.

Also, Technology life cycle for mobile network is 5 to 6 years. This forces utility for early replacement of modem devices.

3. PERFORMANCE MONITORING OF RTU CONNECTIVITY AND ANALYSIS:

Central monitoring of cellular data connectivity to RTU plays important role in analysing the reasons of failure of automation connectivity. Daily report is designed to capture the offline time of RTU and number of times (frequency) it has gone offline in 24 Hrs. The status parameter of modem device such as signal strength, data activity status is also captured in central Network Management system.

Logs of modem and FRTU are analysed for the high frequency offline stations. The collected data is analysed on daily and monthly basis to find out the reasons. The protocol analyser tools are used to check the performance of IEC 104 traffic between RTU to SCADA front end processor. The analysis done over a period of six month shows following distribution of reasons of failure.



This paper discusses below the measure taken to minimise these failures and improve the overall performance of distribution automation.

4. TUNING OF SCADA PROTOCOL

IEC 60870-5-104 protocol is used for communication connectivity between end FRTU and SCADA FEP server. This protocol link is established via TCP/IP connectivity provided by mobile network. It has observed that increase in the latency time and packet error rate during busy day time for some of the areas as general mobile user load increases on serving cellular site.

Increase in latency time and packet error rate of mobile link led to the frequent failure of IEC 104 link of RTU due to inadequate time out period configuration of t1, t2 and t3 time out parameters of IEC 104 protocol. The time out period of these parameters is tuned to take care of maximum delays introduced by latency delay and packet error. This has significantly reduced the frequent failure of IEC 104 communication link to RTU.

Alternate IEC 101 links which is not in service are disabled in FRTU to avoid unnecessary switchover. Bandwidth of cellular channel is dynamically allocated and keeps on varying. Periodicity of updation of analogue data is reduced for the sites where bandwidth allocation by cellular network is not adequate. This avoid unnecessary loading of data channel which may leads to higher packet dropping.

5. IMPROVE PERFORMANCE OF CELLULAR MODEM

3G/4G modem used for connecting FRTU plays very vital role in overall availability of SCADA control at CSS.

Cellular data interface of modem is designed to work on best effort basis. Performance of radio link between the modem. Nearest cell site and the overall traffic load on cell site at particular time decides the performance of 3G data connectivity through modem. Use of following features helped to improve the performance significantly.

(a) Idle link is dropped by cellular network to optimise the channel resource at cell site. The 'keep alive packet' is used to avoid the dropping of cellular link due to idle period.

(b) In case the data link is idle for longer period of time, radio channel is automatically restarted after preconfigured time period. This resolves any issue of 3G radio link hanging.

(c) Remote rebooting of modem through SMS helped to reduce the restoration time in some of the cases

(d) All unused interfaces, ports and protocols such as wi-fi, serial interfaces are administratively shutdown and unused Services are stopped. This device level hardening helped to reduce computing load on cellular modem leading to reduction in problems like unnecessary heating of device and software hanging.

6. MITIGATION MEASURES FOR LOW NETWORK SIGNAL STRENGTH

Signal strength of cellular network at CSS depends on various factors such as distance of CSS from cellular site, obstruction to wireless signal due to surrounded high rise building, location of CSS in building basement and weather conditions. Following measures helped to improve overall signal strength.

(a) In some of the cases, modems are relocated to a place in the same premise where signal strength is good.

(b) Use of high gain antennae extended through low attenuation RF cable

(c) Network fall back from 3G to 2G helped in some cases where penetration of 2G network is better than 3G

(d) Dual SIM card modem having SIMs from two different service provider and auto switching over between them used for critical CSS.

7. PROVISION OF REDUNDANT INFRASTRUCTURE FOR HIGH AVAILABILITY

Redundancy is provided at various level to avoid major failure of system due to common or single component failure. Redundant architecture is implemented at FEP SCADA server. Backhaul communication link from mobile service provider with link redundancy. Mobile data services from two separate service provider are used to avoid complete failure in case of any major issue in any one of the service provider's network.

8. RELIABLE POWER SUPPLY SOLUTION

FRTU, modem and Motor must have reliable power supply at site. Availability of the controls heavily depends on the battery performance during the power shutdown at CSS. Monitoring of the charger and battery performance is critical for maintaining the reliable supply. In order to have better monitoring of power supply, FRTU having inbuilt charger module is selected.

This charger has integrated battery performance test which periodically checks the performance of battery and notifies any abnormality as a SCADA alarm. Also, care is taken during engineering stage to ensure suitability of charger having adequate input range to take care of variation in input supply voltage and protection against the surge current and voltages. Daily analysis of diagnostic alarms of charger and battery performance helped to capture the early detection of defects in battery.

9. BEST PRACTICES FOR BETTER SERVICE RESPONSE

Resolution of any issue related to network is totally depended on service response of mobile service provider. It is experienced that restoration of failure gets delayed due to additional delay introduced by trouble call ticket handling process of service provider. These tickets are treated as general ticket of internet users and processed through regular channel of troubleshooting.

In order to avoid this unnecessary delay, process change is made at service provider side in which these tickets are tagged as IOT service tickets and are serviced on high priority by internal technical teams.

SIM cards are also tagged as VIP SIMs to avoid any disconnection or baring of data services due to payment related issues.

SIM connection and Backhaul links are taken as managed service from service provider. This gives facility of monitoring the its traffic performance on web.

10. MAINTENANCE PRACTICES OF FIELD DEVICES

Periodic maintenance is carried out to maintain the healthiness of battery and avoid any sulphation of battery terminal. Healthiness of earthing of FRTU panel and equipment is also checked and ensured during this activity.

Ring Main Unit (RMU) switchgear operation is carried out through motorised isolators. Due to tropical condition the motor mechanism gets rusted and jammed, if isolator is not operated for longer period. Regular trial operation of the isolators (Once in six months) to detect and repair the jamming mechanism so as to avoid non-operation on requirement.

This jammed motor mechanism leads to failure of remote command issued during tripping as voltage of battery dips due to excessive current drawn by motor for higher torque. Maintenance practices of motor mechanism is revised to identify the jamming and attend the jamming issues-If any operation on isolator takes significantly longer time in the trial operations, this isolator is taken out for attending the problems.

11. CYBER SECURITY MEASURES

Distribution system requires to be secured from cyber threat since they are more vulnerable as remote devices like FRTU and Modem are installed at consumer premises and communication connectivity is through public mobile network. Following measures are taken to mitigate the risk

(a) Secure access private network service from mobile service provider is used for creating private APN on mobile network for distribution automation. This prevents any public user having internet enabled SIM card to access distribution automation network device.

(b) Access control rules are configured at both modem end server end to allow only legitimate traffic.

(c) Basic hygiene measure like periodic password changes, shutdown the unused port and services is carried out.

CONCLUSION

Use of public mobile services for the automation of distribution network is most feasible option as it has lowest commercial cost and faster deployment however it may not perform up to the mark if it is not properly deployed.

As mentioned in paper, the overall performance of distribution automation system availability and command success rate can be improved significantly by properly tuning the protocol parameters to adapt the dynamics of mobile network, improve the signal quality by using suitable antennae solution, using performance enhancing features of modem, deploying redundancy for critical component, providing reliable battery solution and following best maintenance practices.

As per experience, these techniques helped to improve availability and command success rate up to 97% and 99% respectively. It also helped significantly reduce the time required for restoration of power supply during the fault in distribution network leading to lower CAIDI index.

In future, It is promising to improve the performance further by using upcoming new technologies in mobility area like 5G mobile network and NB-IOT system for automation of distribution network.

Parametric Study of 500MW Subcritical Coal Power Plant with High Ash and Low Volatile Material Indian Coal at Technical Minimum Load

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ABSTRACT

Nowadays, intermitent uses of renewable energies as a base electric load of the grid are getng more importance for its enormous environmental benefts. Thereby, the conventonal coal based power generatng units are facing diferent challenges for its feeible operaton. In literatures, there is a huge gap of practcal based thermodynamic study of the power plants considering its operaton feeibility and thereby, this paper mainly focuses on the actual feasibility study of a 500MW Subcritcal (SubC) Coal based power plant for feeible operaton by using high ash and low volatile material (VM) Indian coal and diferent Parametric studies of the plant at technical minimum load conditon are also carried out in details. Efect of feeible operaton on the operatng parameters is study at ramp down conditon. Plant performance comparisons are also carried out and suggestve measures with diferent constraints for feeible operaton of the plant are also discussed in this paper. Overall study concludes that plant running with less numbers of mills with proper air-fuel rato enhance the combuston characteristc of coal and improves the fame and furnace conditon of the plant at technical minimum load operaton. It is also concluded that unit can be run at technical minimum load with running both turbine driven boiler feed pumps (TDBFPs) with suggestve measures. Ramp down and ramp up rate in the load range of 63-55% of rated load are found about 2.52 MW/minute and 1.48 MW/minute, respectvely which is comparatvely lower than the higher load range due to poor fame conditon. For the low VM coal, eecess oeygen and use of coal burner tlt should be within 4-4.5 % and ±8^o for beter fame and furnace conditon. Special precautons are suggested during winter season to avoid acid corrosion in the fue gas duct from low fue gas eeit temperature and high vibraton in turbine from very low condenser back pressure. Deterioraton of plant performance are also observed at low load operaton compared to full load conditon but considering the environment friendly power generaton, switching of carbon-based energy supply to renewable energies (RE) based energy supply should be given more prority in modern society. Moreover, proper monitoring of condenser back pressure and hot reheat temperature may improve the plant performance.

***Keywords** : Environment; Fleeible operaton; Low VM; Power plant; Renewable energy; Technical minimum load.*

1. INTRODUCTON

The advantages of a nature-based energy supply are enormous compared to conventonal way of energy supply i.e. mainly coal based energy system. It does not only reduce the environmental pollutants but also enhances the energy independence as well. The global community has set an objectve of limitng global warming to well below 2°C under Paris agreement and this can only be achieved with signifcant decarbonisaton of energy systems over the long period [1]. India has installed electric generatng capacity of about 345.49 GW [2] and the share of coal power plants are about 57 % of total which is the highest among the other sources. As per CEA Eeecutve summary report, 2018, Renewable Energy Sources (RES) share about 70.65 GW which is about 20.44 % of total installed capacity. India's Intended Natonally Determined Contributon (INDC) aims to supply base load of about 40% of the total installed power generaton capacity from nonfossil fuel resources by 2030 [3]. As per previous year's record startng from 2012 to 2016, the all India average PLF are decreased from 77.5% to 59.6 % and peak to installed capacity rato are also decreased from 0.66 to 0.57 due to plant capacity additon but demand did not increased in the same proporton [3]. This decreasing trend will proceed further due to integraton of RES in near future and it will create various challenges in conventonal power plants [4]. However, intermitent RES penetraton into the power grid system causes diferent challenges like load variability and grid stability[5]. Carbon-based power plants are normally designed for the base load operaton and it will increasingly need to operate on a load following or cyclic basis due to operatonal feeibility to grid could not be achieved by demand side management system [6] and non availability of large scale energy storage technology [7]. Moreover, in the future, cheaper bateries are eepected to ofer new solutons in this storage domain [7]. It means that carbon-based power systems need to ramp up and ramp down to technical minimum load more frequently and more rapidly. Fleeibility of conventonal power plants can be accomplished by defning new operatonal strategies and redesigning the components. Fleeible power generaton is eepected to remain the most critcal soluton to deliver feeibility in the short- to medium-term, as it is more mature [8]. However, it may have various negatve impacts on fossil-fuel power plants, like fatgue and creep failure of components, increased forced outage rates and reduced lifetme. Moreover, cycling loading of the coal power plants causes performance degradaton and enhances the air pollutants like partculate maters, CO2, NOe and SOe over the long period of operaton.

Various studies related to feeible operaton of coal-based power plants were carried out by diferent researchers by dynamic simulatons [9-11]. Benato et al. [12] performed a dynamic simulaton of combined cycle power plants using MATLAB and Dymola for simulatng the variatons of diferent operatng parameters during transient conditons and life predictons of thermal components. For using the thermal energy storage in turbo-generator cycle, Lausterer [13] proposed a concept of condensate throtling for increasing electric power output rapidly. Some research papers [14,15] developed dynamic simulaton of diferent capacites plants for studying the various efect of condensate throtling system and modifed the eeistng co-ordinated master control system. Zhao et al. [16] showed an approach to increase the ramp up rate of about 6.02 % of rated load in a 1000MW SupC coal power plant by throtling of high pressure heaters (HPHs) eetracton steam line and the proposed power system was dynamically simulated using GSE software.

As per authors knowledge, there is a very few literature related to actual parametric study of the power plants with high ash and low VM coal in details during technical minimum load operaton. The trend of operatng parameters variaton with tme has a great impact on the life of thermal components and its performance also. So, in the present scope of work, 500MW SubC coal-fred power plant is mainly considered as a reference plant as at present, it has maeimum share of installed generatng capacity in Indian power scenario.

2. OBJECTVES

Considering the above technical and economic aspects, the objectves of the present study are as follows:

(i) Test runs for determining the eeistng feeibilisaton capability and potental limitatons of 500MW capacity SubC coal power plant with high ash and low VM Indian coal.

(ii) Analysis of operatng data at technical minimum load conditon.

(iii) Determining the stability of the downstream heatng components.

(iv) Performance comparison of the plant at technical minimum load.

(v) Suggeston for further improvement in OMM procedures if any required.

3. UNIT RUNNING STATUS AND PRECAUTINARY MEASURES BEFIRE THE TECHNICAL MINIMUM LIAD

The unit was generatng load of about 315 MW in coordinated master control (CMC) mode with coal elevatonss A,B,C,D, M E in service and without any oil support. Details of mills in service are given in Table 1. The classifer outlet temperature of all running mills (bowl mills) were maintained about 90 0C. Secondary Air Damper Control (SADC) was in auto with windboe-furnace DP set point of about 60 mmWc and

Table 1 : Data of diferent Mills combinatons at diferent load conditons

LOAD	315 MW						275.70MW		
TIME	10:00HRS			10:20HRS			11:30HRS		
MILLS	Coal flow t/h	Mill DP mmWc	PA flow t/h	Coal flow t/h	Mill DP mmWc	PA flow t/h	Coal flow t/h	Mill DP mmWc	PA flow t/h
A	40.74	116.17	88.81	48.53	142.67	93.6	45.85	140.74	90
B	40.65	158.93	87.07	48.41	182.72	94.95	49.44	182.99	93
C	36.94	119.81	86.05	44.65	140.31	92.08	41.86	130.42	88
D	37.08	105.2	88.59	44.8	125.07	92.2	42.08	115.82	89
E	40.24	121.13	88.28	NS	-	-	NS	-	-
F	NS	-	-	NS	-	-	NS	-	-
G	NS	-	-	NS	-	-	NS	-	-
H	NS	-	-	NS	-	-	NS	-	-

NS: Not Service

aueiliary air damper positon of about 14%. The positon of aueiliary manual ‘AA’ damper was at 50%. PA header pressure and O2% at APH inlet were about 730mmWc and about 3.45 %, respectvely. Both Turbine driven Boiler Feed Pumps (TDBFPs) were in service and all others auto loops were in service.

From Table 1, it was found that initally, loading of every mill was about 60-65%. Thereby, mill’s loading was frstly tried to increase to about 75-80% by gradually withdrawal of coal millsE from service. As a result, air to fuel rato of each mill was well maintained in the range of 1.95 to 2.07 and SADC aueiliary damper positon increased to about 25% at 10:20 hrs which will help for proper coal combuston dynamics inside the boiler and resultng in stabilizaton of fame and furnace inside the boiler. Necessary arrangement was made for coal ash sampling. Table 2 shows the coal analysis report. Aueiliary pressure reducing de-superheated steam (APRDS) line to TDBFP was charged slightly for avoiding slow response of TDBFP for controlling drum level at low load operaton.

4. RESULTS AND DISCUSSIIN

4.1 Ramp diwn and Ramp up rate during liad changing frim 63% ti 55% if rated liad

For testng the feeibility operaton of the unit, at 10:23 hrs unit load was started to reduce in CMC mode from about 314.79 MW load to technical minimum load of about 274.44 MW load (about 55 %) at 10:39hrs. Ramp down rate was found about 2.52 MW/minute which is about 0.50 % of full load. After achieving the technical minimum load, it was maintaining since about 30 minutes and unit load was again brought back to scheduled generaton which was about 312.89 MW at ramp up rate of about 1.48 MW/minute. The same is shown in Fig.1. The ramp down and up rate was comparatvely lower than the higher load range due to fame and furnace disturbances due to poor quality of coal..

4.2 Effect if Technical Minimum Liad in pperatng Parameters

Efect of feeible operaton on the main operatng parameters, primarily drum level, hotwell level, MS temperature, HRH temperature, % O2 and etc. are given below. When the unit load was brought to technical

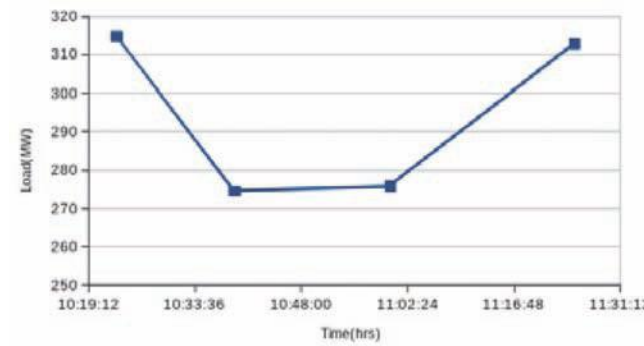

Fig. 1 : Trend of load change with tme during feeible operaton

minimum load, there was no such variaton in drum level but slight variaton of hotwell level in positve was also found due to load reducton. The drum level was controlled by using two numbers of Turbine Driven boiler Feed Pumps (TDBFPs) without Motor Driven Boiler Feed pump (MDBFP) in service. The positon demand of control valves of TDBFPs reduced with reducton in load for controlling drum level. When the IPT eetracton pressure reduced at load, aueiliary control valves of both TDBFP s started to increase to control the set live steam pressure before the main control valves of both TDBFPs. The opening positon and duraton of opening of aueiliary control valve of TDBFPsA were more compared to TDBFPsB during feeible operaton.

During the ramp up tme, both aueiliary control valves were again closed conditon. Average steam consumpton of individual TDBFP was found about 20 t/h. However, the drum level control was smooth and steady with the value of about -30 to -40 mmWC.

Figure 2 shows the variatons of MS and HRH temperatures during the technical minimum load operaton. It was observed that there was a decreasing trend of both MS and HRH temperatures with load. Before the feeible operaton, MS and HRH temperatures of the unit were maintained about 540 0C and 509 0C , respectvely with SH spray of about 67 t/hr. At the technical minimum load, the corresponding values were reduced to about 528 0C and 500 0C, respectvely. The SH spray water requirement was also reduced accordingly (Figure 3) and after some tmes in technical minimum load operaton, the

Table 2 : Coal analysis report

FEEDER COMBINATION	IM (%)	ASH (%)	VM (%)	FC (%)	GCV-ADB (KCal/Kg)	TM (%)	GCV-ARB (KCal/Kg)
A	1.9	46.6	15.3	36.2	3891	3.4	3832
B	2.3	48.9	14.5	34.3	3654	4.9	3557
C	2.1	49.1	14.2	34.6	3619	4.3	3538
D	1.9	47.2	14.8	36.1	3799	3.5	3737
Composite	1.8	49.1	14.2	34.9	3731	4.3	3636

MS and HRH temperatures again reached to about 540 0C and 520 ^{0}C, respectvely. The rate of MS pressure and MS temperature falling were about 0.86 ksc/min and 0.81 ^{0}C / min which was in normal limit. The HRH temperature falling trend was also found about 0.50 ^{0}C / min.

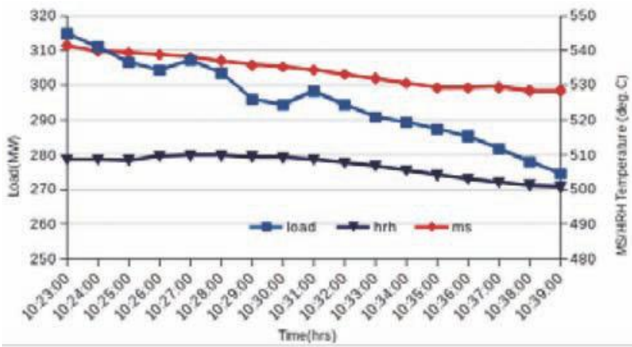

Fig. 2 : MS/HRH temperatures variaton during feeible operaton

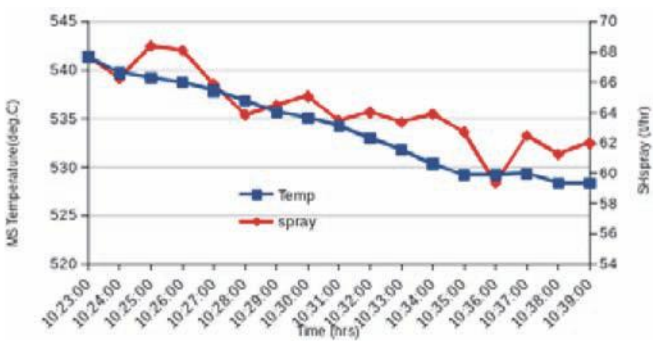

Fig. 3 : SH spray variatons during load change

The variaton in MS pressure, HPT 1st stage pressure and condenser back pressure with tme during transient load conditons are given in Fig.4. From Fig.4, it is observed that the pressure diference across the HPCVs are almost same of about 45 ksc during load reducton conditon and there was no found any variaton in condenser back pressure during load reducton tme which is about 0.0782 ksc and after sometmes of technical minimum load operaton, it was changed to about 0.0739 ksc .

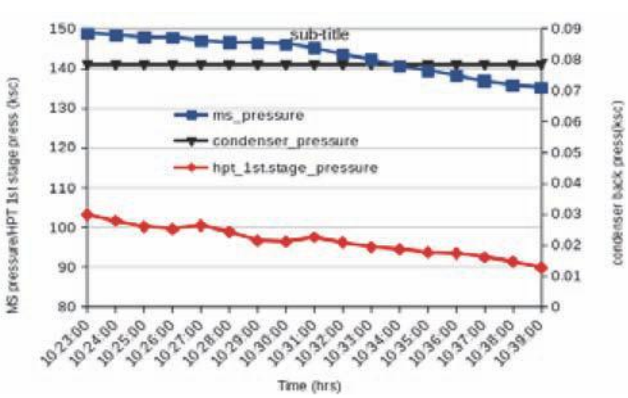

Fig. 4 : Variaton of diferent operatng pressures at feeible operaton

The variaton of fuegas eeit temperature and % O2 at APH inlet were also observed which is shown in Fig.5. It is found that fuegas eeit temperature reduced from about 119 ^{0}C to about 117 ^{0}C due to reducton in HPHs6 outlet temperature (Fig.6) . % O2 at APH inlet initally was maintained of about 3.89% and at low load operaton, its value was maintained of about 4.5%.

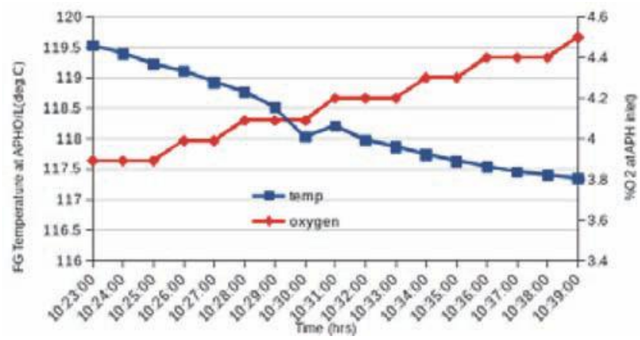

Fig. 5 : Variaton in FG eeit temperature and % O2 during load reducton conditon

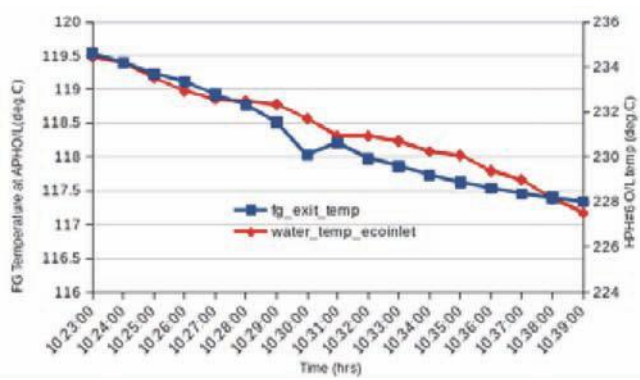

Fig. 6 : Variaton in FG eeit temperature and HPHs6 water outlet temperature during load reducton tme.

It was found that the used Indian coal having lower VM and higher ash which causes the poor fame conditon and igniton delay as very high fuel rato (FC/VM rato) was found in coal report

(Table 2). In additon with high ash presence in coal causes lower (FC+VM)/Ash rato and resultng in slower energy release rate [17]. Thereby, it disturbs both the fame and furnace conditons of the boiler. Further, it was also observed that the change in burner tlt positon more than ± 8^{o} causes more fame disturbances. However, optmizaton of coal mills in service with desired air-fuel rato (about 1.9-2.10) can help to maintain beter fame and furnace conditons inside the boiler.

After taking the above said precautonary measures, in the present case, fame and furnace conditon were good enough which is shown in Fig.7. In Fig.7, fame intensity deep in ABs1 corner was found at 10.40hrs and after that it was stable. During that tme windboe-furnace DP was maintained of about 60mmWc.

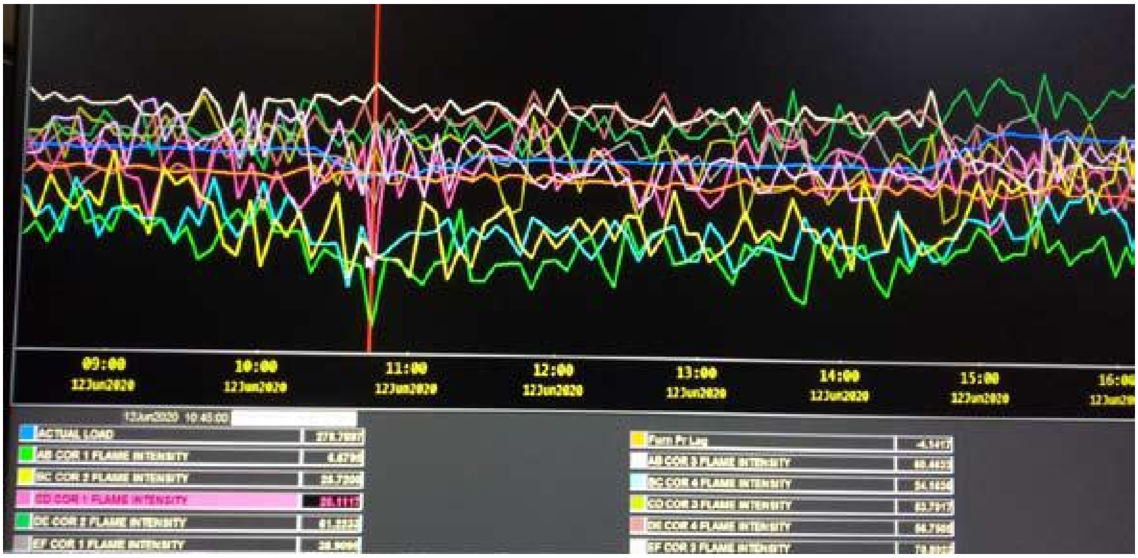

Fig. 7 : Furnace and fame conditon during feeible operaton

4.3 Plant perfirmance at Technical Minimum Liad cinditin

Unit Heat Rate (UHR) is only considered to measure the plant performance in the present work.

Direct method of UHR calculaton is used here which is given below:

UHR (kCal/kWh) = SFC * GCV

Where, SFC (kg/kWh) indicates the specifc fuel consumpton and GCV (kCal/kg) indicates the gross calorifc value of coal in air dry basis. Recommended design UHR at part load of the plant is also considered for the comparison of plant performance [18].

Plant operatng parameters at technical minimum load conditon are given in Table 3 and the performance comparison is given in Figure 10. From Fig.10, it is concluded that the UHR of the plant at technical minimum load conditon is deteriorated compared to full load conditon. At low load, more throtling of control valves and very low condenser back pressure (0.073 bar-absolute) in Turbo-Generator (TG) cycle causes more eeergy destructon of the power cycle and higher eecess % O2 at APH inlet also increases the amount of dry fue gas. Sliding pressure control mode of operaton may be implemented for avoiding eeergy destructon rate in the TG cycle. For avoiding very low condenser back pressure, optmizaton of running CW pumps and adjustng of CW recirculaton valve opening may be done for improving TG cycle efciency and life of Low Pressure Turbine (LPT) also. Optmizaton of eecess oeygen at APH inlet is required for avoiding un-burnt carbon loss and eecess dry fue gas loss. At the present study, considering fame conditon, about 4.25 % of eecess O2 at APH inlet is the optmum value. Moreover, improvement in HRH temperature may increase the plant performance and

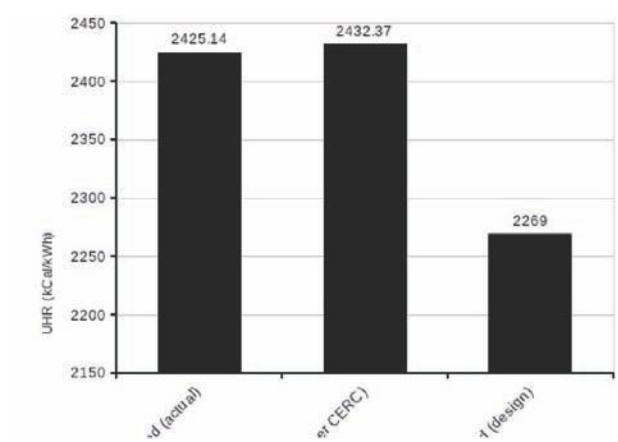

Fig. 10 : UHR comparisons at diferent conditons

Table 3 : Important operatng data at Technical Minimum Load

Load	MS flow	Feed Water flow	Coal flow	MS Pressure	MS Temperature	HRH Temperature
MW	t/hr	t/hr	t/hr	ksc	ksc	deg.C
275.77	885.77	867.38	179.25	135.87	539.1	514.93
HRH pressure	CRH Temperature	CRH pressure	HPH#6 Drip Temp.	HPH#6 water I/L press.	HPH#6 water I/L temp.	HPH#6 water O/L temp.
ksc	deg.C	ksc	deg.C	ksc	deg.C	deg.C
25.11	343.31	25.45	185.72	147.55	184.41	226.65
HPH#6 extraction press.	HPH#6 extraction temp.	SH spray	Spray water temp	Spray water press.	Total air flow	O2 at APH inlet
ksc	deg.C	t/hr	deg.C	ksc	t/h	%
24.83	342.52	74.35	217.87	145.41	1007	4.27

for this, the frequency of soot blowers' use in boiler side should be more. However, plant performance at part load conditon was beter compared to recommended design UHR.

5. CINCLUSIINS & RECIMMENDATINS

It can be concluded from the above case study that 500MW SubC coal power plant can be run smoothly with high ash and low VM Indian coal at Indian climatc conditon. Following recommendatons may be taken as guidelines for feeible operaton of the plants.

- Optmisaton of Number of Coal mill/elevaton is needs to be done and implemented for boiler fame stability. Preparaton of Coal mill scheduler on eeperimental basis may be taken up to optmise the number of coal mill/elevaton operaton.
- It has been observed that Coal with VM in range of 14 %, Unit low load operaton can be done with sustainable basis with optmise number of coal mills/ Elevatons are in service.

  There is high variaton of coal quality are being received in Indian power plants. Fleeible operaton with this high variaton of coal quality is become difcult and to cope up the problem proper blending arrangement needs to be eeplored and implemented. As there is no proper blending arrangement, as a stop gap arrangement is suggested to feed good quality coal in bunkers CMD for maintaining technical minimum load.
- CMC and other auto loops tuning are recommended to rectfy the fuctuatons in load and MS temperature during low load operaton.
- Wall blower to be put into service in regular basis to remove the soot deposits in Furnace wall. LRSB to be put into service on regular basis for maintaining the heatng surface clean and maintaining Super Heater and re-heater temperature.
- Flame scanner periodic cleaning schedule to be prepared and adherence of that schedule to be monitored. SADC local feedback at control room is to be eeplored and implemented for beter monitoring of SADC. Botom de-ashing during Unit running conditon is to be done in consultaton with operaton department.

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Enhancing Existing Transmission Line & Corridor Capacities through Voltage Upgrade

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ABSTRACT

Electricity demand growth is increasingly driven by the residential and commercial sector, with fast-growing cities & increasing urbanization. Building new transmission infrastructure to feed into these load centers is becoming increasingly difficult due to high population density and Right of Way (RoW) challenges. Further, with the integration of renewables, the power flows vary with time due to seasonal as well as daily variations in the weather. Thus, the peak loading on the lines may occur only for limited durations. Developing new transmission infrastructure every time to cater to such power flows may not be an economical solution always.

To overcome these challenges, a solution that considers optimum utilization of RoW and existing transmission infrastructure can be of great significance. Enhancing the capacity of existing transmission lines & corridors by uprate and upgrade, therefore are considered as prudent alternative solutions. The capacity can be enhanced through uprate/upgrade of the existing system through various technologies, methods & execution techniques. This paper focuses on the voltage upgrade of existing transmission lines for the enhancement of transmission corridor capacity and its benefits.

INTRODUCTION

The development of the power sector is dependent on a robust, secure, and reliable transmission system. The CAGR of electrical energy requirement for India was estimated to be 6.18% and 6.88% for peak electricity demand from 2016-17 to 2021-22 [1]. FY19-20 has seen an actual peak demand of about 183GW and is estimated to be 225GW by FY21-22. The Government of India has set a target of installing 175GW of renewables by the year 2022 and 450MW by the year 2030, as a part of its commitment to curb carbon dioxide emissions.

Electricity demand growth is increasingly driven by the residential and commercial sector, with fast-growing cities & increasing urbanization. Building new transmission infrastructure to feed into these load centers is becoming increasingly difficult due to high population density and Right of Way (RoW) challenges. Further, with the integration of renewables, the power flows vary with time due to seasonal as well as daily variations in the weather. Thus, the peak loading on the lines may occur only for limited durations and under limited operating and weather / seasonal conditions. Developing new transmission infrastructure every time to cater to such power flows may not be an economical solution always.

To overcome these challenges, a solution that considers optimum utilization of RoW and existing transmission infrastructure can be of great significance. Enhancing the capacity of existing transmission lines & corridors by uprate and upgrade, therefore are considered as prudent alternative solutions. The capacity can be enhanced through uprate/upgrade of the existing system through various technologies, methods & execution techniques. This paper focuses on the voltage upgrade of existing transmission lines for the enhancement of transmission corridor capacity and its benefits.

TRANSMISSION LINE UPGRADE

Voltage upgrade of exiting transmission lines along with an upgrade of tower structures can potentially achieve much higher power transfer capability (more than ~4 times to even up to 15 times or more) with reduced electrical losses and increased utilization of the existing corridor and infrastructure. Increasing the voltage rating of overhead lines is possible if sufficient electrical clearance is achieved within existing RoW (or with incremental RoW) and the addition of line bays at terminal substations at both line ends is made.

Upgrading of the existing transmission line is performed to improve transmission line capacity as well as reliability. It is done by improving structural performance i.e., tower strength, foundation strength, and/or by improving electrical performance i.e., insulation strength, earthing system improvement, etc.

Table 1 below shows such solutions recognized by the CIGRE Working Group as well.

Table 1 : Voltage Upgrading Options (Source: CIGRE WG B2.13 353)

Driver	Method	Technique	Solution
Increase Voltage Rating	Increased electrical Clearances	Insulators	Insulator crossarms
		Increased conductor attachment height	Structure body extension
			Insulator crossarms
			Interspaced structures
	Increase Structural Performance	Tower Strength	Structure Strength
			Foundation Strength

While upgrading the transmission corridors from lower voltage levels to higher voltage levels, consideration of RoW as per standards is very critical to maintaining the transmission line clearances. The width of RoW is based on the horizontal safety clearances/insulator swing angle as per central regulatory guidelines. The current RoW at different voltage levels is as per Table-2 below.

Table 2 : Voltage Upgrading Options
(Source: CBIP Manual on Transmission Lines)

Voltage Level	RoW Requirement (m)
66kV AC	18
110kV AC	22
132kV AC	27
220/230kV AC	35
400kV AC Single Circuit (Horizontal Configuration)	52
400kV AC D/C / 400kV S/C (Vertical /delta configuration)	46

RoW requirement of transmission lines depends on the following factors -

(a) Configuration of Towers (single circuit or double circuit)

(b) Span length

(c) The sag of conductor, which depends upon the type of conductor, maximum operating temperature of the conductor, and span length

(d) Wind velocity, wind angle & swing angles

(e) Projection of cross arm or distance of conductor attachment point from the center line of the tower, which depends on wind velocity, swing angle, metal clearances, tower body width at bottom conductor level

(f) Configuration of insulators (I/V/Y configuration) and length of insulator string

Few options available for optimization of RoW are as follows -

(a) Reduction in Span length

(b) Reduction in the footprint of tower base (Narrow Base Towers, Monopoles, etc)

(c) Use of Multi-Circuit Multi-Voltage (MCMV) towers

(d) Use of towers with insulated cross arms

A few of these options are discussed in more detail here below.

APPLICATION OF MULTI-CIRCUIT MULTI-VOLTAGE TOWERS

Traditional transmission tower typically carries a single circuit or a double circuit line of the same voltage levels. A multi Circuit towers a designed to carry multiple circuits i.e., more than double circuits in the same corridor. Multi-circuit multi-voltage towers carry multiple circuits of different voltage levels in the same corridor while maintaining the required clearances.

Application of MCMV, especially in conjunction with high-performance conductors (providing higher ampacity compared to traditional ACSR conductors) shall improve the power carrying capacity in multiples compared to traditional tower design of S/C or D/C.

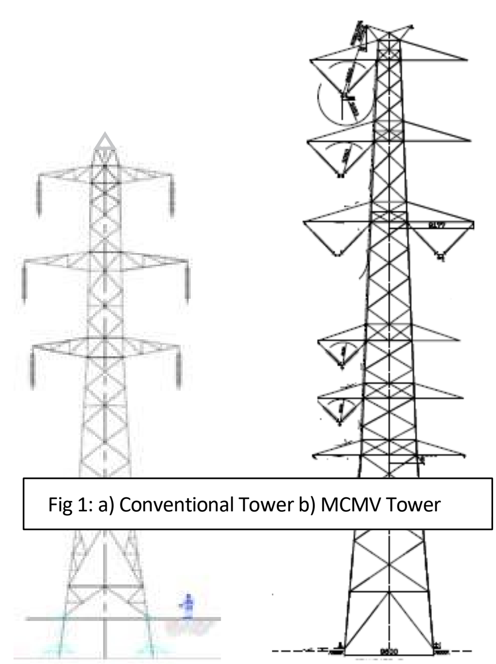

Fig 1: a) Conventional Tower b) MCMV Tower

While planning for a new transmission infrastructure with multiple lines in new ROW, existing single circuit or double circuit transmission corridors can be considered for converting into multi-circuit or multi-circuit multi-voltage corridors to meet the same objective of new built.

Generally, while upgrading an existing transmission corridor to MCMV, existing towers in the corridor will be replaced with MCMV towers utilizing the same RoW (or with incremental RoW). Hence during planning, the shutdown feasibility of the existing lines to be upgraded needs to be ascertained and confirmed.

APPLICATION OF MONOPOLES/NARROW BASE TOWERS

Monopole typically consists of polygonal tubular sections with a tubular cross arm arrangement for fixing tension and suspension clamps on it. The tubular structure can be in a singular tubular or H form.

Monopoles require much lesser space compared to lattice towers, thus helping to reduce the footprint on the ground (to keep it similar or even lower than the existing footprint of towers of the existing line, despite the line being at higher voltage) and also contributes towards reducing the need for additional RoW. Due to this characteristic of monopoles, these can be used in voltage up-gradation using the same right of way.

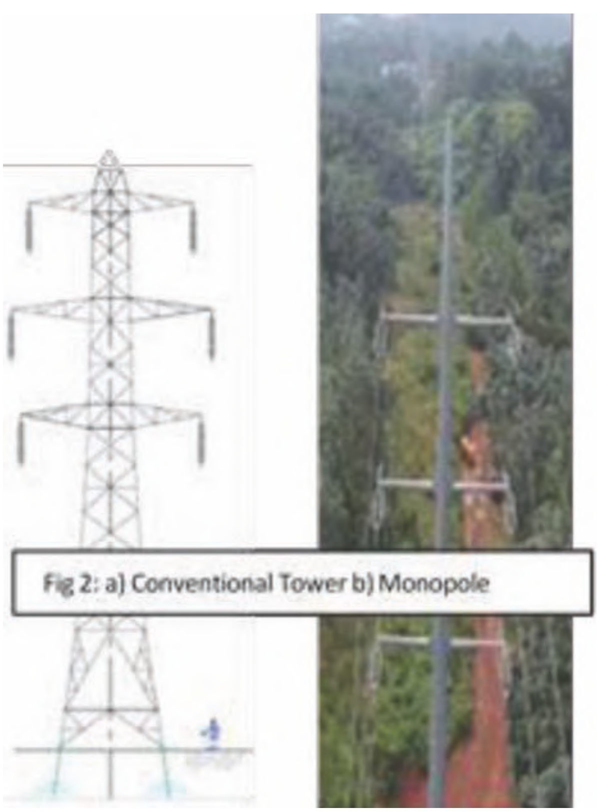

Fig 2: a) Conventional Tower b) Monopole

APPLICATION OF INSULATED CROSS ARMS (ICA)

Insulated cross arms are intended to replace a metal cross arm along with suspension insulators, thus helping to achieve required ground clearances at higher line voltages during an upgrade. Due to avoidance of suspension insulators, the conductor swing is also reduced, which helps to minimize additional RoW during voltage upgrade.

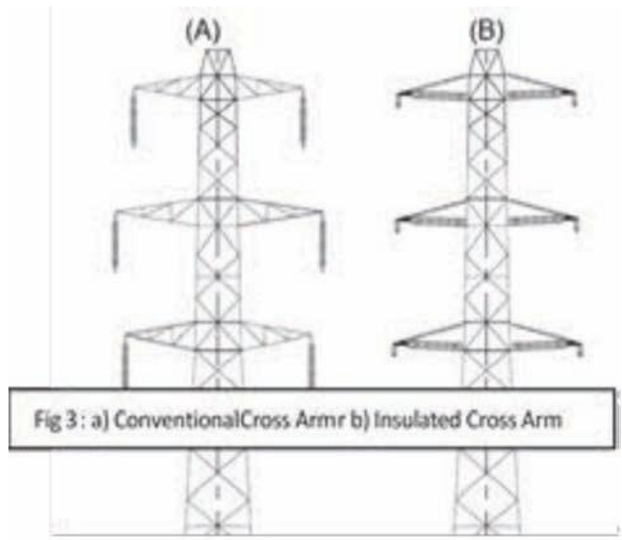

Fig 3 : a) ConventionalCross Armr b) Insulated Cross Arm

Example RoW Calculation for Upgrade from 132 kV to 220 kV on Existing Tower

A typical RoW calculation for an upgrade of a 132kV line to 220 kV using insulated cross arms and ACCC (Aluminium Conductor Composite Core) HTLS (High tension low sag) conductor, on existing 132kV line towers, provided in Table 3. Figure 4 is to be referred to along with this table. It shows 132 kV existing arrangement on the left side and modified arrangement with OCA and ACCC conductor on the right side. Tower and insulator string dimensions correspond to a typical 132 kV tower.

The above example demonstrates how an existing 132 kV line can be upgraded to 220 kV while maintaining all clearances within the existing available RoW. The RoW could have been further optimized if a new tower with monopole or narrow base tower were to be deployed in place of the existing normal broad-based tower in the above example.

INCORPORATING UPGRADES IN NETWORK PLANNING

The manual on Transmission Planning Criteria, issued by the Central Electricity Authority (CEA) of India, already includes (clause 3.11) the options for voltage upgrade of transmission lines. Hence, network planners must look out for such upgrade solutions in comparison to or as an

Table 3 : Typical calculation – 132 kV to 220 kV upgrade

132 kV to 220 kV Line Upgrade using ICA & HTLS (ACCC) conductor on existing towers : Typical RoW Calculation						
		132 kV			**220 kV**	
		Existing			**Upgrade**	
(A)	Length of Cross arm (tower center to arm tip)		=	3.51	ICA	4.24 m
(B)	Suspension Insulator & h/w length	I-String	=	1.90		0.20 m
(C)	Maximum Sag of conductor	ACSR	=	6.74	HTLS	5.83 m
(D)	Minimum clearance b/w conductor & any object nearest to the corridor		=	4.00		4.60 m
(E)	Maximum Swing of conductor (35 deg)		=	4.96		3.46 m
(F)	Ruling Span		=	320		320 m
	Calculated ROW 2*(A+D+E) =		=	24.93		24.60 m

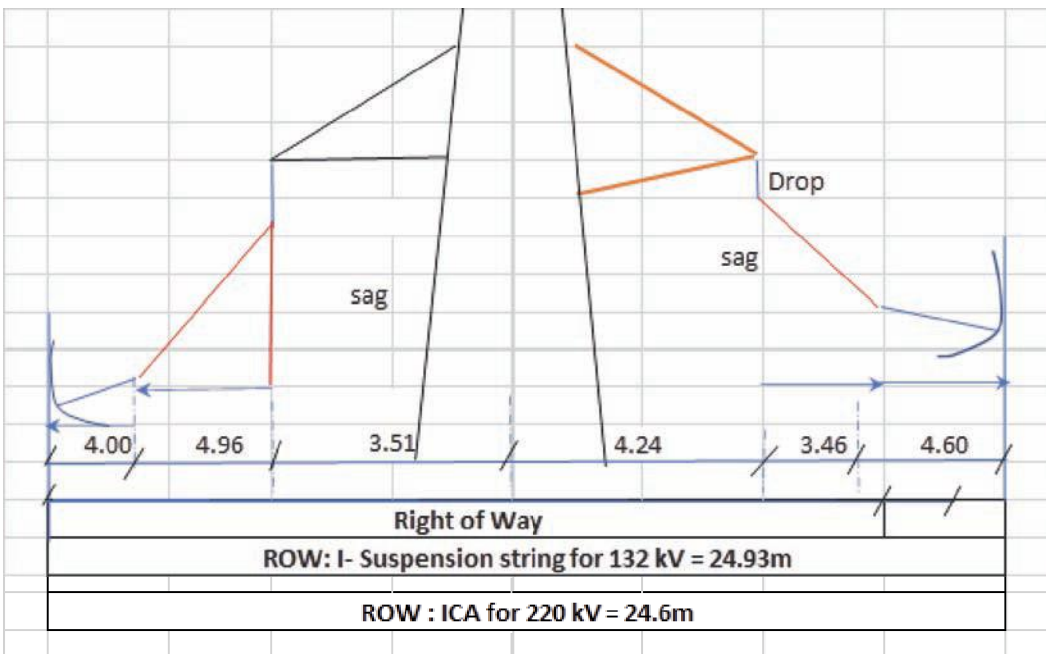

Fig. 4 : RoW Calculation

alternative to new lines in new corridors. The latter can be validated by the field teams of the utilities, to decide on the best way forward keeping in mind the benefits of time, space & capital.

An example of how such upgrade opportunities can be identified during network planning or project evaluation is given below.

Below schematics (Figure 5) show a typical S/S and line upgrade options compared to traditional new infrastructure. In the below schematics, a new 220kV substation is proposed at location D which is near 132kV substation B along with a 220kV connectivity from 220/132kV substation A. After ensuring the space availability at 132kV substation B through a detailed survey, the same objective can be met through an upgrade of existing 132kV substation B to 220kV/132kV substation and connectivity through an upgrade of existing 132kV line between substation A & B through 220/132kV Multi-Circuit Multi-Voltage.

The concept is explained through Figures (5a) and (5b). Figure (5a) depicts a typical situation in a utility wherein 132/33kV substation B feeds additional 132 kV substations on its downstream and the load is estimated to increase in coming time. The area fed by substation B also suffers from low voltage problems as the load is ever increasing in the area. To overcome this problem, the planner decides to create a 220 kV substation D in close vicinity of substation B. This new substation is planned to be fed from an existing 220 kV substation A. 132 kV feeders from this new substation D are then planned to substations B and C. This solution would require a new

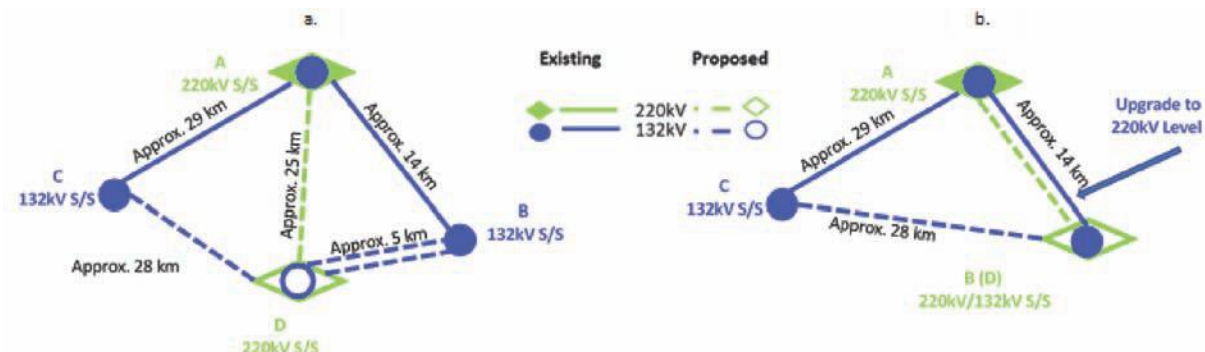

Fig 5: a) New build proposal b)Upgrade Proposal

RoW for the new 220 kV line and also land has to be acquired for the proposed new substation. Availability of both of these remains to be determined subject to survey and assessment.

However, Figure (5b) depicts an alternate solution with an upgrade. In this case, instead of constructing new substation D, the available space in existing substation B can be used to build 220 kV bays (and additional 132 kV bays if required). While spare land may not seem to be available in an existing substation for this, optimized substation layouts and use of GIS switchgear can be deployed to make it feasible in a majority of the cases, Most of the old substations of utilities do have spare land available. Further, the existing 132 kV line from A to B can be upgraded to 220 kV in the same corridor. This would eliminate the necessity to find new RoW and ensure that the project proceeds without any legal or social or environmental challenges. The line between substations C and B can be constructed as planned.

A comparison of the elements needed in these two options are listed in the table below -

SN	As per Figure 5a	As per Figure 5b	Remarks
1	New 220/132 kV substation D	Construct 220 kV bays and 132 kV bays in existing substation B	No land is needed for a new substation
2	New 220 kV line from A to D: 25 km	Upgrade existing 132 kV line from A to B to 220 kV in the same corridor: 14 km	No new RoW needed
3	New 132 kV line from C to D: 28 km	New 132 kV line from C to B: ~28 km	Same as per plan
4	New 132 kV lines from D to B: 2 * 5 km	Not required	Saving in total investment

Clearly, the above alternate solution would result in savings in capital (lower investment), time (on-time execution due to reduced RoW challenges), and space (no new land required). Even if all 3 benefits are not accrued in a specific case, overall this would most probably still turn out to be a better proposition for the utility and ultimately for the consumers and society at large, should the time value of money and damages due to project delays are taken into account.

One aspect which needs to be ensured is that during an upgrade of a line from substation A to B, an alternate source of supply is available at substation B. More often than not, more than one source is available at such substations. In any case, this can be checked during the planning study before proposing such an alternative solution.

CONCLUSION

With the growing power demand, the Transmission System is a critical part to provide quality & reliable supply. Due to severe RoW challenges, the construction of new Transmission infra is becoming difficult

and expensive. Upgrading of existing transmission lines shall address these RoW challenges and offers benefits for reduced timelines and optimal CAPEX. Upgradation of existing transmission lines along with exiting substation upgrades shall be a more effective way of strengthening the transmission infrastructure for future demand requirements.

These solutions/proposals of upgrade need to be evaluated along with new infrastructure development during the planning stage of future network for optimal utilization of capital expenditure and reduce the execution timelines.

Restricted Earth Faults -A Complementary Protection to the Differential Protection



K.K.Murty[1] **Smt Nutan Sharma[2]** **Pranay Joshi[3]**

ABSTRACT

Most vital and important Protection to protect the Transformer is the Biased Differential Protection which provides excellent protection against Ph to Ph faults and phase to earth faults for the faults within the Differential zone protecting the winding covering 80% from the bushing, however it is not capable of providing protection against Single Phase to Earth faults near the neutral in a star connected Transformer, with solidly earthed (grounded) Neutral because of its feature of biasing. To address this constraint REF protection is the only answer. Thus REF Protection may be called as a Complementary Protection to the Biased Differential protection as this protection too is based on Merz-price methodology. [1]

1. REF PROTECTION CONCEPT

1.1 REF is the acronym for Restricted Earth fault. The area of protection is restricted to whole winding from bushing turrets to neutral of the Star connected transformers with solidly earthed Neutral.

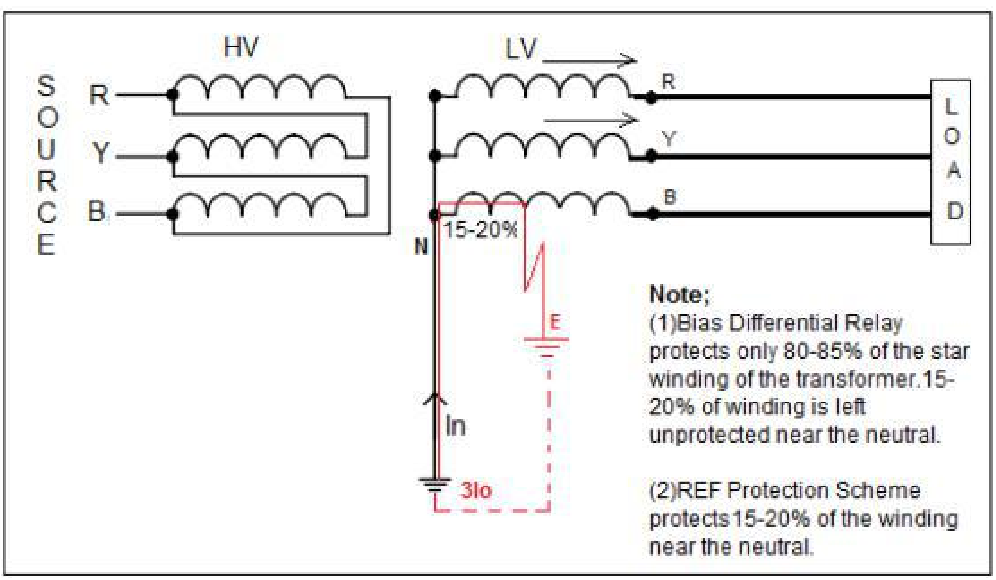

Fig.1 : Depicting unprotected15-20% of winding of Star connected transformers near the neutral against Phase to Earth Fault

1.1.1 *Type of REF Protections*

(1) Low Impedance (2) High Impedance

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2. Executive Engineer, 400 kV Dn, Indore

3. Asstt.Engineer (Testing), 400kV S/S Nagda, MPPTCL

2. LOW IMPEDANCE REF PROTECTION

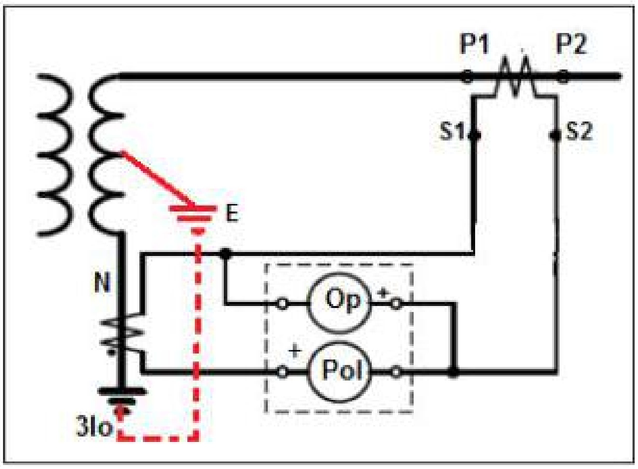

Fig. 2 : Schematic diagram of Low Impedance REF Protection.

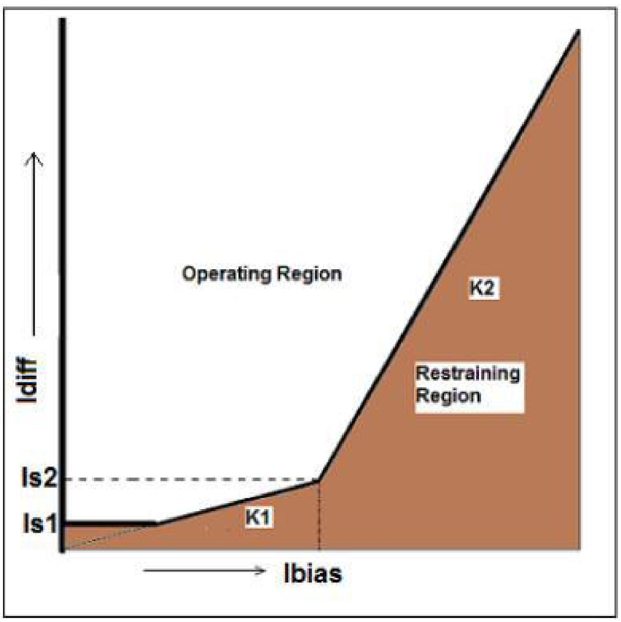

Fig. 2A : Bias Curve.

Low impedance REF relay is a numerical relay it has percentage bias function like differential relay. This function facilitates use of different ratio CTs in the line/ turret and neutral. The ratio differences are taken care in the Low Impedance Relay itself through scaling factor which has to be selected in the relay .It has accelerant sensitivity and stability against CT saturation due to heavy through transient faults by automatically selecting the appropriate percentage bias.

Although actual Low impedance REF may differ in algorithm from relay make to make in general, but Low Impedance REF protection commonly uses a directional element that compares the direction of an operating current derived from the line/turret-end CTs, with the polarizing current obtained from the neutral CT.

The directional element compares the angular difference between polarizing current (3Io derived from line/turret CTs) with the operating current (In from Neutral CT) and indicates forward (internal) fault location when angular difference is < 90 degrees or reverse (external) fault location, if the angular difference is > 90 degrees. The forward/internal indication occurs if the fault is within the protected winding, between the line/turret- end CTs and the neutral CT. [2]

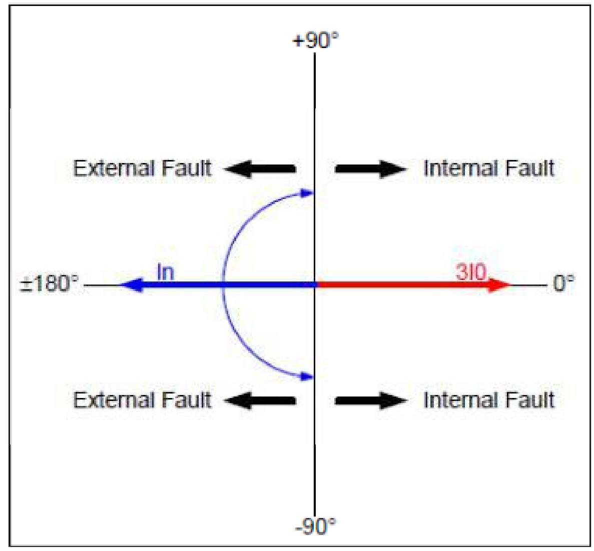

Fig. 3 : Graphical representation of Internal or external fault[3]

2.1 High Impedance REF Protection;

The operating principal of the high impedance REF is to balance the sum of the residual phase currents with the output of a current transformer in the neutral. The CT connections of the scheme are show in Figure 4 where the transformer is solidly earthed significant part of the winding is protected. For external faults the secondary current of affected line/turret CT is balanced against the secondary of neutral current in opposition, causing no current to flow in the High Z REF relay thus this protection is stable, however for internal Earth faults near the neutral the REF relay shall sense the secondary of the fault current through the neutral and operate. This protection is widely used as it has better sensitivity against CT saturation.

2.1.1 *REF Protection –Out of zone fault;*

As per the High Impedance REF scheme, the secondary of Earth fault current ‘In’ entering the source through the Neutral is balanced against the secondary current of the affected CT. All the Secondary windings of the phase CTs (line/turret) connected in parallel ie all the S1 terminals and all the S2 terminals are connected in parallel to form the residual Circuit (please refer Fig. 4) and are balanced against the secondary current of the Neutral CT.

In case of through earth fault the direction of the secondary loop current of '3Io' from the affected phase line/turret CT would be from S2 to S1and the secondary of the Neutral current 'In' entering the Transformer through Neutral in the opposite direction shall have the direction from S1 to S2.Since the loop currents are in opposition to each other therefore shall cancel each other and there shall not be any current though REF relay 64 R.

For clarity please refer to Fig. 4, the earth fault occurs in LV 'B' at the location 'F'. The secondary loop current (in pink colour) 'Ib' is balanced against 'In'.

Note : In this High impedance REF scheme it is essential to have same ratio and characteristics of line/turret CTs and the Neutral CT ie the knee-point voltage should be same and the CTs should be of PS Class confirming to IS :2705(part-4) of Indian standard or PX class confirming to IEC 61869(Earlier IEC 600440)/IEEE Std. C57.13 class C of International Standards.[4,5]

2.1.2 *REF protection- In-zone fault (20% of unprotected winding)*

The % Bias Differential relay with 20% bias setting and with operating current setting of 0.2PU can cover 80-85% of the winding only. High Impedance REF protection takes care of the faults between phase winding and earth against the unprotected 20% of the winding close to neutral. In a star connected transformer the voltage also reduces in proportion to the remaining turns (distance) from the neutral.

Thus whenever Phase to Earth fault occurs within 20% distance from the neutral, the driving voltage of earth-fault current very low. The secondary replica of this low earth fault current (3Io) is sufficient to activate the REF relay 64 R.

LV B Phase to earth fault occurs at a location F of the winding in the vicinity of 15-20% of the winding from the neutral .The zero sequence earth fault current (3Io) shall follow in the path shown in red coloured dotted lines and shall enter the source through the Neutral N (please refer to fig.5).The secondary replica of zero seq.

Primary Earth fault current IN (3Io) is (In) and is in the opposite direction of it (as per characteristic of a CT). This'In' shall circulate in the loop actuating the REF 64R relay and in-turn give a trip command to the Circuit breaker.

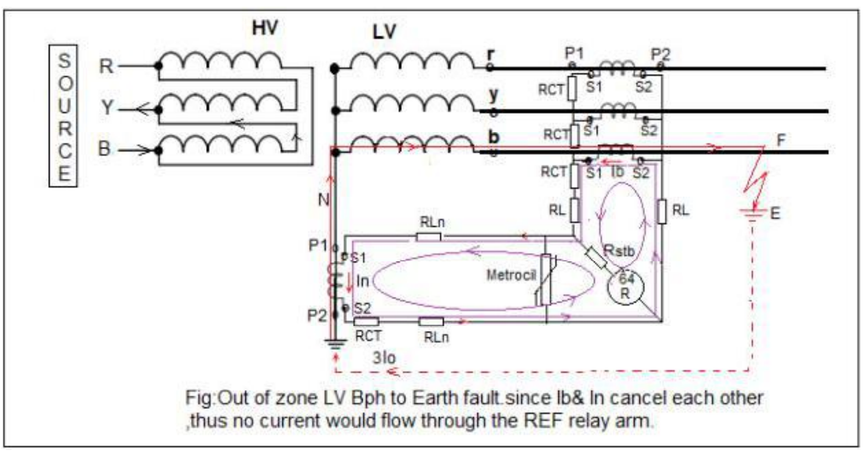

Fig. 4 : Schematic diagram of circuit for out of zone fault in REF Protection

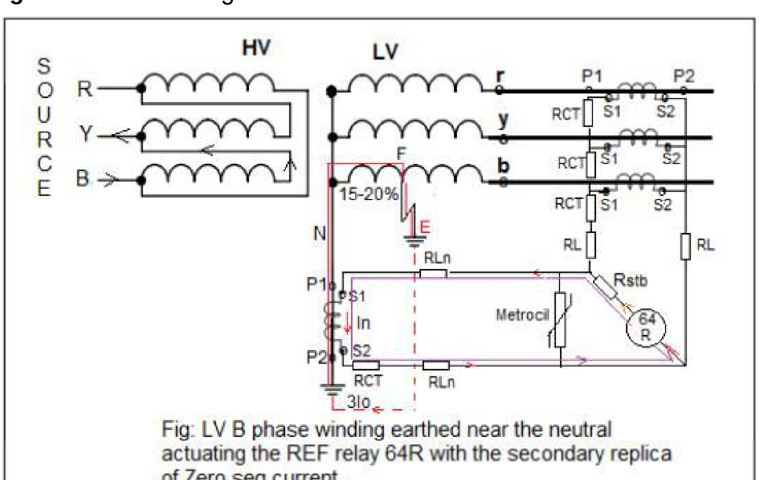

Fig. 5 : Schematic diagram depicting High Impedance REF fault with in 15-20% of the Star winding nearer to the neutral

A question comes to mind that why there is no contribution of the secondary currents from the turret CT? This is because the induced EMF from the HV Source winding B-Y , rises from LV Neutral to the LV B Phase bushing in a healthy Transformer but in this instant case it is getting earthed at point “F”, thus there is no contribution from the Turret CT of LV -B phase.

It is not out of place to mention here that the Star connected Transformer windings have graded insulation ie insulation level decreases vis-à-vis decrease in voltage of the winding as it approaches to the neutral ie number of turns reduce. This concept is used in the REF relay.

2.2.1 *Protection of Delta winding in conjunction with Zig-zag Transformer;*

The delta winding is protected in conjunction with the Zig-zag Transformer as depicted in the schematic diagram in Fig. 6.

2.2.2 *REF Protection in an Auto-transformer:*

The difference between an Auto transformer and 2 winding Star/Star transformeris an Auto transformer has only one Neutral and 2 windingStar/star transformer has 2 neutrals.ie one each in the HV side and LV side.

In this protection secondary replica of neutral current ’3Io’ is balanced against the secondary of HV turret CTs paralleled together and also secondary IV Turret CTs paralleled together against the High Z REF relay as shown in the figure 7.

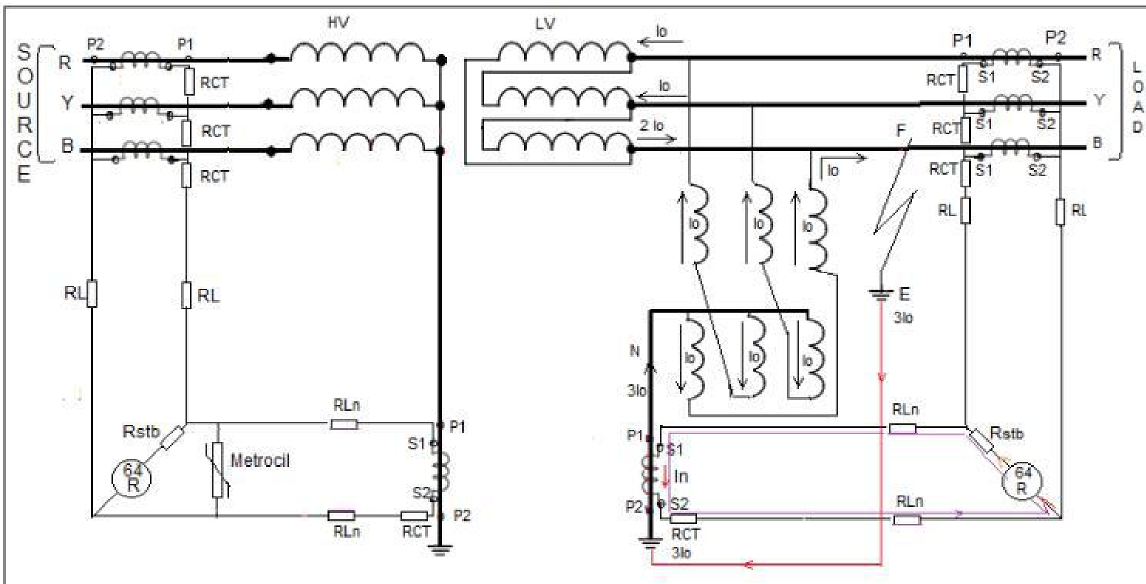

Fig.: Schematic diagram for REF protection of Delta windingincluding Zig Zag transformer.

Fig. 6 : Schematic diagram of protection of Delta winding as a whole and also Zig-zag Transformer windings.

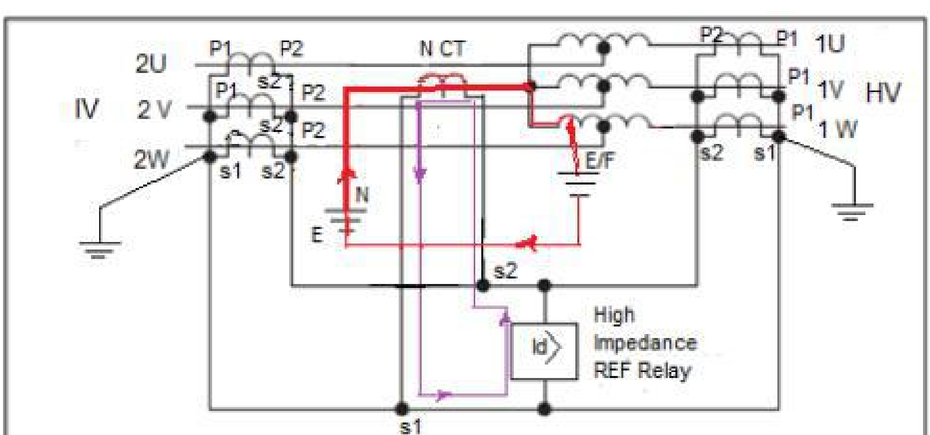

Fig.7 : Schematic diagram of REF protection in Auto transformer.[6]

3. CT SATURATION AND ITS EFFECT ON REF PROTECTION

Severe transient earth faults in the out of zone region may cause the CT of the affected phase to get saturated. (Fig.8).When fully saturated, the CT secondary provides no current. It behaves like a very low impedance(almost zero Ω) between S2 and S1 terminals in the secondary circuit thus the driving voltage developed across S2-S1 shall be zero .The Differential current in the secondary circuit ‘In’ is nothing but the secondary replica of the primary Zero sequence Current 3Io which enters the Transformer through its neutral. Since there is no current to oppose this ‘In’, it would have two paths, either through the impedance of the affected Saturated CT or through the REF relay. A stabilizing register is connected in series with the REF relay 64R (voltage operated relay) to ensure that the operating voltage at current setting is greater than the maximum voltage which can appear across the REF relay + stabilizing register during maximum assigned through fault current.

To understand this phenomena, the figure 8 may be referred to; ‘In’ has two paths in parallel, one through C-G and the other through C-D-F-G .Since a Stabilizing register of appropriate value is connected in series with the REF relay the current will bypass the C-G path and would follow the lower resistance path ie C-D-F-G and complete the loop A-B-C-D-F-G-A .The relay has to be set above the maximum voltage that would appear against C-D at the opted current setting in mill amperes.

3.1.1 Purpose of Stabilizing register;

The stabilizing register ”Rst” is connected in series with the REF relay 64R.This is provided to offer larger resistance to the path of secondary Differential current.

This large secondary Differential current is experienced due to the saturation of the affected phase CT on account of out of zone heavy earth fault.

Sample Calculation of stabilizing regiater;[7]

Say it is a 50 MVA 132/33kV transformer with %Z=10.10,RCT=0.5Ω & RL=1.4Ω,

$$\text{Iflc(Full load Current)} = \frac{50\times1000}{\sqrt{3}\times132} = 218.7\text{A}$$

$$\text{Iflt(Fault current)} = \frac{\text{Iflc}}{\text{Zpu}} = \frac{218.7}{0.1010} = 2165.34 \text{ A}$$

$$\text{Vs} = \text{Iflt x}\frac{\text{CT sec}}{\text{CT pry}}(\text{RCT} + 2\text{RL}),$$

$$\text{Vs} = 2165.34\text{x}\frac{1}{400}(0.5 + 2\text{x}1.4) = 17.86 \text{ V}$$

If ‘Is’ Current setting for operation is 0.1A

$$\text{Rst} = \frac{\text{Vs}}{\text{Is}}, = \frac{17.86}{0.1} = 178.6\ \Omega$$

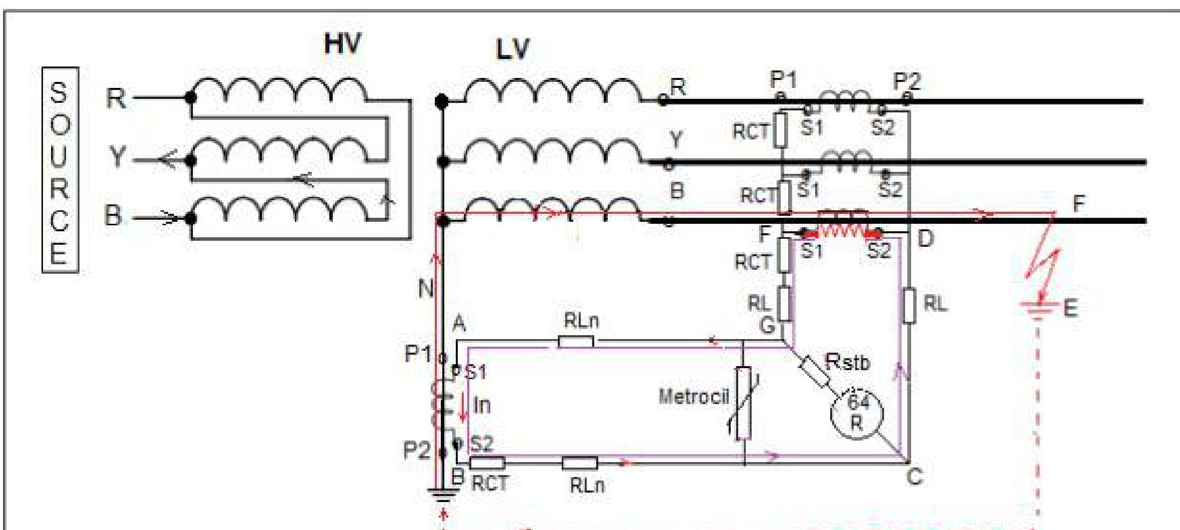

Fig:Out of zone severe E/F resulting into saturation of LV B Phase CT. Thus the CT winding Impedance becomes almost zero and so also the secondary voltage. In the absence of secondary replica of primary fault current only the secondary replica of Zero Seq, current shall flow in thewhole loop by passing the REF relay 64R arm.

Fig. 8 : Schematic diagram of High Z REF Protection for Out of Zone sever fault causing CT saturation.

Therefore as per calculation the Stabilising resister works out to be 178.6 Ω.

Note: Please see the fig.7 Stabilising registers mounted in a Relay panel is shown therein.

3.1.2 Purpose of Metrocil (Non-Linear Register);

It is Voltage limiting Non-Linear Register. It is connected in parallel with the REF Relay and the Stabilizing Register to limit the peak voltage developed across them and to safeguard not only the REF relay and the Stabilizing Resister but also the conne

Formula and sample Calculation [7]

$\mathbf{Vp = 2\sqrt{2Vk(Vf - Vk)},}$

$Vf = If \times \frac{CT\ sec}{CT\ pry}(RCT + 2RL + Rr)$ where If : Fault current,

RCT : Resistance of CT winding, RL :: Lead resistance &Rr : Relay resistance

Vk = Knee point voltage of the CT

$$Vf = If \times \frac{CT\ sec}{CT\ pry}(RCT + 2RL + Rst + Rr),$$

where,

RC : Resistance of CT wdg, RL: lead resistance, Rst: Stabilizing register & Rr : Relay resistance(assumed negligible)

Say If = 7873 A, RCT = 0.5Ω, RL = 0.98Ω, Rst = 455Ω & Rr − negligible, CT ratio 400/1.

A

$$Vf = 7873 \times \frac{1}{400}(0.5 + 2 \times 0.98 + 455) = 9004V$$

$$\mathbf{Vp = 2\sqrt{2Vk(Vf - Vk)},}$$

$$= 2\sqrt{2 \times 200(9004 - 200)} = 3753V$$

Note:

- Since this value is above >3000V therefore Non linear resistance is required.
- Vk value should be actual value as per name plate details of The CT.

Note: Please see the Fig. 9 Metrocils are shown mounted in a Relay panel.

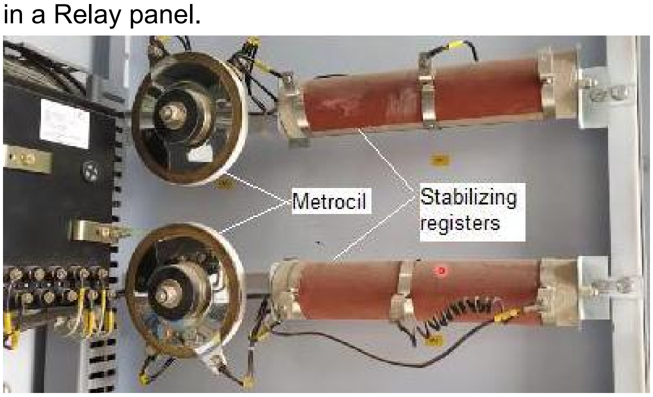

Fig. 9 : Metrosils& Stabilizing registers mounted in a Relay panel

4. TRUE CALCULATION OF A 132/33KV,50 MVA TRANSFORMER;

(1) 132/33 KV 50 MVA Two Winding Transformer with HV CTR-400/1 , LV CTR-1200/1A ,% Z= 10.10 and RCT+ RW = 3.3 Ω.

I. For High Impedance REF protection we have to set the value of Variable Resistance or stabilising resistance (Rs) on the basis of current setting on which we want to operate the REF.

II. Stabilising Resistance Rs = $Rs = \frac{Vs}{IS}$, here Vs is Voltage across REFelement and 'Is' is the current setting opted for REF.

III. Voltage across Element ; $Vs = If \times \frac{CT\ sec}{CTpri}(Rct + Rw)$

Where 'If' is the maximum through fault current and Rct &Rw are CT core and lead resistance.

IV. Rct & Rw are either calculated theoretically as per the core resistance mention at CT secondary name plate and lead cable or directly measures on the CT terminal at C&R panel where the REF leads are connected

V. Through Fault current(Primary) 'If'

$$If = \frac{Iratd}{Z\ pu}$$

VI. Now Calculations for HV REF are as follows:

(a) Current Pick setting adopter for REF relay 'Is' = 0.1 Amp.

(b) Rct + Rw measured directly at C&R panel on Terminal where REF Cable is Connected (This is the combination of HV Turret CT and HV Neutral Turret CT) which comes to 3.3 Ohm.

(c) Through Fault current If = (HV Rated current)/(% Impedance).

$$Iratd = \frac{MVA \times 1000}{\sqrt{3} \times KV} = \frac{50 \times 1000}{1.732 \times 132} = 218.7A$$

$$If = \frac{Iratd}{Zpu} = \frac{218.7}{0.1010} = 2165.34\ Amp$$

(d) Voltage across Element

HV CT prim = 400 Amp and CT sec = 1 Amp

$$Vs = If \times \frac{CT\ sec}{CTpri}(Rct + Rw),$$

$$= 2165.34 \times \left(\frac{1}{400}\right) \times 3.3$$

$$= 17.86\ V$$

(e) Therefore Stabilising Resistance Rst;

$$\frac{Vs}{Is} = \frac{17.86}{0.1}$$

= 178.6 Ω

(f) Hence we have to set the Stabilising resistor at 178.6 Ω for HV REF Protection with 0.1 Amp Current pick up setting.

VII. Now Calculations for LV REF are as follows :-

(a) Adopting Current Pick setting for REF relay 'Is' = 0.1 Amp.

(b) Rct +Rw measured directly at C&R panel on Terminal where REF Cable is Connected(This is the combination HV Turret CT and HV Neutral Turret CT) which comes as 3.3 Ω

(c) Through Fault current If = $\frac{\text{LV Iratd}}{\text{Zpu}}$

$$= \frac{50 \times 1000}{\sqrt{3} \times 33} \div 10.10\%$$

= 8661.37Amp

(d) Voltage across Element

LV CT pry = 1200 Amp and CT sec = 1 Amp

$$\text{Vs} = \text{If} \times \frac{\text{CT sec}}{\text{CTpri}}(\text{Rct} + \text{Rw})$$

$$= 8661.37 \times \left(\frac{1}{1200}\right) \times 3.3$$

$$= 23.8 \text{ V}$$

(e) Therefore Stabilising Resistance Rst = Vs/Is

$$\frac{\text{Vs}}{\text{Is}} = \frac{23.8}{0.1}$$

= 238.18 Ω

(f) Hence the Stabilising resistor works out to be 238.18 Ω for LV REF Protection with 0.1 Amp Current pick up.

5. COMPARISONS BETWEEN LOW Z AND HIGH Z REF PROTECTION

Details	LOW IMP. REF	HIGH IMP. REF
Input Impedance	Very low	Very high
Principle	Low Impedance REF protection uses a directional element that compares the direction of an operating current, derived from the line/turret-end CTs, with the polarizing current obtained from the neutral CT.	The operating principal of the high impedance REF is to balance the sum of the residual phase currents with the output of a current transformer in the neutral.
CTS	It can work with CTs of unequal Ratios. Free of any need of matched CT characteristics or ratio or resistance.	Requires all Identical CT ratios and turns ratio. knee point voltage and the winding resistance of the Turret CTs and the neutral CT should be same.
CT Saturation and Stability	Low-impedance REF protection has low inherent stability against CT saturation for external faults.	High-impedance REF protection has high inherent stability against CT saturation for external faults.
Burden	Imposes less burden on CTs.	Imposes comparatively high burden on CTs.

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(3) Meyer Kao and Garry Cobet(Tennessee Valley Authority):Considerations and Experiences in implementing ground Differential protection for Transformer protection at TVA.

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Improving Specification of Transformers Based on Operational Experience

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ABSTRACT

A transformer in power system is a critical equipment and availability of this to be maintained at highest reliability. These are used for transferring power at elevated voltages to reduces losses. Failure of transformer jeopardise the utility and customer system and need to be avoided. Offline condition monitoring practices, though well established, fails to predict the failure of transformer. Online condition monitoring to be adopted for real time analysis and knowing the deterioration and in-time corrective actions with planned outages. Transformer failure data of Tata Power for last 10 years are analysed and based on the learning from these, operation and maintenance practiced were improved. The learnings from these failures/repairs were the actionable item for improving specification/design at the time of conceptualisation of new transformer and are presented in the paper.

***Keywords** : Furan analysis, Continuous Transposed Conductor (CTC), Transformer Specification, Disk winding, Conservator Oil Preservative system (COPS), Frequency Domain Spectroscope (FDS)*

1. INTRODUCTION

The Tata Power Company limited (TPC) is an integrated private sector utility in the business of Power Generation, Transmission, Distribution and Renewables in India. It has installed capacity of Generation of 10757 MW as on date and had footprint. Transformers are the critical series elements in power system and failure of this asset will have huge impact on reliability of power system. With increase in load requirement, development of large grids, high expectation of customers as well as regulators and shrinking of investment plan, Power utilities are forced to reconsider operating and maintenance strategies to operate critical assets like power transformers till their useful life. There are variety of power transformer based on different parameter

(a) MVA and Voltage rating- 4 to 960 MW, 5 kV to 800 kV,

(b) Single Phase (Generator transformer, ICT) and Three phase Unit,

(c) Cooling: Air Natural (AN), Air Forced (AF), Oil Natural (ON), Oil Forced (OF), Oil Draft (OD)

(d) Cooling medium: Mineral, Natural Ester, Resin (<2 MVAf)

(e) Radiator: Unit type, Separate bank

(f) Bushing: Solid, OIP, RIP, hollow

(g) Vector group: YNd1, YNyn0, Dd0, Dyn11, YNzn11, Dzn11, YNa0d11

(h) Application: Generation trf (GT), Distribution trf (DT), ICT (Inter-connecting trf), Bus and Line reactors, Fault limiting series reactor, Auxiliary Trf, lighting transformer.

Tata Power completed more than 102 years of operation in Mumbai area with a good track record of reliable power supply to consumers. There are large numbers of transformers which are in service for more than 57 yrs with 2 nos. of transformers crossing 82 yrs of life and still in service. Good operation and maintenance practices supplemented by condition monitoring are the critical factors which have led to the long service of these assets. By 2020, Tata Power has experienced failures of new (< 5 years) as well as old (> 10 years) Power Transformers. In view of increase in failure of Power Transformers, study of these failures was carried out along with operation and maintenance practices review, system studies, design review etc. to obtain workable solutions to avoid transformer failures in present or future.

Performance of the protection systems has also improved over the years in clearing the faults faster than before by adoption of new technology and improvements in protection scheme. Long service of transformer life can be achieved by good operational practices that will reduce the stress on the transformers in terms of thermal overload as well as electro-mechanical stresses experienced by the transformers during close-in through faults.

2. OVERVIEW OF TRANSFORMER IN TATA POWER

In Tata Power, 25 Power Transformer failures were experienced in the period from year 2011 to 2020. Ten numbers failure were of new transformers, which failed within 5 years where as 15 nos. old transformer failed having age more than 10 years. One transfer failed after 7 years of service, 8 transformers were of age between 21 -30 years, one was between 31-40 years and 4 nos were older than 40 years. Age and failure mode wise failure analysis are given in table 1,2,3.

Table 1 : Transformer at different Area

Location	Power Trf	Trf Fail after 2011	% Failure
Transmission	80	11	13.75
Thermal	111	14	12.61
Hydro	20	0	0.00
Total	**211**	**25**	**11.85**

Table 2 : Transformer failure service age wise

New Trf (≤ 5 yrs)		Old Trf (> 5 yrs)	
Age	**Nos**	**Age**	**Nos**
0	7	5 - 20	2
2	2	21- 30	8
3	1	31 - 40	1
5	0	> 41	4
Total	**10**	**Total**	**15**

Table 3 : New & Old Transformer failure reasons

Failure Mode	Trf	New	Old
Interturn short - LV Wdg	10	3	7
Internal flash-over	5	0	5
Bushing Failure	5	4	1
Interturn short - HV Wdg	3	2	1
Others (OCTC, Rusting)	2	1	1
	25	10	15

There are some examples of transformer failures, while feeding through faults / starting of motors (Figure 1, Trf failure reason), which clearly indicate inadequacies in manufacturing/ material & design. In few cases, failure of tertiary winding is noticed where the Paper Insulated Copper Conductor (PICC) with layer winding is used, which are mechanically weak as compared to other types of winding e.g. Epoxy Bonded Continuous Transposed Conductor (CTC) Layer or Disc.

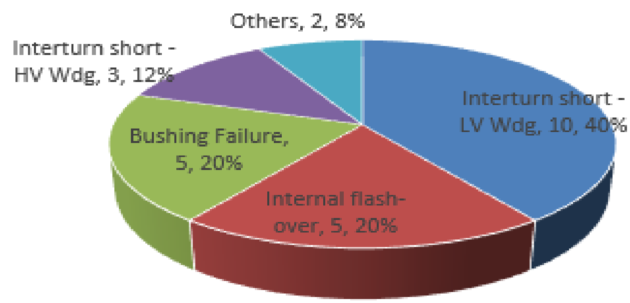

Fig. 1 : Transformer failure reasons

There were some instances of new transformer failures on account of bushing failures (due to Improper joint near flange portion) highlighting inadequacies in manufacturing process / workmanship (Figure - 2). In one case ICT bushing failed (Age-15 years) after feeding a close in LA fault during re-energisation, reason being damage on internal lead and pitting inside the hollow cylinder for housing lead.

In Transmission network, 6 nos. old Transformers had failed during through faults. Internal inspection of failed transformers revealed failures in Low Voltage winding due to inter turn short (Figure 3).

3. OPERATION, MAINTENANCE AND CONDITION MONITORING PRACTICES

Following key observations were made during detail analysis of transformer data.

(a) Many old transformers which have failed were indicating signs of ageing (high furan content, high moisture, low Insulation Resistance / Polarization

Fig. 2 : Bushing failure

Fig. 3 : Failures in Low Voltage (LV) / Tertiary winding due to inter turn short

Index and high Winding Tanδ). Moreover, some of in-service transformers are showing ageing effect based on condition monitoring parameters and overhauling (drying) or proactive replacement is worked out.

(b) Furan content was found more than 4 PPM in 8 number old Transformers, out of which 4 nos. have failed and remaining 4 nos. in-service transformers are having furan content in range of 4 – 6 ppm. Challenge is actual paper DP don't match with DP results estimated by furan.

(c) Around the year 2000, Conservator Oil Preservative system (COPS) were installed on old Transformers. Thus, the moisture absorbed by paper insulation before COPS installation might have played a role in low IR & PI values.

(d) Moisture content in few Power Transformers were found more than specified limit, even though oil filtration was carried out in the recent past. Higher moisture content can be attributed to oil leakages or degradation of paper insulations (ageing effect). Vacuum Dry-out process is one of the best methods at site for reducing moisture content.

(e) At many Transmission stations, Transformers are being operated in parallel for reliable power supply to consumers. However, this has resulted in higher fault levels. Under this operating condition, number of through faults seen by individual transformer is higher compared to sectionalized operation.

(f) There is substantial increase in numbers of MV cable faults due to infrastructure / construction works happening in Mumbai region, which stress the transformer.

(g) At present, most of the outgoing feeders are provided with time delay in instantaneous over current function, to have proper protection coordination between consumer faults and cable faults. This has resulted in delayed fault clearance and increased stress on asset.

4. SUGGESTED APPROACH

Based on transformer failure analysis and observations of condition monitoring as well as O&M practices, following technical cum administrative approaches are planned to support Asset Manager to derive necessary justifications for life cycle management of Power Transformers (Design, Operation & Maintenance, Renovation and Modernization).

(a) Review of transformer specification, SQP (Standard Quality Plans) for getting strong and dry transformer from factory.

(b) Strengthening of condition monitoring through

  (i) Trending of test results of transformer in SAP through measurement point for analysis and decision making.

  (ii) Detailed testing (Thermo-vision scanning, Acoustic & UHF PD and FDS) along with routine testing of transformers having age more 20 years for identifying problems and corrective action.

(c) Interventions in Operation & Maintenance practices:

  (i) DGA, PPM, Acidity, BDV trends every six months. Online DGA, PPM monitor for critical GT & ICT

  (ii) SFRA tests subsequent to Close-in through fault.

  (iii) During oil filtration process, desired oil temperature (60-65 Degree Celsius) to be maintained and use of new filters to be ensured. Low frequency heating is desirable.

  (iv) Introduction of On-line Moisture Removal system for transformer oil in order to reduce moisture content, without outage of transformer.

  (v) During vacuum dry out at site, the quantity of water collected from winding should be monitored closely. During vacuuming process, monitor improvements in IR, PI & Tanδ in addition to moisture content to check the effectiveness.

(vi) Protection relays with fast algorithm and pessimistic Relay settings to achieve faster clearance for terminal/bus faults in instantaneous over current protection.

(vii) Sectionalisation of the buses to reduce stress on Transformers.

(viii) Transient Overvoltage studies and Protection Co-ordination studies for identifying any gaps in present system.

(ix) Nitrogen injection system for containing the effect of transformer fire in case of failure of insulations.

(x) RTCC (Remote tap control circuit) operation from SCADA , for proper voltage control.

(xi) Measurement of sulphur in Oil, which can form cupric Sulphide and damage paper.

(d) Availability of spare transformers, to support the overhaul/repair activity and take care of any transformer failures in future.

(e) Devising Out-Line Arrangement (OLA) for overhauls and rewinding of problematic Transformers with OEM or repair agencies. This will help in reduction of cycle time and emergency cost along with other intangible benefits like increase in availability / reliability of grid, reduction of risks.

5. REVIEW OF TRANSFORMER SPECIFICATION/ MANUFACTURING PRACTICES

Review of Technical specifications and design after interactions with academicians, Industry Experts (OEMs & Service Providers) and operational experience. Improvements were introduced in the technical specifications in terms of Testing criteria, online condition monitoring practices, introduction of new material, inspection process, manufacturing (Learning form OEMs & Repair agencies) and at conceptualisation stage.

A. Testing Improvements

1. Partial discharge limit of 150 pc was introduce instead of 500 pc.
2. Tanδ limit of O.5% for transformer and 0.4 % for RIP bushings, o.3% for OIP @ 20oC of 110 kV and above rating insulations.
3. FDS (Frequency Domain Spectroscope i.e. Variable frequency Tanδ) test to be introduced to know the moisture in cellulose at manufacturing and trends during operation period.

B. Online monitoring Devices and New Material

1. Online monitors: (a) DGA and PPM, (b) Bushing Capacitance and Tanδ measurement, (c) Fiber Optic (FO) based WTI measurement, (d) Continuous monitoring of conventional WTI & OTI through 4-20 mA converters.
2. On line monitoring of conservator oil level through eMOLG and oil pressure through ePRD.
3. Air-cell failure relays for monitoring healthiness of COPS system.
4. Regenerative silica gel drying arrangement.
5. Vacuum tap changer (123 kV) for reliable operations and are practically maintenance free.
6. Epoxy bonded CTC (consciously transpose conductor) for HV, MV, Tap and LV winding.
7. Reputed make pre-compressed high-density pressboard & densified laminated wood insulations
8. Use of Resin impregnated paper (RIP) bushing in place of oil impregnated paper (OIP) bushing for 110 kV and above.

C. Inspection Improvements

1. Introduction of CHP (customer Hold points) and additional inspection points in SQPs, during manufacturing of transformer like CCA inspection, Tank, Radiator inspection.
2. Detail testing and verification with clearing criteria for failproof inspection.
3. Vendor evaluation of transformer and its auxiliary manufacturing unit for quality assurance.

D. Manufacturing

1. Disc or helical single layer (semi hard, 150mpa hardness conductor) type LV winding with 5mm thick PCB cylinder. All windings should have 12/18/24 spacers (equally distributed) and need to be locked on outer side, inner side fixed on cylindrical board. This will restrict the spiral movement of winding.
2. Spacer between turns in each coil in all HV, IV, LV, tap Winding (inner coil to outer coil) needs to be aligned properly and with perfect concentricity. This will increase the mechanical strength of coils during faults (Figure 4,5).
3. Top frame was modified for Jack type arrangement. Benefits are (a) Quantified pressure on winding from top can be applied (b) Uniform pressure on winding by densified wood. This is not possible in Top frame was having Screw type pressing arrangement at top of winding, because it is a) Manual crimping method. b) Pin point pressure from top on winding.
4. HV/LV Lead connection to be made by crimping process rather than by brazing process. Brazing may

Fig. 4 : Spacers between coil are not in straight line (not concentric)

Fig. 5 : Between windings, insulating board, spacer sticks are in loose condition.

cause oxidation and further deterioration of copper and paper.

5. Epoxy or Antirust (mineral oil resistance) solution to be applied on core edges for avoiding rusting.
6. PD ring and caps are provided on all nut bolts and sharp edges.

E. Conceptualisation

1. Disc type HV / IV main winding; disc or helical single layer type HV / IV tap winding.
2. Revised NGT parameters (X0/X1) and 10 sec. current rating for restricting healthy phase voltage rise for phase to ground fault in network. Neutral grounding transformer with COPS.
3. Current density - less than or equal to 2.5a / sq. Mm & flux density - less than or equal to 1.7t at rated voltage and frequency
4. Review of dynamic & thermal short circuit calculations, temperature rise calculations and transformer internal Drawings
5. Pumpless design for cooler bank for improved reliability, less maintenance and reducing auxiliary consumption.
6. Pilot project for Use of Natural Ester Oil instead of mineral oil for fire safety and environment friendly transformer.
7. Complete 10 kV Core, Frame and Tank (CFT) insulation instead of 2 kV to arrest CFT insulation aging and failure problem
8. 52 kV cable box design for 33 kV LV rating with louvers for avoiding flashover. Design of single-phase cable boxes to minimise the footprint of transformer.
9. Safety railing and platform for accessing transformer devices.
10. Provision of necessary isolation facility for carrying out electrical testing on HV bushings and transformers which are directly connected to cables.
11. Extending performance guarantee requirement up to 5 years

6. CONCLUSION

In the recent past, there have been some failures of new as well as old transformers in Tata Power System. In view of increase in failure and repair of Power Transformers, detailed study of these failures was carried out along with system studies, operation and maintenance practices, design review etc. Technical specification / manufacturing practices were studied and reviewed, which will ensure rugged and dry transformer at factory. These transformers will be more stable during power system stress. With online condition monitoring technologies, result will be trend and analysed promptly and corrective action will be practiced, thus avoiding force outages.

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Challenges during Replacement of Static Generator Relay Protection (GRP) of Gas Turbine Generator and Standardisation like Conventional Generators Protection

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The Tata Power Company (TPC) is the largest integrated private sector utility in the business of Power Generation, Transmission and Distribution in India. It has installed capacity of Generation of 12742 MW as on date. Generator in power system is an extremely critical equipment and should be available round the clock. Unit 7 at Trombay is Combined Cycle Power Plant with a capacity of 180 MW (Gas Turbine - 120 MW, Steam Turbine - 60 MW) commissioned in the year 1993-94. This is quick starting unit and very critical being black start unit. The static relays were replaced by latest numerical relay and the discreet scheme was standardised as typical Generator protection for ease of operation and Maintenance, with same terminologies.

For protection of Generator from various faults and abnormalizes, protection relays are required, which can correctly identify and isolate the fault. The mix of protection for Generator (Stator & Rotor) is called GRP (Generator Relay protection). The old GRP was static and discreet type protection for various function such as Generator Differential, Loss of excitation, Reverse Power, UAT Differential, GT Overcurrent etc (Refer Fig 1). Following equipment are protected by relays:

(1) Generator
(2) Generator Transformer (GT)
(3) Unit Auxiliary Transformer (UAT)
(4) Static Frequency Convertor & Static Excitation Equipment

In Unit 7 there were individual relays for every protection. Trip output from these relays were extended to following locations through Trip Matrix (Refer Fig 2):

(1) 220 kV Generator Transformer breakers
(2) 6.6 kV UAT LV I/C breakers
(3) AVR/SEE
(4) Turbine
(5) 6.6 kV SEE Switchgear
(6) GT cooler
(7) Static Frequency Convertor

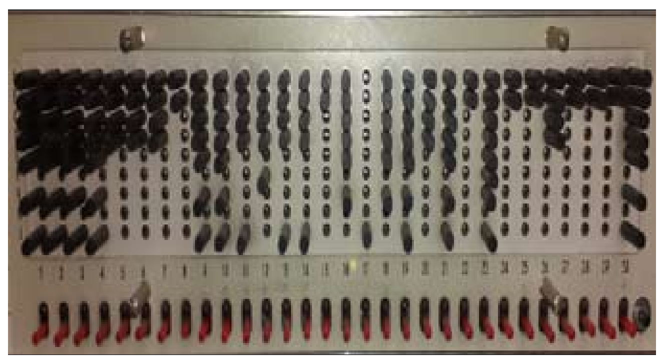

Fig. 2 : Trip Matrix for GRP

Need for GRP Replacement

1. Static protection which had Card/Track failures.
2. Obsolete/Unavailability of spares from OEM.

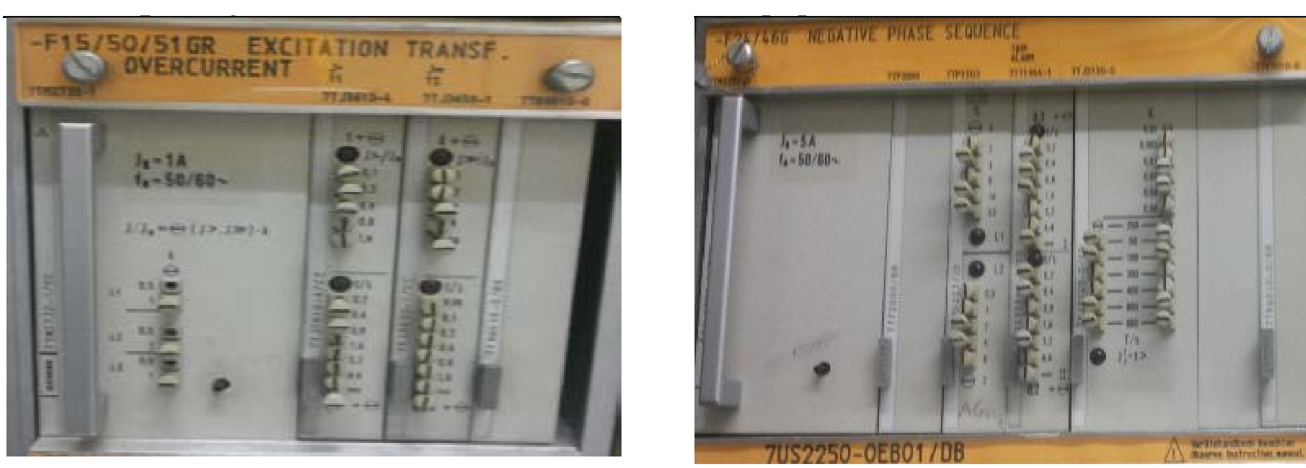

Fig. 1 : Separate Relay for Each protection

3. No DR facility for Analysis in the event of Disturbance.
4. Not possible to track values of functions such as Stator E/F and Rotor E/F.

Proposed scheme for GRP

1. 100% redundant, Main 1 & Main 2 Numerical protection relays which encompasses all Generator protections (Two separate IED with identical functions).
2. Stator and Rotor E/F scheme to be part of both M1 & M2 protections.
3. Separate relays for UAT Differential, GT Differential, UAT O/C+E/F, SEE Transformer O/C and GT HV O/C+E/F.
4. Conversion of Equipment based tripping scheme to Class ABCD lockout scheme.
5. Implementation of Convertor E/F scheme in Numerical relay.
6. OEM to provide latest series relays for Machine and Differential schemes

Conversion from Matrix to Lockout scheme

Challenge was to convert Matrix based equipment Tripping to Lockout based Tripping. Several discussion with seniors and brain storming sessions helped in classifying tripping in 4 categories which were based on lockout. For tripping SFC and 6.6 kV SEE switchgear we used equipment based tripping method using Relay BO through auxilliary Relay (Refer Fig. 3).

Calibration at Site for following protection:

1. Stator E/F
2. Rotor E/F
3. Convertor E/F protection
4. Calibration of Thermistor for Excitation Transformer Protection

Fine tuning of protection depending on site condition and machine parameter required calibration at site for 4 protection in GRP.

Stability Test after Replacement

For proving correctness of Polarity and connections, stability test was performed in 7 ways to prove correctness of all protection.

1. GT bkr 1 & UAT 7A LV side (87OA/87GT/87UAT)
2. Gen & UAT 7A LV side (87G/87GT/87OA/87UAT)
3. GT bkr 1 & 2 (87GT/87OA)
4. GT bkr 1 & UAT 7B LV side (87OA/87GT/87UAT)
5. Gen & UAT 7B LV side (87G/87GT/87OA/87UAT)
6. GT bkr 1 & Gen (87G/87GT/87OA)
7. GT REF

These 7 checks proved correctness of all protection system based on current criteria for REF and Differenrial protection (Refer Fig. 4)

SCC on Bkr

We did SCC as current was more as compared to offline stability. Also we wanted to check phase angle in Relay and direction of Power Flow involving CT and PT connections. Values from various protection were noted and found in order (Refer Fig. 5).

OCC

OCC was performed as routine test for checking Vf and If parameters. We utilized this oppurtunity to confirm Polarity, phase angle and phase sequence of PT circuit (Refer Fig. 6). Phase angle measurement were available directly in Relay. We used phase sequence meter to determine phase sequence of voltage circuit entering in GRP.

S.NO	TYPE	FUNCTION
1	TYPE-1	87G, 87OA, 87GT, 87UAT, 64GT, GT E/F, 64G1, 64G2, 64G3, 50UAT, 50/51UAT, UTBZ, 6.6KV LBB, UAT BZ, UAT OTI, UAT WTI
2	TYPE-2	U/F STG-2 WITH TIMER, 21G, EMERGENCY TRIP, GT OTI+WTI, 220KV LBB
3	TYPE-3	RP1 STAGE -2, U/F STAGE -1 &2, 51NGT, 46G,21G T3, RP2 STAGE-2, 78G1, 78G2, DM, SPEED MONITOR
4	TYPE-4	50/51 GR, EXCI.FAIL TRIP, EXCI.TR WTI
5	TYPE-5	SFC CONV TRIP
6	TYPE-6	40G STAGE-1, 40G STAGE 2, RP-1 STAGE-1, 51GT, RP-2 STAGE-1
7	TYPE-7	64F1/F2, 99G1, 99G2
8	TYPE-8	59 G1+G2
9	TYPE-9	64 SC

		220KV CB	6.6KV CB	AVR	RPS	GT COOLER
CLASS-A	TYPE-1 + TYPE-2 + TYPE-4	X	X	X	X	X
CLASS-C	TYPE-3	X				
CLASS-B	TYPE-5				X	
CLASS-D	TYPE-6 + TYPE-7+ TYPE-8	X	X	X		

TRIP TO EX.CB	TYPE-4 + TYPE-8
TRIP TO CONVERTER	TYPE-1+TYPE-4+TYPE-7+TYPE-9

Fig. 3 : Conversion from Matrix to L/O Based Tripping

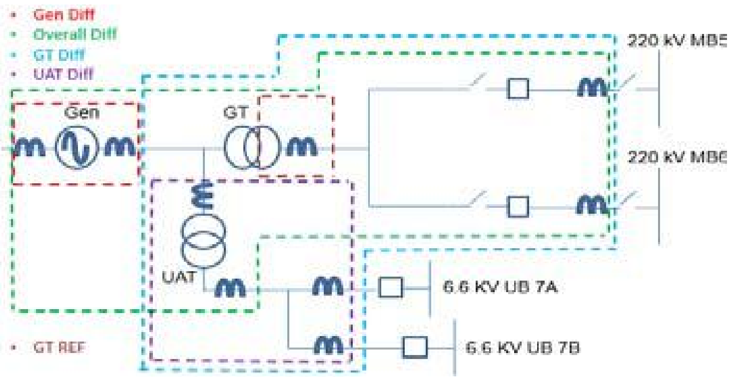

Fig. 4 : Various Protection and respective zones

87OA

SIDE-1	PHASE	CURRENT (A)
1000/1A	A	165∠0°
GT HV	B	165∠-120°
	C	165∠120°

SIDE-2	PHASE	CURRENT (kA)
10000/5A	A	3.55∠150°
GEN NEU	B	3.55∠30°
	C	3.55∠-90°

Diff Stability	I diff	Irest
A	0.008	0.359
B	0.008	0.358
C	0.008	0.358

87GT

SIDE-1	PHASE	CURRENT (A)
1000/1A	A	165∠0°
	B	165∠-120°
	C	165∠120°

SIDE-2	PHASE	CURRENT (kA)
10000/5A	A	3.55∠150°
	B	3.55∠30°
	C	3.55∠-90°

Diff Stability	I diff	Irest
A	0.008	0.359
B	0.009	0.358
C	0.008	0.358

50/51GT

PHASE	CURRENT (A)
A	165
B	165
C	165

IREF 0A
VREF 0.175V

87OA

SIDE-1	PHASE	CURRENT (A)
1000/1A	A	165∠0°
GT HV	B	165∠-120°
	C	165∠120°

SIDE-2	PHASE	CURRENT (kA)
10000/5A	A	3.55∠150°
GEN NEU	B	3.55∠30°
	C	3.55∠-90°

Diff Stability	I diff	Irest
A	0.008	0.359
B	0.008	0.358
C	0.008	0.358

87GT

SIDE-1	PHASE	CURRENT (A)
1000/1A	A	165∠0°
	B	165∠-120°
	C	165∠120°

SIDE-2	PHASE	CURRENT (kA)
10000/5A	A	3.55∠150°
	B	3.55∠30°
	C	3.55∠-90°

Diff Stability	I diff	Irest
A	0.008	0.359
B	0.009	0.358
C	0.008	0.358

50/51GT

PHASE	CURRENT (A)
A	165
B	165
C	165

IREF 0A
VREF 0.175V

Fig. 5 : Stability for Various Protection during SCC

GR1	Voltage (kV)	GR2	Voltage (kV)
Va-n	5.79∠0°	Va-n	5.93∠0°
Vb-n	5.90∠-120°	Vb-n	5.91∠-120°
Vc-n	5.82∠120°	Vc-n	5.92∠120°
Va-b	10.19∠31°	Va-b	10.18∠31°
Vb-c	10.18∠-89°	Vb-c	10.19∠-90°
Vc-a	10.19∠150°	Vc-a	10.19∠150°

V/F	0.97		0.97

87GT

Va-n	126.26∠0°	Va-b	218.3∠30°
Vb-n	126.05∠-120°	Vb-c	218.37∠-90°
Vc-n	126.11∠120°	Vc-a	218.62∠150°

Fig. 6 : Voltage measurement during OCC

Difficulties Faced

1. Converting old scheme in New 3 panels increased lot of wiring in Panels as space was available only for 3 panels (Traditionally it requires 4 panels for GRP).
2. Inter panel wiring increased as DCS cables could not be shifted from one location to another.
3. Testing convertor E/F protection (Refer Fig no: 7) with actual simulation was not available.
4. Matrix to L/o conversion involved preparation of Class A/B/C/D scheme.
5. Unavailability of Sample Gas Turbine scheme with OEM for reference as Trip matrix for Gas Turbine is different as compared to Steam Turbine.
6. Protection philosophy for Gas Turbine was discussed with OEM (for deviations as compared to Steam Turbine) but we could not get proper answer to queries raised.
7. Entry of Panels was difficult at Panels had to be taken inside container which had restricted and small entry.
8. Very less current seen in GT HV side during stability.
9. Polarity found reverse for wiring during GT REF stability.
10. Deviations in Gas Turbine protection scheme from regular scheme.
11. Modifications done in Speed monitoring Trip circuit (Separate scheme in DCS for various frequency conditions).
12. Convertor not available till last moment. Calibration done at last moment during commissioning.
13. Thermistors for Exc. Transformer were not available till last moment. Also, they were not suitable for our application. Modified Excitation Transformer WTI and Core Temp Trip scheme to alarm.

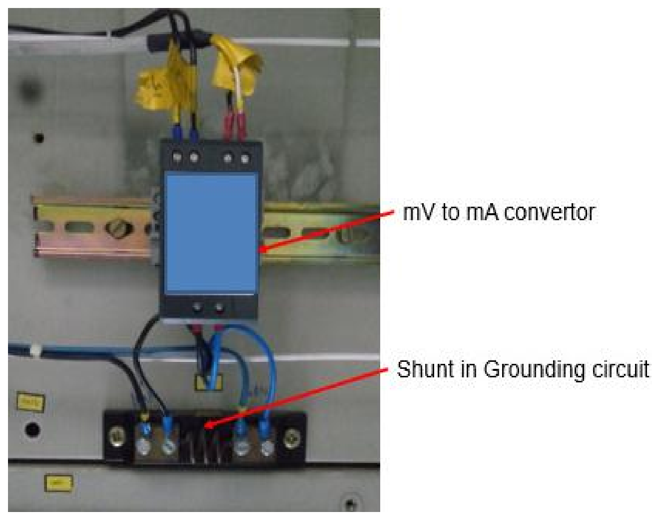

Fig. 7 : Convertor and Shunt connection

Additional Features/Modifications implemented

1. Convertor E/F Protection implementation (Refer Fig 8).

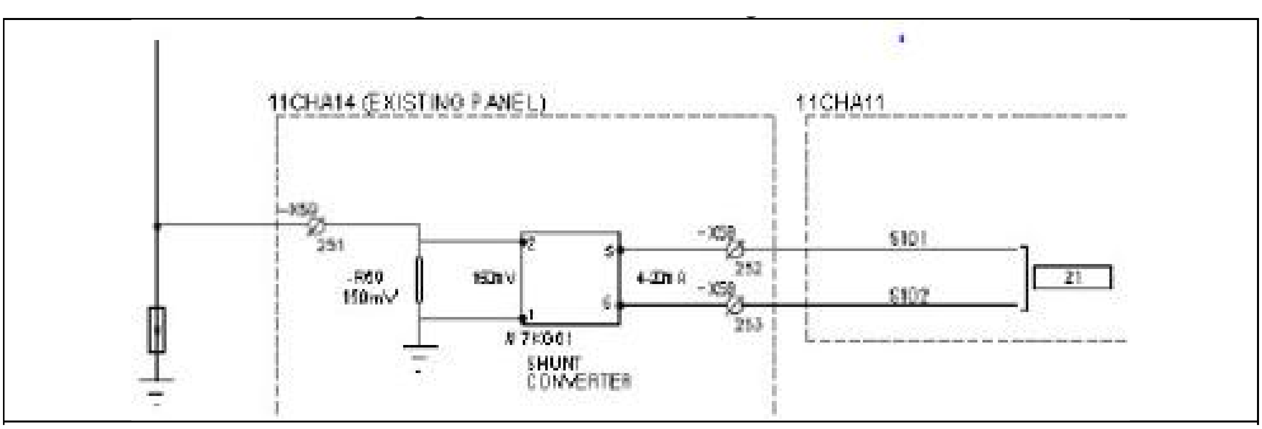

Fig. 8 : Convertor E/F protection

2. Stator E/F protection modification to include SFC operation (Refer Fig 9).
3. Rotor E/F wiring modification by shifting voltage divider arrangement in GRP.
4. Implementation of GT HV breaker LBBU protection GRP.
5. Over Frequency based changeover scheme implemented.
6. Lockout concept instead of equipment based tripping.
7. Black start permissive to start DG set through lockout operation.
8. Improvements in various protection such as 21/46/40/32/2.5 LBB.
9. Networking done all relays done for accessing relays through switch.

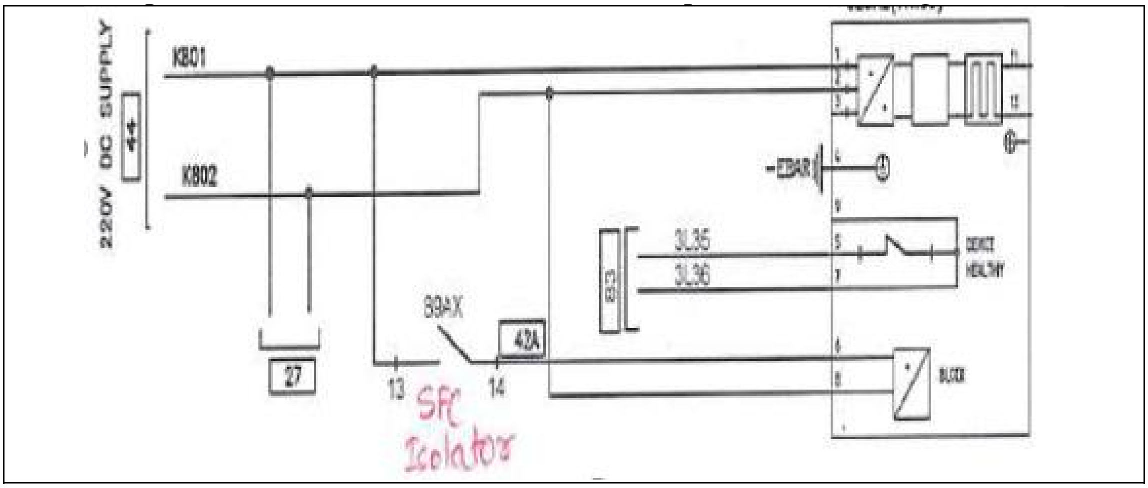

Fig. 9 : Blocking Stator E/F during SFC operation

CIGRE (India)

BENEFITS AND MEMBERSHIP RIGHTS

The main benefits against this membership are:

- Collaborate with experts from across the whole power system.
- Access perspectives and peers from every corner of the globe.
- Learn from other professional's and organisations practical experiences.
- Up skill and be prepared for the future.
- Opportunities to participate & present papers at CIGRE sessions held at PARIS on discount registration fee.
- CIGRÉ's membership directory – available on CD-ROM – provides a link to all members and is an essential tool for extending professional contacts.
- Many services, information and links with CIGRÉ national committees and study committees, which organize regional meetings and local events

Membership rights:

- Unlimited free access to more than 10000 technical reports through (e-cigre.org), The e- library of CIGRE's comprehensive publications and the world's authorative source of technical reference information.
- Free access to ELECTRA- The bimonthly technical journal of the association, the window on a world of power systems solutions.
- Opportunities to participate in technical work & join the CIGRE's unique knowledge development programme by joining a working group or study committee.
- Reduced registration fees for CIGRE events Including the Paris Session the global thought leadership congress of the community
- Eligibility to enter CIGRE's prestigious awards.

Activities of CIGRE-India - 2021

About CIGRE-India

CIGRE-India functions as the 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

Governing Body of CIGRE India

President CIGRE-India

I.S. Jha
Member, CERC

Vice-Presidents

U.K. Bhattacharya
Director, NTPC

Renuka Gera
Director, BHEL

Seema Gupta
Director, Powergrid

Anil Saboo
President, IEEMA

Praveer Sinha
MD, Tata Power

Manish Agrawal
CEO, Infra and Solutions Business, Sterlite Power Transmission

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Technical Council

Chair
R.P. Sasmal
Ex Director, POWERGRID

Technical Council

Joint Chair
N.N. Misra
Ex Director, NTPC

Member

J. Panday
Sr. Director, IEEMA

Secretary CIGRE-India

A.K. Dinkar
Secretary, CBIP

Director CIGRE-India

Sanjeev Singh
Director, CBIP

1. **Membership in CIGRE**
   (i) Steering Committee Members:
   - Mr. I S Jha Hon'ble Member, CERC in 2018-2020 & 2020-2022
   - Mr. R P Singh the then President CIGRE-India and Former CMD, POWERGRID in 2006-2008

   (ii) Administrative Council Member:
   Mr. I.S.Jha Member, Steering Committee, CIGRE (Paris) & Hon'ble Member, CERC, since January 2017.

iii. Honorary Member :

- Mr. C.V.J.Verma, Former -MS, CBIP

iv. Growth of Membership :

- In the year 2016 - 593 nos. equivalent members
(Individual: 131; Young: 24; Collective-I: 69; Collective-II: 12)
- In the year 2017 - 768 nos. equivalent members
(Individual: 151; Young: 28; Collective-I: 91; Collective-II: 19)
- In the year 2018 - 826 nos. equivalent members
(Individual: 169; Young: 35; Collective-I: 98; Collective-II: 17)
- In the year 2019 – 820 nos. equivalent members
(Individual: 165; Young: 25; Collective-I: 96; Collective-II: 22; Student Member: 96)
- In the year 2020 - 800 nos. equivalent members
(Individual: 159; Young: 22; Collective-I: 95; Collective-II: 20; Student Member: 142)
- In the year 2021 – 514
(Individual 147; Young : 26 ; Collective: 53; Institutes: 12 Student Member 142)

At present India is at fifth at fifth position in the world on the basis of membership count (805). The membership of few other country are Brazil – 1101; US-1039; Japan-959; Germany-808; India-805; Russia-777; China-770; Australia 741; UK-657; and France-611. The membership of 30 NC's is given, for information of members (Fig. 1). CIGRE has now offered 18 Month membership to new members registering from July 2021 onwards.

- The country wise rank for nine top countries where members are maximum accessing CIGRE documents are; US; India; Germany; UK; China; Australia; brazil; Canada and Japan.

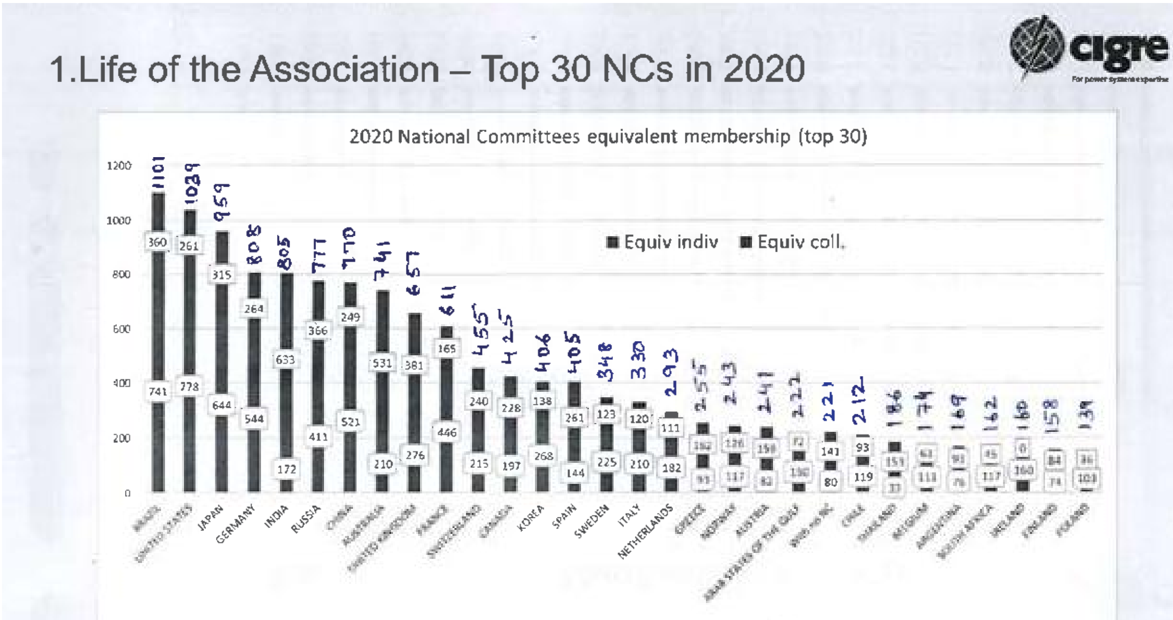
2. Participation in CIGRE Study Committee meeting at various places in the world:

- List of participants in CIGRE Study Committee at various placed from India since 2016 is attached as Annexure 1.

3. CIGRE Study Committee Meetings held in the recent past, proposed in India and status of approval by CIGRE

Year	Event
2013	SC D2: Information Systems & Telecommunication
2015	SC B4: DC Systems & Power Electronics
2017	SC B1: Insulated Cables
2019	SC A1: Rotating Electrical Machines
	SC A2 : Power Transformers & Reactors SC B2 : Overhead Lines SC D1 : Materials and Emerging Test Techniques
2021 - Approved	SC B5 – Protection & Automation – shifted to Oct 2023
	SC A3 : Transmission & Distribution Equipment (planned on 7-11 March 2022)
2023 - Proposed	SC B3 : Substations & Electrical Installations SC C2 : Power System Operation & Control SC C4 : Power System Technical Performance SC C5 : Electricity Markets & Regulation
2025 - Proposed	C1: Power System Development & Economics C6: Active Distribution System and Distributed Energy Resources

FIG. : 1



4. CIGRE-India - Women in Engineering Forum

Forum has been created under chairmanship of Madam Seem Gupta Director (Operation) Powergrid

- 1st meeting of WIE forum held on 18/10/2019 at Power Grid.
- 2nd Meeting held on 19/11/2019 at Hotel Royal Plaza. The report covered in Electra
- We plan try to ensure :

  – Participation of at least five women engineers from India in CIGRE session 2021.

  – To induct at least one women engineer as member in each of the 16 NSC.

5. NGN Forum of CIGRE India

- The forum dedicated to the young professionals.
- The aim is to provide a good opportunity for development through networking with global Young Members
- The name of Mr. Rajesh Kumar, Sr. DGM, and distinguished member CIGRE (2020) has been nominated to lead this forum of young engineers.
- We plan to induct at least one young engineer as member in each of the 16 NSC.

6. CIGRE Steering Committee Meeting at Goa in India

- The meeting planned for 17-19 Nov. 2020 was cancelled due to current pandemic.
- The steering committee proposed to visit India and have their meeting in April 2021, which was confirmed by Shri R.P. Sasmal technical Chair, CIGRE-India during above steering committee meeting.
- As already decided, a two days Colloquium on "Grid stability with enhanced penetration of Renewables" will also be planned.

7. National Representative on Study Committee for 2020-22 from India. (Technical Council of CIGRE-India)

The proposal from India:

- The approval on the proposal from India from CIGRE, has been received. We are representing in all the 16 Committees additional seat one each in two study committees i.e. C1 & C6

Seema Gupta
Director, Powergrid
Chairperson CIGRE NSC A2

B.B. Chauhan
Former MD, GETCO
Chairman CIGRE NSC C4

K.V.S. Baba
CMD, POSOCO
Chairman CIGRE NSC C2

Subir Sen
ED, Powergrid
Chairman CIGRE NSC C1

B.N. De Bhomick
Former ED, Powergrid
Chairman CIGRE NSC C3

Anish Anand
ED, Powergrid
Chairman CIGRE NSC B2

R.K. Tyagi
ED, Powergrid
Chairman CIGRE NSC A3

Subhas Thakur
AGM, NTPC
Chairman CIGRE NSC B5

D.K. Chaturvedi
Former GM, NTPC
Chairman CIGRE NSC A1

Dr. B.P. Muni
GM, BHEL
Chairman CIGRE NSC D1

Nihar Raj
VP, Adani
Chairman CIGRE NSC B3

S.S. Misra
GM, NTPC
Chairman CIGRE NSC C6

Santanu Sen
GM, CESC Ltd.
Co-Chairman CIGRE NSC C1

Y. B. K. Reddy
AGM, SECI
Co-Chairman
CIGRE NSC C6

S.C. Saxena
SGM, POSOCO
Chairman CIGRE
NSC C5

Anil Kumar Arora,
Former ED, Powergrid
Chairman CIGRE
NSC B4

Debasis De,
ED, NLDC, POSOCO
Chairman CIGRE
NSC D2

Lalit Sharma
COO, KEI
Chairman CIGRE
NSC B1

8. CIGRE fellow Award from India:

The name of Shri D.K. Chaturvedi, Chairman, NSC A1 who fulfilled the entire requirement has been approved by CIGRE

9. List of events held for 01st Jan -30th June 2021

- International Tutorial on Integration of Renewables to the Grid: Challenges and solutions to overcome variability and intermittency in 15th January 2021
- International Tutorial on Wide Area Measurement Systems and their use in improving Power System resiliency in 22nd January 2021
- International Tutorial on Indian Power System & Relevance of CIGRE SC D2 Activities in 27th January 2021
- International Tutorial on System security challenges with high penetration of inverter-based resources in 28th January 2021
- International Tutorial on State of the Art on Spacer and Spacer Dampers used on Overhead Transmission Lines with Bundled Conductors in 29th January 2021
- International Tutorial on Assessment of Conducted Disturbances above 2 kHz in MV and LV Power Systems in 04th February 2021
- International Tutorial on Asset Management for Electrical Utilities: Some Basics and Recent Developments in 05th February 2021
- International Tutorial on Transmission lines with fiber reinforced polymer composites in 10th February 2021
- International Tutorial on ICT and Smart Grid Technologies: An enabler for Transformation in the Distribution sector in 12th February 2021
- International Tutorial on Modelling and Dynamic Performance of Inverter Based Generation in Power System Transmission and Distribution Studies in 15th February 2021
- International Tutorial on Cyber Security Measures for Energy Systems in 26th February 2021
- International Tutorial on Extrapolation of measured values of power frequency magnetic fields in the vicinity of power links in 03rd March 2021
- International Tutorial on Compact AC Overhead Lines in 16th March 2021
- International Tutorial on Core IT technologies – AI and IoT, as a powerful tool for energy supply systems of the future in 19th March 2021

10. CIGRE-India - List of events Planned

- International Tutorial on Insulated Cable in 21st & 23rd July 2021
- National Tutorial on 'Earthing Systems' in 26th-27th July 2021
- Panel Discussion (Virtual) on Important tips for writing papers by engineering professionals for consideration at international level in 28th July 2021
- Training on 'Cyber Security For Critical Assets' in 4th-5th August 2021
- Training on 'Distribution Automation' in 17th -18th August 2021
- International Tutorials & Colloquium on Transmission & Distribution Equipment's- 07-12th March 2022
- CIGRE steering Committee Meeting at Goa in April 2022 and International Colloquium on "Grid stability with enhanced penetration of Renewables-Technical Challenge and Regulatory frame work"- 11th -15th APRIL 2022 at Goa

11. List of CIGRE Sr. Executives already visited India in recent past :

- Mr. Rob Stephen, as President - CIGRE
- Mr. Philippe Adam, as Secretary General, CIGRE
- Mr. Michel Augonnet, as Ex - Vice-President Finance - currently President CIGRE
- Mr. Nico Smit, as Chairman CIGRE SC A1

- Mr. Peter Wiehe, as Secretary CIGRE SC A1
- Mr. Simon Ryder, as Chairman CIGRE SC A2
- Mr. Hiroki Ito, as Chairman CIGRE SC A3
- Mr. Marco Marelli, as Chairman CIGRE SC B1
- Mr. Pierre Argaut, as Chairman SC B1
- Dr. Konstantin Papailiou, as Chairman CIGRE SC B2
- Mr. Herbert Lugschitz, as Chairman CIGRE SC B2
- Mr. Terry Krieg, as Chairman CIGRE SC B3
- Dr. Mohamed Rashwan, as Chairman CIGRE SC B4
- Ms. Chirstine Schwaegerl, as Chairperson CIGRE SC C6
- Mr. Nikos Hatziargyriou, as Former Chairman CIGRE SC C6
- Dr. Ralf Pietsch, as Chairman CIGRE SC D1
- Mr. Carlos Samitier, as Chairman CIGRE SC D2
- Ms. Khayakazi Dioka, as Chairperson of CIGRE WiE International

13. Publication of half yearly CIGRE India Journal

To increase the activities and membership CIGRE India has taken the initiative to publish its Journal initially with the frequency of six months. The issues of the Journal up to January 2021 have already been published.

The CIGRE India journal contains details about the activities of the association, technical articles, and data and is circulated to its members within the country. The journal serves an excellent purpose of disseminating the technological, etc. amongst the concerned organizations of the energy sector, which are taking place at the national and international level. The journal is available both in print and online versions.

13. A. CIGRE Virtual Session 2021: (20-25 August 2021)

- Registration fees have been lowered to reflect the virtual nature of the event.
- Those who registered for the 2021 full Session can carry their registration forward to 2022 and access this year's virtual event for a special highly discounted rate*.
- Similarly those who now register for 2022 will access the same rate. The fee Schedule is as under :

Registration Rate	STANDARD	STUDENT	YOUNG PROFESSIONAL
A - Virtual Centennial Session	- Member : € 395 - Non member : € 595	- Member : € 198 - Non member*: € 298	- Member : € 316 - Non member*: € 476
B - Virtual Centennial Session (Delegate already registered) to 31st July 2021	- Member : € 195 - Non member : € 295	- Member : € 195 - Non member : € 295	- Member : € 195 - Non member*: € 295
C - Virtual Centennial Session + 2022 Hybrid Session (B+D)	- Member : € 1194 - Non member : € 1530 - Companion : € 196	- Member : € 695 - Non member*: € 913 - Companion : € 196	- Member : € 994 - Non member*:€ 1283 - Companion : € 196
D - 2022 Hybrid Session only*	- Member : € 999 - Non member : € 1235 - Companion : € 196	- Member : € 500 - Non member*: € 618 - Companion : € 196	- Member : € 799 - Non member*: € 988 - Companion : € 196

- Full programme of session is available on "CIGRE session2021" and online registrations be done directly and open at registration.cigre.org.
- India Pavilion during CIGRE Session:

Fee paid for participation in India pavilion during CIGRE session 2021 by the following is being adjusted for 2022 session:

NTPC- 18 sqm;	Power Grid – 12 sqm
Scope (12 sqm) ;	KEI (18 sqm);
Modern Insulator (9 Sqm);	IEEMA (45 sqm)

Total Space 114 sqm.

14. CIGRE Session 2022: (21-26 August 2022)

- 75 synopses out of 203 Synopses selected by CIGRE-India and already uploaded by 21 June 2021.
- Synopses notification of acceptance: 24th September 2021
- Receipt of full papers at Central Office: 24th January 2022
- Full papers Notification of acceptance: 27th May 2022

15. National Study Committee (Shadow Committee)

The nominations for all the sixteen committees at national level have been requested and the committees are being reconstituted. As advised we plan to include

- One Woman engineer and one young engineer in each of the committee

16. Decisions/ discussions held in the last two Steering Committee Meetings attended by Shri R.P. Sasmal, Chair, technical, CIGRE-India:

The Summary of discussion of Steering Committee Meeting (Virtual) held On 28 April 2021 (attended by Shri R. P. Sasmal) & Major issues discussed and agreed were informed as under:

- 2021 CIGRE centenary conference shall be only virtual without physical presence of delegates.
- There is no exhibition in the year 2021.
- The money deposited for exhibition at Paris 2021 shall be utilised for 2022 session .
- Our membership for 2020 was 805 and China membership was 770.
- We are 5th in the membership and China stood 7th.
- Brazil with highest membership of 1101.
- The fee for virtual conference for year 2021 shall be revisited and those who have paid registration fee for 2021 shall be adjusted against 2022 conference.
- We confirmed the date of steering committee meeting on 12th of April 2022 at Goa.

17. New Initiatives

- Online programme to overcome the effect of COVID 2019
- CIGRE India has launched series of online International and National Tutorials throughout the year on the subject of each of the Studty Committee of CIGRE.

Acknowledgement of support of CIGRE

CIGRE India acknowledges the support and guidance extended by CIGRE, which has helped CIGRE-India in increasing the activities of CIGRE in India.

CIGRE Technical Council Award for the year 2021 to Shri Anish Anand, Executive Director, POWERGRID

Presented by CIGRE during the Virtual CIGRE Centennial Session

This prestigious CIGRE award has been bestowed to only two Indians prior to this Since its inception in 1993. Award is granted to select CIGRE Members as a reward for their activities participation in the activities of CIGRE.

Shri Anish Anand graduated in engineering in 1985 and over the years assumed various responsibilities & positions in the power sector Central PSUs, NTPC Ltd. & Power Grid Corporation of India Ltd. He has more than33 years of professional experience in the field of power transmission and currently, as Executive Director in POWERGRID.

Shri Anand has carried out transmission line design optimization & project engineering of more than 100 transmission projects of voltage levels from 66 kV to 1200 kV in various type of terrains including high altitude snow bound mountainous terrains and also looked after construction and O&M of 765 kV & 400 kV transmission lines and substations in Western Region. Besides project engineering & execution, he has been involved in standardization, Research & Development, in-house software development, in-house tower & foundation design developments, environmental impact/line interference studies, uprating/upgrading studies, transmission line ROW conservation measures, “Make in India” initiatives and vendor development in the field of transmission line.

Shri Anand has been associated with design optimization and engineering of India’s first 765 kV line, high capacity 500 kV HVDC line, 400 kV High SIL line, 765 kV double circuit lines, 800 kV UHVDC lines & 1200 kV line as well as introduction of new technologies in the country viz. OPGW, HTLS conductors, composite insulators, modern survey techniques using satellite imageries, emergency restoration systems, narrow base/pole structure towers.

Shri Anish Anand has been associated with CIGRE activities for many years. He is presently Chairman of CIGRE National Committee B-2 on Overhead lines and member of various CIGRE working groups. Previously, he had been Chairman of CIGRE National Committee C3 on System Environmental Performance. Shri Anand is also co-convener of working group of IEC Technical Committee 122 for formulation of new IEC Specification on Design of UHV Transmission System and Chairman of Technical Committee ETD 37 of Bureau of Indian Standards (BIS), responsible for updating of various existing National Standards/Codes and formulation of new Standards for transmission line design & construction, conductors & associated fittings & accessories.

Over the years, Shri Anand has contributed more than 40 technical papers as main/co-author for presentation in National & International conferences/seminars organized by different agencies (viz. CIGRE-France, CIGRE-India, CBIP, GRIDTECH, CEA, CII, ELECRAMA, IEEMA, Afro-Asian Forum, Power-India, Map-India etc.) His salient contributions in CIGRE include paper in CIGRE-France 2008 session on improving reliability of existing transmission lines; two papers on design optimization of +/-800 kV HVDC & 1200 kV line in CIGRE UHV Colloquium in 2013; paper on innovation and best practices for TL developments in India in CIGRE-India International conference in 2013; papers on new technology applications for minimizing land use & design of +/- 800 kV HVDC for CIGRE-France 2014 session, paper on technological solutions & compensation measures for ROW constraints in construction of large network of overhead transmission lines in CIGRE-France 2018 session.

Participation in CIGRE Study Committee Meetings Since 2016

	Study Committee (SC)	2016 - at Paris in August 2026	2017		2018 - at Paris in August 2018	2019	
			Date & Venue	Participants		Date & Venue	Participants
1	**A1: Rotating Machine**	Mr. D.K. Chaturvedi, NTPC	18-23 Sept.17 Vienna, Austria	Mr. D.K. Chaturvedi, NTPC	Mr. D.K. Chaturvedi, NTPC Mr. N.N. Misra, CIGRE India	24 Sept. 2019 New Delhi	Mr. D.K. Chaturvedi NTPC
2	**A2 : Transformers**	Ms. Tanavi Srivastava, Alstom	29 Sept. to 6th Oct. 2017 Poland	Mr. B.N. De Bhowmick	Mr. Selvakumar P. Victor, PG	19th Nov. 2019 New Delhi	Ms. Seema Gupta, POWERGRID
3	**A3 : High Voltage Equipment**	Mr. N.N. Misra, CIGRE-India	30 Sept. – 6th Oct. 2017 Canada	R.K. Tyagi, PG	Mr. N.N. Misra and Mr. R.P. Sasmal CIGRE -India	7-13 Sept. 2019 Bucharest Romania	Mr. R.K. Tyagi, PG and Mr. Rakesh Kumar, PG
4.	**B1 : HV Insulated Cables**	Mr. Dipal Shah, Pfistrer	9-13 Oct. 2017 India	Mr. Dipal Shah	Mr. Lalit Sharma, KEI and Mr. Dipal Shah	9th Sept. 2019 (Denmark)	**NIL**
5	**B2 : Overhead Lines**	Mr. Gopal Ji, POWERGRID	29-30 May 2017 Dublin, Ireland	Prof. C. Johnson Excel Engg. college	Mr. A..K. Vyas, PG	19 Nov. 2019 New Delhi	Mr. Anish Anand, PG
6	**B3 : Substations**	Mr. Abhay Choudhary, POWERGRID	Sept. 2017 Brazil	Mr. Rajil Srivastava, PG	Mr. R.P. Sasmal, CIGRE-India and Mr. Rakesh Kumar,	20-25 Sept. 2019 China	Mr. Raji Srivastava, PG & Mr. Abhay Kumar, PG
7	**B4 : HVDC Link and AC Power Electronic Equipment**	Shri R.K. Chauhan, PowerGrid	30 Sept. – 6th Oct. 2017 Canada	Shri R.K. Chauhan PG	**Nil** ~~Mr. Rakesh Kumar~~	28-30th Sept 19, 1-5th Oct 2019- South Africa	Mr. R.K. Chauhan, Dir, PG and Mr. B.B. Mukharjee, PG
8	**B5 : Power System Protection and Local Control**	Mr. Subhash Thakur NTPC	Sept. 2017 New Zealand --	Mr. Subhash Thakur NTPC	Mr. Subhash Thakur	24-28th June 19 Norway	Mr. Abhishek Khanna, Mr. Debashish Dutta, Mr. Anand Pandey, NTPC
9	**C1 : Power System Planning and Development**	Ms. Seema Gupta, PowerGrid	May 2017 Dublin, Ireland	Mr. K.V.S. Baba, POSOCO	Mr. R.K. Verma and Mr. R.P. Sasmal, CIGRE -India	20-26th Sept. 2019 Chengdu, China	Ms. Seema Gupta, POWERGRID and Mr. Ashok Pal, PG
10	**C2 : Power System Operation and Control**	K.V.S. Baba POSOCO	May 2017 Dublin, Ireland	Mr. K.V.S. Baba, POSOCO	Mr. P.K. Agarwal	4-7th June 2019 Aalborg, Denmark	Mr. KVS Baba, POSOCO
11	**C3 : System Environmental Performance**	**Nil**	Sept. 2017 Seoul, Korea	Mr. K.V.S. Baba, POSOCO	**Nil** ~~Mr. Anil Jain, PG~~	4-7th June 2019 Aalborg, Denmark	Mr. B.N. De Bhowmick, PG
12	**C4 : System Technical Performance**	Mr. N.M. Seth, GETCO	May 2017 Dublin, Ireland	Mr. K.V.S. Baba, POSOCO	Mr. Selvakumar P. Victor,	4-7th June 2019 Aalborg, Denmark	Mr. B.B. Chauhan, GETCO
13	**C5 : Electricity Markets and Regulation**	K.V.S. Baba, POSOCO	May 2017 Dublin, Ireland	Mr. S.C. Saxena, POSOCO	Mr. P.K. Agarwal	16-19th Sept19 Canada	Mr. P.K. Agarwal, POSOCO
14	**C6 : Distribution Systems and Dispersed Generation**	Dr. Subir Sen, POWERGRID	May 2017 Dublin, Ireland	Mr. S.C. Saxena POSOCO	**Nil** ~~Dr, Subir Sen, PG~~	(3-6 June 2019) Aalborg, Denmark	Dr, Subir Sen, PG and Mr. Rajesh Kumar, PG
15	**D1 : Material for Electro technology**	Mr. Jithinsunder, BHEL	30 Sept. – 6th Oct. 2017 Canada	**Nil**	Mr. Jithinsunder, BHEL	18-23 Nov. 2019 New Delhi	Mr. B.P.Muni, BHEL
16	**D2 : Information Systems & Telecommunications for System**	N.S. Sodha, PowerGrid	20-22/09/2017 Moscow	Mr. N.S. Sodha	Mr. N.S. Sodha	11-14th June 2019 Helsinki, Finland	Mr. N.S. Sodha

Series of International Tutorial (Virtual) Organize by CIGRE-India in the Recent Past

CIGRE-India is one amongst the most active national committee. It is our honor that Mr. I.S. Jha, President CIGRE-India & Hon'ble Member of Central Electricity Regulatory Commission is representing India in CIGRE Steering Committee (the decision making body of top executives) as well as in CIGRE Administrative Council.

It is a matter of pride for all of us that India is represented in all the 16 CIGRE Study Committees and the members are actively involved in the activities of CIGRE study Committees.

It has always been our endeavor to promote CIGRE in India through its activities like organization of regular Training programmers/ Conferences/ Workshops/ Tutorials etc., which has greatly helped involvement of maximum professionals with CIGRE – India including young professionals.

In this unusal situation in the past where skill enhancement and training of professionals emerged as an important aspect and a challenge, CIGRE- India launched series of virtual Tutorials/ Workshops/ Webinars on the subject relevant to 16 CIGRE Study Committees The tutorial organized in the past are listed below:

International Tutorial (Online)

Integration of Renewables to the Grid: Challenges and Solutions to Overcome Variability and Intermittency

15th January 2021

It was conducted under the aegis of CIGRE National Study Committee C2 on System Operations and Control held on 15th January 2021.

The following technical subjects were presented and discussed during the tutorial:

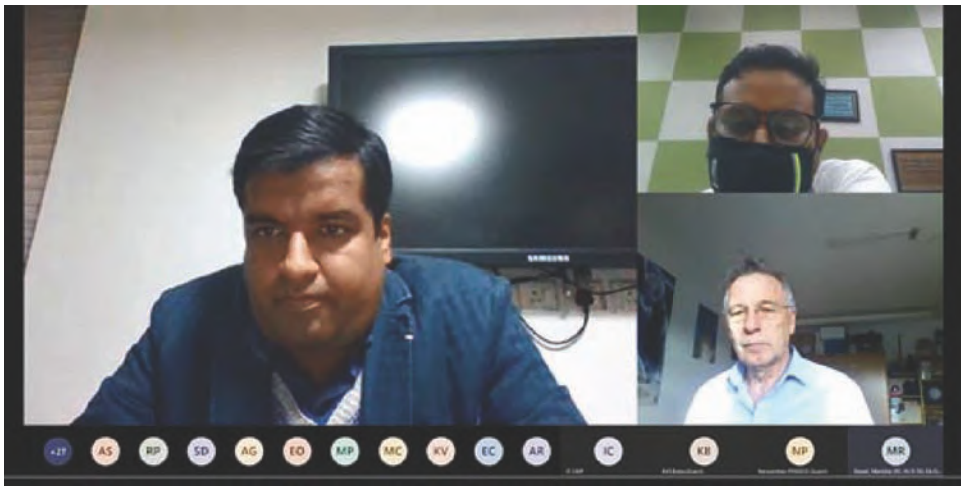
- Challenges in power system operation with high share of renewable energy sources and way forward.
- Forecasting, Scheduling and Imbalance settlement for integration of renewable energy-based generation in large interconnected systems

Shri K.V.S Baba, Chairman, CIGRE NSC C2 & Chairman and Managing Director, POSOCO, graced the opening session. The key speakers for the session were Mr. Vinay Sewdien from Netherland (International) and Mr. M. Venkateshan, Chief Manager from POSOCO (National). There were about 70 participants from different organization.

International Tutorial (Online)

Wide Area Measurement Systems and their use in Improving Power System Eesiliency

22nd January 2021



It was conducted under the aegis of CIGRE National Study Committee C2 on System Operations and Control held on 22nd January 2021.

The following technical subjects were presented and discussed during the conference:

- Wide Area Monitoring, Protection and Control Systems- Support for control room applications
- Experience in commissioning and utilization of wide area measurement system for Power System Operation

Mr. KVS Baba
CMD, POSOCO

Mr. Walter Sattinger
Germany

Mr. Rahul Shukla
POSOCO

Mr. A. RajKumar
POSOCO

Shri K.V.S Baba, Chairman, CIGRE NSC C2 & Chairman and Managing Director, POSOCO, graced the opening session. The key speakers for the session were Mr. Walter Sattinger from Germany (International); Mr. Rahul Shukla, Manager and Mr. Rajkumar A, Chief Manager from POSOCO (National). There were about 70 participants from different organization.

International Tutorial (Online)

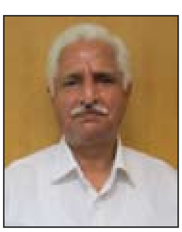
Indian Power System & Relevance of CIGRE SC D2 Activities

27th January 2021

It was conducted under the aegis of CIGRE National Study Committee D2 on Information Systems and Telecommunication held on 27th January 2021.

The following technical subjects were presented and discussed during the conference:

- CIGRE SC D-2 Committee broadly deals with ICT applied to Digital networks from UHV to Distribution (Smart meter, IoT, Big Data, and EMS etc.)
- Communication solutions for information exchange in the Smart delivery of Electrical energy. Interoperability and data exchange between network operators, market players, off-grid premises.
- Cyber security issues from field equipment to corporate IT (Governance constraints, System design, implementation, testing, operation and maintenance).Technologies and architecture to ensure business continuity and disaster recovery. IT systems to support the decision-making process in Asset Management.
- "One Nation One Grid" Indian Power System has seen enormous growth with RE growing at fast pace & ICT Technology played pivotal role in transforming Indian Power System to "Smart Grid".
- First webinar in this series will cover-How Indian Smart Power Grid is managed 24x7 with challenges faced in recent years? How Smart ICT interventions gradually changed Grid Operations? How CIGRE SC D-2 Activities are relevant in reforming Generation, Transmission & Distribution Sectors? This Webinar series will certainly benefit all Power Sector engineers in understanding Smart Grid, ICT, Cyber Security etc.



Shri N.S. Sodha
Former ED, POWERGRID

Shri Debasis De
Executive Director, NLDC, POSOCO

Shri Debasis De, Chairman, CIGRE NSC D2 & Executive Director, POSOCO, graced the opening session. The key speaker for the session were Mr. N S Sodha, advisor, Strategic Advisory Group of CIGRE D2 (Paris) and Former ED Power Grid (National). There were 25 participants from different organization.

International Tutorial (Online)

System Security Challenges with High Penetration of Inverter-Based Resources

28th January 2021

It was conducted under the aegis of CIGRE National Study Committee C2 on System Operations and Control held on 28th January 2021.

The following technical subjects were presented and discussed during the conference:

- System Security Challenges with high penetration of inverter-based resource: Modeling issues
- Power system load flow and stability studies (transient, small signal, voltage) for integration of renewable energy resources

Mr. KVS Baba
CMD, POSOCO

Dr. Nilesh Modi
Australia

Mr. Pradeep Reddy
POSOCO

Mr. Panisankar Chilukuri
POSOCO

Shri K.V.S Baba, Chairman, CIGRE NSC C2 & Chairman and Managing Director, POSOCO, graced the opening session. The key speakers for the session were Dr. Nilesh Modi from Australia (International); Mr. Pradeep Reddy, Manager and Mr. Panisankar C, Chief Manager from POSOCO (National). There were 30 participants from different organization.

International Tutorial (Online)

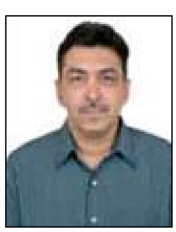
State of the Art on Spacer and Spacer Dampers used on Overhead Transmission Lines with Bundled Conductors

29th January 2021

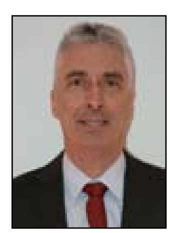
It was conducted under the aegis of CIGRE National Study Committee B2 on Overhead Lines held on 29th January 2021.

The following technical subjects were presented and discussed during the tutorial:

- The general description of the different types of spacers and spacer dampers used on overhead transmission lines with bundled conductors.
- The material requirement and also the different types of clamping systems currently used. This will also cover the Mechanical, dynamic, electrical and environmental design characteristics. The actual experience with current practices.



Mr. Anish Anand
Executive Director, POWERGRID



Dr. Pierre Van Dyke
Canada

Shri A K Dinkar, Secretary, CBIP and CIGRE-India, delivered the welcome address. Shri Anish Anand, Chairman, CIGRE NSC B2 & Executive Director, Power Grid Corporation of india, graced the opening session. The key speakers for the session were Dr. Pierre Van Dyke from Canada (International) and. There were 29 participants from different organization.

International Tutorial (Online)

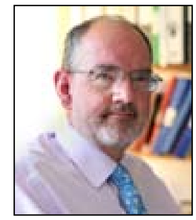
Assessment of Conducted Disturbances above 2 kHz in MV and LV Power Systems

4th February 2021

It was conducted under the aegis of CIGRE National Study Committee C4 on Power System Technical Performance held on 04th February 2021.

The following technical subjects were presented and discussed during the tutorial:

- An assessment of conducted disturbances above 2 kHz in MV and LV power systems.
- Awareness of the issues involved and technical description of the phenomena.
- Existing recommendations and guides and gaps for future work.
- Information on electric power definitions.
- Measurement techniques, modeling and aggregation.
- The method for measuring and calculating conductor impedances.
- Example study of the aggregation and propagation of the conducted emissions above 2 kHz.



Prof. Dave Thomas
CIGRE

Shri A K Dinkar, Secretary CIGRE, graced the opening session. The key speakers for the session were Prof. Dave Thomas from CIGRE (International). There were about 25 participants from different organization.

International Tutorial (Online)

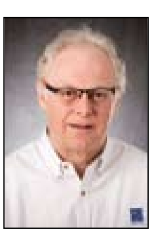
Asset Management for Electrical Utilities : Some Basics and Recent Developments

5th February 2021

It was conducted under the aegis of CIGRE National Study Committee C1 on Power System Development and Economics held on 05th February 2021.

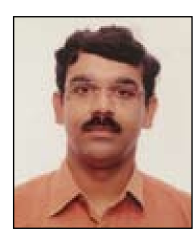
The following technical subjects were presented and discussed during the tutorial:

- Equipment focused and strategy focused aspects of Asset Management with examples
- Recent developments in improving Asset Management techniques and methodologies.
- ISO55000
- Asset Performance Management (APM) tool
- CIGRE AM activities
- Asset Management maturity pyramid



Mr. Yury Tsimberg
Canada

Mr. Subir Sen
Executive Director, Power Grid



Mr. Santanu Sen
DY. General Manager, CESC Ltd.

Shri Santanu Sen, Co-Chairman, CIGRE NSC C1 and Deputy General Manage at CESC Ltd., graced the opening session on behalf of Shri Subir Sen, Chairman, CIGRE NCS C1 and Executive Director, Power Grid Corporation of India. The key speaker for the session were Mr Yury Tsimberg from Canada (International). There were about 25 participants from different organization.

International Tutorial (Online)

Transmission Lines with Fiber Reinforced Polymer Composites

10th February 2021

It was conducted under the aegis of CIGRE National Study Committee B2 on Overhead Lines held on 10th February 2021.

The following technical subjects were presented and discussed during the tutorial:

"The brief content of brochure CIGRE WG B2.61 and the description of Fiber Reinforce Polymer (FRP) composite structures for transmission lines. Materials used, manufacturing methods implemented, structures built, as well as advantages, disadvantages, and benefits of FRP structures."

Dr. Janos Toth
Canada

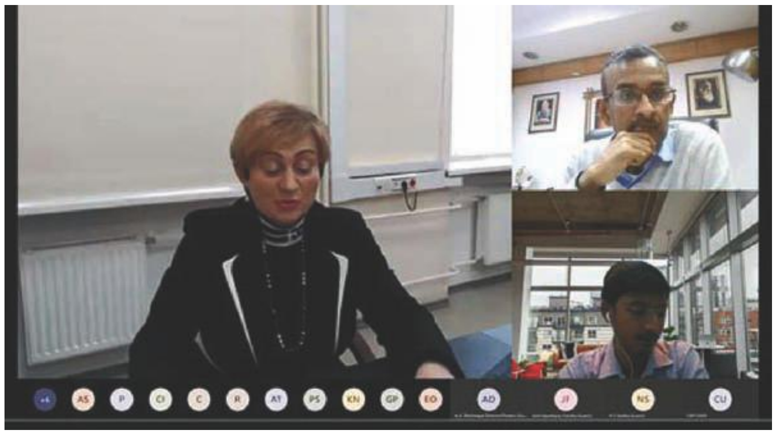
Mr. Anish Anand
Executive Director, POWERGRID

Shri A K Bhatnagar, Director, CBIP and CIGRE-India, delivered the welcome address. Shri Anish Anand, Chairman, CIGRE NSC B2 and at CESC Ltd., graced the opening session. The key speaker for the session were Dr. Janos Toth from Canada (International). There were about 50 participants from different organization.

International Tutorial (Online)

ICT and Smart Grid Technologies: An enabler for Transformation in the Distribution Sector

12th February 2021



It was conducted under the aegis of CIGRE National Study Committee D2 on Information Systems and Telecommunication held on 12th February 2021.

Mr. Ganesh Srinivasan
Tata Power elhi Dist. Ltd.

Shri Debasis De
Executive Director, NLDC, POSOCO

Shri Debasis De, Chairman, CIGRE NSC D2 and Executive Director, POSOCO, graced the opening session. The key speaker for the session were Mr. Ganesh Srinivasan, Chief Executive Officer, Tata Power Delhi Distribution Ltd. There were about 30 participants from different organization.

International Tutorial (Online)

Modelling and Dynamic Performance of Inverter Based Generation in Power System Transmission and Distribution Studies

15th February 2021

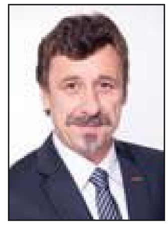
It was conducted under the aegis of CIGRE National Study Committee C4 on Power System Technical Performance held on 15th February 2021.

The following technical subjects were presented and discussed during the tutorial:

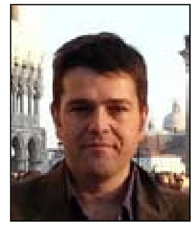
"The brief content of brochure CIGRE JWG C4/C6.35/CIRED and the description of guidance on inverter-based generator models with associated functions that should be used for specific phenomena such as frequency deviation, large voltage deviation and long-term voltage deviation. This guideline helps to reduce the computational burden when performing simulations as well as to represent more accurate power system dynamic behavior with inverter-based generators following faults.."

Mr. A K Dinkar
Secretary
CBIP

Dr. Koji Yamashita
Japan



Prof. Herwig Renner
Austria



Mr. Sergio Martinez
Spain

Dr. Petros Aristidou
Cyprus

Shri A K Dinkar, Secretary CIGRE, delivered the welcome address. The key speakers for the session were Dr. Koji Yamashita, Japan; Prof. Herwig Renner, Austria; Mr. Sergio Martinex, Spain and Dr. Petros Aristidou, Cyprus (International). There were about 50 participants from different organization.

International Tutorial (Online)

Cyber Security Measures for Energy Systems

26th February 2021

It was conducted under the aegis of CIGRE National Study Committee D2 on Information Systems and Telecommunication held on 26th February 2021.

The following technical subjects were presented and discussed during the tutorial:

"The energy transformation in the power industry, mainly due to distribution systems dynamics, intensive use of intermittent types of renewables sources, e-mobility and massive electrification is strongly related to the evolution of digital infrastructures for the energy sector demanding high adequate cyber security measures. This tutorial focuses on cyber security measures for advanced energy systems."

Shri Debasis De
ED, NLDC, POSOCO

Dr. Giovanna Dondossola
Italy

Dr. Roberta Terruggia
Italy

Dr. Mauro G. Todeschini
Italy

Shri Debasis De, Chairman, CIGRE NSC D2 and Executive Director, POSOCO, graced the opening session. The key speakers for the session were Dr. Koji Yamashita, Japan; Prof. Herwig Renner, Austria; Mr. Sergio Martinex, Spain and Dr. Petros Aristidou, Cyprus (International). There were about 50 participants from different organization.

International Tutorial (Online)

Extrapolation of Measured Values of Power Frequency Magnetic Fields in the Vicinity of Power Links

03rd March 2021

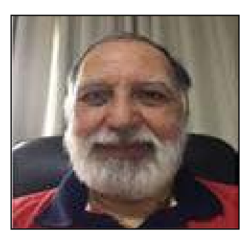
It was conducted under the aegis of CIGRE National Study Committee C4 on Power System Technical Performance held on 03rd March 2021.

The following technical subjects were presented and discussed during the tutorial:

"Nowadays, many countries have national regulations asking for magnetic field measurements in a certain reference condition. The principal motivation for such regulations is to provide an experimental confirmation that the human beings are adequately protected against the biological effects produced by the magnetic field originated from the electric power systems.

As the understanding of what is a magnetic field, and the perception of the health risk, is different in the different countries, the purpose of CIGRE TB 795, and of this presentation, is to provide a common framework for the experiences of the different countries. In order that any country, when dealing with this problem, can utilize not only its own experience but also the data gathered by other countries.

Mr. A K Dinkar
Secretary, CBIP



Prof. Patricio E Munhoz-Rojas,
Brazil

Shri A K Dinkar, Secretary CIGRE, delivered welcome address. The key speaker for the session were Prof. Patricio E Munhoz-Rojas from Brazil (International). There were about 30 participants from different organization.

International Tutorial (Online)
Compact AC Overhead Lines

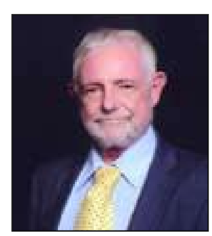
16th March 2021

It was conducted under the aegis of CIGRE National Study Committee B2 on Overhead Lines held on 16th March 2021.

The following technical subjects were presented and discussed during the tutorial:

- The theory the engineer needs to consider for compacting of AC lines as well as calculated examples.
- Case studies from around the world relating to compacting of lines as well as voltage upgrading.
- Live line maintenance and construction issues as well as mechanical issues such as sub-span oscillation and galloping mitigation.

Mr. Anish Anand
Executive Director, POWERGRID



Dr. Rob Stephen
South Africa

Shri Anish Anand, Chairman, CIGRE NSC B2 and Executive Director, Power Grid Corporation of India, graced the opening session. The key speaker for the session were Dr. Rob Stephen from South Africa (International). There were about 70 participants from different organization.

International Tutorial (Online)

Core IT Technologies – AI and IoT, as a Powerful Tool for Energy Supply Systems of the Future

19th March 2021

It was conducted under the aegis of CIGRE National Study Committee D2 on Information Systems and Telecommunication held on 19th March 2021.

The following technical subjects were presented and discussed during the tutorial:

"Renewable energy, new power equipment and newly installed loads pose new challenges to the operation of modern power grids. On the other hand, increasing labor costs and power grid scale have also increased the difficulty of power grid management. The digital transformation of the power grid is expected to solve these problems, and AI and IOT technologies are two major trends throughout the digital transformation of the power grid. How to use the state-of-the-art AI and IOT technologies on the power grid to enhance power grid operation and management capabilities and reduce personnel and material costs? This webinar summarizes AI and IOT technologies that are helpful to modern transmission and distribution networks, and shares relevant practical cases."

Mr. Debasis De
Executive Director, NLDC, POSOCO

Mr. Gao Kum Lun
China

Shri Debasis De, Chairman, CIGRE NSC D2 and Executive Director, POSOCO, graced the opening session. The key speaker for the session were Mr. Gao Kum Lun from China (International). There were about 55 participants from different organization.

International Tutorial (Virtual)
Insulated Cable

21st & 23rd July 2021

Day 1 : Importance of Distributed Temperature sensing system for HV Cable system

Day 2 : Testing HVDC cable systems and comparison with HVAC procedures

It was conducted under the aegis of CIGRE National Study Committee B1 on Insulated Cables held on 21st & 23rd July 2021.

Lalit Sharma
COO, KEI

Dr. Pietro Corsaro
Germany

Dr. Vercellotti Uberto
Italy

Shri Lalit Sharma, Chairman, CIGRE NSC B1 and Chief Operating Officer, KEI, graced the opening session. The key speakers for the session were Dr. Pietro Corsaro from Germany and Dr. Vercellotti Uberto from Italy (International). There were about 40 participants from different organization.

Panel Discussion (Virtual)

Important Tips for Writing Papers by Engineering Professionals for Consideration at International Level

28th July 2021, New Delhi, India

BRIEF REPORT

Central Board of Irrigation & Power (CBIP) Jointly with CIGRE-India and the National Committee for International Commission on Large Dams (INCOLD) organized a Panel Discussion on the subject of "Important tips for writing papers by engineering professionals for consideration at international level" on July 28th, August 2021. It was attended by about 220 participants from different utilities, PSUs, manufacturing hubs and Academic Institutions. It was a very successful and well received event.

The event was joined by following seven globally known personalities as panel members who shared their valuable views and experience on the subject:

1. **Prof. Konstantin O. Papailiou** from Switzerland. He is former Chairman, CIGRE Study Committee on Overhead Lines and was also the Chief Editor of prestigious Science & engineering Journal of CIGRE for 5 years. He was also CEO of Pfisterer. He has authored more than 100 papers and 4 reference books. He is CIGRE Fellow and recipient of CIGRE Medal 2020.
2. **Mr. D K Sharma**, he is currently Vice President, International Commission on Large Dams (ICOLD) and also Hon'ble Chairman, Himachal Pradesh Electricity Regulatory Commission.
3. **Mr. A S Bakshi**, who is Former Member Central Electricity Regulatory Commission & Former Chairperson, Central Electricity Authority.
4. **Mr. N.N. Misra**, Jt. Chairman-Technical, CIGRE-India & Former Director (Operations), NTPC Ltd.
5. **Prof. Arun Kumar**, Indian Institute of Technology Roorkee
6. **Prof. S V Kulkarni**, Indian Institute of Technology Mumbai
7. **Dr. Venkatesh Raghavan**, Vice President, TDK Electronics

The program started with welcome address by Shri A.K. Dinkar, Secretary, CBIP & CIGRE-India. He welcomed all the esteemed panel members and conveyed thanks to them for their gracious presence in the event. He also welcomed the other invitees and participants and conveyed thanks to them also for their active participation in the Panel Discussion. Shri Dinkar conveyed special thanks on behalf of CBIP to all the organizations which actively participated and supported the programme. While welcoming he informed that the aim of the Panel Discussion is to learnt Lessons with reference to preparation of technical papers for consideration at International Level from highly experienced professionals of International repute.

The session was chaired by **Prof. Konstantin O. Papailiou**, who set the tone for the panel discussion with his opening remarks.

During his remark Dr. Konstantin mentioned that there is a big gap between our thoughts and what we write in the research papers. The idea of this Panel discussion is to exchange the views on how to close this gap.

He also made a mention of recently published Springer document on Power system for which he wrote a chapter having 150 pages with over 288 references including 3 core references from Indian author who are living abroad. He showed his concern that though the professionals in India are doing wonderful job and India has already built thousands of Kilometer of AC & DC lines, but why there is no reference of single author from India in the above publication. Dr. Konstantin expressed his observation that there are very less research paper from India and to increase participation for writing the papers, we require motivating individual & organisations. He further mentioned that the most important thing for writing the paper is to choose the right subject.

After this other panel members were invited to shared their valuable views and experience on the subject one by one.

Shri D.K. Sharma appreciating the efforts of CBIP during the occasion for organizing such a unique programme, shared his valuable views on the subject. Mr. Sharma said that due to improper documentation of research, poorly structured title and entirely different formatting we generally fail to get our paper accepted in international forum. He also mentioned that our papers mostly do not meet the requirement as per the international standards. He advised that authors should focus on the title of the paper and an abstract is supposed to be concise and structured and should clearly define what the paper is about.

Shri A.S. Bakshi appreciated CBIP & CIGRE India for providing a unique platform and huge opportunities for all young engineers and professionals to learn lot of things and grow in the sector. Mr. Bakshi admired CBIP for organizing lot of seminars for the dissemination of knowledge and also suggested more such seminars to motivate the professionals to take their time out especially in a country like India where technical professionals are doing wonderful innovations. Mr. Bakshi also suggested expanding that scope of panel discussion from “tips for writing a structure research paper“ to the actions to be initiated to incentivize and motivate the organization who are not actively participating.

Shri N.N. Mishra praised young engineers and professionals in India stating that the world is watching the work that is being done in India. Thousands of kilometres of HVDC, increase renewable penetration, Reactive power management are the things that are being done in a gigantic proportion. The world wants to know how we can improve upon, what we have done and wants to help us. Unfortunately we have not been able to present the above on an international platform. He also believes that the practicing engineers are too busy with their work and they do not have time for writing down their analysis. They did not even jot down whatever they are doing. Also the engineers are not incentivized or are not recognized for writing the number of papers while in academic.

He further suggested the researchers by virtue of their exposure to international platforms, to not only right but to present papers. First few lines should be able to capture the grounds for selecting the paper. It should be precise and concise and to the point saying that this is what the paper should contain.

Prof Arun Kumar encouraged engineers and practitioners to publish the papers in journals instead of online Publications as the references in that case would have been easy to pick up. In regard to incentivizing the practitioner's, he suggested that, 5 marks should be given as an incentive for an annual report of the authors with in their organisation, instead of cash prize because cash prizes are not successful. Prof Kumar further informed that one of the main reasons why engineers and practitioners are not able to deliver successful research papers lies in the fact that authors in the field of Engineering find it difficult to write a research paper for Publication. The primary difference is in the approach - the act of applying a Theory versus that of studying or explaining it.

He advised engineers and practitioners do not consider publishing results with lack of scientific interest or any outdated work. Avoid plagiarism or any incorrect data. Filter the information and focus on the quality of the data presented. Engineering manuscripts do not require large amounts of information. The more information you include the more likely you are to confuse your readers.

Shri S.V. Kulkarni suggested that the research papers may be in the form of advancement in available state of the art and knowledge. It could be theoretical and experimental. Research may have a societal impact or could be amongst the current topics of practical interest. Correct use of grammar and clarity of thoughts is essential for effective technical communication. One of the common mistakes is to get confused between abstract and introduction. An abstract is the summary of work commenced and it should not have more than 1 introductory statement that directly introduces our intent. An abstract must not be more than 8 to 10 lines and should concisely capture the entire research. Consequently we have the literature survey, research methodology, results in the form of data and charts, discussion, conclusion, acknowledgement and lastly references.

Shri Venkatesh Raghavan shared his views on the subject and advised stating that we need to have an original contribution. Research is about creating knowledge and paper is about communicating the new knowledge. He said that the title needs to be very catchy and attractive just like newspaper headlines and it should represent just what the paper conveys. There must be a very high level of correlation between the paper and the title. Mr. Raghavan said that he has seen a lot of papers where the Abstract will be different from the research and it is very confusing. The Abstract is very different from background and introduction. An abstract is an essence - summation of what author has said in the entire research paper. It's not an introduction, it's a whole paper summed up briefly. Also focus on the keywords because in the digital world people search a lot of keywords.

Secondly, he advised not to use a lot of flowery language. The author can have a style of writing which is very simple but the paper must be very well structured. There must be an objective, a background, a problem statement and what you intend to do. Methodology could be analytical, could be experimental or even a literature survey. The data and text that you write must correlate. Most importantly you must have a summary or a conclusion which should capture your original contribution. When it comes to research papers do not recycle or reuse. Subject matter can be the same but don't repeat the same paper over 2-3 times because it loses its value.

The Panel Discussion was concluded with Q&A session at the end.

RECOMMENDATIONS BY PANEL MEMBERS

1. To choose the right subject for the paper.
2. The title should be very catchy and attractive. It should clearly represent just what the paper conveys.
3. The paper should be precise, concise and to the point. It must be clearly presented and logically constructed with the correct use of sentences and grammar.
4. The contents must include the title, a very well described abstract summing up the paper briefly, the keywords, main text, conclusion highlighting the contribution to the paper, acknowledgement, correctly cited references and supporting material.
5. Do not copy-paste facts and figures unless permission taken from designated authors and avoids Plagiarism, Promotion for product & organization?
6. Incentives to encourage the professionals/ Organisations to increase participation in writing research papers, and case studies etc..
7. The Research paper could be basic research, applied research and case studies.

CIGRE Members from India in 2021
(As on January 2021)

Summary of Membership

	Collective-1 (Organisation)	Collective-2 (Regulatory & Institution)	Individual-1	Young (below 35 years of age)	Student Members
	95	20	159	22	142
Total equivalent	x 06	x03	x01	x0.5	
	570	60	159	11	
Grand Total	**800**				**142**

INSTITUTIONAL MEMBERS

S. No.	Organisation
1	Central Electricity Regulatory Commission
2	CIGRE INDIA- COE,Centre of Excellence
3	Delhi Electricity Regulatory Commission
4	Electrical Research and Development Association
5	Gujarat Electricity Regulatory Commission
6	IEEMA
7	Punjab State Electricity Regulatory Commission
8	Ramelex Testing & Research Institute
9	U.P. Electricity Regulatory Commission
10	Uttarakhand Elec. Regul. Commission

INDIVIDUAL MEMBERS

	Organisation	Name
1	ABB	Urmil Parikh
2	ABB Global Industries & Services Ltd.	Sachin Srivastava
3	Adani Transmission	Sanjay Bhatt
4	Adani Transmission Ltd.	Nihar Raj
5	Adishaktyai- India	Neeraj Khare
6	Alfa Consultants	Ramesh Dattaraya Suryavanshi
7	Apar Industries Ltd.	Srimanta Kumar Jana
8	AVAADA Power	Deepak Kumar Saxena
9	CBIP	A K Dinkar
10	Central Power Research Institute	Devender Rao Karre
11	Consultant	R P Sasmal
12	Consultant	Pramod Rao
13	Consultant	Praveen Kumar Agarwal
14	Consultant	Lokesh Thakur
15	Consultant	Sundaram Sudalai Shunmugam
16	Consultant	Gopal Ji
17	Consultant	N S Sodha
18	Consultant	Virendra Kumar Lakhiani
19	CTR Manufacturing Industries Ltd.	T P Govindan
20	CTR Manufacturing Industries Ltd.	Vijaykumar Wakchaure
21	CTR Manufacturing Industries Ltd.	Ravindra Vishnu Talegaonkar
22	Deccan	Vikas Jalan
23	Diagnostic Technologies India Pvt Ltd	Aditya Korde
24	DNV-KEMA	Ravi Kumar Puzhankara
25	DTL	Rajesh Kumar Arora
26	DVC	Abhijit Chakraborty
27	DVC	Sudipta Maiti
28	DVC	Arindam Das

29	Former-M.P. Power Transmission Co. Ltd	K. Kamlesh Murty
30	Free Lance	Balubhai Rakholia
31	Free Lance	Hosalli Bhashyam Mukund
32	GE T&D India Ltd.	Mohan Vadivel
33	GE T&D India Ltd.	Mahesh Raman
34	GE T&D India Ltd.	Santosh Kumar ANNADURAI
35	GE T&D India Ltd.	Pandiyaraj Kalyani
36	GETCO	Narendrabhai P. Jadav
37	GETCO	Y J Gamit
38	GETCO	ASHISH RASIKLAL PIPARIA
39	GETCO	Pankajbhai Suthar
40	GETCO	Ashokkumar J. Chavda
41	GETCO	Kishorkumar R. Solanki
42	GETCO	Zulfikarali M Vijapura
43	GETCO	Bhasmang N. Trivedi
44	GETCO	Bhupendra B Baria
45	GETCO	Nilesh Sheth
46	GETCO	Rameshchandra P. Satani
47	GETCO	Bankim Pravinchandra Soni
48	GETCO	Dipak kumar Patel
49	GETCO	Chetan G Thakkar
50	GETCO	Asha M Agravatt
51	GETCO	Bhavesh Bachubhai Ahir
52	GETCO	Arjunbhai B. Rathod
53	GETCO	Kantilal M Chhaiya
54	Hitachi ABB Power Grid	Dr. Shivani Sharma
55	Hitachi ABB Power Grids	O.D.Naidu
56	IIT-Bombay	Himanshu Bahirat
57	IIT-Goa	Shakthi Prasad Dakappa
58	Indigrid India Ltd.	Niraj Agarwal
59	Indolite Devices Pvt. Ltd.	Maninderjit Singh Sethi
60	IRADE	Vinod Kumar Agarwal
61	J&K Power Development Department	Habib Chowdhary
62	Kalpataru Power Trans. Ltd	Pervinder Singh Chowdhry
63	Kalpataru Power Trans. Ltd	Milind Nene
64	Kalpataru Power Transmission Ltd.	Prasanna Kumar Dewangan
65	KEI Industries Ltd	Lalit Sharma
66	Kerala State Electricity Board Ltd.	DONY C S
67	Laxmi Associates	Aradhana Ray
68	Mahati Industries Pvt. Ltd.	Udaybabu Ratanchand Shah
69	Modern Insulators Limited	Ram Kumar Vaithilingam
70	Modern Insulators Limited	Ranka Shreyans
71	National Inst. of Technology Karnataka	I R Rao
72	NIT Kurukshetra	Atma Ram Gupta
73	North East Transmission Company Ltd.	Satyajit Ganguly
74	NTPC Ltd.	Nagesh Kondra
75	NTPC Ltd.	Subhash Thakur
76	Persotech Solutions	Pravinchandra Mehta
77	POSOCO	SUBHENDU MUKHERJEE
78	POSOCO	Saibal Ghosh
79	POSOCO	Sushil Kumar Soonee
80	POSOCO	Sudhansu Sekhar Barpanda
81	POSOCO	Manoj Kumar Agrawal
82	POSOCO	Santosh Kumar Jain
83	POSOCO	K V S Baba
84	POSOCO	Vivek Pandey
85	POSOCO	Aditya Prasad Das
86	POSOCO	Rajiv Kumar Porwal
87	POSOCO	S.R. Narasimhan
88	POSOCO	Nallarasan Nagarathinam
89	POSOCO	Manas Das
90	POSOCO	Ankit Gupta
91	POSOCO	Nitin Yadav

92	POSOCO	Samir Chandra Saxena
93	POSOCO	Rajib Sutradhar
94	POSOCO	M. Venkateshan
95	POSOCO	SATYENDRA SINGH RAGHUWANSHI
96	POSOCO	Sajan George
97	Power Grid	Subhash C Taneja
98	Power Grid	Seema Gupta
99	Power Grid	Arun Kumar Mishra
100	Power Grid	B N De Bhowmick
101	Power Grid	Manash Jyoti BAISHYA
102	Power Grid	Abhay Kumar
103	Power Grid	Alok Kumar
104	Power Grid	Biswajit Bandhu Mukherjee
105	Power Grid	Nitin Kumar Sinha
106	Power Grid	Manish Kumar Tiwari
107	Power Grid	Pradeep Kumar
108	Power Grid	Anish Anand
109	Power Grid	R K Tyagi
110	Power Grid	Dr. Sunita Chohan
111	Power Grid	Shouvik Bhattacharya
112	Power Grid	Chandra Kant
113	Power Grid	Subir Sen
114	Power Grid (Central Trans. Utility)	Rajesh Kumar
115	Power Technology Centre	Parantap Krishna Raha
116	Power Trans.Corp. of Uttarakhand Ltd.	Lalit Kumar
117	Raj Petro Specialities Pvt Ltd	Dr. Daya Shankar Shukla
118	Raj Petro Specialities Pvt Ltd	Baburao Keshawatkar
119	Rajasthan Test & Research Centre	Jaspaul Kalra
120	SJVN Ltd.	Rashi Tyagi
121	Skipper Limited	DAYANAND SWAMY KUNA
122	Sterlite Power Grid Ventures Ltd	Rajesh Suri
123	Syselec Technologie Private Limited	Hrushaabh Prashaant Mishra
124	TAG Corporation	Vivek Thiruvenkatachari
125	Takalkar Powerr Engin&Consult. Pvt Ltd	Subhash Chandra Takalkar
126	Tata Power Skill Development	Umesh Maharaja
127	Taurus Powertronics Pvt. Ltd.	Narasimhan Ravinarayan MAKARAM
128	Technical Associates	Vishnu Agarwal
129	The Tata Power Co. Ltd.	Rajendra Vinayak Saraf
130	TS Transco	Arogya Raju Pudhota
131	UPPTCL	Sanjeev Kumar Bhasker
132	WAPCOS Ltd.	Hillol Biswas
133	Western U.P. Power Transmission Co. Ltd.	Satyanaryana Raju Pericherla
134	Yash Highvoltage Ltd.	Nirav Patel
135	ZTT Cable	Deepal Shah

ORGANISATIONAL MEMBERS

S.NO	Organisation
1	Adani Electricity Mumbai Limited - Tran.
2	Adani Transmission Limited
3	APAR Industries Limited
4	BAJAJ ELECTRICALS LTD.
5	Bhakra Beas Management Board (BBMB)
6	Bharat Heavy Electricals Ltd., Noida
7	Central Power Research Institute
8	CESC Limited
9	CTC Global India Pvt. Ltd.
10	CTR Manufacturing Industries Ltd.
11	Easun-Mr Tap Changers (P) Limited
12	Indigrid Ltd
13	KEI Industries Ltd.
14	Larsen & Toubro Limited- Construction
15	Larsen & Toubro Limited- Construction
16	NHDC Ltd.
17	NHPC Limited
18	NTPC Limited, Jhanor
19	NTPC Limited, Kudgi STPS

20	NTPC Limited, SIPAT STPS
21	NTPC Tanda
22	ONGC Tripura Power Company Ltd.
23	POSOCO- ERLDC
24	POSOCO- H.Q.
25	POSOCO-NERLDC
26	Power Research & Develop. Cons. Pvt. Ltd
27	Powergrid Corp. of India Ltd, Lucknow
28	Powergrid Corporation of India, H.Q.
29	Powergrid Corporation of India, Patna
30	Siemens Energy - Gas & Power – Transmission
31	SJVN Limited
32	Solar Energy Corporation of India Ltd.
33	Sterlite Power Transmission Limited
34	Tata Power Delhi Distribution Limited
35	The Motwane Manufacturing Co. Pvt Ltd
36	Transformers & Rectifier (India) Ltd.
37	Transrail Lighting Limited
38	Universal Cables Limited

YOUNG MEMBERS

S.No.	Organisation	Name
1	ABB Power Technology Services Pvt. Ltd.	Rakesh Reddy Vattigunta
2	Central Power Research Institute	Sreeram Vengayil
3	ETP Earthing and LPS Solution Pvt. Ltd.	Keyur J Nanavati
4	GETCO	Bhavesh kumarmanubhai Rana
5	GETCO	Sanjay Jadav
6	Hitachi ABB	Teja Bandaru
7	POSOCO	Anisha Chopra
8	POSOCO	K V N Pawan Kumar
9	POSOCO	Phanisankar Chilukuri
10	POSOCO	Saif Rehman
11	POSOCO	Sourav Mandal
12	POSOCO	Praveen Kumar Gurram
13	POSOCO	Momai Das
14	POSOCO	Aman Gautam
15	POSOCO	K B V Ramkumar
16	Power Grid	Gaurab Dash
17	Raja Ramanna Centre for Advanced Dept. of Atomic	Shivam Tamrakar
18	Secure Meters Ltd.	Vikash Kumar Singh
19	Vestas Technology Chennai R&D Pvt. Ltd.	Sivaraman Palanisamy
20	Yash Highvoltage Ltd.	Gautam Nikam

STUDENT MEMBERS

S.No	Organisation	Name
1	College of Engineering	Rijo Ranjan
2	College of Engineering Guindy	Ramesh Rahul
3	Engineering College Banswara	Abhishek Bhoi
4	Engineering College Banswara	Manisha Bhuriya
5	Engineering College Banswara	Ajay Bunkar
6	Engineering College Banswara	Durgesh Bunkar
7	Engineering College Banswara	Ashish Chatwani
8	Engineering College Banswara	Bhavesh Kumar Gamot
9	Engineering College Banswara	Meena Bhushan
10	Engineering College Banswara	Meena Mahesh Kumar
11	Engineering College Banswara	Ashok Meena
12	Engineering College Banswara	Abhishek Mishra
13	Engineering College Banswara	Ajay Ninama
14	Engineering College Banswara	Avinash Yadav

15	Engineering College Banswara	Suraj Banjara
16	Engineering College Banswara	Ratan Lal Barad
17	Engineering College Banswara	Suresh Chandra Bhedi
18	Engineering College Banswara	Gautam
19	Engineering College Banswara	Ajay Katara
20	Engineering College Banswara	Ragineejoshi
21	Engineering College Banswara	Rahul Singh
22	Engineering College Banswara	Amit Singh
23	Engineering College Banswara	Yajan Joshi
24	Engineering College Banswara	Surbhi Singhale
25	Engineering College Banswara	Abhishek Tiwari
26	Engineering College Banswara	Adarsh Verma
27	Indian Institute of Technology Kanpur	Anamika Dubey
28	Indian Institute of Technology Kanpur	J G sreenath
29	Indian Institute of Technology Kanpur	Aasim
30	Indian Institute of Technology Kanpur	AKHILESH PRAKASH GUPTA
31	Indian Institute of Technology Kanpur	Vineeth V
32	Indian Institute of Technology Kanpur	Piyush Warhad Pande
33	Indian Institute of Technology Kanpur	P.Naga Yasasvi
34	Indian Institute of Technology Kanpur	Gaurav Khare
35	Indian Institute of Technology Kanpur	Priyanka Gangwar
36	Indian Institute of Technology Kanpur	Saurabh Kesherwani
37	Indian Institute of Technology Kanpur	Ankit Yadav

38	Indian Institute of Technology Kanpur	Avinash kumar
39	Indian Institute of Technology Kanpur	Rajarshi Dutta
40	Indian Institute of Technology Kanpur	Syed Mohammad Ashraf
41	Indian Institute of Technology Kanpur	Arindam Mitra
42	Indian Institute of Technology Kanpur	Bandopant Pawar
43	Indian Institute of Technology Kanpur	Anamika Tiwari
44	National Institute of Technology, Calicut	Amararapu Satish
45	National Institute of Technology, Calicut	Aswin Bhaskar P E
46	National Institute of Technology, Calicut	Cheemala Vaishnavi
47	National Institute of Technology, Calicut	Divya P
48	National Institute of Technology, Calicut	K Vamsi Krishna
49	National Institute of Technology, Calicut	Sarov Mohan S
50	National Institute of Technology, Calicut	Thalluri Chaitanya Sai
51	National Institute of Technology, Calicut	Vipul Kumar
52	National Institute of Technology, Calicut	Avinash Nelson
53	National Institute of Technology, Calicut	Gowrishankar S
54	National Institute of Technology, Calicut	Joyce Jacob
55	National Institute of Technology, Calicut	Emil Ninan Skariah
56	National Institute of Technology, Calicut	Jacob P Varghese
57	National Institute of Technology, Calicut	Lakshmi Tharamal
58	National Institute of Technology, Calicut	Anjitha V
59	National Institute of Technology, Calicut	Haritha G
60	National Institute of Technology, Calicut	Ravishankar A N
61	National Institute of Technology, Calicut	Athira Raju

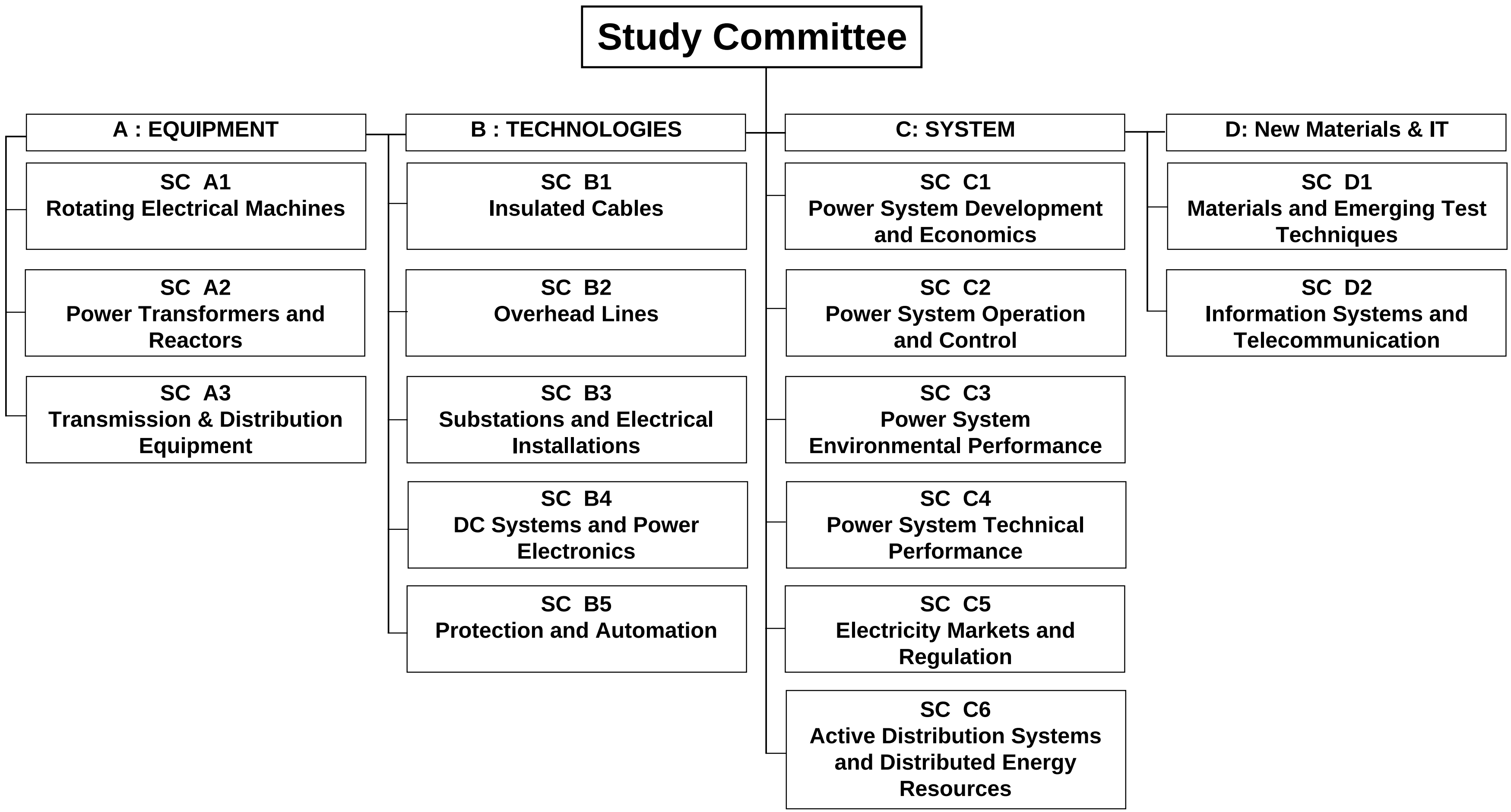
62	National Institute of Technology, Calicut	Subin Koshy
63	National Institute of Technology, Calicut	Rahul S
64	National Institute of Technology, Calicut	Rinsha V
65	National Institute of Technology, Calicut	T S Bheemraj
66	National Institute of Technology, Calicut	Sanila P
67	National Institute of Technology, Calicut	Najda V M
68	National Institute of Technology, Calicut	Renuka V S
69	Indian Institute of Technology Bombay	Lokesh Kumar Dewangan
70	Indian Institute of Technology Bombay	Vatsal Kedia
71	Indian Institute of Technology Bombay	Santanu Paul
72	Indian Institute of Technology Bombay	SIBA KUMAR PATRO
73	Indian Institute of Technology Bombay	Aditya Nadkarni
74	Indian Institute of Technology Bombay	Kaustav Dey
75	Indian Institute of Technology Bombay	Santosh V Singh
76	Indian Institute of Technology Bombay	Kavita Kiran Prasad
77	Indian Institute of Technology Bombay	ANEES V P
78	Indian Institute of Technology Bombay	soumya Ranjan mohapatra
79	Indian Institute of Technology Bombay	Kevin Gajjar
80	Indian Institute of Technology Bombay	Rohit Thute
81	Indian Institute of Technology Bombay	B. Sai Ram
82	Indian Institute of Technology Bombay	Minal Chougule
83	Indian Institute of Technology Bombay	Soumya Kanta Panda
84	Indian Institute of Technology Bombay	Joel Jose
85	Indian Institute of Technology Bombay	Hemantkumar Goklani

86	Indian Institute of Technology Bombay	vinay chindu
87	Indian Institute of Technology Bombay	Gopakumar
88	Indian Institute of Technology Bombay	PATIL NIKHIL SURESH
89	Indian Institute of Technology Bombay	Pragati Gupta
90	Indian Institute of Technology Bombay	SUMAN KUMAR NEOGI
91	Indian Institute of Technology Bombay	AJITH J
92	Indian Institute of Technology Bombay	Makarand M Kane
93	Indian Institute of Technology Bombay	Annoy Kumar Das
94	Manipal University Dahmi Kalan Jaipur	Udayan Atreya
95	Indian Institute of Technology Delhi	Deep Kiran
96	Malaviya National Institute of Tech.	Sapna Ladwal
97	Malaviya National Institute of Tech.	Anil Kumar Kesavarapu
98	Malaviya National Institute of Tech.	MD Kaifi Anwar
99	Malaviya National Institute of Tech.	Rohit Bhakar
100	Malaviya National Institute of Tech.	Bhupesh
101	Malaviya National Institute of Tech.	Sandeep Chawda
102	Malaviya National Institute of Tech.	Debollena
103	Malaviya National Institute of Tech.	Sunil Jangid
104	Malaviya National Institute of Tech.	Jitendra Kumar
105	Malaviya National Institute of Tech.	Ajay Kumar
106	Malaviya National Institute of Tech.	Andru Tarun Kumar
107	Malaviya National Institute of Tech.	Prerna Kuntal
108	Malaviya National Institute of Tech.	Priyanka Kushwaha
109	Malaviya National Institute of Tech.	Parul Mathuria

110	Malaviya National Institute of Tech.	Yash Pal
111	Malaviya National Institute of Tech.	Arushi Relan
112	Malaviya National Institute of Tech.	Umesh Saini
113	Malaviya National Institute of Tech.	Shalini Kumari
114	Malaviya National Institute of Tech.	Sunanda Sinha
115	Malaviya National Institute of Tech.	Aniruddh Takshak
116	Malaviya National Institute of Tech.	Falti Teotia
117	Malaviya National Institute of Tech.	Rajive Tiwari
118	Malaviya National Institute of Tech.	Shefali Tripathi
119	Malaviya National Institute of Tech.	Shakti Vashisth
120	Malaviya National Institute of Tech.	Shivanjali Yadav
121	Malaviya National Institute of Tech.	Amit Kumar
122	Malaviya National Institute of Tech.	Archana
123	Malaviya National Institute of Tech.	Nilesh B Hadiya
124	Malaviya National Institute of Tech.	Chandra Prakash Barala
125	Malaviya National Institute of Tech.	Shivani Garg

126	Malaviya National Institute of Tech.	Sakshi Gupta
127	Malaviya National Institute of Tech.	Archee Gupta
128	Malaviya National Institute of Tech.	Bhavna Jangid
129	Malaviya National Institute of Tech.	Nitesh Kataria
130	Malaviya National Institute of Tech.	Gautam Raina
131	Malaviya National Institute of Tech.	Navneet Sharma
132	Malaviya National Institute of Tech.	Deepak Singh
133	Malaviya National Institute of Tech.	Yamujala Sumanth
134	Malaviya National Institute of Tech.	Dheeraj Verma
135	Malaviya National Institute of Tech.	Raj Kumar Yadav
136	Malaviya National Institute of Tech.	Anjali Jain
137	Malaviya National Institute of Tech.	Rohit Vijay
138	Manipal University Dahmi Kalan Jaipur	Udayan Atreya
139	MNIT, Jaipur	Sumanth Yamujala
140	NIT HAMIRPUR	SUCHANDAN DAS
141	RGPV University	Vishal Telang
142	M. S. Ramaiah Institute of Technology	Wajid Ahmed

Four Group of CIGRE Study Committees



FIELDS OF ACTIVITY OF CIGRE STUDY COMMITTEES

Study Committees No.	Scope
A1	**Rotating Electrical Machines** : The SC is focused on the development of new technologies and the international exchange of information and knowledge in the field of rotating electrical machines, to add value to this information and knowledge by means of synthesizing state-of-the-art practices and developing guidelines and recommendations.
A2	**Power Transformers and Reactors** : The scope of SC A2 covers the whole life cycle of all kind of power transformers, including HVDC transformers, phase shifters, shunt reactors and all transformer components as bushing and tap-changers.
A3	**Transmission & Distribution Equipment** : The scope of the SC A3 covers theory, design, construction and operation for all devices for switching, interrupting and limiting currents, surges arresters, capacitors, busbars, equipment insulators and instrument transformers used in transmission and distribution systems.
B1	**Insulated Cables** : The scope of SC B1 covers the whole Life Cycle of AC and DC Insulated cables for Land and Submarine Power Transmission, which means theory, design, applications, manufacture, installation, testing, operation, maintenance, upgrading and uprating, diagnostics techniques. It has been focused on HV & EHV applications for a long time. Nowadays MV applications are more and more taken into consideration.
B2	**Overhead Lines** : The scope of the Study Committee SC B2 covers all aspects of the design and refurbishment of overhead power lines. The Study Committee's strategic goals include: increased acceptance of overhead lines; increased utilization of existing overhead lines; improved reliability and availability of overhead lines.
B3	**Substations and Electrical Installations** : The scope of work for SC B3 includes the design, construction, maintenance and ongoing management of transmission and distribution substations, and the electrical installations in power stations, but excluding generators.
B4	**DC Systems and Power Electronics** : The scope of SC B4 covers High Voltage Direct Current systems and Power Electronics for AC networks and Power Quality improvement. Overhead lines or cables, which may be used in HVDC systems are not included in the scope, but are the responsibility of SC B2 and SC B1 respectively. The members of B4 come from Manufacturers, Utilities, transmission system operators (TSOs), Consultants and Research Institutes. SC B4 is active in recruiting young engineers to participate in its activities.
B5	**Protection and Automation** : The scope of the Committee covers the principles, design, application and management of power system protection, substation control, automation, monitoring, recording and metering – including associated internal and external communications and interfacing for remote control and monitoring.
C1	**Power System Development and Economics** : The SC's work includes issues, methods and tools related to the development and economics of power systems, including the drivers to: invest in expanding power networks and sustaining existing assets, increase power transfer capability, integrate distributed and renewable resources, manage increased horizontal and vertical interconnection, and maintain acceptable reliability in a cost-efficient manner. The SC aims to support planners to anticipate and manage change.
C2	**Power System Operation and Control** : The scope of the SC C2 covers the technical, human resource and institutional aspects and conditions needed for a secure and economic operation of existing power systems under security requirements against system disintegration, equipment damages and human injuries.
C3	**Power System Environmental Performance** : The scope of this Study Committee is focused on the identification and assessment of electric power systems environmental impacts and the methods used for assessing and managing these impacts during the all life cycle on the power system assets.
C4	**Power System Technical Performance** : The scope of SC C4 covers system technical performance phenomena that range from nanoseconds to many hours. SC C4 has been engaged in the following topics: Power Quality, EMC/EMI, Insulation Coordination, Lightning, and Power systems performance models and numerical analysis.
C5	**Electricity Markets and Regulation** : The scope of the Study Committee is "to analyze the different market approaches and solutions and their impact on the electric supply industry in support of the traditional economists, planners and operators within the industry as well as the new actors such as regulators, traders, technology innovators and Independent Power producers.
C6	**Active Distribution Systems and Distributed Energy Resources** : SC C6 facilitates and promotes the progress of engineering, and the international exchange of information and knowledge in the field of distributions systems and dispersed generation. The experts contributes to the international exchange of information and knowledge by the rizing state of the art practices and developing recommendations.
D1	**Materials and Emerging Test Techniques** : The scope of Study Committee D1 covers new and existing materials for electrotechnology, diagnostic techniques and related knowledge rules, as well as emerging test techniques with expected impact on power systems in the medium to long term.
D2	**Information Systems and Telecommunication** : The scope of this SC is focused on the fields of information systems and telecommunications for power systems. SC D2 contributes to the international exchange of information and knowledge, adding value by means of synthesizing state of the art practices and drafting recommendations.

HIGHLIGHTS OF POWER SECTOR

GROWTH OF INSTALLED CAPACITY

(Figures in MW)

	At the end of 12th Plan (August 2017)	As on 31.05.2021
THERMAL	218330.00	234728.218
HYDRO	44478.00	46209.22
NUCLEAR	6780.00	6780
RENEWABLE ENERGY SOURCES	57244.00	95656.245
TOTAL	**326832.00**	**383373.683**

Source : CEA

ALL INDIA REGION WISE INSTALLED CAPACITY

As on 31.05.2021

(Figures in MW)

Region	Thermal	Nuclear	Hydro	RES	Total
Northern	62108.569	1620	20288.77	19046.97	103064.309
Western	86686.662	1840	7562.5	29907.16	125996.322
Southern	55469.989	3320	11774.83	44686.27	115251.089
Eastern	27872.475	0	4639.12	1595.3	34106.895
N. Eastern	2550.475	0	1944	385.325	4879.8
Islands	40.048	0	0	35.22	75.268
All India	234728.218	6780	46209.22	95656.245	383373.683
Percentage	61.23	1.77	12.05	24.95	100

Source : CEA

SECTOR WISE INSTALLED CAPACITY AND GENERATION

As on 31.05.2021

Sector	Installed Capacity (MW)					Percentage Share	Net Capacity added
	Thermal	Nuclear	Hydro	RES	Total		During May 2021
STATE	74404.863	0	27069.5	2395.272	103869.635	27.1	0 MW
PRIVATE	86875.445	0	3493	91628.673	181997.118	47.47	
CENTRAL	73447.91	6780	15646.72	1632.3	97506.93	25.43	
TOTAL	234728.218	6780	46209.22	95656.245	383373.683	100	

Source : CEA

GROWTH OF TRANSMISSION SECTOR

	Unit	At the end of 12th Plan (August 2017)	As on March 2021	Addition after 12th plan (2017-22) (up to March '21)
TRANSMISSION LINES				
HVDC	ckm	15556	19375	73970
765 kV	ckm	31240	46090	
400 kV	ckm	157787	189910	
220 kV	ckm	163268	186446	
Total Transmission Lines	**ckm**	**367851**	441821	73970
SUBSTATIONS				
	Unit	**At the end of 12th Plan (August 2017)**	**As on March 2021**	**Addition after 12th plan (2017-22) (up to March '21)**
HVDC	MW	19500	29500	284703
765 kV	MVA	167500	238700	
400 kV	MVA	240807	362327	
220 kV	MVA	312958	394941	
TOTAL	**MW/MVA**	**740765**	1025468	284703

RURAL ELECTRIFICATION / PER CAPITA CONSUMPTION

Total no. of Villages	597464
% of Villages Electrified	100.00
No. of Pump-sets Energized (at end of 12th plan)	21212860
Per Capita Consumption during 2019-20*	1208 kWh

**Provisional*

RE SECTOR IN INDIA: POTENTIAL AND ACHIEVEMENTS

Sector	FY- 2020-21 Target (MW)	FY- 2020-21 Achievements (April-March 2021)	Cumulative Achievements (MW) (As on 31.03.2021)
GRID-INTERACTIVE POWER (CAPACITIES IN MWp)			
Wind	3000	1503.3	39247.05
Solar Power (SPV)	11000	5457.58	40085.37
Small Hydro (up to 25 MW)	100	103.64	4786.81
Bio-Power (Biomass & Gasification and Bagasse Cogeneration)	250	270.61	10145.92
Waste to Power	30	21	168.64
Total (Approx)	14380	7356.13	94433.79
OFF GRID/CAPTIVE POWER (CAPACITIES IN MW_{EQ})	510	191.87	1368.44
Other Renewable Energy Systems (Capacity in No.s) (Biogass plants)	**0.6**	0.11	51.65

Source: MNRE

News

GOVERNMENT ASKS CERC TO RELIEVE POWER PLANTS DELAYED DUE TO FORCE MAJEURE FROM TRANSMISSION LEVY

The government has invoked special powers to direct electricity regulator to make changes in regulations freeing power plants delayed due to justifiable reasons from paying penalties to associated transmission projects. The penalties would now be borne equally by all beneficiary discoms of a generation project, as per the directions issued by the Union power ministry to the Central Electricity Regulatory Commission (CERC) under section 107 of the Electricity Act 2003. While power generation and transmission companies welcomed the relief, distribution companies said the move asking them to pay for delay in generation projects came as a shock to them.

"Penalties for delay in COD (commissioning) of generating stations, or for delay in completing transmission system, or operationalising the LTA (long-term agreement) shall invite penalties to be paid to CTU (central transmission utility). The penalties shall be equitable; and shall not extend to compensating either the Generation companies for power it could not despatch because of delay in transmission or to compensate the transmission company for the delay in generation or the associated transmission," the central government directions to CERC to amend Sharing of Inter-State Transmission Charges and Losses Regulations, 2020 said.

Power transmission projects attached to delayed generation plants are considered 'deemed commissioned' and are liable to compensation but the complexity in arrangement makes it difficult to claim any amount. In the present system, the CTU coordinates with transmission licensees on one hand and all other users on the other. There are back-to-back agreements between CTU, the transmission licensees and distribution companies and generation companies are outside these contracts. The power ministry is working to amend the structure to bring in transmission licensees and generators together.

A senior government official said the directions are aimed at ease of process. "If the delay is not attributable to the parties, none of them should take the hit," he said. The directions said the entire burden of strengthening which will serve many procurer or power producers in the future cannot be levied on one party.

"Over 3-4 years, it is being realised that is possibility of mismatch in timelines in commissioning of generation companies and associated transmission lines. The regulators deny compensation since the line is not being used. Lack of agreement with generation companies closed hopes of compensation. The investors to these

transmission lines have started worrying over collection of the charges. This is a very positive development," said an industry official. Electricity distribution companies opposed the move calling it unfair to be penalised for no fault. "This will lead to passing of private losses to the general public and tariff shocks," an official said. The directions said events of force majeure may be defined by CERC and provision included enabling the CTU to extend the commissioning of a generating station.

Source : ET Bureau, January 19, 2021

POLICY AND REGULATORY FRAMEWORK FOR DISCOMS IN THE OFFING : PM MODI

Asserting that reforms in the regulatory and process framework have significantly 'improved' the outlook towards the power sector, Prime Minister NarendraModi on Thursday said the Centre is working to remove problems in the distribution sector and a policy and regulatory framework for DISCOMs is in the offing.

Asserting that reforms in the regulatory and process framework have significantly 'improved' the outlook towards the power sector, Prime Minister NarendraModi on Thursday said the Centre is working to remove problems in the distribution sector and a policy and regulatory framework for DISCOMs is in the offing. Consumers should be able to choose their supplier according to performance like any other retail commodity, he said at a webinar for consultation towards effective implementation of the Union Budget provisions in the power and renewable energy sector, the Prime Minister's Office (PM) said in a statement.

Modi said the government treats power as a separate sector and not as part of the industry sector, while adding that the Centre's approach towards it has been holistic and guided by the four mantras of "reach, reinforce, reform and renewable energy". He noted that the renewable energy capacity of the country has been enhanced by two-and-a-half times in the last six years and the solar energy capacity by 15 times.

"This year's budget has shown unprecedented commitment towards investment in infrastructure. This is evident in mission hydrogen, domestic manufacturing of solar cells and massive capital infusion in the renewable energy sector," Modi said.

Referring to the PLI (performance-linked incentive) scheme, he said high-efficiency solar PV modules are now part of it and the government is committed to investing Rs 4,500 crore in this. Modi hoped for a massive response to the scheme. Under the PLI scheme, integrated solar PV manufacturing plants with a capacity of 10,000 MW will be operationalised with an estimated investment of Rs 14,000 crore. This is likely to increase demand for locally produced materials such as EVA, solar glass, backsheet and junction box. "We want to see our companies to become global manufacturing champions, not just to fulfil local demands," the prime minister said. The government has indicated its commitment of additional capital infusion worth Rs 1,000 crore in the Solar Energy Corporation of India to promote investments in the renewable energy sector. Similarly, the Indian Renewable Energy Development Agency (IREDA) will get additional investments worth Rs 1,500 crore. This will enable the Solar Energy Corporation of India to invest in innovative projects worth Rs 17,000 crore. The investment in the IREDA will lead to additional loans of Rs 12,000 crore by the agency. This will be over and above the IREDA's current loan-giving capacity of Rs 27,000 crore, the statement noted. Stakeholders and experts of the power sector, representatives of industries and associations, MDs of DISCOMs, CEOs of state nodal agencies for renewable energy and consumer groups attended the webinar.

Modi noted that the energy sector plays a big role in the country's progress and said the webinar is an indication of trust between the government and the private sector and an attempt to find ways for a quick implementation of the budget announcements for the sector. The government is focussed on reaching every village and every household, and India has become a power-surplus country from a power-deficit country, he said. In recent years, the country has added 139 gigawatts capacity and reached the goal of one nation-one grid-one frequency, the prime minister pointed out.

Reforms like the UDAY scheme with the issuance of bonds worth Rs 2.32 lakh crore were undertaken to improve financial and operational efficiencies, he said, adding, "For monetising the assets of the PowergridInfrastructure Investment TrustInvIT was established, which will soon be open for investors." Modi said work is on to make the distribution sector free of entry barriers and licensing for distribution and supply. Efforts are underway for prepaid smart metres, feeder separation and system upgradation, he added. Under the PM KUSUM scheme, farmers are becoming energy entrepreneurs and the goal is to create 30-GW solar capacity through small plants in their fields, the prime minister said. Already, 4-GW solar capacity is installed through rooftop solar projects and 2.5 GW will be added soon. In the next one-and-a-half years, 40-GW solar power is aimed through rooftop solar projects, he added.

Source : PTI, Feb 18, 2021

LADAKH GETS CENTRE'S NOD FOR TRANSMISSION LINES AT REVISED COST OF RS 1,310 CRORE

The central government has approved intra-state transmission works at a revised cost of Rs 1,309.71 crore to link far-flung villages of Ladakh to the grid and phase out DG sets towards achieving carbon neutrality in the Union Territory, a top official said on Saturday. The project on completion would also provide the army and the far-flung villages with clean power round the clock, he added. Congratulating the people of Ladakh on the approval of the project, Lt Governor R K Mathur said the intra-state transmission works have been sanctioned by the Union Ministry of Power and include 220 KV S/C transmission lines of D/C tower (total 307 km), including Kargil-Padum (Zanskar) (207 km) and Phyang to Diskit (Nubra) (100 km) and two 220/33 KV Grid substation – one each at Diskit, Nubra (50 MVA) and Padum, Zanskar (50 MVA) with an outlay of Rs 1,309.71 crore.

Mathur expressed gratitude to Prime Minister Narendra Modi, Home Minister Amit Shah and Power Minister R K Singh. Secretary Power, UT Ladakh, Ravinder Kumar said these projects were part of the Prime Ministers Development Package (PMDP) 2015, which could not have been taken up due to various issues. However, due to the painstaking efforts of the Lt Governor, his administration and public representatives, it is now approved and ready for tendering of works, Kumar added. He said the REC Transmission Projects Company Limited (RECTPCL) is the project implementing agency for executing the transmission works in Ladakh, while Power Grid Corporation NSE 1.36% India Limited (PGCIL) is the project management agency.

"These transmission lines will link far-flung villages to the Grid and phase out DG sets used in far-flung villages, thus taking one more step towards achieving Carbon Neutrality in Ladakh. This will also provide the Army and far-flung villages with clean power round the clock," he noted. The DPR cost of the projects has been revised from Rs 354.74 crore to Rs 1,309.71 crore by the Central Electricity Authority (CEA), Kumar added.

Source : PTI : May 29, 2021

International Council on Large Electric Systems (CIGRE)

International Headquarters:

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

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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.

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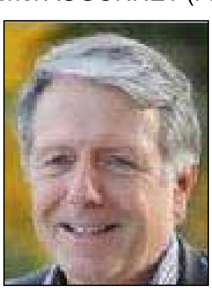

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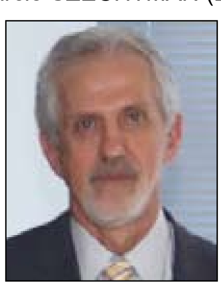

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