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

Cigré INDIA Journal

Vol. 6, No. 2 - July 2017 (Half Yearly Journal)

Join CIGRE
The World Forum for Power System

cigré INDIA

CIGRE MEMBERS FROM INDIA IN 2017

Organizational Members

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

CIGRE INDIA JOURNAL

Volume 6, No. 2 *July 2017*

CONTENTS

All communications to be addressed to:

The Secretary & Treasurer
CIGRE India
CBIP Building, Malcha Marg
Chanakyapuri, New Delhi - 110021

Subscription Information 2017/ (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

V.K. Kanjlia
Secretary & Treasurer
CIGRE India

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

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

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

CIGRE (India) was set up as society in the year 1991 with Central Board of Irrigation & Power (CBI&P), Malcha Marg, Chanakyapuri, New Delhi as its secretariat. It functions as the National Committee, i.e., CIGRE (India) for CIGRE HQ (Paris). The CIGRE (India) coordinates interest of Indian members; organises National Study Committee (NSC) meetings. It recommends appropriate persons for CIGRE Study Committees. The National representatives are instrumental in providing feed back to CIGRE Study Committees at Paris.

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

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

The Membership of CIGRE from India is also on the rise and we are expecting a membership of about 800 in the year 2017 as against 612 in the year 2016.

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

We are bringout this Journal on half yearly basis. The last issue was published in the month of January 2016.

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

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

V.K. Kanjlia

Secretary & Treasurer CIGRE India

SMART GRID SCHEME USING INTELLIGENT LOAD PRIORITIZATION FOR INDUSTRIES

Muhammad Ehsan, Kevin Ark Kumar, K. Gnanasekaran, V. Ratchanniya Samuel

Bharat Heavy Electricals Limited, Tiruchirappalli

ABSTRACT

Several industries have implemented grid connected solar PV power generation systems to fulfil their SPO and as a co-yield, they are meeting their partial power demands. Today smart grid systems are reliable and improve efficiency and security of electrical networks by making the grid controllable with continuous monitoring and automation. The smart grid system schedules and manages electrical demand in a reliable, economic, and sustainable manner. The smart grid system also possess demand response capacity to support and stabilize electrical consumption with electrical supply. The smart grid system has the potential to integrate new technologies to enable energy storage elements and the large-scale use of electrical installations, including transportation systems like electric vehicles. Proper control and management schemes are imperative to utilize the available electricity in an efficient manner and to avoid overdrawing power beyond the contractual demand. Through this paper, a novel smart grid scheme with intelligent load prioritization method is proposed for industries with grid integrated PV plants. A simulated smart grid scheme is proposed for implementation on an experimental basis in Tiruchirappalli unit of Bharat Heavy Electricals Limited (BHEL), one of the largest Indian engineering and manufacturing enterprises, catering to the needs of energy, industry and infrastructure sectors. This paper presents the design aspects, operational features and various control methodologies with simulation results. Such a smart grid scheme enables industries to have a greater control over their electricity consumption and also ensure compliance to demand-side regulations. The simulation results prove the proposed scheme is feasible and reliable for large scale integration in industries.

Keywords *: Smart Grid; Load Prioritization; Fuzzy Systems; Renewable resources*

1. INTRODUCTION

Growth of manufacturing sector is a key indicator of socio-economic development and prosperity of a country. As such, better energy infrastructure and its growth are important to sustain the pace of industrial development. Use of solar photovoltaic power in industries is seen to be growing in a rapid pace from different case studies[1-3]. Increase in power demand, power reliability, reduction in greenhouse gas emission etc., are the main reasons for using solar power. Apart from that, industries are also mandated by central and state electricity regulatory commissions for solar purchase obligations (SPO) to promote solar energy across the state and to reduce their carbon footprint. Several industries have implemented grid connected solar PV power generation systems to fulfil their SPO and as a co-yield, they are meeting their partial power demands. BHEL Tiruchirappalli, one of the major engineering enterprises in India has also initiated the use of solar photovoltaic power through various grid connected projects to meet more than one-third of its maximum demand.

Presently the industrial power distribution network has an abundant accord of intelligence and these network forms a beginning for the development of Smart Grid schemes. In the literature, the smart equipment are provided with localized programs, minimum processing capacity, and local data and measurement results are obtained from the equipment for the process. Smart devices in multi-vendor systems communicate and operate industry-wide with each other[4,5]. Most of the features of Smart Grid concept are also desirable in an industrial power supply network, which can form part of a wide Smart Grid[6-8]. Power density inside the factory site is often very high and the distribution network is heavily loaded. It is built on an advanced architecture and regulated to facilitate the integration of all involved energy resources. Power demand in the industrial distribution network may be considerable large (in a range of hundreds of MW). Most of the features of Smart Grid concept are also desirable in an industrial power supply network, which can form part of a wide Smart Grid. Power density inside the factory site is often very high and the distribution network is heavily loaded. A novel smart grid scheme with intelligent load prioritization method is proposed for industries with grid integrated PV plants. The schematic of the proposed smart grid networking scheme for Industries is shown in Fig.1.

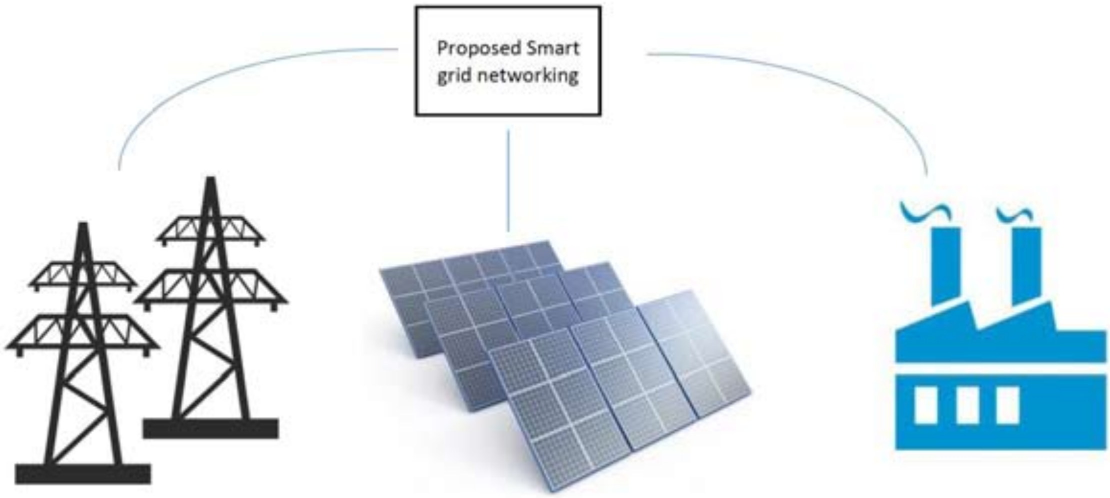


Fig. 1 : Smart grid scheme for Industries

The proposed smart grid scheme continuously compares the industry's demand with PV power generation and grid. Whenever there is a reduction in PV power generation and an increase in demand is simultaneously envisaged by the scheme, load prioritization program is activated and production centres are made to curtail certain percentage of their loads. This will help the industries to utilize the solar PV power to a maximum extent and to avoid penal charges for crossing the sanctioned maximum demand. Due to high level of nonlinearity in the system, a model-free optimization algorithm is used. Fuzzy systems solve problems with imprecise and incomplete data, and can model nonlinear functions of random complexity. Fuzzy systems has the advantage of effortless programming and provide stable results. The flow chart of the load shedding process is shown in Fig. 2. For load shedding prioritization, fuzzy logic system is used and this will prioritize the loads for shedding to avoid overshooting the contractual demand. The loads will be resumed back using the optimization algorithm, once PV power generation improves. This scheme helps to integrate the existing and upcoming grid connected PV generation systems for smart power scheduling operations of the unit. This paper presents the fuzzy approach for load prioritization methodologies with simulation results.

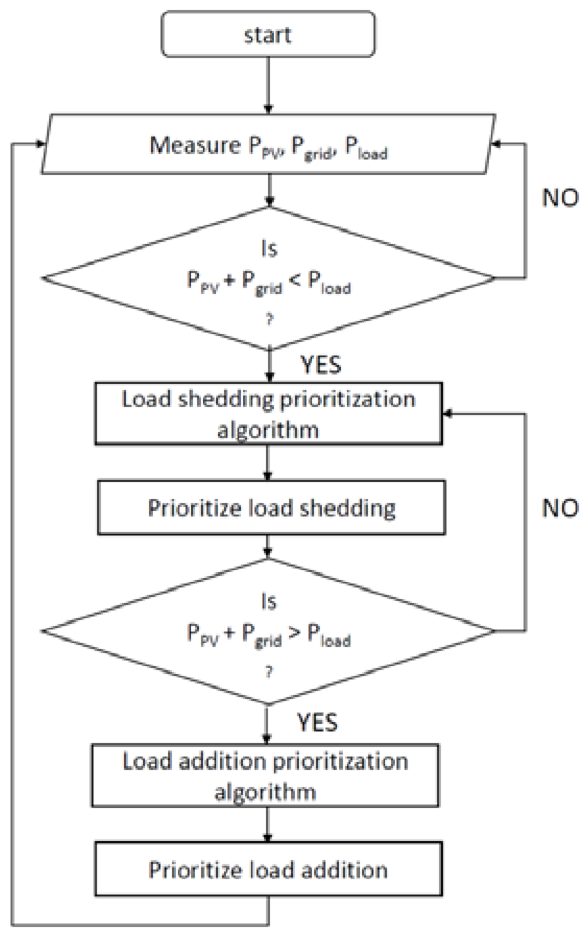


Fig. 2 : Flow chart for load prioritization

2. FUZZY BASED LOAD SHEDDING PRIORITIZATION

The load prioritization consists of resource allocation to production activities that optimizes the production performance measures. When scheduling production activities there are some resource conflict and in order to solve this conflict, a priority is calculated for the activities considering time, electrical power rating of the machinery and criticality of the production activity. Mapping these parameters with load prioritization is highly non-linear and models could become uncertain. Considering the non-linearity and model uncertainty, a fuzzy based load prioritization approach is proposed in this paper. In this paper, three important production centres of tubular shop of a boiler manufacturing industry is considered. The three important work centres are (1) auto welding machines; (2) CNC tube bending machines and (3) tube preparation machines, which are very essential in the boiler manufacturing process. The time of the operation is critical input parameter to decide on the load prioritization. For example in the start hours of the shift, importance will be given to tube preparation rather than welding functions. Similarly during peak hours of operation welding work centres and CNC tube bending machines will be given top priority as compared to tube preparation machines. Yet another parameter that affect the decision making process in load prioritization is the criticality of the production. The criticality of the production depends on the availability of job materials and scheduled loading of work centres. The criticality can be fed online to the system though enterprise resource planning (ERP). Apart from that, the maximum power demand needs to be monitored continuously and it should be taken as an input for load prioritization.

The architecture of the fuzzy logic controller used in this proposed system are shown in Fig. 3. The crisp values of inputs such as time, maximum demand and activity are fuzzified into corresponding fuzzy values by input fuzzification. Fuzzy rules are established with the knowledge of relationship between inputs and outputs based on a set of IF-THEN rules. The fuzzy values of input and fuzzy rules are fed to the fuzzy inference engine, which consists of computational algorithms based on the fuzzy inputs and fuzzy rules and compute the output truth values. The output truth values are defuzzified into real time values in output defuzzification. The real time values of production load priority are then processed by the microcontroller to control the proposed system. To design a fuzzy controller, the range of possible values, universe of discourse, of the real time input variables and real time output variables are to be detailed. In fuzzy set theory, the membership functions are used to map the universe of discourse into fuzzy values in the range 0 to 1. In general, the shape of the membership function is triangular, trapezoidal, Gaussian or sigmoidal. The fuzzy membership functions of the input and output variables are shown in Figures 4, 5, 6, 7, 8 and 9. The rules establish a relationship between the input domains and output domain. The relationships are defined using IF-THEN statement, based on a proper analysis on the input numerical values and expert's opinion. The rule base of the proposed system is tabulated in Table 1.

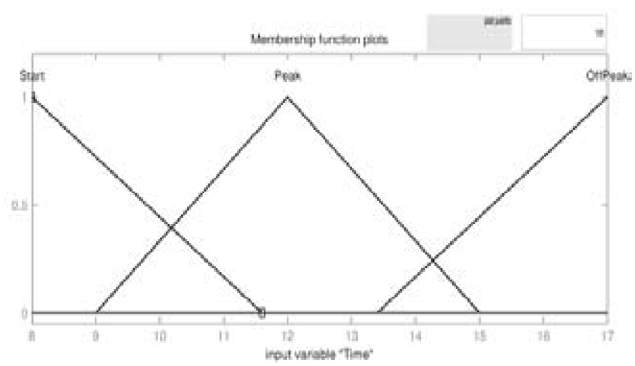


Fig. 4 : Input variable 'Time of the day'

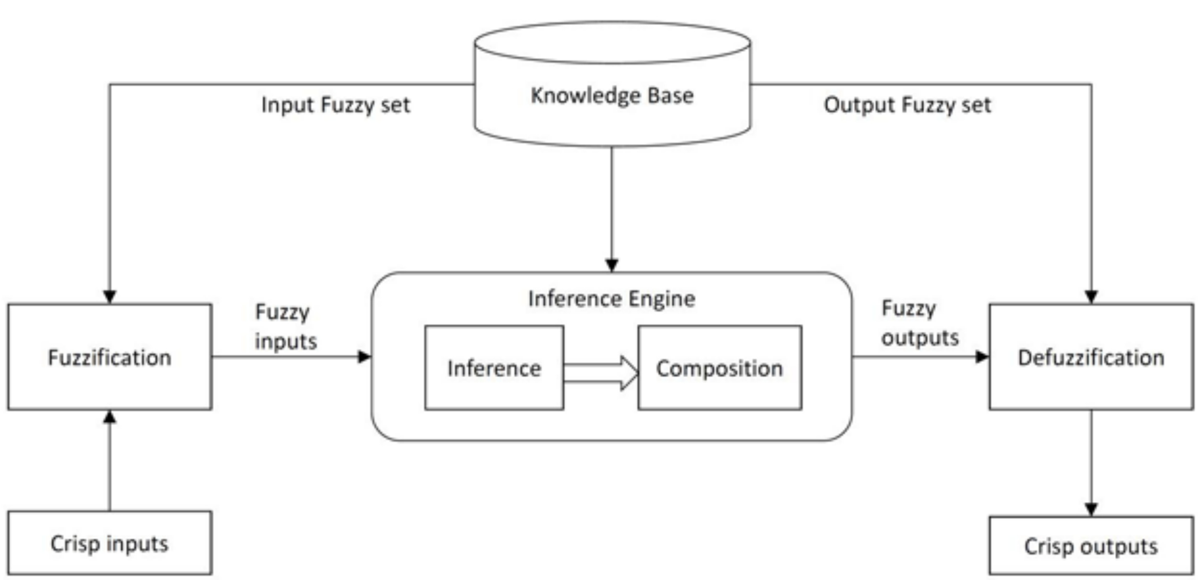


Fig. 3 : Fuzzy architecture for load prioritization

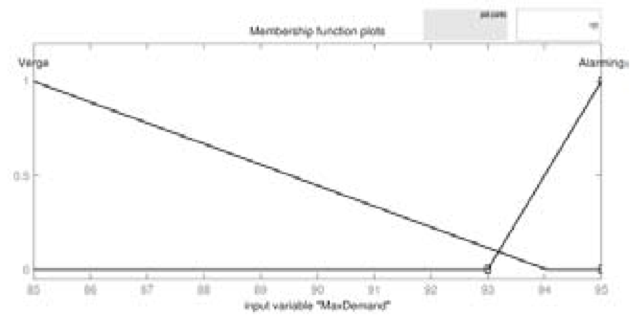


Fig. 5 : Input variable 'Maximum Demand'

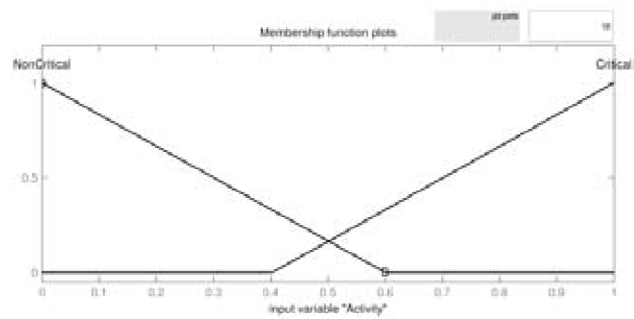


Fig. 6 : Input variable 'Production Activity'

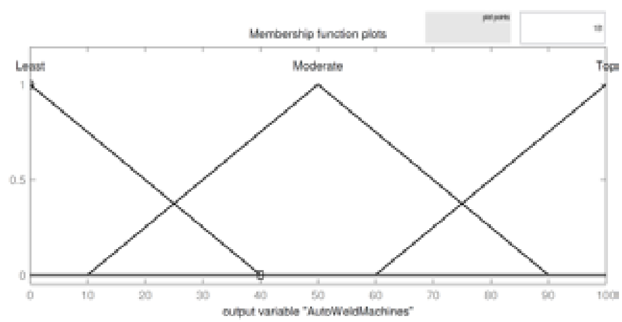


Fig. 7 : Load Priority of Welding machines

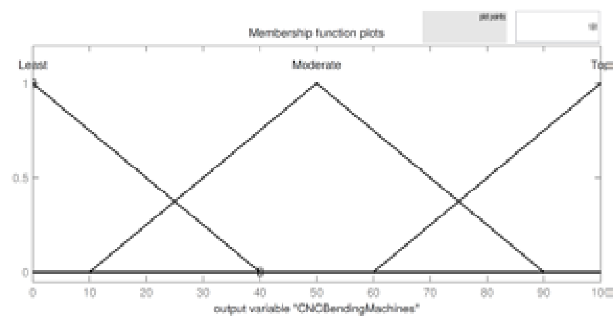


Fig. 8 : Load Priority of Bending machines

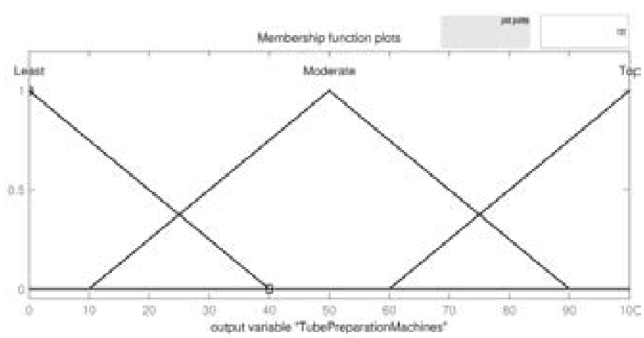


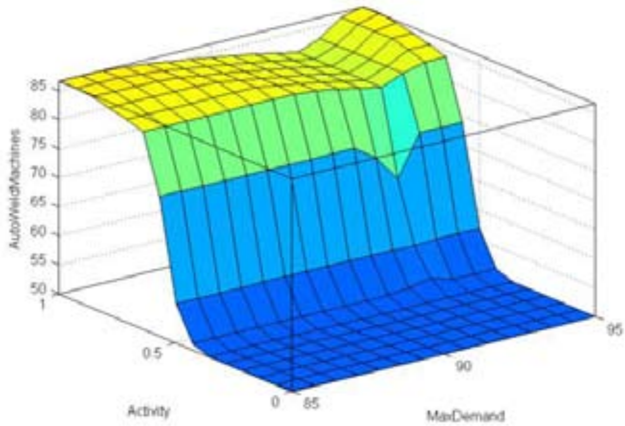
Fig. 9 : Load Priority of Tube Preparation

Table 1 : Fuzzy Rule Base

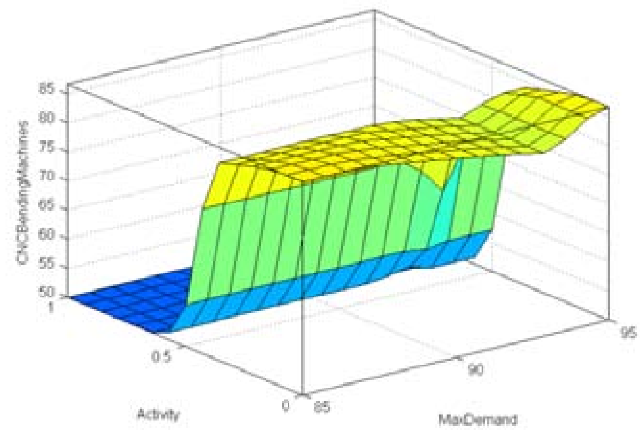
Input			Output (Priority)		
Time	**Max. Demand**	**Activity**	**Auto Weld**	**CNC Bending**	**Tube Preparation**
Start	Verge	Critical	Least	Moderate	Top
Start	Verge	Non-Critical	Least	Moderate	Top
Start	Alarming	Critical	Moderate	Least	Top
Start	Alarming	Non-Critical	Moderate	Least	Top
Peak	Verge	Critical	Top	Moderate	Least
Peak	Verge	Non-Critical	Moderate	Top	Least
Peak	Alarming	Critical	Top	Moderate	Least
Peak	Alarming	Non-Critical	Moderate	Top	Least
Off Peak	Verge	Critical	Top	Least	Moderate
Off Peak	Verge	Non-Critical	Top	Moderate	Least
Off Peak	Alarming	Critical	Moderate	Top	Least
Off Peak	Alarming	Non-Critical	Top	Least	Moderate

3. RESULTS AND DISCUSSIONS

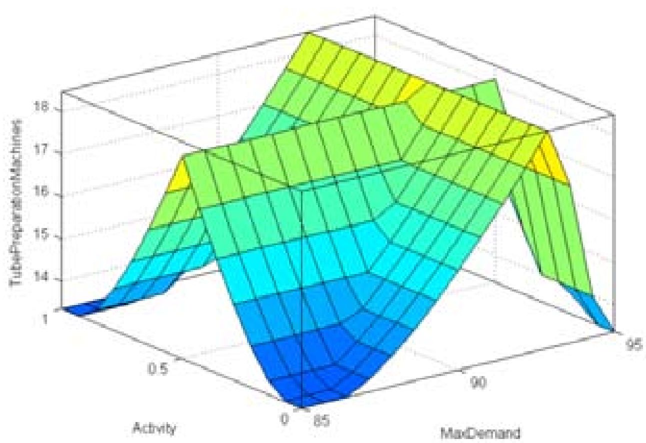
The input values provided by the appropriate sensors are processed using the rule base to determine the load priority. The response surface of the input-output relations are shown in Fig.10 (a) to (i).



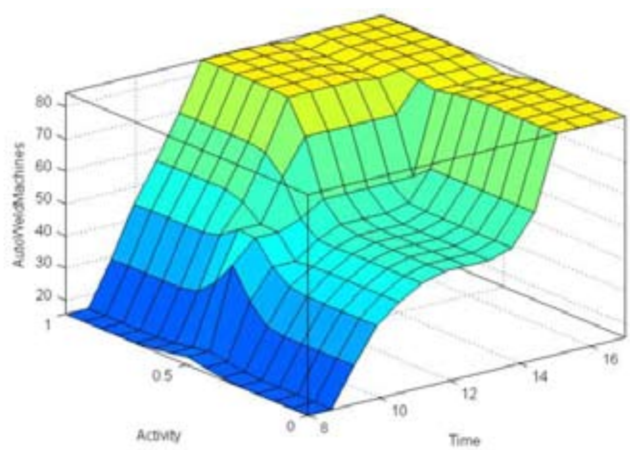
(a)



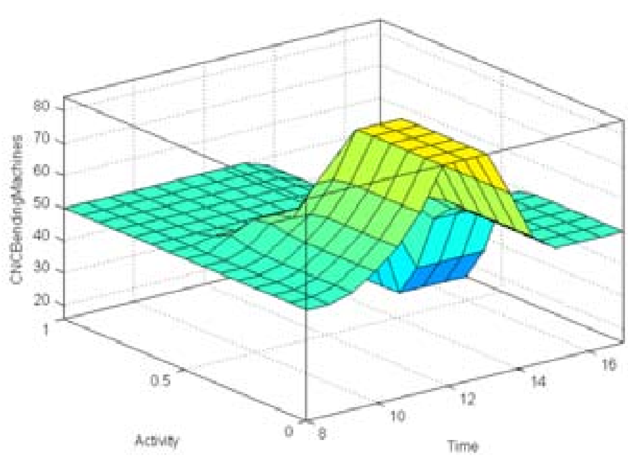
(b)



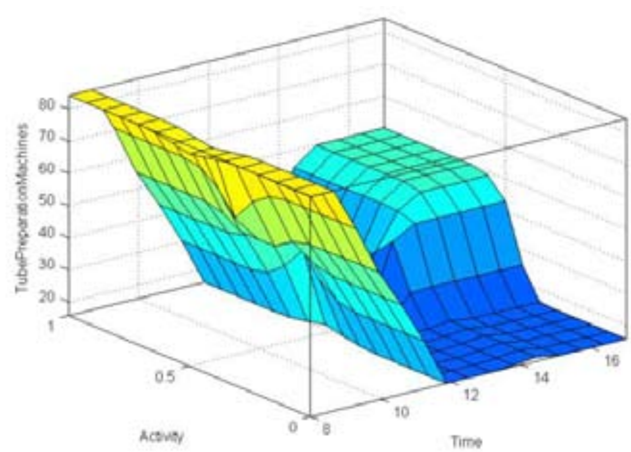
(c)



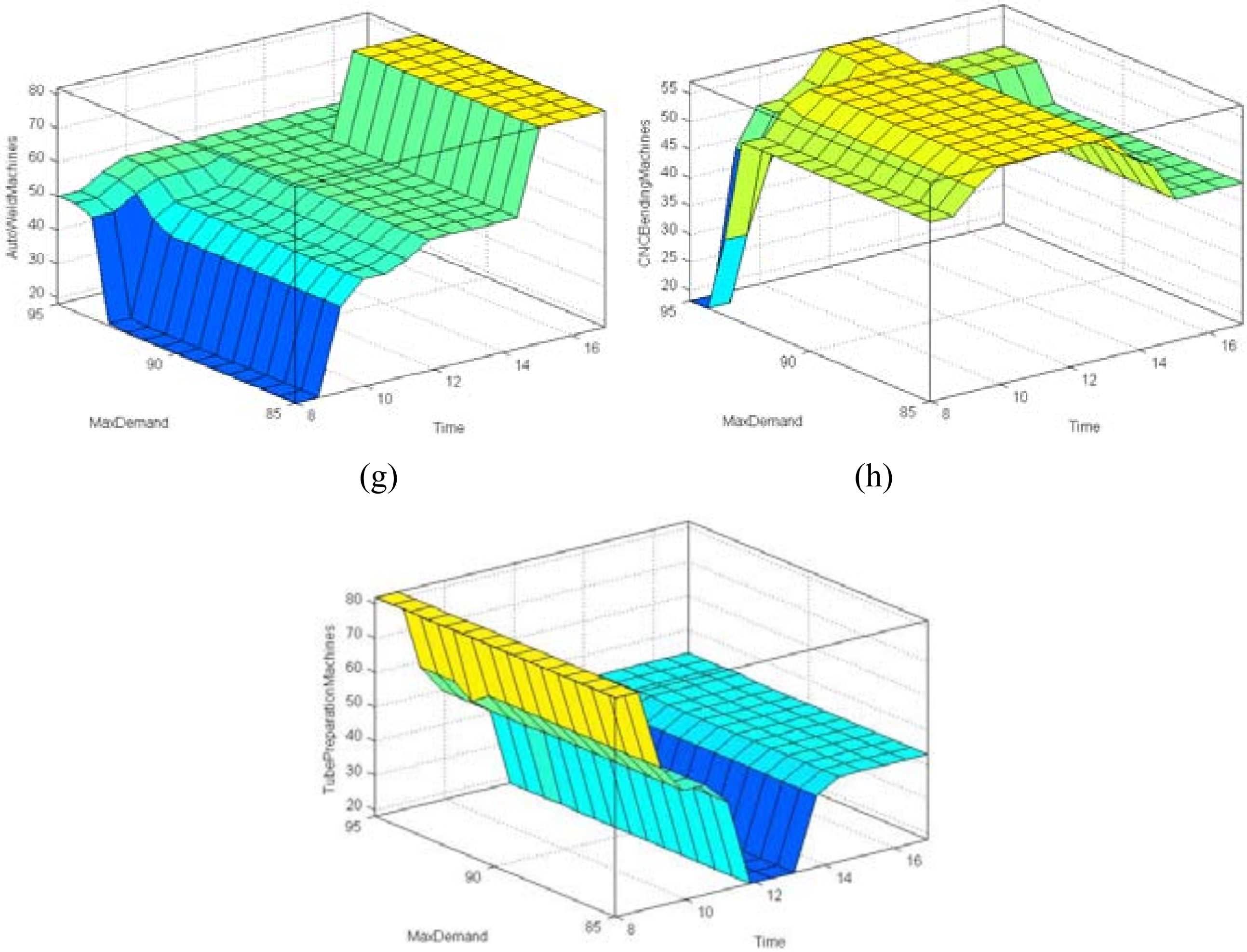
(d)



(e)



(f)



(g) (h)

(i)

Fig. 10 : Surface plots of input-output variables

The figures shows the way the proposed system will respond to different working conditions, for instance if the operation is done during 8:30 hrs and the activity is non-critical, then the load scheduling priority proposed by the fuzzy logic control (FLC) is 15% of welding machines, 50% of CNC bending machines and 84% of tube preparation machines. This means most of the auto welding machines can be switched OFF and this clearly shows that during the start of the shift, material preparation should be of prime importance and hence during load shedding, material preparation will be given the least priority. Thus the simulation results prove that the proposed fuzzy system is capable of generating reliable and stable control signals.

5. CONCLUSION

A smart grid scheme enables industries to have a greater control over their electricity consumption and also ensure compliance to demand-side regulations. This paper outlined a scheme for optimizing power demand in industries through soft computing technique. The load prioritization of different work centres is carried out using fuzzy logic system. The simulation results prove the proposed scheme is feasible and reliable for large scale integration in industries.

BIBLIOGRAPHY

(1) Tariq Samad and K. Sila. “Smart grid technologies and application for the industrial sector” (Computers and Chemical Engineering 47 July 2012 pages 76-84).

(2) K.A. Kumar, K. Sundareswaran, P.R. Venkateswaran. "Performance study on a grid connected 20 kWp solar photovoltaic installation in an industry in Tiruchirappalli (India)" (Energy for Sustainable Development 23 December 2014 pages 294-304)

(3) K. Sundareswaran, K.A. Kumar, P.R. Venkateswaran. "Dual input autonomous solar photovoltaic powered motor drive system for industrial applications" (Journal of Renewable and Sustainable Energy 7 (1), January 2015 pages 013128 1- 7)

(4) ABB working group. "Smart Grid in Industrial Networks" (ABB Industrial Smart Grid February 2011)

(5) Enrique Santacana. "The Importance of Standardizing the Smart Grid" (Electric-light-power. Volume-87. Issue 4)

(6) Manuela Sechilariu, Baochao Wang and Fabrice Locment." Building-integrated microgrid: Advanced local energy management for forthcoming smart power grid communication" (Energy No. 59 January 2013 pages 236–243)

(7) Konark Sharma and Lalit Mohan Saini. "Performance analysis of smart metering for smart grid: An overview" (Renewable and Sustainable Energy Reviews No. 49 May 2015 pages 720–735)

(8) M. Welscha, M. Howells, M. Bazilian, J.F. DeCarolis, S. Hermann, H.H. Rogner. "Modelling elements of Smart Grids Enhancing the OSeMOSYS (Open Source Energy Modelling System) code" (Energy 46 September 2012 pages 337-350)

Energy Conservation is the Foundation of Energy Independence

DEVELOPMENT OF 420 KV GAS INSULATED SWITCHGEAR WITH ONE–BREAK SPRING OPERATED GAS CIRCUIT BREAKER

M. Kawahigashi, M. Fujioka, H. Kajino, D. Yoshida and H. Koyama

Mitsubishi Electric Corporation, Japan

ABSTRACT

Reduction of life-cycle cost of high-voltage electric equipment including installation and maintenance costs is an increasing need for electric power utilities. In general, gas insulated switchgear (GIS), which is one of the high-voltage electric equipment, should be compact and have high-reliability that enables the reduction of installation period and maintenance work. 420 kV GIS with one-break spring operated gas circuit breaker (GCB) has been developed to meet the growing demand for substation construction together with the demand for reduced installation and maintenance costs. The paper presents key benefits and their supporting technologies applied to the developed GIS.

Reduced installation period is achieved by the compact design of GIS with concentrated configuration. Application of one-break GCB enables reduced size of GCB and contributes to the concentrated configuration of the primary circuit of the GIS connected to both sides of the GCB. Operating mechanism for GCB is arranged in front of GIS, which results in lower height of GCB and easy accessible for maintenance than that for existing GIS. Concentrated configuration enables single transportation per GIS unit and reduction of installation work to 60% because many gas compartments assembled in factory can be installed without assembly work on site. Compactness also reduces the installation footprint of switchgear to 60% of that for existing switchgear, and results in the reduction of building cost for the whole substation.

Reduced maintenance work is achieved by GCB with torsion-bar spring operating mechanism and flexible linkage applied to disconnectors (DS) and earthing switches (ES). Operating mechanism with torsion bar spring possesses enough capability to applied one break GCB while also providing benefits of increased mechanical reliability and reduced maintenance work. It also enables to design a compact operating mechanism with large stored energy, and higher interrupting capability can be achieved with simple mechanical puffer interrupter. Flexible linkage using metallic wires is applied to DS and ES to achieve easy access for maintenance work. Metallic wires transmit operating force from the operating mechanism to the moving parts of DS or ES, while enable the flexible location of the operating mechanism. They also contributes to concentrated configuration of all operating mechanisms located in front of the GIS unit, that results in enables single location for maintenance of the GIS unit and reduction of the maintenance work. Reduced environmental impact is achieved by the compact design of the developed GIS. SF_6 gas is reduced to 60% compared to existing GIS. Use of material can also be reduced to 50%. Type tests were carried out on prototype GIS in accordance with IEC standard.

Keywords *: Gas insulated switchgear, Gas circuit-breaker, Torsion-bar spring operating mechanism, Flexible linkage*

1. INTRODUCTION

Reduction of life-cycle cost of the high-voltage electric equipment including installation cost and maintenance cost is a growing demand for electric power utilities. 420 kV gas insulated switchgear (GIS) has been developed to meet the growing demand of the substation construction together with the demand for reduced installation and maintenance cost.

Key features and benefits to reduce life-cycle cost of the developed 420 kV GIS and their supporting technologies are presented.

2. BASIC SPECIFICATIONS AND STRUCTURE

Major ratings for developed GIS are shown in Table 1. International standards are considered and the ratings are determined in accordance with IEC-62271-100, 102 and 203.

Application of one-break GCB and concentrated main bus configuration enables compact structure of GIS. Figures 1 shows comparison of internal structure of existing and developed GIS. Reduction of the size of GCB contributes to the concentrated configuration of the primary circuit connected to both sides of the GCB.

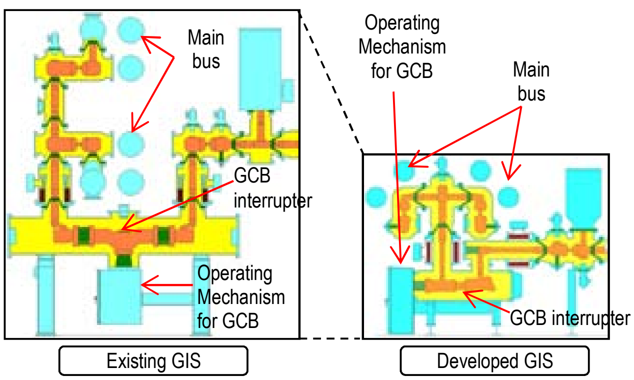


Fig. 1 : Comparison of internal structure between existing and developed GIS

Horizontal arrangement of operating mechanism and interrupter enables lower height of GCB compared to two-break GCB where operating mechanism is arranged beneath the interrupter. Three-phase double main bus arranged horizontally in the developed GIS so that the total height of the GIS can be reduced, while they are arranged vertically in existing GIS resulting in tall configuration.

Table 2 shows comparison of the footprint, cubic content and total height between existing GIS and the developed GIS. They are reduced to 50%, 30% and 50%, respectively.

Table 2 : Comparison typical size of existing and developed GIS

	Existing GIS	Developed GIS
Footprint	100%	50%
Cubic content	100%	30%
Height	100%	50%

3. FEATURES OF DEVELOPED 420 KV GIS

3.1 Reduced Installation Period

3.1.1 *Single Package Transportation*[1]

Site construction work can be minimized because whole unit can be transported with single package, whereas each unit is required to divide into five packages for existing GIS. Figure 2 shows difference of transportation packages for one unit of existing GIS and developed GIS. Transportation with single package results in the reduction of the on-site installation period to 60% when developed GIS is applied. Reliability is also improved because many gas compartment assembled in clean factory is installed without assembly work on site.

3.1.2 *Integrated DS with the Main Bus*

Number of parts and length of DS for main bus are reduced to 40% and 50% respectively, because moving side of DS is integrated with the main bus. Figure 3 shows comparison of configuration between DSs for existing and developed GIS. Moving side of DS constitutes a part of the main bus in developed GIS whereas DS is separated with the main bus in existing GIS.

Table 1 : Ratings of 420 kV GIS

GIS	Rated voltage		420 kV
	Rated normal current		up to 5000 A
	Rated short time withstand current		63 kA
	Rated frequency		50 / 60 Hz
	Dielectric	Lightning impulse voltage	1425 kV
		Switching impulse voltage	1050 kV
		Power frequency voltage	650 kV
GCB	Rated breaking current		63 kA
	Rated breaking time		2 cycles
DS	Bus transfer current switching		20 V / 1600 A
Fast Earthing Switch (FES)	Electromagnetically induced current switching		10 kV / 160 A
	Electrostatically induced current switching		20 kV / 18 A

Compact structure contributes the reduction of land and building cost for substation. Figure 4 shows comparison of top view of the typical whole switchgear construction between existing GIS and developed GIS. The footprint of the total construction of developed GIS is 60 % of that of existing GIS.

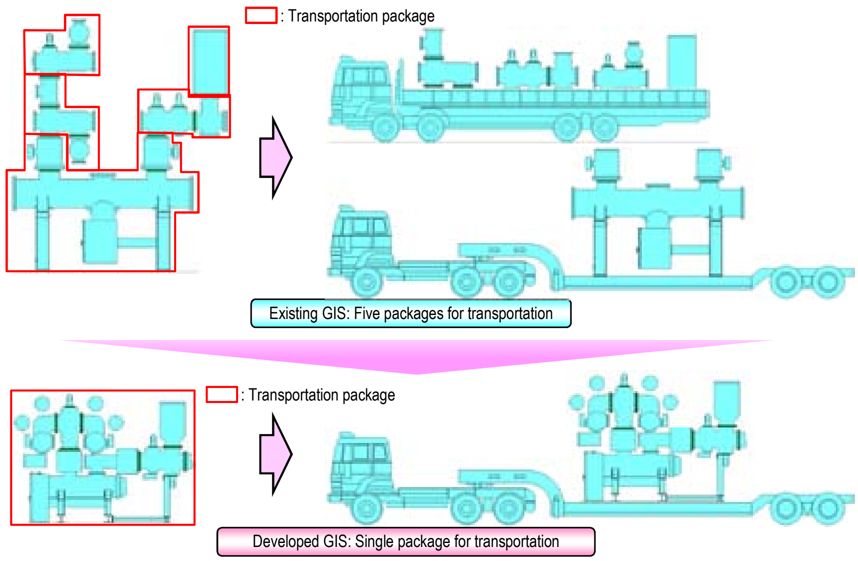


Fig. 2 : Transport configuration

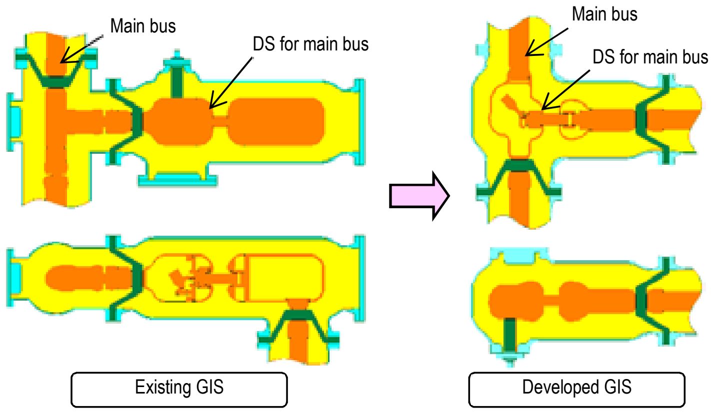


Fig. 3 : Comparison of configuration of DS for main bus

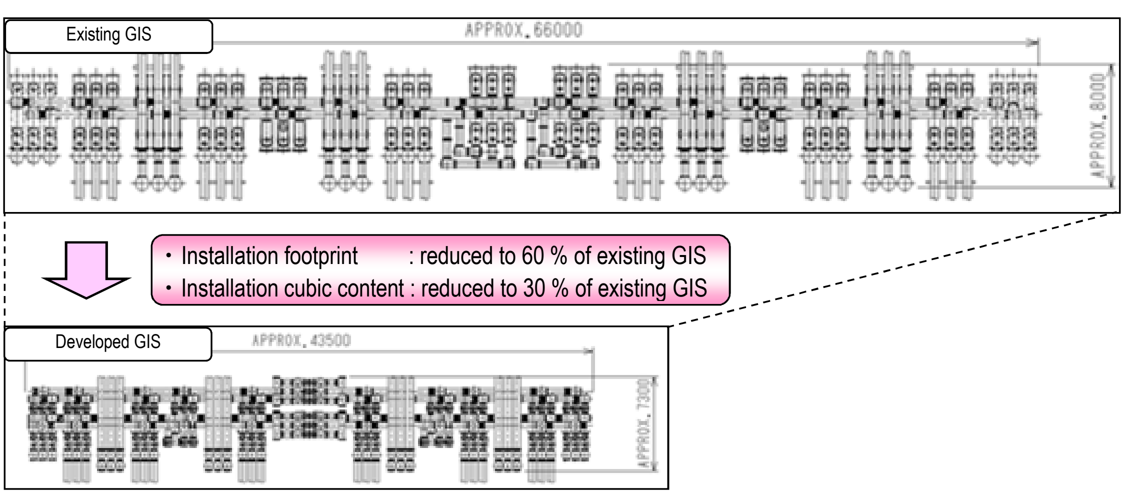


Fig. 4 : Reduced substation footprint

3.2 Reduced Maintenance Work

3.2.1 *Torsion-bar Spring Operating Mechanism*(2)(3)(4)

Spring operating mechanisms have been used to develop higher interrupting capabilities while also providing benefits of increased mechanical reliability and reduced maintenance work.

A spring operating mechanism stores mechanical energy in the solid spring. Since the operating characteristics of a spring operating mechanism are less affected by the change of ambient temperature and loss of mechanical pressure, which often occurs in hydraulic mechanisms due to hydraulic leakage, spring mechanisms are inherently superior in long-term reliability as compared with a pneumatic or hydraulic operating mechanism. Lubricating material, such as sulfur molybdenum, is thermally applied on the sliding parts to optimize long-term mechanical performance by reducing friction and preventing rust.

The use of a torsion-bar spring divided into two bars makes it possible to design a compact operating mechanism with large stored energy. A picture of a torsion spring operating mechanism is shown in Figure 5. The mechanisms have been verified by extensive testing programs. The programs include the normal mechanical endurance tests of 2,000 operations where the stored energy is 120 % of the normal value, special mechanical endurance tests to confirm the change of operating characteristics when greases are removed, as well as extended mechanical endurance tests of up to 30,000-50,000 operations. A highspeed motion analyzer was also used to detect any changes during these mechanical endurance tests.

3.2.2 *Improved Accessibility to Operating Mechanism*

Concentration of the mechanism for GCB, DS and ES to the front of GIS unit enables easy access during maintenance. Introducing a one-break GCB makes it possible to arrange the operating mechanism and the interrupter horizontally. All the operating mechanisms for DS and ES can be also located in front of the GIS thanks to an application of flexible-linkage system. Figure 6 shows structure of linkage system for DS and ES in existing GIS and developed GIS together with the direction of access for maintenance. All the maintenance can be done in front of developed GIS. Detail construction of flexible linkage system is also shown in the figure. Metallic wires are used to transmit operating force from the operating mechanism to the moving part of DS or ES, and ensure flexible location of the operating mechanism. Since all the maintenance can be done on the mechanism side where the motor is located, concentrated configuration of the mechanism location is essential to reduce the time for maintenance work. On the other hand, maintenance needs to be done in three places for existing GIS because their rigid linkage system limits the location of mechanism.

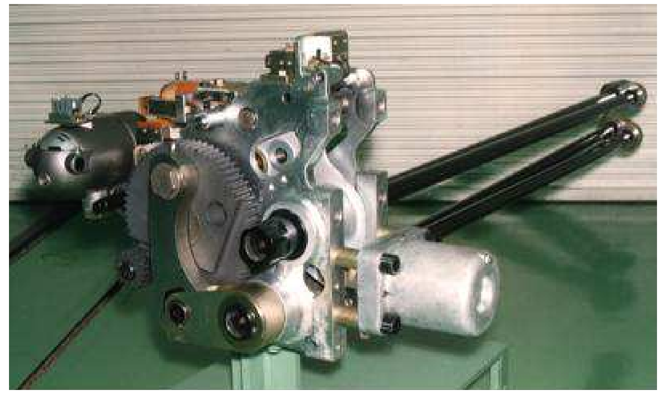


Fig. 5 : Torsion bar spring mechanism

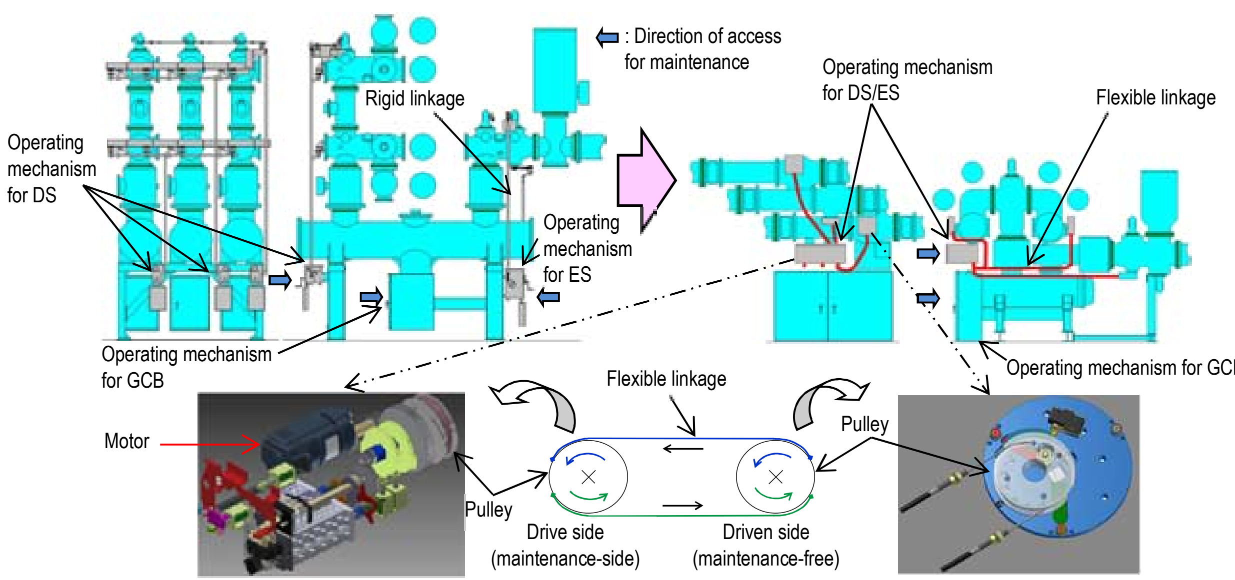


Fig. 6 : Cross-section of flexible linkage

3.3 Reduced Environmental Impact

Reduction of SF_6 gas and reduced use of materials are achieved due to the compact design of developed GIS. Table 3 shows a summary of the comparison of environmental impact between existing and developed GIS. Use of SF_6 gas and material weight are reduced to 60% and 50%, respectively.

Table 3 : Reduction of environmental impact

	Existing GIS	Developed GIS
SF_6 gas weight	100%	60%
Material weight	100%	50%

4. TESTING

Type test to verify the performance of developed GIS were carried out in accordance with IEC 62271-100, 102, 203 and other related standards. Table 4 shows performance verified with test items. Figures 7, 8 and 9 show pictures of dielectric test, short-circuit making test and interruption test with prototype GIS. All the tests finished with successful results.

Table 4 : Items included in type test accordance with IEC

Performance	Items
Dielectric strength	Lightning impulse voltage tests Switching impulse voltage tests Power frequency voltage tests Partial discharge tests
Current carrying	Temperature rise tests Short time withstand current and peak withstand current tests
Mechanical endurance	Transportation tests Seismic analysis
Making and breaking current	Bus transfer current switching tests Induced current switching tests Short-circuit making tests Bus charging current switching tests
Operation	Satisfactory operation at temperature limits tests Satisfactory operation and mechanical endurance tests
Interruption	Short-circuit tests Short-line fault tests Out-of-phase making and breaking tests Capacitive current switching tests

Fig. 7 : Prototype 420 kV GIS under dielectric test

Fig. 8 : Prototype 420 kV GIS under short-circuit making

Fig. 9 : Prototype 420 kV GCB under interruption test

5. CONCLUSIONS

420 kV GIS with one-break GCB has been developed considering the reduction of the cost imposed on the utility during installation, operation and maintenance. The following benefits are presented.

(1) Reduced installation cost

Transportation with single package per unit reduces on-site construction work. Compact structure reduces substation footprint resulting in the reduction of land and building cost.

(2) Reduced maintenance cost

Maintenance work and replacement of parts reduced because of the application of onebreak GCB. Concentrated mechanism location in front of the GIS unit enables easy access and reduction of time for maintenance.

(3) Reduced environmental impact

Reduction of SF_6 gas and reduced use of materials are achieved due to the compact design of developed GIS.

BIBLIOGRAPHY

1. S. Nakauchi, et al., "Development of compact type 550 kV GIS", IEEJ Power and Energy 7-291 (2015).
2. Y. Yoshitomo, et al., "Development of 362 kV 63 kA spring mechanism GCB", IEEJ National convention 6-221 (2010).
3. T. Mori, et al., "Development of 550 kV 63 kA Spring Operated Gas Circuit-Breaker", CIGREAORC-E-3-0005 (2013).
4. H. Wilson, et al., "Development of GCBs with a torsion bar spring operating mech-anism and their applications to severe SLF duty and non-standard reactor switching", CIGRE SC A3 & B3 Joint Colloquium 105 (2005).

LIFE IS A COMBINATION OF SUCCESS AND FAILURE BOTH ARE NEEDED

ERP INTEGRATED MAINTENANCE MANAGEMENT & BEST PRACTICES FOR T&D ASSET MANAGEMENT

Kuldeep Kumar Jain, Raj Kumar Sharma, Yogesh Gupta, Zia Al Nasir Khan

TATA Power Delhi Distribution Limited

ABSTRACT

TPDDL operates in an area of 510 sq. km. with fleet of nearly 120,000 maintainable electrical assets and an installed capacity of nearly 3900 MVA. A major of the O&M effort is currently under way to maintain the required asset availability but it is already clear that the average age of the asset cannot be maintained at its current level due to several constraints like financial and human resource availability limitations as also regulatory constraints. TPDDL is taking the following approaches to maintain the required electrical asset availability inthe coming years: -

- *Gradually renewing the ageing fleet of assets in line with regulatory guidelines, starting with those whose condition is cause for concern and among them, those which are most critical to the maintenance of reliable supply to the consumer.*
- *Reduction in the number of failures and also of impact of failures by the use of enhanced monitoring and optimized maintenance.*

Key challenges being inability to monitor and respond to asset conditions in real time and planning efficient maintenance execution. Given these challenges, TPDDL is taking the following approaches to extract the most potential from aging assets while ensuring reliability and optimizing costs.

- *Current Approach : Preventive and Condition Based Maintenance*
- *Futuristic Approach : Condition and Reliability Based Maintenance*

With a view to bring in a turnaround in commercial, operational and financial performances TPDDL went ahead with implementation of Enterprise Resource Planning (ERP) to achieve excellence in Operational activities.

This paper will elaborate on ERP based maintenance framework and algorithm for risk indexing, condition based maintenance technique deployed for reliability enhancement vis-à-vis life enhancement and utilization of critical assets.

SAP (System Application and Products in Data Processing) is the ERP implemented at TATA Power-DDL. The Plant Maintenance Module of SAP (SAP-PM) caters to the needs for its T&D maintenance and enterprise asset management purposes.

***Keywords** : ERP, SAP, Preventive Maintenance, Condition Based Maintenance, Risk Based Maintenance, Risk Index, Notification, Measuring Point, Measuring Document, SAP-PM, Customer Exit IMRC0001.*

1. INTRODUCTION

ERP are software packages composed of several modules, such as operations and maintenance, human resources, sales, finance and production, providing cross-organization integration of data through imbedded business processes. These software packages can be customized to answer the specific needs of each organization. ERP systems integrate (or attempt to integrate) all data and processes of an organization into a unified system. SAP PM Module encompasses the Maintenance Management and the Enterprise Asset Management functions.

1.1 Maintenance Strategies in Transmission and Distribution Networks

The maintenance framework and philosophy are based on two primary factors of the object i.e. its condition and the importance.

Based on this the maintenance strategies are primary of four types

(i) Failure Based Maintenance (FBM)

Failure Based Maintenance is maintenance performed once breakdown occurs and the equipment is out of service. It is based on a breakdown maintenance trigger. It may be either planned or it can be unplanned. Breakdown maintenance can be costlier than preventative maintenance.

(ii) Preventive Maintenance (PM)

Preventive maintenance is maintenance that is regularly performed on a piece of equipment to lessen the likelihood of it failing. Preventative maintenance is performed while the equipment is still working, so that it does not break down unexpectedly. Preventive maintenance can be time based (i.e. calendar based) and number of operations based (i.e. counter based).

(iii) Condition Based Maintenance (CBM)

CBM is a maintenance strategy that monitors the actual condition of the asset to decide what and when maintenance needs to be done. CBM dictates that maintenance should only be performed when certain indicators show signs of decreasing performance or upcoming failure.

The goal of condition based maintenance is to spot upcoming equipment failure so maintenance can be proactively scheduled when it is needed – and not before and also not after.

(iv) Risk Based Maintenance (RBM)

RBM aims to implement a specific maintenance strategy for each of the assets of the company. RBM identifies the functions and in turn equipment of the company that are most critical and then seeks to optimize their maintenance strategies to minimize system failures thereby leading to an increase in equipment reliability and availability. Assets likely to fail often or have large consequences of failure are the most critical ones. RCM aims to identify the possible failure modes and their consequences; taking into account both the condition and importance of the asset. Cost-effective maintenance techniques that minimize the possibility of failure can then be determined. The most effective techniques are then adopted to improve the reliability of the facility as a whole.

2. PRESENT APPROACH: PREVENTIVE AND CONDITION BASED MAINTENANCE

In “As-Is” scenario Condition Based & Preventive Maintenance philosophy and associated scheduling is undertaken at TPDDL.

2.1 Preventive Maintenance

PM refers to all the measures for determining the actual condition (inspection) and for maintaining the target condition (maintenance) of assets.Every technical asset has a certain service life. If the service life is exhausted, then maintenance measures must be taken to renew it. As a rule, these measures are carried out periodically. PMhas fixed timeframe of maintenance schedules irrespective of asset health parameters, ageing, loading, fault stress and criticality of equipment.

In time-based preventive maintenance, the maintenance tasks are planned and performed depending on the time-dependent intervals determined.Further it involves shutdown of asset at periodic interval which may result in over or under maintenance of asset.

In counter-based preventive maintenance, the tasks are planned and performed based on the service characteristics of the technical assets. (e.g. number of operations of a breaker, number of operations of an OLTC).

2.2 Condition Monitoring Parameters

A prerequisite of condition-based maintenance is that the critical asset conditions that make certain maintenance necessary are known. There must also be a connection between asset condition and the maintenance tasks to be performed.The assets’ conditions must be monitored automatically or manually and entered or copied to the ERP system.TPDDL uses three main condition monitoring techniques :

(a) Infrared Scanning (I/R)

(b) Dissolved Gas Analysis (DGA)

(c) Ultrasonic Scanning (U/S)

The inputs from the above three monitoring techniques are fed into the SAP system. The data entry is subject to the definition and assignment of counters or measuring points to technical assets. One or more counters or measuring points can be assigned to an asset.

Measuring points in the ERP system describe the physical and/or logical locations at which a condition is described. Measurement readings are taken at measuring points in particular measurement units at particular intervals. Table 2, shows a set of sample measuring points for a power transformer.

Table 1 : Preventive & Condition Based Maintenance Strategy of TPDDL.

Equipment	Timelines	Type	Condition Monitoring Parameters
Power Transformer	Daily	W/O shutdown	Physical condition, Oil level, Oil leakage, Silica Gel, Abnormal sound, Oil level in capacitor bushing, Fan operation, NIDS healthiness
	Six month	W/O shutdown	Ultrasound, Infrared inspection, Oil BDV, Moisture, DGA
	Annual	W/O shutdown	Oil Analysis (Resistivity, Tan Delta etc.)
	Two years	Shutdown	IR value, PI , DC logic for PTR & NIDS, Relay maintenance
	Four Years	Shutdown	Complete testing.
On Load Tap Changer	Daily	W/O shutdown	Physical condition, Oil level, Oil leakage, Silica Gel, Abnormal sound, OLTC operation
	Six month	W/O shutdown	Infrared inspection, Oil BDV
	Annual	Shutdown	OLTC maintenance based on operation count
	Two Years	Shutdown	Winding resistance (only when contacts / mechanism are attended / replaced)
Circuit Breakers	Daily	W/O shutdown	Physical condition, Abnormal sound, Visible hot spot
	Six month	W/O shutdown	Ultrasonic, Infrared inspection
	Two years	Shutdown	Contact resistance, IR value, Relay maintenance
	Four years	Shutdown	Dynamic contact resistance
Current and Potential Transformers	Daily	W/O shutdown	Physical condition, Oil level, Oil leakage, Silica Gel, Abnormal sound
	Half Yearly	W/O shutdown	Ultrasound, Infrared inspection
	Two years	Shutdown	IR value, PI
	Four years	Shutdown	Tan delta
Outdoor Indoor Bus	Daily	W/O shutdown	Physical condition, Visible hot spot, Abnormal sound, bird nest
	Six month	W/O shutdown	Ultrasonic, Infrared inspection
	Four years	Shutdown	IR value
Capacitor Bank	Daily	W/O shutdown	Physical condition, Oil level, Oil leakage, Abnormal sound, Unbalance current
	Half Yearly	W/O shutdown	Ultrasound, Infrared inspection
	Two Years	Shutdown	Capacitance of individual unit, complete bank, IR value, IR value of reactor
Battery Charger	Daily	W/O shutdown	Physical condition, Abnormal sound, Float voltage & current, leakage current
	Monthly	W/O shutdown	Checking important parameters
	Half yearly	W/O shutdown	Remote signal
Battery Bank	Daily	W/O shutdown	Physical condition, Electrolyte level, pilot cell checking
	Monthly	W/O shutdown	Specific gravity, Cell voltage
	Annual	Shutdown	Capacity testing, Impedance testing
Isolator	Daily	W/O shutdown	Physical condition, Visible hot spot, Abnormal sound, bird nest
	Six month	W/O shutdown	Ultrasonic, Infrared inspection
	Four years	Shutdown	IR value
Lightening Arrestors	Daily	W/O shutdown	Physical condition, Visible hot spot, Abnormal sound
	Six month	W/O shutdown	Ultrasonic, Infrared inspection
	Two years	W/O shutdown	Leakage Current Measurement
	Four years	Shutdown	IR values

Table 2 : Sample of Power Transformer Measuring Points with their limits

Lower Limit	Upper Limit	Measuring Point	Unit of Measure
	1	Tan Delta Main Tank	Unit less
	50	Moisture Content	Ppm
	2500	Carbon Di-Oxide Content	Ppm
	350	Carbon Mono-Oxide Content	Ppm
	35	Acetylene Content	Ppm
	50	Ethylene Content	Ppm
	65	Ethane Content	Ppm
	120	Methane Content	Ppm
	100	Hydrogen Content	Ppm
40		OLTC Oil BDV	kV
40		Main Tank Oil BDV	kV
500		IR Value LV to HV	MOhm
300		IR Value LV to Earth	MOhm
500		IR Value HV to Earth	MOhm

In many cases, there may be an optimum value or range of values for a particular measuring point to which the device concerned is calibrated. You can specify this measurement reading as a target value for the measuring point, in case of optimum value, or define limits (lower/ upper) in case of operational range.

The data transferred to the system after a measurement has been taken at a measuring point or a counter is described in the SAP system as a measurement document. This transfer can be performed automatically or manually. The measurement document is therefore the result of a measurement or counter reading being entered in the system.In a standard SAP system measurement document creation is a one to one job i.e. one measurement document for each measuring point. To facilitate the Maintenance Engineer a customized program (Z-development in SAP ABAP)has been developed in SAP-PM for bulk uploading of Measurement Values. The data for measurement documents against measuring points is directly uploaded from Excel format as listed below.

Table 3 : Measuring Document Bulk Creation Format

Measuring Point	Date & Time	Reading	Valuation Code	Document Text	Reading Done By	Measuring Point Description
321	20.08.2015 11:00:00	65	0010	Sample Text	Maintenance Engineer	Oil Flash Point
322	21.09.2015 10:00:00	52	0020	Sample Text	Maintenance Engineer	Oil Flash Point

The above excel format saves the data entry time of a Maintenance Engineer in SAP. Thereafter, the standard Plant Measurement Information System is used for analysis of created measurement documents.

Fig. 1 : Sample Measurement Documents for Oil Flash Point

SAP UserExit IMRC0001 is used to :

1. Define particular field contents in measuring points, counters and measurement documents
2. Define and trigger automated business processes
3. Update customer-specific tables

You have the following options for automating business processes with the customer exit IMRC0001:

(a) Condition-Based Maintenance (via Notifications/ Orders)

(b) Scheduling Maintenance Plans

In Customizing for Measuring Points, Counters and Measurement Documents, you can configure the settings so that the system issues a warning or an error message in the event of the measurement exceeding the measurement range.

TPDDL has configured the customizing so that a preventive maintenance notification is triggered when measurement readings exceed a particular threshold value. In addition to the measurement reading,the valuation code which is a standardized code for evaluating the measurement reading is also specified. For example, measurement point for Bushing Temperature of a Transformer is 60 degrees Celsius with valuation code 0010 (which means Temperature OK)while a measurement reading 80 degrees Celsius with the valuation code 0020 (which means) "Hotspot-HT Bushing" or 0030 symbolizing "Hotspot-LT Bushing" . In certain cases, it is sufficient to specify a valuation code (for example inputs from Ultrasonic Inspection it is recorded as follows, 0010"Corona Suspected", 0020 "Tracking Suspected", 0030 "Arching Suspected" and 0040 "Ultrasonic Scan OK". In the case of certain predefined valuation codes, the system automatically triggers a preventive maintenance notification that contains the text of the valuation code as the problem description.

The coding code is used to provide the linkage for condition based maintenance notifications triggered from the creation of maintenance documents against measuring points. The Maintenance Engineer can further adopt these notifications to plan, schedule and execute maintenance tasks to enhance the life of the electrical asset and bring it to the desired target state. Figure-2 shows the structure of a sample notification created against a measuring point violation.

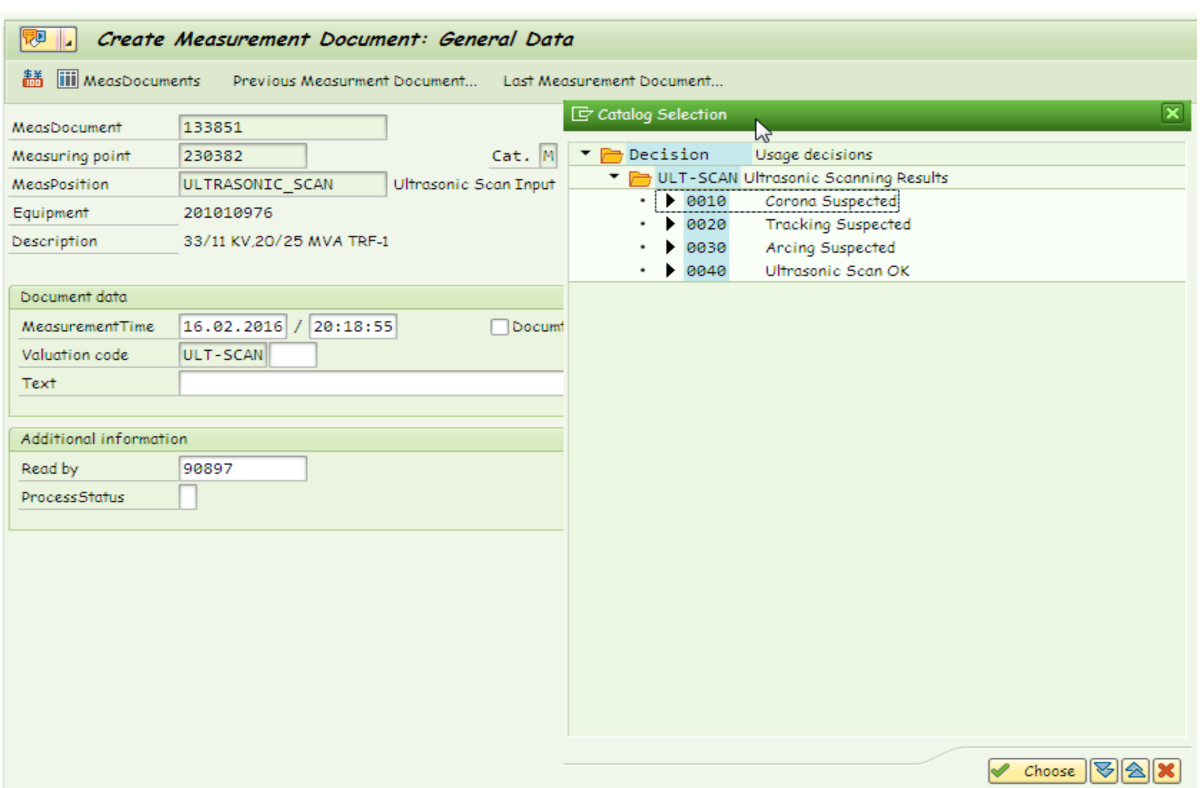


Fig. 2 : Sample Measuring Point for Ultrasonic Scan

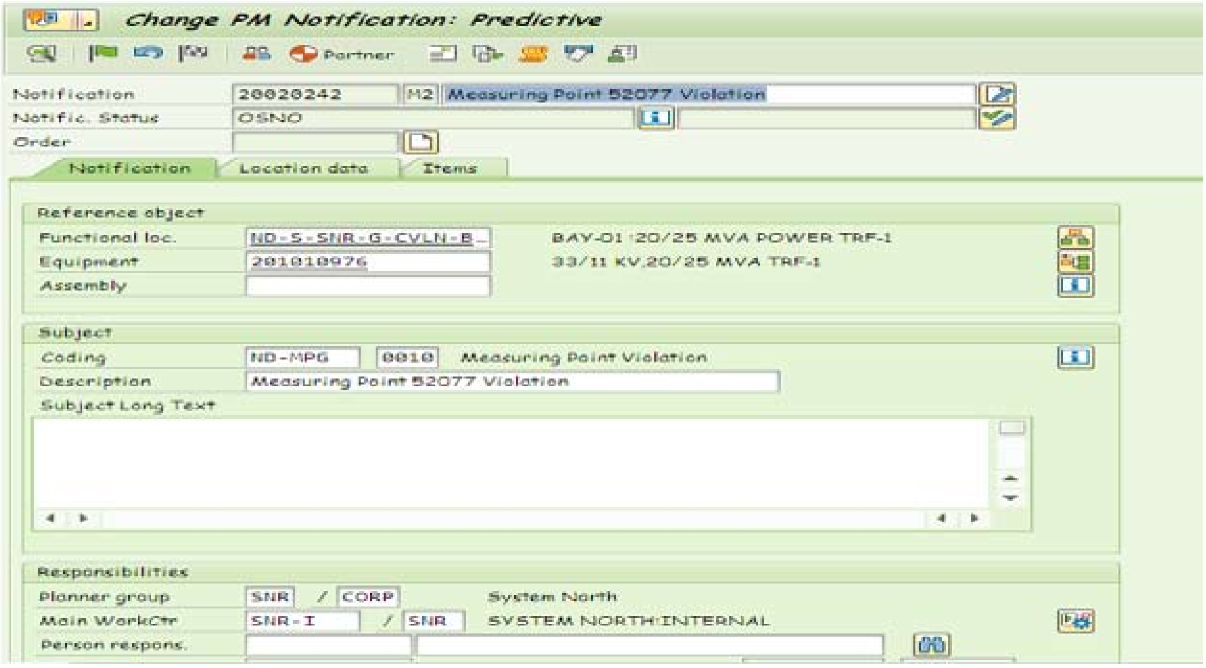


Fig. 3 : Predictive Maintenance Notification for CBM

3. FURTURISTIC APPROACH:RISK BASED MAINTENANCE

Maintenance Philosophy and planning is critical component of utility asset management and has direct impact on Reliability, Operational Expenditures, Inventory Planning vis-à-vis a replacement plan for ageing asset. Risk Based Maintenance Plan for Sub-Transmission & Distribution asset involves risk segmentation of critical asset based on failure probability and impact of failure. In simplistic terms, high risk assets will have shorter time frame between two maintenance cycles while low risk asset will have longer timeframe between two maintenance cycles. Overall Risk Based Maintenance plan and schedules will balance out Over & Under maintenance issue and result in optimized maintenance framework.

3.1 Potential Benefits

Following are potential benefits associated with Risk Based Maintenance:

1. Reduction in Planned Shutdown and associated loss of un-served energy.
2. Reduction in Operational Expense from optimized manpower cost and lesser equipment failures.
3. Improvement in system reliability.
4. Material requirement for maintenance activities.
5. CAPEX planning.
6. Scheduling of Condition Monitoring like DGA, Ultrasonic, Thermal Imaging, and Physical Inspection cycle can be customized and scheduled based on risk categorization of assets (Power Transformer, Switchgear, and Sub-Transmission Lines).

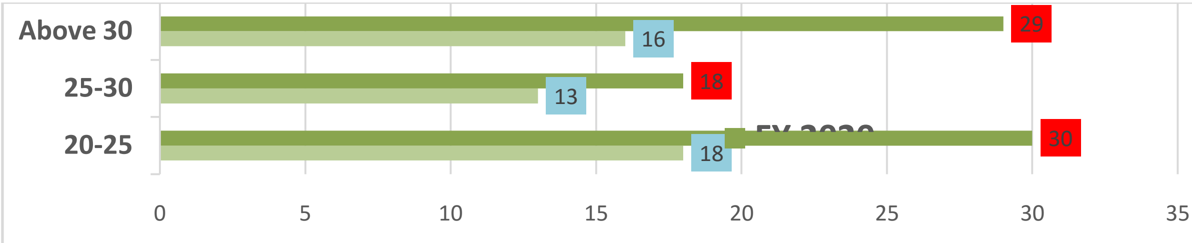
3.2 Trigger

Following are key triggers which corroborates need to adopt Risk based Maintenance framework at TPDDL.

1. Fixed Preventive Maintenance Schedule: In as-is framework, maintenance schedule of Power Transformer, Line Bays, 66/33/11 kV Switchgear is 2 years irrespective of asset health parameters like DGA result, Inter Facial Tension, Furan, Degree of Polymerization, Tan Delta etc. and doesn't take into account result of Ultrasonic, Thermal, fault interruptions, loading and ageing factors.
2. Fleet of Ageing Assets
3. Regulatory Environment.
4. Global Operational Experiences
5. Manpower Optimization
6. Data Analysis and Outcomes

3.3 Risk Index for Power Transformer

TPDDL has 175 power transformers, ranging from 10 MVA to 50 MVA in service supplying more than 1.4 million customers.The Power Transformer being the most crucial and capital intensive asset for a T&D Utility, has been selected for a pilot deployment of Risk Based Maintenance Strategy. The following section depicts the parameterization of the Risk Index for Power Transformers.



	20-25	25-30	Above 30
FY 2020	30	18	29
FY 2015	18	13	16

Fig. 4 : Power Transformer Age Analysis

Risk is a function of probability of failure and the impact of the failure.

Inputs for determining the "Probability of Failure" are: -

(1) Oil Parameters

  (a) DGA (presence of gases e.g.CH_4, C_2H_6, C_2H_2, C_2H_4, CO, CO_2)

  (b) BDV (Breakdown strength of Oil in Transformer Main Tank& OLTC)

  (c) Acidity

  (d) Water Content

  (e) Inter Facial Tension

(2) Paper Parameters

  (a) Furan Analysis

  (b) Degree of Polymerization (DP)

(3) Electrical Parameters

  (a) Tan Delta (Bushing)

  (b) Tan Delta (Transformer Main Tank)

  (c) Loading of the Transformer

(4) Condition Based Inputs

  (a) Infrared Scanning

  (b) Ultrasonic Scanning

(5) General Parameters

  (a) Age

Inputs for determining the "Impact of Failure" are: -

(1) Energy Loss (MUs, loss resulting from subsequent Breakdowns, Load Shedding, Emergency Shutdowns)

(2) Revenue Loss (Rs., resulting from consumer supply disruption)

As a prerequisitefor allocation of weightages to all the above mentioned parameters under Probability of Failure the linkage of the critical asset conditions to the internal health of the asset must be known, so as to trigger certain necessary maintenance tasks to improve the asset condition.

For allocation of weightages involving Impact of Failure, which depends on the MUs and revenue lost, past historical data for Breakdowns, Load Shedding, Emergency Shutdowns & Planned Shutdown has to be referred. Table 4, depicts the Risk Index categorization matrix for the implementing RBM for power transformers in a Transmission and Distribution Utility.

Table 4 : Sample Risk Index Categorization Matrix for Power Transformers

Maintenance Schedule as per RBM	Risk Category	Risk Index = Probability of Failure X Impact of Failure
1 Year	Category A	Risk Index ∊ [10,8)
2 Year	Category B	Risk Index ∊ [8,6)
3 Year	Category C	Risk Index ∊ [6,4)
4 Year	Category D	Risk Index ∊ [4,0)

The Risk Categorization will now be driving the SAP maintenance plans and not time based scheduling. The Risk index can be reviewed on a regular basis say quarterly or annually depending on one's specific requirements. The maintenance plans are prioritized based on the Risk Index calculated above. The maintenance plan priority is used to reflect the Risk Index categorization which will further drive the maintenance scheduling of the asset to be maintained, thus achieving ERP integrated Reliability Based Maintenance Planning.

4. CONCLUSION

The RBM strategy drawn out for power transformers from the Risk Index calculation and its subsequent categorization will result in

- Lesser number of time based scheduled maintenance outages, lesser supply interruptions for the customer and lesser MUs lost – Right Maintenance at the Right Time
- Focused maintenance leading to reduction in equipment failure, saving in OPEX and manpower optimization.
- Better inventory planning for spares and CAPEX planning for asset replacement

The RBM strategy is being further planned for all the T&D assets in the network i.e. Overhead Lines, Underground Cables, Switchgears, Isolator, Current Transformers, Potential Transformers, Distribution Transformers, Ring Main Units, Lightening Arrestors, and Capacitor Banks.

BIBLIOGRAPHY

1. TPDDL-o-Pedia - IMS Documents - Maintenance Planning Group
   (a) MPG-P-01_Maintenance Management
   (b) MPG-P-04_Power Transformer Management
2. Plant Maintenance with ERP: PracticalGuide 3/E2014, SAP Press, Karl Liebstückel.
3. PLM310Preventive Maintenance and Service, Version 2005.
4. Configuring ERPPlant Maintenance 1/E 2014, SAP Press, Karl Liebstückel.

SAVE ONE UNIT A DAY
KEEP POWER CUT AWAY

OPERATION AND DYNAMICS OF VSC-HVDC TRANSMISSION SYSTEM

Tirupathi Reddy, Sanjeev Shrivastava, Aruna Gulati and Renuka Gera

Bharat Heavy Electricals Limited

ABSTRACT

Indian Power System is growing with a rapid pace. In recent years, there has been huge planning for development and deployment of renewable energy resources to meet the ever increasing electric power demand and to limit the use of fossil fuels. Wind generation poses grid integration challenge such as long distance under sea transmission and managing the variability of wind power variation on in the power grid. These challenges can be properly met by the use of VSC HVDC Transmission. VSC HVDC is rapidly growing due to selective advantages versus the conventional HVDC; independent control of active & reactive power and reliable operation with a weak (or) even passive system, including black start. This work deals with the modelling of Voltage Source Converter High Voltage Direct Current (VSC HVDC) systems for power system analysis. Proposed VSC HVDC model can be used for power flow and dynamic analysis. Control systems, DC circuit and converter transformers are part of the dynamic model. For demonstrating the ability of VSC HVDC in regulating and improving stability of power grid, simulation of Indian power system with VSC based HVDC is envisaged. From simulation, list of controls are discussed in detail for easy understanding.

***Keywords** : VSC HVDC- Dynamics –PWM - MMC*

1. INTRODUCTION

1.1 Background

Power is the most vital input for the growth of any economy. Therefore, it is considered as a core industry as it facilitates development across various sectors, such as manufacturing, agriculture, commercial, education, railways etc. to achieve economic growth. Energy needs of the country is growing at a very fast pace to meet high GDP growth rate. Present peak electricity demand of the country is 135GW which is expected to grow to about 200 GW & 283 GW by the end of 2016-17 (12^{th} plan) & 2021-22 (13^{th} plan) respectively as envisaged in the 18th EPS report of CEA. To meet growing demand and to reduce supply-demand gap, there is a need of large capacity addition through conventional as well as from renewable energy sources.

India is endowed with abundant renewable potential which presents an excellent solution to meet challenges like meeting long term energy requirements, attaining energy security along with affordability, addressing climate change concerns etc. government is also promoting development of renewable generation through an attractive mix of fiscal and financial incentives as well as conducive policy environment. MNRE has envisaged about 175 GW renewable capacity through solar (100 GW) & Non solar (75 GW) by 2022[1].

The renewable energy resources are located at remote locations, e.g. offshore wind generation. The on-shore (receiving) converter station can be located close to the shore or further inland. The grid is sometimes rather weak (radial structure) along the coastline. The new HVDC technology based on Voltage Source Converter (VSC) is a feasible and attractive solution to interconnect these renewable energy sources to main Indian powergrid. It is also easy to bring the connection point to a major substation at some distance from the shore by means of DC cables. The main advantages to compared as the LCC alternative are smaller converter size, smaller filters, possibility to use XLPE cables, independent control of active and reactive powers, fast control response and black start capability and reliable operation in weak system.

1.2 VSC- HVDC Projects under Planning in India

A number of voltage source converter projects are under planning in India. The projects have been planned as VSC based HVDC technology due to feasibility issues[2]:

(1) *India –Srilanka -2 × 500 MW HVDC system*: the line shall transmit power from/to India to/from island of Srilanka which has a weak AC grid and further undersea cable shall be used for interconnection

(2) *Pugalur –Trichur -2000 MW HVDC System*: Trichur in Kerala has severe right of way issues, therefore a combination of Hybrid AC-DC line (existing as line

can be reconfigured to lay DC lines) and underground cable (XLPE cable) shall be a part of the transmission system.

(3) As per the Desert Power India -2050 report, power from solar parks, identified in the region of Rann of Kutch, Thar, Laddakh and Lahul & Spiti. The transmission system planned to evacuate this bulk solar power shall also comprise of approximately eighteen nos. (18) of VSC HVDC Links

1.3 Power Transmission by Cable/Transmission Line

Undersea cable is used for power evacuation from offshore renewable (or) power transmission between two islands. Further if the power transmission link is onshore but right of way is a limitation such as urban areas, then underground cable can also be selected for interconnection. In VSC HVDC scheme, the power reversal is done by reversing the direction of current without changing the polarity of voltage. Therefore XLPE Cables can be used for VSC HVDC System instead of Mass Impregnated (MI) cables used in LCC HVDC system.

As the XLPE cable is much cheaper than MI cables, the VSC technology is being preferred for the systems that uses long distance DC cable transmission. The highest voltage rating of the XLPE cable commonly used is 320 kV[2].

1.4 Outline

This paper gives an overall introduction of VSC HVDC technologies in section 2. Section 3 discusses about the modelling in PSSE software. Section 4 shows the results of simulation.

2. VSC -HVDC

The fundamental operation of a VSC-based HVDC converter implies the presence of a voltage source on the DC side. The voltage source maintains a prescribed voltage across its terminals regardless of the magnitude or polarity of the current flowing through the converter.

There are three types of VSCs used in HVDC applications, two-level, three-level and modular multilevel converters. The categorization is done based on the voltage levels produced in the AC output of the converter, before it is filtered. Configuration of VSC-HVDC system with two level converter is shown in Fig 1.

Main components of VSC HVDC Converter is as follows:

Transformers : Usually, the converters are connected to the AC system via transformers. The transformer has the main purpose of transforming the AC voltage to a level suitable to the converter.

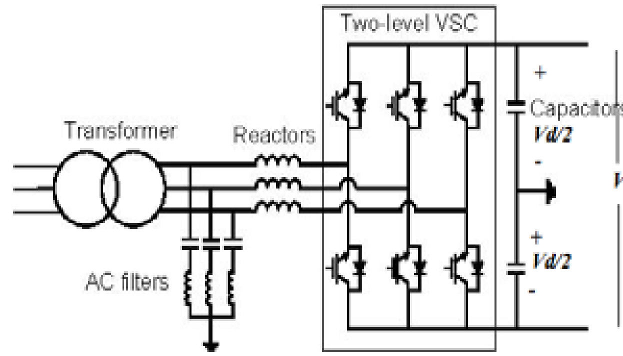


Fig. 1 : Typical configuration of VSC - HVDC with level converter[3]

Converter reactor : The AC side of the converter bridge is connected to a series reactor, the Converter Reactor, providing low-pass filtering of the PWM-switched converter voltage, to give the desired fundamental-frequency voltage, and providing impedance between the converter voltage and the AC filter bus voltage. The power flow between the AC and DC side is defined by the fundamental-frequency voltage across the reactor. The amplitude and phase of the voltage on the AC side of the converter reactor is determined by grid.

DC Capacitor : A capacitor bank on the DC side of the converter bridge provides energy storage and a low-inductance path for the turn-off current. The capacitor bank is connected between the positive and negative DC pole, and it is mid-point grounded to provide a ground reference for the converter.

AC filters : In addition to the series inductance of the reactor, AC filters can be used to eliminate the voltage harmonics entering into the AC system. A typical AC filter is a shunt connected high pass filter containing two or three earthed or unearthed filter branches tuned in the order of the PWM frequency[3].

Valve : Typically, many series-connected IGBTs are used for each semiconductor shown (see Fig 1) in order to deliver a higher blocking voltage capability for the converter, and therefore increase the dc bus voltage level of the HVDC system. It should be noted that an antiparallel diode is also needed in order to ensure the four-quadrant operation of the converter.

2.1 Two Level Converter

Two level converter is shown in Fig 1. The converter's two-level topology means that, by turning the valve transistors (IGBT) on and off, the AC connection point of the converter bridge is switched between +Vd/2 and –Vd/2. The valve switching method uses Pulse Width Modulation (PWM) as shown in Fig 2. The AC side of the converter bridge is connected to a series reactor, providing low-pass filtering of the PWM-switched converter voltage, to give the desired fundamental-frequency voltage (V_{Ao}), and providing an impedance between the converter voltage and the AC filter bus voltage.

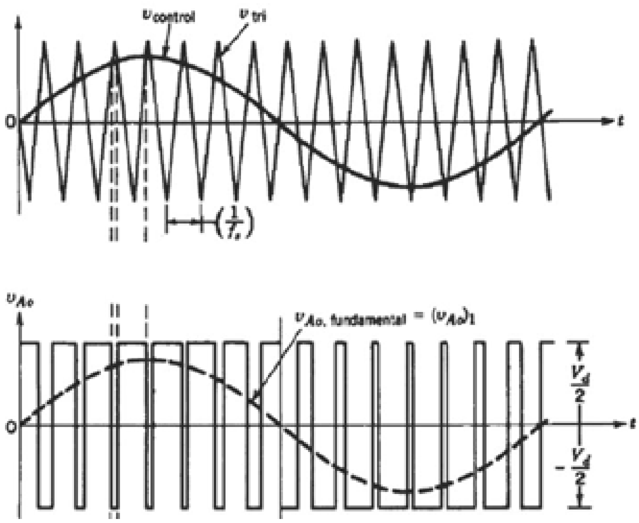


Fig. 2 : Upper: Principle of using PWM switching and Lower : Sinusoidal output voltage generated by PWM switching[4]

2.2 Modular Multilevel Converter

The MMC converter, or sometimes referred to as Cascaded Two-Level converter (CTL), is based on the same operating and control principles as the VSC, but each phase-arm consists of several two-level submodules, as can be seen in Fig 3. Compared to the other two types of converters, the difference is that there is not common capacitor of MMC connecting buses.

The operation principle of MMC is that each switch module consisting of two valves can be switched in three modes as described below:

- S1 is turned on and S2 is turned off, the capacitor is inserted into the circuit. The module contributes with voltage to the phase voltage.
- S1 is turned off and S2 is turned on, the capacitor is bypassed.
- S1 and S2 are both turned off; the module is blocked when the capacitor voltage is higher than outside voltage.

MMC is attractive to the HVDC application, in contrast to two- or three-level converters, because cascaded connection method permits each module theoretically only needs to switch on and off only once per period, which greatly reduces the switching losses. The output waveform can be closely sinusoidal when the number of modules is large enough (usually more than 100 modules of each leg for HVDC application). This results in a very small harmonic content of the voltage, and means that the ac filter is not necessary any more in the HVDC stations[3].

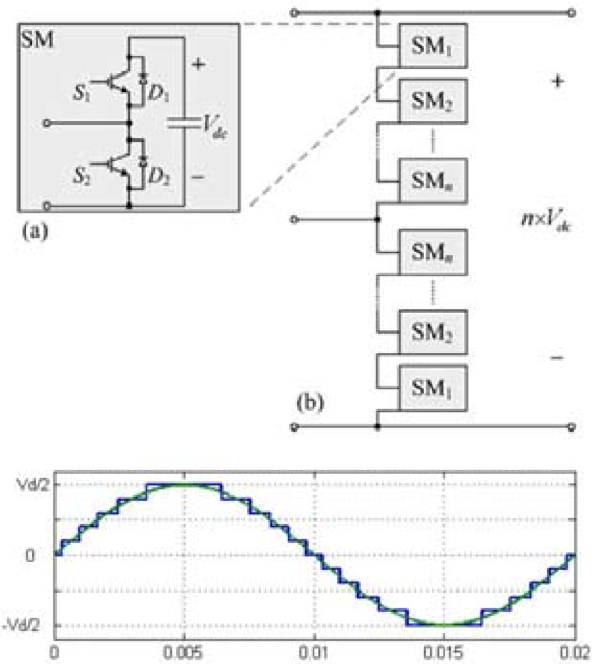


Fig 3 : Upper: modular multilevel converter topology, (a) Structure of one module (SM) and (b) Phase leg. Lower: AC Line voltage waveform[3]

3. VSC HVDC MODEL IN PSSE SOFTWARE

The VSCDCT, PSSE model is a time-averaged model and is therefore intended to be used in order to study the effect of the VSC-HVDC on the network on the electromechanical time frame. In general VSC-HVDC models can be either detailed or time-average. In detailed models, all the components of the VSC-HVDC line, such as all the semiconducting components, are modeled. Special electromagnetic transient software tools, such as PSCAD, ATP etc, are needed in order to perform simulations with these models.

These models can be used to study the behavior of different HVDC topologies, PWM techniques or high frequency component harmonics. On the other hand, time-average models do not model in such detail the HVDC components. Also there is no distinction made between different topologies or switching techniques. All phenomena related to the fundamental switching frequency can be studied adequately. The main principle of time-average models is that the HVDC line is represented as controllable three-phase voltage sources on the AC side and a controllable current source on the DC side. Time-averaged models can be used both by electromagnetic transient programs as well as power flow simulation tools, such as PSSE, SIMPOW etc.

Since the VSCDCT model is used for electro-mechanical time frame studies only the outer controllers are represented. The inner control loop and the DC side characteristics have a much faster response than the time scale of PSSE. Therefore the DC side dynamics are modeled in an approximate way while the inner current controller is not modeled at all. The active and reactive current components are assumed to take instantaneously their reference values created by the outer controllers.

The VSCDCT model consists of three modules, two of which represent the VSCs (VSCDYN) and the other the DC line (DCLINE) shown in Fig 4. The converter modules have modeled the outer controllers and enable the user to control AC voltage or reactive power, DC voltage or active power as well as to apply current limitation strategies. Additional features are active power ramping and converter blocking. Regarding active power control, the DC line module coordinates the power flow between the two converters and is therefore responsible for creating a power order for each converter and assigning it to each VSC module. In the case of a current limitation in the network of a converter, e.g a fault in the AC system close to one of the converters, an imbalance in the power flows of the converters will occur resulting in a change of the DC voltage. The active power reference of the VSC modules will be lowered appropriately, by the DC line module, in order to bring the active power exchange between the converters in balance once again. The DC line module also is responsible for taking into account the DC transmission losses. It creates the appropriate active power reference in order to compensate these losses. The losses are compensated in the DC voltage controlling converter. By changing the appropriate set point value in the VSCDCT model, active power ramping is performed by the DC line module[5].

3.1 Time Step

For the dynamic simulations with VSC HVDC, the time step has to be reduced compared to simulations of normal AC systems. A time step of 10 ms is normally used for AC systems in PSSE, while for simulation with VSC HVDC a time step of (¼ cycle) 5 ms (or) less will give a good representation of the dynamic response close to the VSC HVDC converters[5].

4. SIMULATION AND RESULTS

Bulk renewable energy resources are located at remote locations. VSC based HVDC transmission technology is required for interconnection of these renewable resources to Indian powergrid. To demonstrate the key features of VSC HVDC, typical 320 kV 500 MW VSC HVDC from Pugalur to Trichur is modelled for study and its parameters are given in Table 1.

Table 1 : VSC HVDC Parameters

Description	Value
Power	500 MW
DC Voltage	320 kV
DC Line	250 km
DC line resistance	2.02
AC Series reactor	0.17 pu on Converter MVA rating

PSSE software is used for simulation and prepared Single Line Diagrams (SLD) of VSC HVDC area shown in Fig. 5, where VSC HVDC is connected between sending PUGALUR4 (54413) bus and receiving NTRICUR (534011) bus. Power flow in the HVDC link is 500 MW measured at sending end.

Normal control philosophy is, sending converter is in DC voltage control mode, while the receiving converter is in

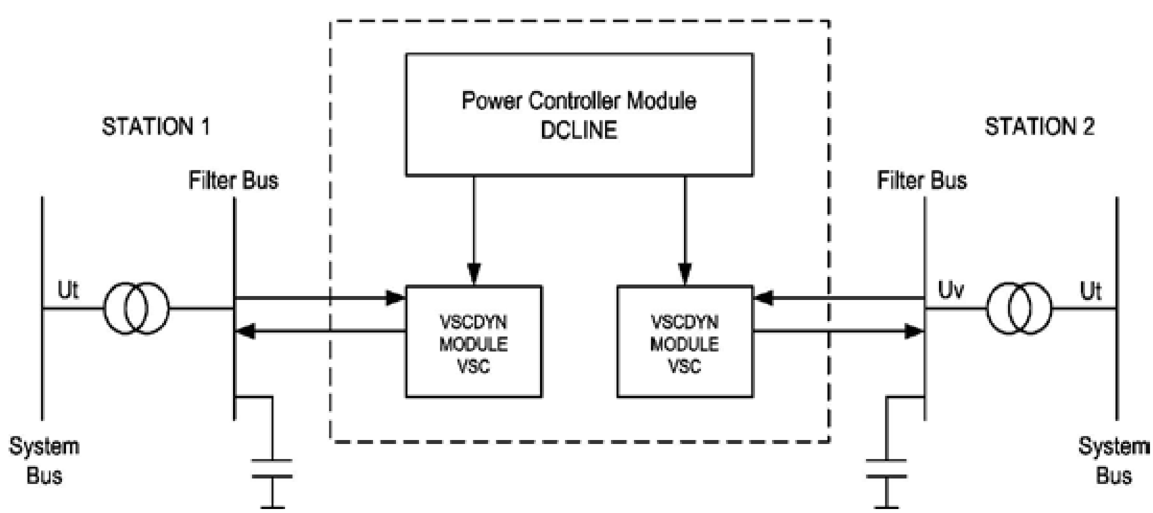


Fig. 4 : VSCDCT PSSE Model[5]

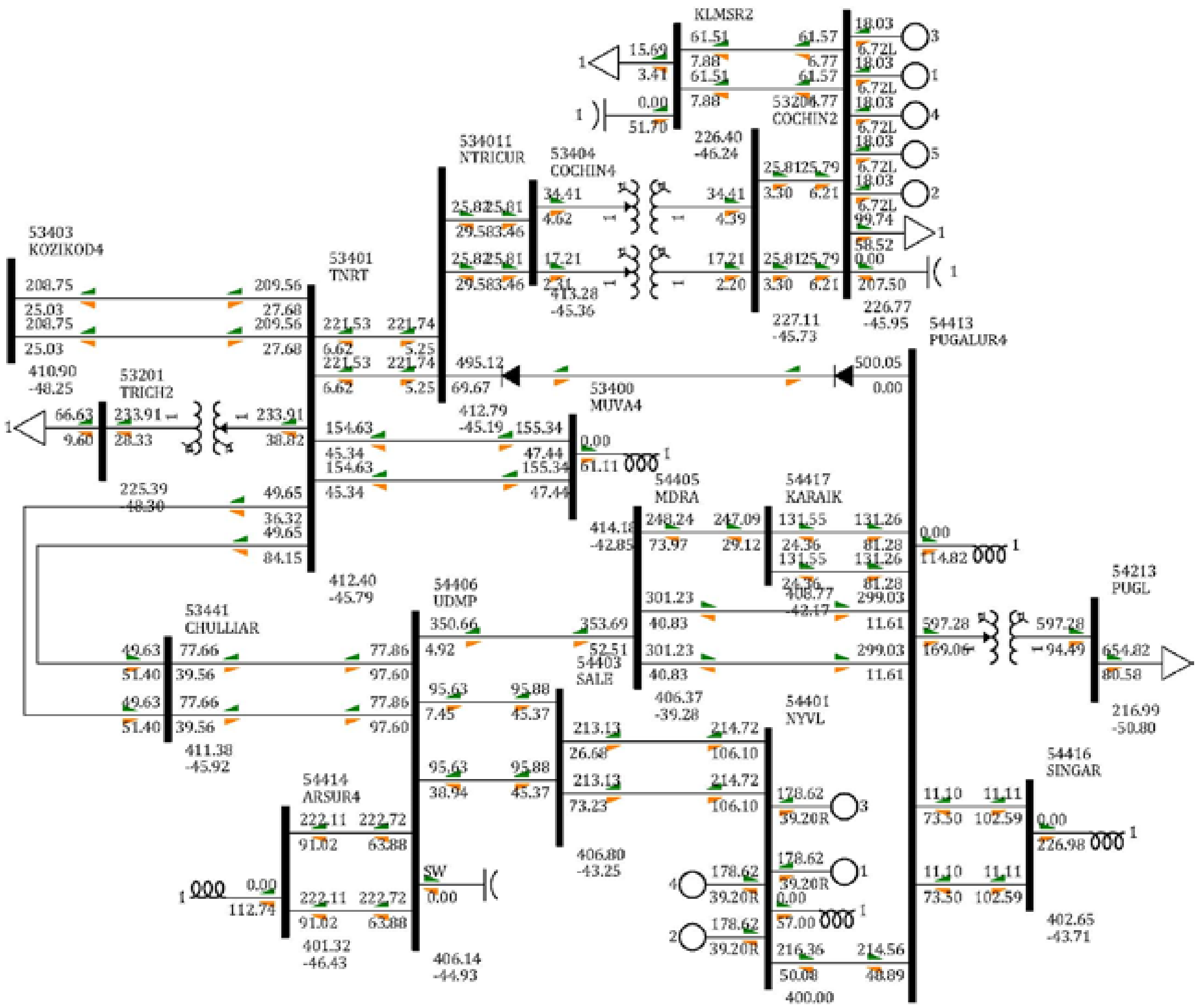


Fig. 5 : Single line diagram of indian power system around the VSC HVDC link

active power control mode. AC side is AC Voltage control mode on both the converters i.e. Converters are set to control the voltage of their respective filter buses.

In a traditional HVDC system, a communication link between the two converter stations is needed in order to control the power flow. The voltage is measured in one end, and the DC voltage is controlled in the other end so that the voltage difference divided by the DC-line or cable resistance equals the set point of the DC-current. A VSC HVDC system does not require any communication between the two converters. The converters communicate through the measured DC voltage at each end.

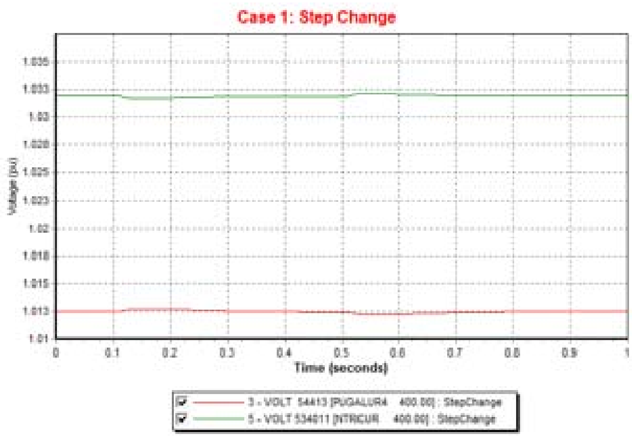
(1) Case 1 Step change in DC power flow :

DC Power shown in below Plot 1, is in pu on 100 MVA system base. A step change is applied at time = 0.1 sec from 500 MW to 400 MW and at time = 0.5 sec from 400 MW to 500 MW. Final value is reached in 0.2 sec, which is fast and final value is reached without any overshoot.

Plot 2 shows the converter bus voltage response for step change in DC power reference input.

Since VSC HVDC has capability of independent control of active power and reactive power control, converter voltages are not much effected by step change in DC power.

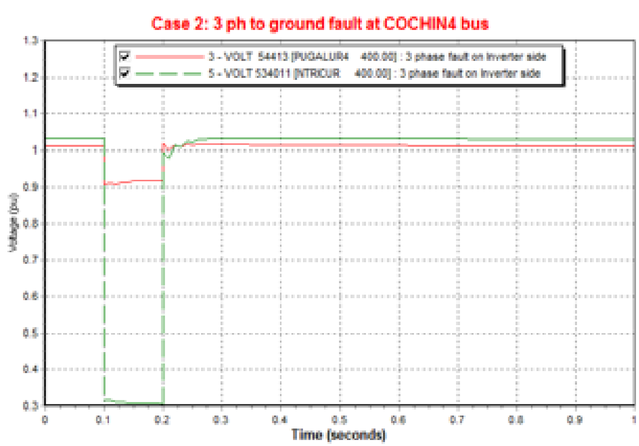
Plot 1 : DC Power response for step change in DC power reference input



Plot 2 : Converter bus voltage response for step change in DC power reference input

(2) Case 2, three phase to ground fault on inverter side bus (COCHIN4) :

3 phase to ground fault is applied at time = 0.1 sec. on COCHIN4 (53404) bus, which is one bus level away from converter bus. Fault duration is 100 msec and voltage response is shown in below Plot 3.

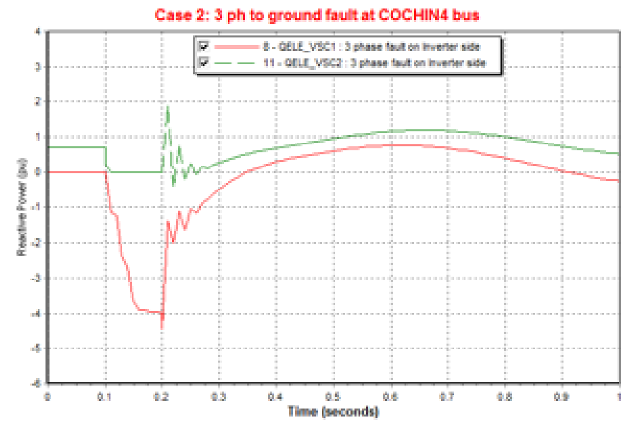


Plot 3 : Voltage response of converter buses for 3 phase to ground fault COCHIN4 bus

Since the fault is created near to inverter bus, inverter bus voltage is dropped to almost 0.3 pu, where as rectifier bus voltage is dropped to approx. 0.9 pu. Rectifier and inverter buses are interconnected through parallel AC transmission lines, fault has propagated through the parallel AC lines instead of through DC Transmission line could be observed from the plot.

When the HVDC is working in AC voltage control the link provides reactive power in order to support the voltage at their filter bus. Plot 4 shows the response of reactive power fed to bus for above case.

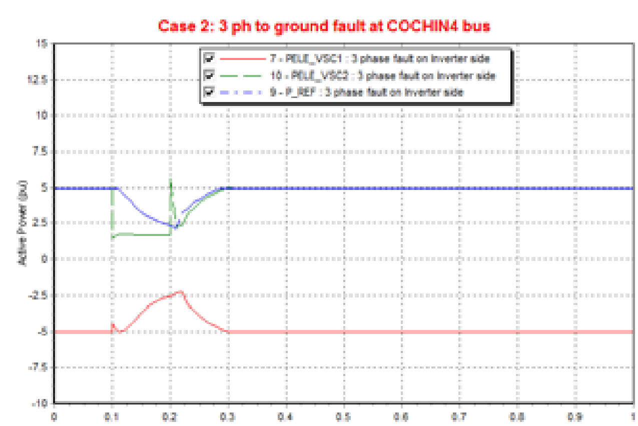
QELE_VSC1 and QELE_VSC2 are reactive power (pu on 100 MVA base) fed into respective buses of converters. By improving the AC system voltages through reactive power injection during a fault, the impact of a fault on the system's dynamic response becomes less severe.



Plot 4. Reactive power response for 3 phase to ground fault at COCHIN4 bus

Plot 4 : Reactive power response for 3 phase to ground fault at COCHIN4 bus

Plot 5 shows the active power response and DC power response for 3 phase to ground fault at COCHIN4 bus. When the fault occurs on inverter side bus, the DC voltage will increase immediately because of the power imbalance between the two converters. The power fed into the DC system from the sending converter is quickly reduced as a response to this in order to reduce the DC voltage. This is how the HVDC control is possible without the telecommunication between converters. PELE_VSC1 and PELE_VSC2 are active power (pu on 100 MVA base) fed into respective buses of converters and P_REF is DC power flow in pu on 100 MVA base. The results show that the HVDC systems stabilize without problems after the fault clearance and are smoothly damped in a short time. The HVDC link has shown a fast recovery response to reach again pre-contingency conditions.



Plot 5. Active power response for 3 phase to ground fault at COCHIN4 bus

Plot 5 : Active power response for 3 phase to ground fault at COCHIN4 bus

5. CONCLUSION

- The paper has discussed the accelerated growth of Indian power sector and the importance of VSC - HVDC in growing Indian power system. An overview of state of art of VSC HVDC technology is introduced. The VSC HVDC converters have black start capability. In order to interconnect the offshore renewable energy resources to Indian powergrid, VSC HVDC is the feasible solution.
- Model for a 320 kV 500 MW VSC HVDC is developed in PSSE software
- The control capability of VSC HVDC is demonstrated under two common disturbances
- From simulation results, it is clear that VSC HVDC have excellent performance at disturbances in the connecting AC networks. The system recovers fully very fast after faults.

BIBLIOGRAPHY

1. I.S. Jha, Subir Sen, Kashish Bhanbhani, Sandeep Kumawat; "Integration of large scale renewables – An indian perspective", GridTech 2015, New Delhi, India
2. Ebin Cherian Mathew, Khirad Dhabhar, Vishwajeet Singh, M.S.Rao, M.M.Goswami, Oommen Chandy;" Planning of a VSC HVDC System –Utilities' Perspective", GridTech 2015, New Delhi, India
3. Feng Wang, Lina bertling, Tuan le, Anders Mannikoff, Anders Bergman; "An Overview Introduction of VSC-HVDC State-of-art and Potential Applications in electric power systems", CIGRE BOLOGNA 2011
4. Mohan, N., Undeland, T. M., Robbins W. P. (2003), Power electronics – Converters, Applications and Design, John Wiley & Sons, Inc.
5. PSSE 33.5 User manual

Deploying Progressive Smart Meters with Industrial IoT solution

Connect To The Smart Grid Today

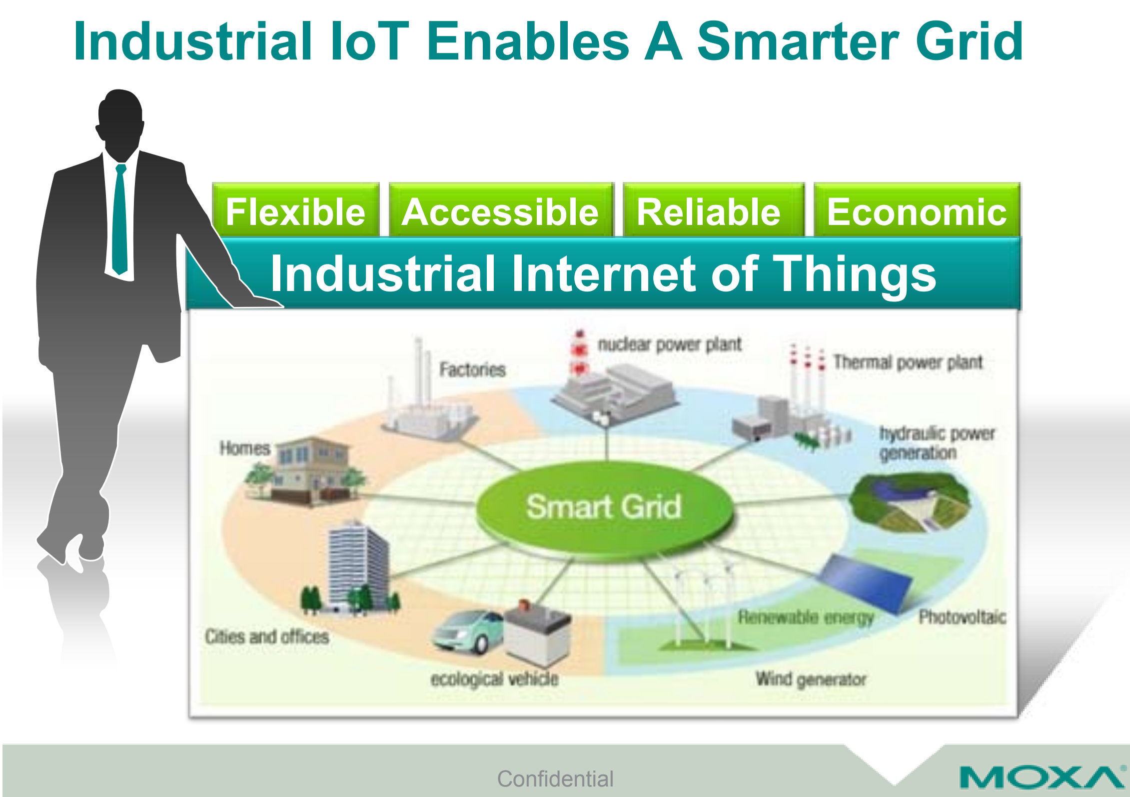
Ming Yu
Manager
25th February, 2016

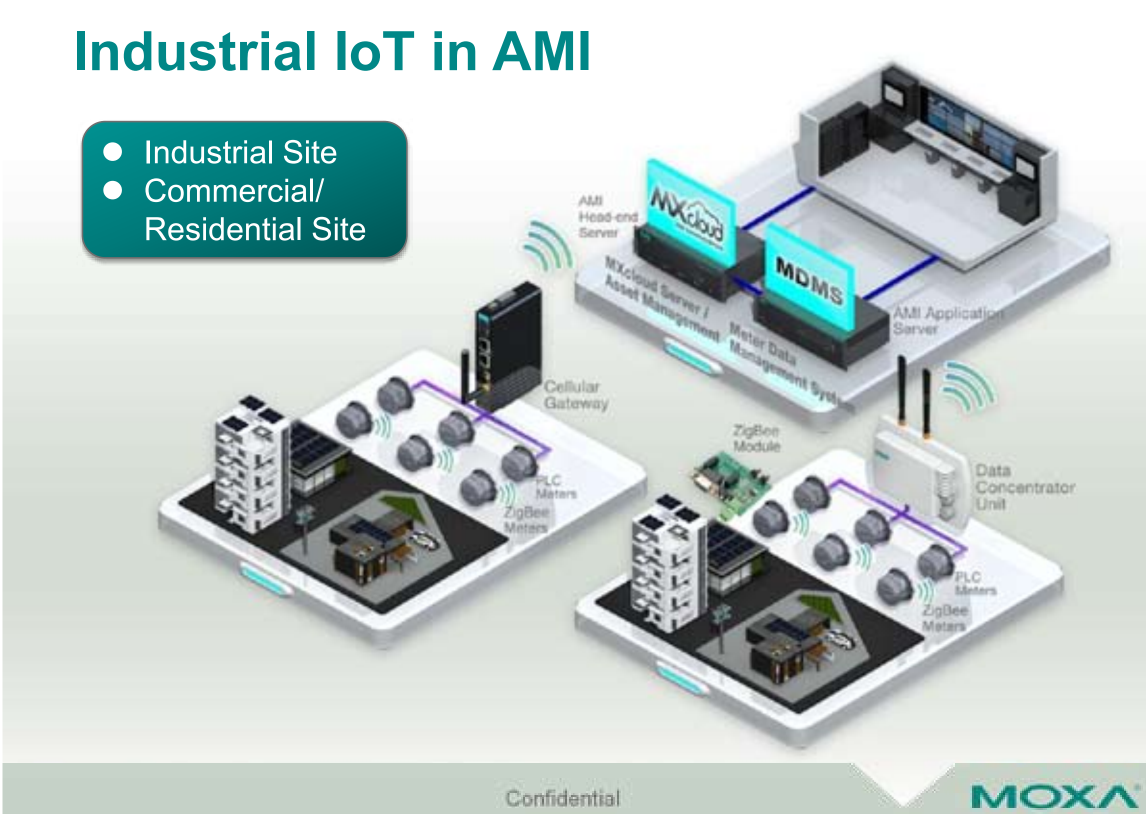
MOXA
Reliable Networks ▲ Sincere Service

"Smart grid is often considered the first (and now largest) example of the Internet of Things (IoT)."

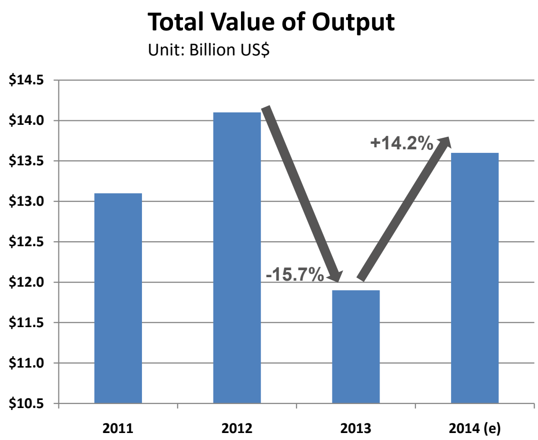
Jesse Berst
Founder & Chairman, Smart Cities Council

Confidential MOXA


Industrial IoT Enables A Smarter Grid
Flexible
Accessible
Reliable
Economic
Industrial Internet of Things
Factories
nuclear power plant
Thermal power plant
Homes
hydraulic power generation
Smart Grid
Cities and offices
Renewable energy
Photovoltaic
ecological vehicle
Wind generator
Confidential
MOXA


Industrial IoT in AMI
Industrial Site
Commercial/ Residential Site
AMI Head-end Server
MXcloud
MDMS
AMI Application Server
Cellular Gateway
ZigBee Module
Data Concentrator Unit
PLC Meters
ZigBee Meters
Confidential
MOXA

Global AMI Market Size



- *2013 Slower demand in **USA** and **China**.*
- *2014 Growth engine in **Spain**, **UK**, **France** and **RPGC** (Rural Power Grids Construction) in **China**.*
- *Total Value of Output include smart meters, communication infrastructure, MDMS and installation services…etc.*

Source: Taiwan Industrial Technology Research Institute (April, 2014)

5 Confidential MOXA

AMI Communication Technology Definition / Basic Knowledge

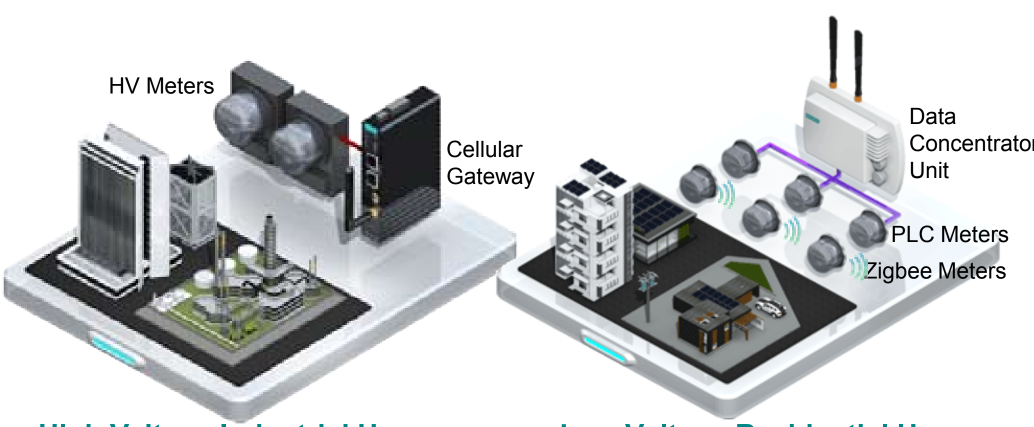
Confidential MOXA

AMI: Advanced Metering Infrastructure

	High Voltage	Low Voltage
User	Industrial / Commercial User	Residential User
Gateway	Metering Interface Units	Data Concentration Units
Deployment	Factory, School, Commercial Building	Residential House
Communication Tech	Public Cellular, Private Cellular	Mesh-RF, NPLC, BPLC, Zigbee

Confidential

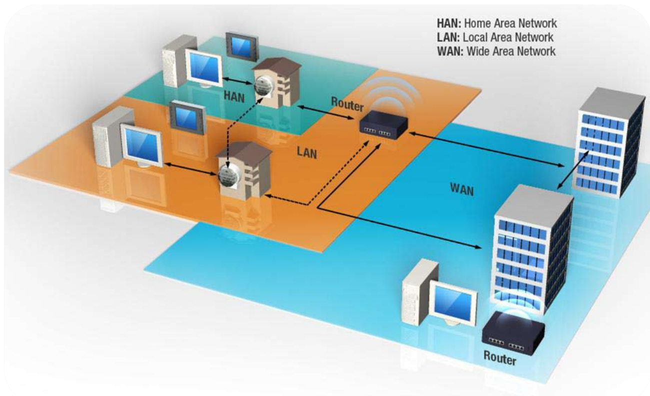
Industrial Site (High/Medium Voltage) v.s. Residential Site (Low Voltage) Structure



8

Confidential

Smart Meters

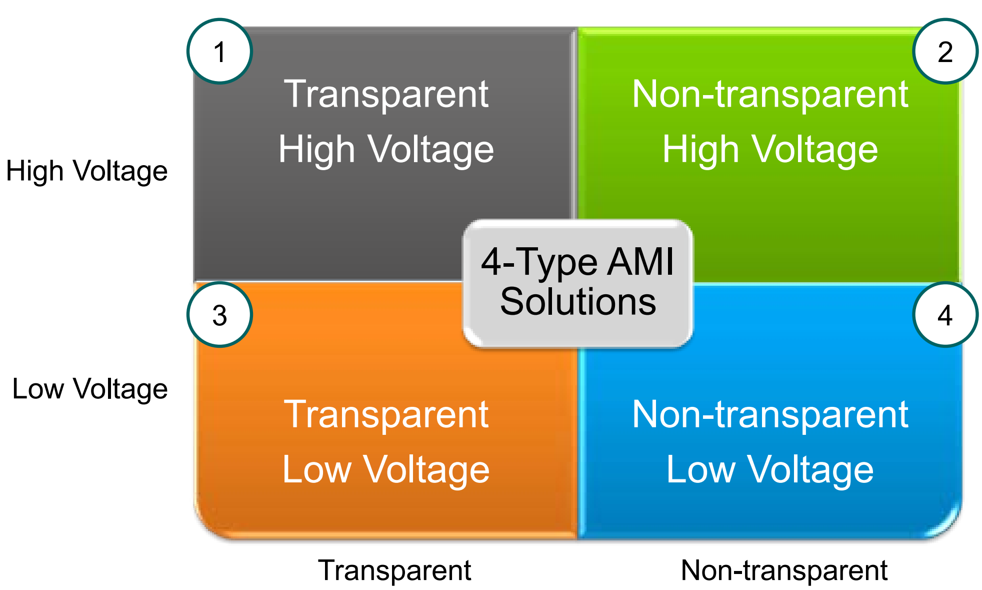


ANSI C12
(US Type)

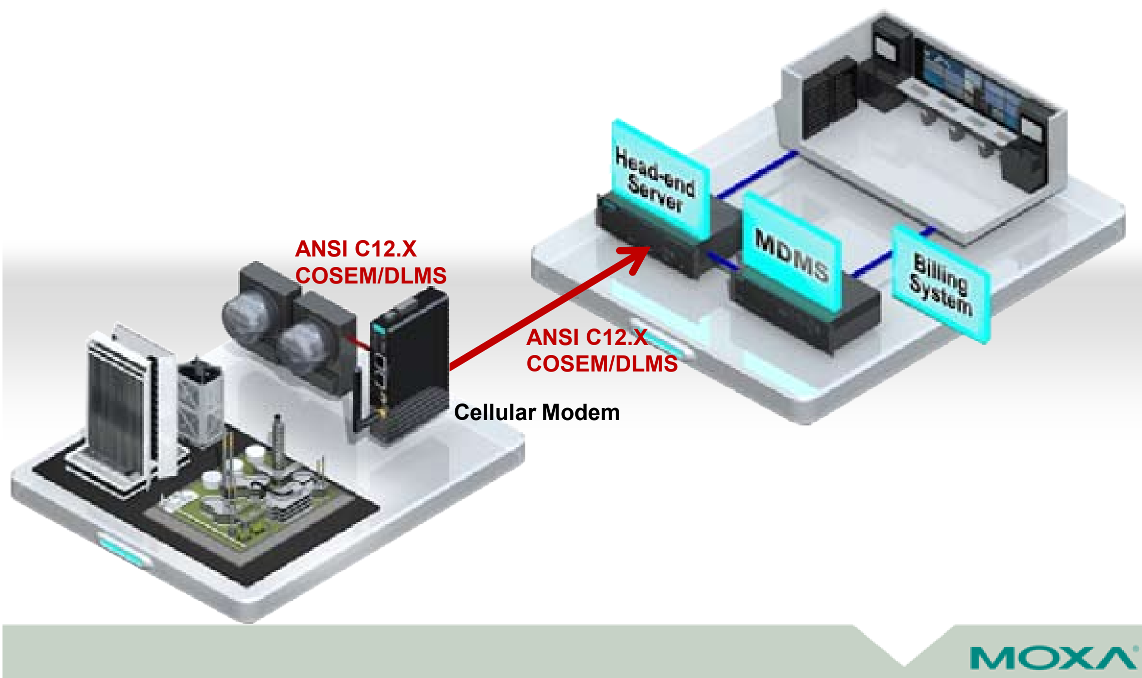
IEC 62056
(EU Type)

Smart Meter	Measurement	Data Recording	Two-way Communication	Quality Monitoring	Remote Power On/Off	Pre-pay Function	HAN (Home Area Network)
Advance	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Basic	Yes	Yes	Yes	Optional	Optional	Optional	No

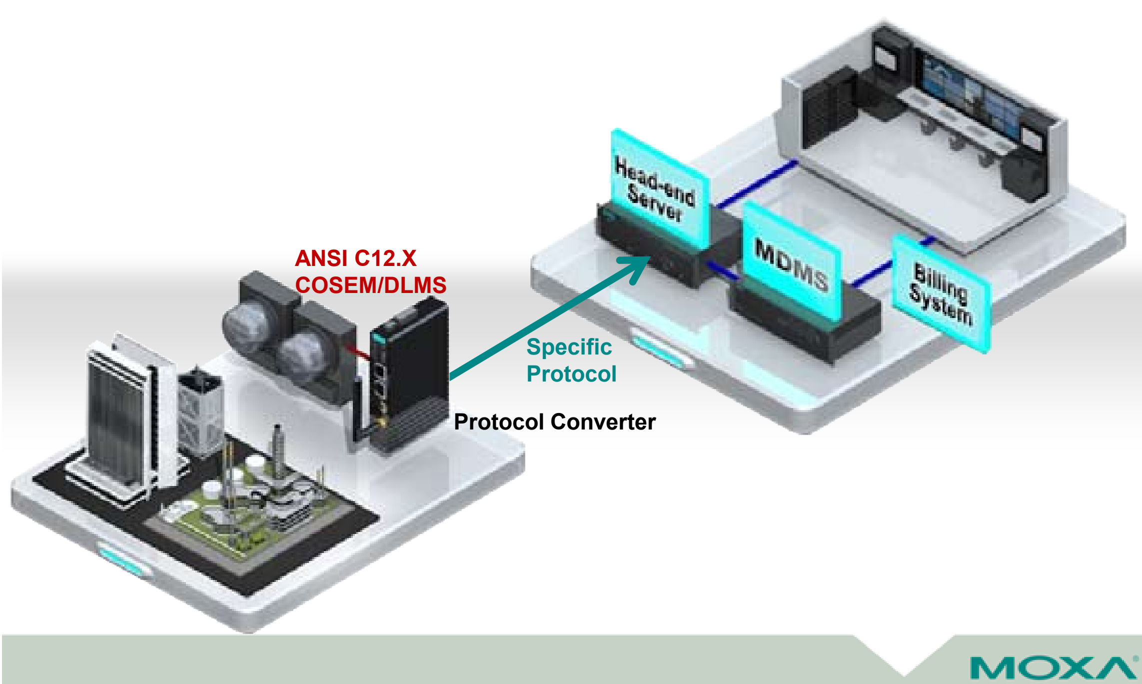
4-Type AMI Solutions



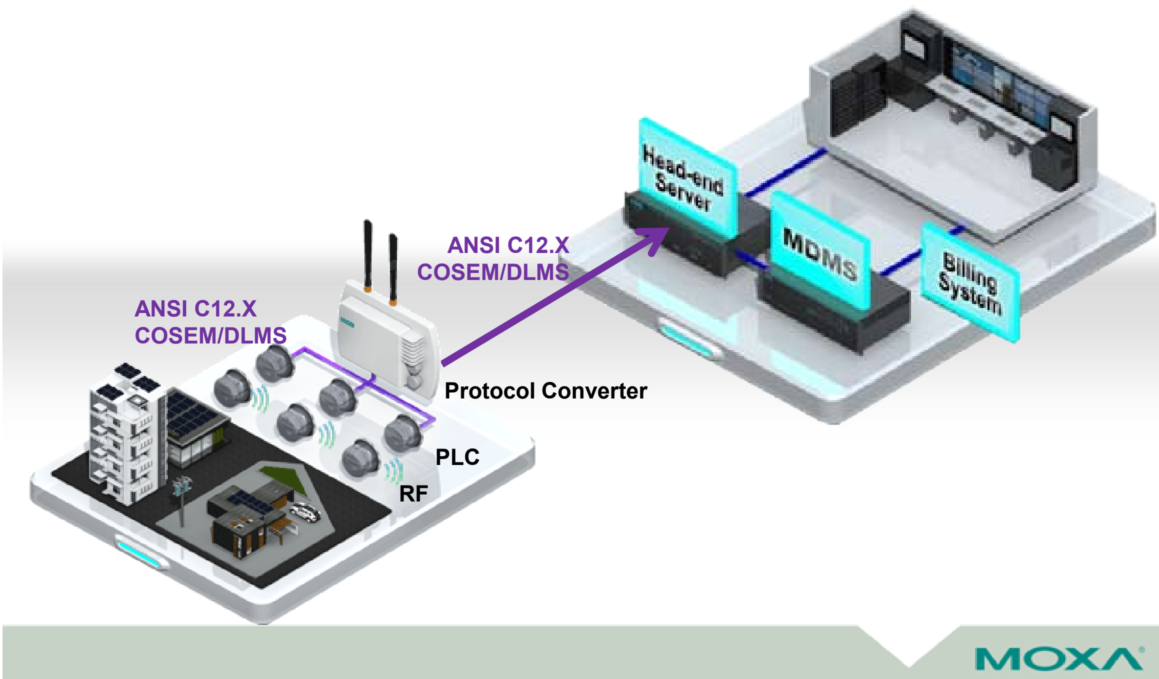
1 Transparent High Voltage



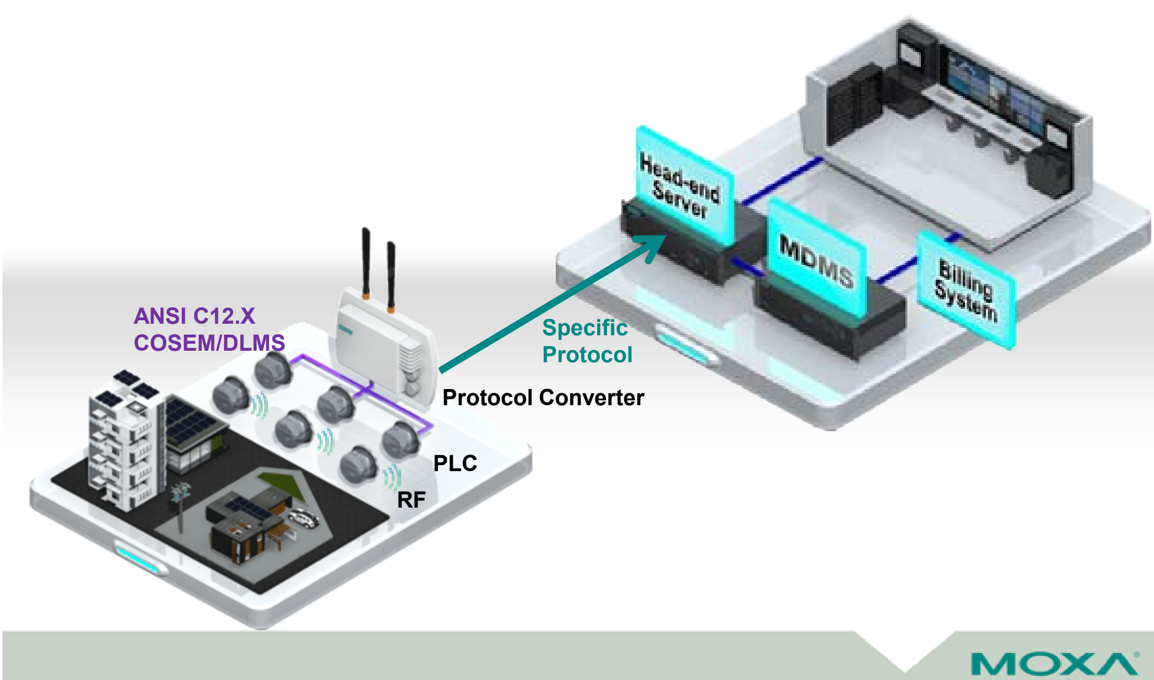
2 Non-transparent High Voltage



3 Transparent Low Voltage



4 Non-Transparent Low Voltage



Basic Knowledge

PLC Standards for Smart Grid / AMI

Standards	Background	Status
G3-PLC	Developed by **ERDF** (Electricite Reseau Distribution France), **Maxim** (chip) and **Sagecom** (communication)	1. Increase **data transmission** efficiency & decrease **interference**. **2. Japan Tokyo Electricity Company** – Home energy management system implement G3 PLC. **3. Ambient** (Smart Grid Communication) launched G3-PLC data concentrator and offer smart meter communication module.
PRIME	Developed by **Iberdora** (Spain)	**1. FCC**: **40-490kHz**. Max. data transmission value reach **1Mbps**. 2. Develop DCU to head-end station communication (WAN). 3. Develop **security spec.** for WAN transmission to MAC layer.
Meters & More	Developed by **Enel** (Italy) & **Endesa** (Spain)	1. Support **DLMS** (Device Language Message Specification) / **COSEM** (Companion Specification for Energy Metering
Echelon LonWorks	Used for **world-wide biggest** smart meter deployment in **Italy**.	**1. Integrate** transceivers, control nodes and software tool to speed up product development and service for **smart building, smart city and smart grid**.

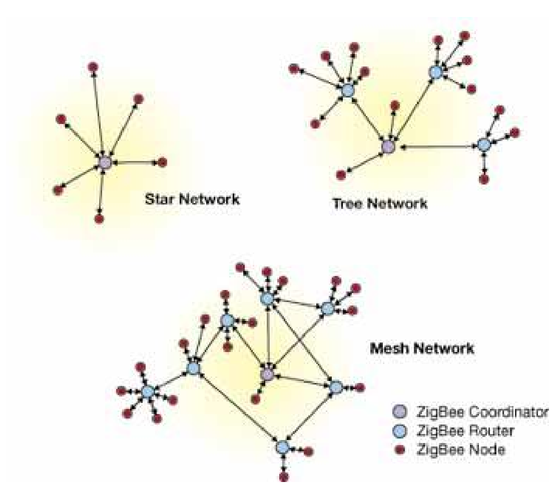
Source: ERDF, Iberdora, Enel & Endesa websites.

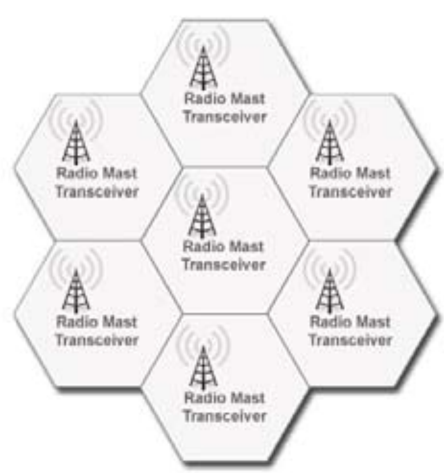
15 Confidential

Basic Knowledge

RF (Radio Frequency) & Cellular

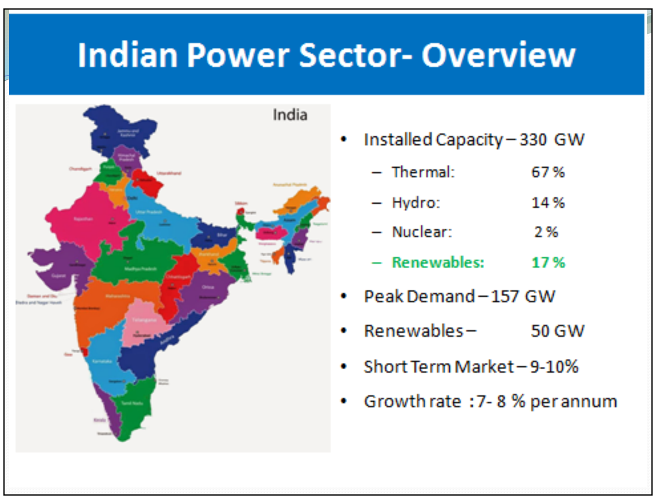
- **RF: Star, Tree & Mesh**
- **Cellular**





16 Confidential

CIGRE-INDIA


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


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


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


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

Chairman, AORC & Secretary, CIGRE India

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

Mr. V.K. Kanjlia
Secretary
CIGRE India

Mr. P.P. Wahi
Secretary
CIGRE AORC

Membership Growth

Category	2016		2017	
Collective 1	69X6	414	80X6	480
Collective 2	11X3	33	12X3	36
Individual	152	152	138	138
Young	24X0.5	12	26X0.5	13
Total				667
In process of Renewal				83
Total		611		750

Technical Committee – CIGRE India

Participation at international level

……..

Major activities of CIGRE India

I. Membership

II. Participation at international level

III. CIGRE National Level activities

Activities during CIGRE session 2016

- Mr. I.S. Jha, President CIGRE India & Member of Admn. Co. attended CIGRE Administrative Council at Paris.

- The Admini Council appreciating the efforts of India for making membership count to more than double invited to explain the best practices adopted by them.

Activities during CIGRE session 2016

- Participation in Meeting of all the 16 study committees by our Representatives at Paris
- Convener for Three (3) Working Groups in SCA1 (Rotating Machines) have been selected from India.
- Secretary for Preferential Subjects 3 of SC D2 for CIGRE Session 2018 has been selected from India.

Activities during CIGRE session 2016

Mr. I.S. Jha, President CIGRE India being honored in CIGRE AORC during Session at Paris

Activities during CIGRE session 2016

- Proposals inviting four (4) CIGRE Study Committee for holding their meetings in India in 2019, made by Mr. P.P. Wahi, have been approved:

➢SC A1 (Rotating Machine) - Sept.19

➢SC A2 (Transformers) - Nov. 19

➢SC B2 (Overhead Lines) - Nov 19

➢SC D1 (Materials) - Nov 19

Activities during CIGRE session 2016

Dr. Subir Sen taking over charge as Chairman of CIGRE AORC

Activities during CIGRE session 2016

- Delegation of more than 100 participants led by Shri I.S. Jha, President, CIGRE-India in last Paris session.
- 18 Technical Papers from India were presented in the session .
- M/s CTR and SCOPE from India participated in the exhibition at Paris.

Keynote presentation on Transformers was made by Mr. B.N. De Bhowmick, GM, POWEGRID, India in the last session on SCA2 at Paris

Dinner hosted by CIGRE India at Paris during 2016

Participation in CIGRE SC Meetings in 2017

Already attended by representative from India

- SC B2; C1; C2; C5 & C6 in May 2017 at Dublin

Planned to be attended

- A1 in Sept. 2017 at Vienna;
- A2; in Oct. 2017 at Poland
- A3; and B4 in Sept. 2017 at Canada
- B1 in Oct. 2017 at New Delhi
- B3 in Sept. 2017 at Brazil
- B5 in Sept. 2017 at New Zealand
- C3 in Sept. 2017 at Korea
- D2 in Sept. 2017 at Moscow

Meeting of CIGRE WG A2 49 in India in Feb. 2016

Mr. Rob Stephen being welcomed by CIGRE India at Conference on Smart Grid at New Delhi in March 2017

CIGRE JWG on System Tech. Performance / Protection (C4/B5.41) Meeting in Feb. 2017, at Bangalore (India)

Mr. R.P. Sasmal, Technical Chair, CIGRE-India welcoming Mr. Rob Stephen for Meeting of 16 CIGRE NSC Chairmen in March 2017 at New Delhi

Tutorials session by Dr. Konstantin, Ex-Chair SC B2 and Mr. C. Rajotte, Ex-Chair, SC A2 was organized by CIGRE India for young engineers at New Delhi in Feb. 2017

Mr. Mata Prasad founder President, CIGRE India greeting Mr. Rob Stephen at New Delhi

Mr. Rob Stephen discussing about activities of CIGRE-India during his Visit

Visit of Mr. Michal AUGONNET, Treasurer, CIGRE to CIGRE - India office in Sept. 2016

Visit of CIGRE President to Control Center of 122 unmanned Stations of POWERGRID at Manesar on 09/03/2017

CIGRE India National Level Activities

……………….

1. CIGRE Tutorials at Elecrama in **Feb. 2016.**
2. CIGRE AORC Conference at New Delhi in **Feb. 2016**
3. 5th National conference at New Delhi in **May 2017**
4. PRE-CIGRE CONFERENCE at New Delhi in **July 2016**
5. Conference on Electrical & Fire Safety at New Delhi in **Oct. 2016**
6. Conference on Condition Monitoring of Electrical Assets **Dec. 2016**
7. Tutorial on Transformer at New Delhi in **Feb 2017**
8. Sixth Intl. Conference on Large power Transformers in **Feb 2017**
9. 5th National conference on Design & O&M of EHV and UHV Transmission lines in **June 2017**.
10. Indian transformers Engineering Conclave (ITEC 2017) **July 2017**

28

Visit of CIGRE President to CBIP/CIGRE India Excellence Center in March 2017

CIGRE TUTORIALS conducted by five Study committee Chairmen of CIGRE DURING ELRCRAMA 2016 in Feb. 2016 at Bangalore, India

29


CIGRE AORC Conference in Feb. 2016 at New Delhi
Dr. Konstantin Chief Coordinator and Mr. R.P. Sasmal
being welcomed


Electrical and Fire Safety in
Power Industry
Cargill


Pre CIGRE Conference on 28-29 July 2016
SCOPE
Unique conference held every two years, attended by 300 participants


Tutorial Course
TRANSFORMERS
Cargill


Conference on
Condition Based Monitoring of Electrical Assets
Organised by
QUALITROL


SCOPE
PROMOTING EXCELLENCE

CIGRE SC Meeting Organized and Planned in India

CIGRE Meetings already organised

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

CIGRE Meeting being held

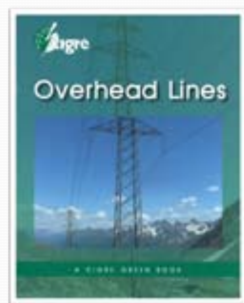
- CIGRE SC B1 on "HV Insulated Cables" – 9 -13 Oct. 2017 in New Delhi
- SC A1 Meeting & Intl. Conf. on Rotating Machines - 23 - 28 Sept. 2019 at New Delhi.
- Meeting of SC A2; SC B2 & SC D1and Joint Colloquium of Three Study Committee i.e. SC A2 (Transformers)/ B2 (Overhead Lines) / D1(Materials) – in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

Meetings Planned to be hosted in

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

Publication by CIGRE Paris

20 Copies of Green Books on Overhead Lines purchased by CIGRE India from CIGRE HQ for dissemination of Knowledge

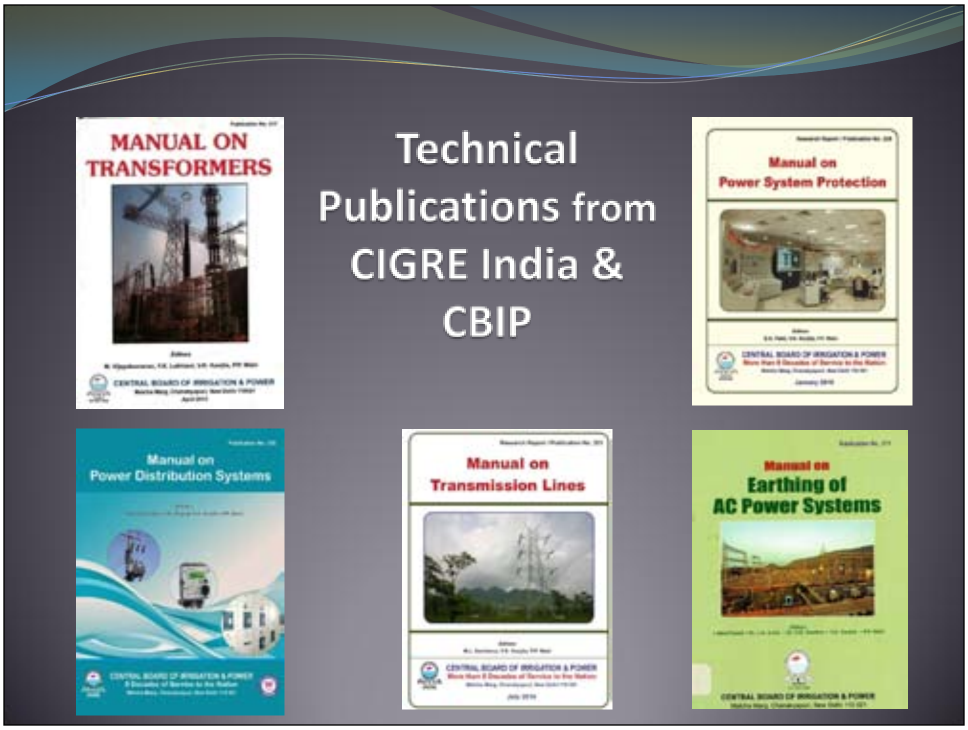


Plan for participation in CIGRE Session 2018

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

Publications by CIGRE India and CBIP

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


Technical Publications from CIGRE India & CBIP
MANUAL ON TRANSFORMERS
Manual on Power System Protection
Manual on Power Distribution Systems
Manual on Transmission Lines
Manual on Earthing of AC Power Systems


Technical Publications from CIGRE India & CBIP
Manual on EHV Substation Equipment Maintenance
MANUAL ON MAINTENANCE OF TRANSMISSION LINES
Manual on SUBSTATION LAYOUT
PROCEEDINGS

CIGRE MEMBERS FROM INDIA IN 2017

Institutional Members

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

Individual Members

S. No.	Name	Organisation
1	Amit Kumar	Antarriksh, INC
2	Abhay Kumar Agrawal	ABB India Ltd.
3	Tarun Kumar Garg	ABB India Ltd.
4	Palki Bapuji	ABB India Ltd.
5	Urmil Parikh	ABB India Ltd.
6	Sachin Srivastava	ABB Global Indst. & Services ltd.
7	Sreenivasa Rao Chava	APTRANSCO
8	Anil Kaplush	Angelique International Ltd.
9	Gopal Ji	Angelique International Ltd.
10	Arvind Gupta	Adani Power Ltd.
11	Bipin B. Shah	Adani Transmission Ltd.
12	Srimanta Kumar jana	Apar Industries Ltd.
13	Usa Savadamuthu	Anna University
14	Ramesh Dattaraya Suryavanshi	Alfa Consultant
15	Manoj Santani	BHEL
16	V.N. Jithin Sundar Sishtla	BHEL
17	Sanjeev Bhatia	Bechtel (I) Pvt. Ltd.
18	Venkata Chalapathi C V	Balfour Beatty Insfra. India Pvt.Ltd.
19	Rajaram Shinde	Cargill India Pvt. Ltd.
20	Rajesh Kumar	Consultant
21	Balasubramanian Krishnan S.	Consultant
22	Sanjay Patki	Consultant
23	Pramod Rao	Consultant
24	Mata Prasad	Consultant
25	Ravindra Vishnu Talegaonkar	CTR Manuf. Industries Ltd.
26	Vijaykumar Wakchaure	CTR Manuf. Industries Ltd.
27	Nageshwar Rao Burjupati	CPRI
28	Nitin Dhamale	Cee Dee Vaccum Equipment Pvt. Ltd.
29	V. K. Kanjila	CBIP
30	Vikrant Joshi	Crompton Greaves Ltd.
31	Sameer Gaikwad	Doble Engineering Pvt. Ltd.
32	Aditya Korde	Diagnostic Technologies India Pvt. Ltd.
33	Anil Kumar Jha	DVC
34	Ravi Kumar Puzhankara	DNV-KEMA
35	Madhuryya Prosad Chakravorty	Energy Infratech Pvt. Ltd.
36	Satish Chetwani	ERDA
37	Singaram Christian Johnson	Excel Engineering College
38	Anagha Dixit	EMCO Ltd.
39	Mary Mody	EMCO Ltd.
40	Rahul Banerjee	GDF Suez Energy Pvt. Ltd.
41	Jayesh Gandhi	GETCO
42	Asha M Agravatt	GETCO
43	Manishkumar K. Jani	GETCO
44	Yogesh Vishnu Joshi	GETCO
45	Bhadreshkumar B. Mehta	GETCO
46	Nikunjkumar Makwana	GETCO
47	Parind Munsif	GETCO

48	Dipakkumar Patel	GETCO
49	Rameshchandra P. Satani	GETCO
50	Ankur Shah	GETCO
51	Nilesh Sheth	GETCO
52	Bankim Pravinchandra Soni	GETCO
53	Praful K. Varsada	GETCO
54	Pankajbhai Suthar	GETCO
55	Bhadresh B. Chauhan	GETCO
56	Ashokkumar J. Chavda	GETCO
57	Rajesh Suri	GE T&D India Ltd.
58	Madhu Sudhan	GE T&D India Ltd.
59	Amit Kothari	GE T&D India Ltd.
60	Vijayakumaran Moorkath	GE T&D India Ltd.
61	Purshottam Kalky	GE T&D India Ltd.
62	Subhasis Jhampati	GE T&D India Ltd.
63	Sukhbir Kapoor	GE Grid
64	Firoz Ahmed	GE Grid Solution
65	Narendra Sharma	General Electric T&D India
66	Sanjib Mishra	General Electric
67	Udaya Kumar	IIS- Bangalore
68	Joy Thomas Meledath	IIS- Bangalore
69	Habib Chowdhary	J & K Power Development Department
70	Sunil Bhanot	KEC International ltd.
71	Sarveshkumar Virendrakumar	KEC International ltd.
72	E.V.RAO	KEC-RPG
73	Arvind Shrowty	KEI Industries Ltd.
74	Pervinder Singh Chowdhary	Kalpataru Power Trans. Ltd.
75	Nene Milind	Kalpataru Power Trans. Ltd.
76	Nitin Kumar Patel	Kalpataru Power Trans. Ltd.
77	Muthuraj Ramaswamy	Kanohar Electricals Ltd.
78	Rupesh Rajhans	Larsen & Toubro Ltd.
79	Puneet Sharma	Larsen & Toubro Ltd.
80	Aradhana Ray	Laxmi Associates
81	Monal Patel	Map Power LLP
82	Dipti Saxena	MNIT Jaipur
83	Udaybabu Ratanchand Shah	Mahati Industries Pvt. Ltd.
84	Dhananjay Kumar Chaturvedi	NTPC Ltd.

85	Narendra Nath Misra	NTPC-Former
86	Subhash Thakur	NTPC Ltd.
87	Bishnu Prasanna Nanda	NTPC Ltd.
88	Dr. Tukaram Moger	NIT-Karnataka
89	I. R. Rao	NIT-Karnataka
90	Venkaiah Chintham	NIT- Warangal
91	Subrata Karmakar	NIT- Rourkela
92	Jora Gonda	NIT- Karnataka
93	Sarasij Das	Organistion Indian Institute of Science
94	Satyajit Ganguly	ONGC Tripura Power Co. Ltd.
95	Pravinchandra Mehta	Persotech Solutions
96	Prakash Nayak	Pena Power Engg. & Automation (P) ltd.
97	Deepal Shah	PFISTERER
98	Pradeep Kumar Gangadharan	Protection Engg. & Research Laboratories
99	Chandan Kumar	POSOCO
100	K V S Baba	POSOCO
101	Manoj Kumar Agrawal	POSOCO
102	S.R. Narasimham	POSOCO
103	Vivek Pandey	POSOCO
104	Rajiv Kumar Porwal	POSOCO
105	Sushil Kumar Soonee	POSOCO
106	Samir Chandra Saxena	POSOCO
107	N. S. Sodha	Powergrid
108	Subir Sen	Powergrid
109	Rajendra Prasad Sasmal	Powergrid
110	Avinash Madhav Pavgi	Powergrid
111	Arun Kumar Mishra	Powergrid
112	Anantha Sarma Boppudi	Powergrid
113	Sunita Chohan	Powergrid
114	Seema Gupta	Powergrid
115	Rajesh Kumar	Powergrid
116	Barindra Narayan De Bhowmick	Powergrid
117	R.K. Tyagi	Powergird
118	I.S. Jha	Powergird
119	Manish Kumar Jha	Powergrid
120	Vinod Kumar Agrawal	Regen Powertech Pvt. Ltd.
121	Sushil Chaudhari	Raj Petro Specialities Pvt. Ltd.
122	Nalin Nanavati	Raj Petro Specialities Pvt. Ltd.

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

Young Members

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

INTERNATIONAL COUNCIL ON LARGE ELECTRIC SYSTEMS

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

MEMBERSHIP APPLICATION FORM – for the year 2017

Please fill in the column of the relevant MEMBER CATEGORY.

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

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

Membership fee in India in Rs. is as below :

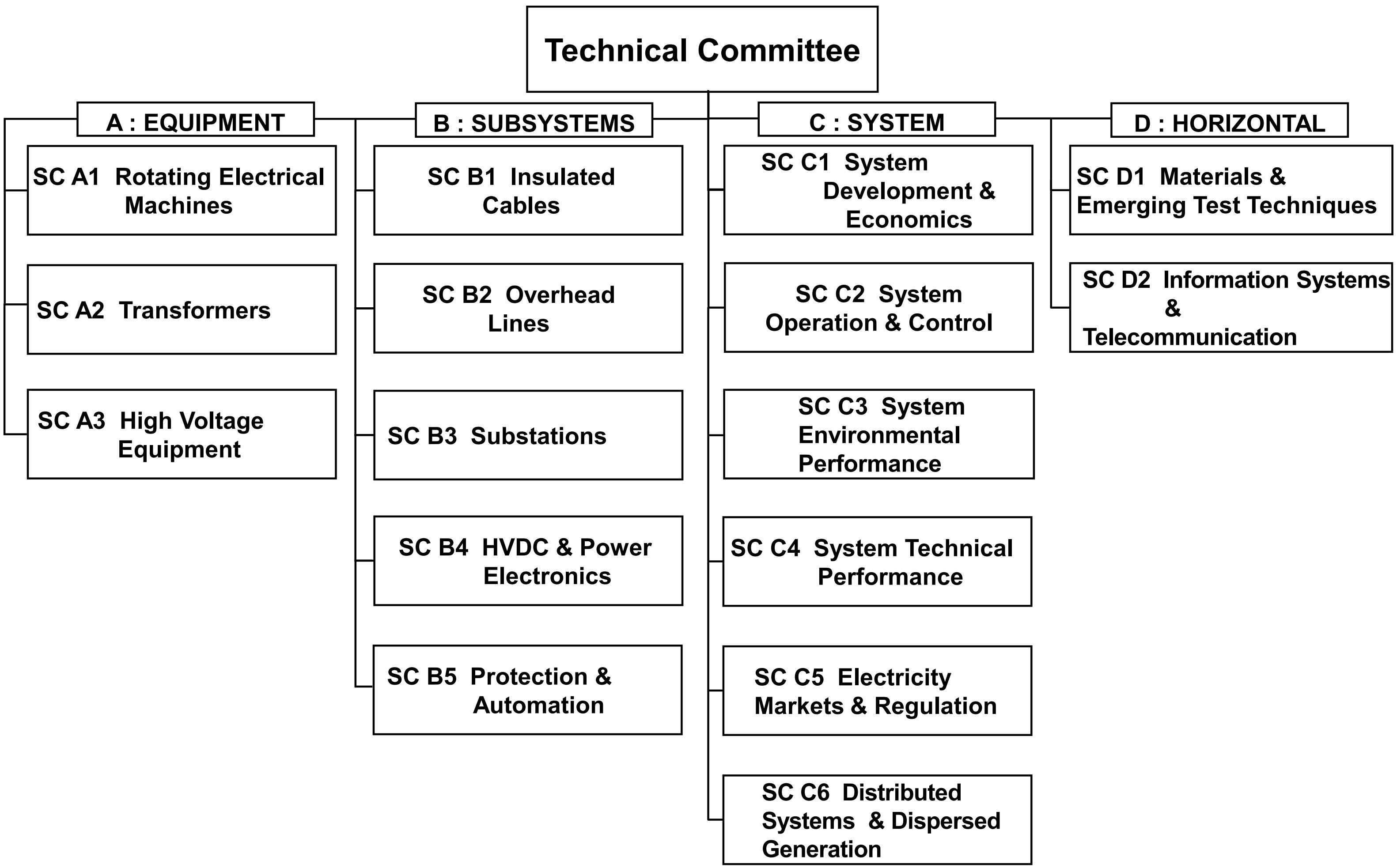
1	Collective I	Rs. 65,000/-
2	Collective II (Universities & Regulatory Commission)	Rs. 25,000/-
3	Individual	Rs. 7,500/-
4	Young - below 35 years of age	Rs. 3,750/-

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

The details for bank transfer

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

CIGRE Technical Committee Subject



FIELDS OF ACTIVITY OF CIGRE STUDY COMMITTEES

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

HIGHLIGHTS OF POWER SECTOR IN INDIA

GROWTH OF INSTALLED CAPACITY

(Figures in MW)

	At the end of 11th Plan (March 2012)	As on 30.06.2017	Planned for 12th Plan	Planned for 13th Plan
THERMAL	131603.18	220575.88	72340.00	56400.00
HYDRO	38990.40	44614.42	10897.00	12000.00
NUCLEAR	4780.00	6780.00	5300.00	18000.00
RENEWABLE ENERGY SOURCES	24503.45	57260.23	30000.00	30500.00
TOTAL	**199877.03**	**329230.53**	**118537.00**	**116900.00**

Source : CEA

ALL INDIA REGION WISE INSTALLED CAPACITY

As on 30-06-2017

(Figures in MW)

Region	Thermal	Hydro	Nuclear	RES	Total
Northern	58430.46	19311.77	1620	11539.36	90901.59
Western	81223.03	7447.50	1840	18304.43	108814.96
Southern	50617.26	11739.03	3320	26132.07	91808.36
Eastern	27878.02	4834.12	0	990.74	33702.87
N. Eastern	2387.07	1282.00	0	281.12	3950.19
Islands	40.05	0	0	12.52	52.57
All India	**220575.88**	**44614.42**	**6780**	**57260.23**	**329230.53**
Percentage	**67**	**13.55**	**2.05**	**17.4**	**100**

Source : CEA

SECTOR WISE INSTALLED CAPACITY AND GENERATION

As on 30-06-2017

Sector	Installed Capacity (MW)					Percentage Share	Net Capacity added
	Thermal	Nuclear	Hydro	RES	Total		During June 2017
STATE	72168.38	0.0	29723.00	1976.90	103868.28	31.55	- 1030 MW
PRIVATE	85216.68	0.0	3240.00	55283.33	143740.01	43.66	
CENTRAL	63190.83	6780.00	11651.42	0.00	81622.25	24.79	
TOTAL	**220575.88**	**6780.00**	**44614.42**	**57260.23**	**329230.53**	**100 .00**	

Source : CEA

GROWTH OF TRANSMISSION SECTOR

	Unit	At the end of 11th Plan (March 2012)	Addition During June, 2017	As on 30.06.2017	Expected addition during 12th Plan	Expected addition during 13th Plan
TRANSMISSION LINES						
HVDC	ckm	9432	0	15556	109440	130000
765 kV	ckm	5250	0	32086		
400 kV	ckm	106819	2085	162653		
220 kV	ckm	135980	743	164411		
Total Transmission Lines	**ckm**	**257481**	**2828**	**3,74,706**	**109440**	**130000**
SUBSTATIONS						
HVDC	MW	9750	0	21000	270,000	300,000
765 kV	MVA	25000	1000	171500		
400 kV	MVA	151027	7650	250752		
220 kV	MVA	223774	3985	320818		
TOTAL	**MW/MVA**	**409551**	**14135**	**7,64,070**	**270,000**	**300,000**

RURAL ELECTRIFICATION / PER CAPITA CONSUMPTION

(As on 31-5-2017)

Total no. of Villages	597464
No. of Villages Electrified	592972
% of Villages Electrified	99.25
No. of Pump-sets Energized	20646924
Per Capita Consumption during 2015-16	*1075 kWh

*Provisional

RE SECTOR IN INDIA: POTENTIAL AND ACHIEVEMENTS

(As on 30.4.2017)

GRID-INTERACTIVE POWER Sector	FY 2017-18 Target (MW)	Cumulative Achievements (MW)
Wind	4000.00	32287.27
Solar Power (SPV)	10000.00	12504.50
Small Hydro (up to 25 MW)	200.00	4384.85
Bagasse Cogeneration/ Biomass	340.00	8181.70
Waste to Power	10.00	114.08
Total (Approx)	**14550.00**	**57472.40**
OFF GRID/CAPTIVE POWER	**183**	**1477.70**

Source : MNRE

NEWS

NTPC TARGETS 250 BU POWER GENERATION IN FY18

State-run power giant NTPCBSE -0.66 % is aiming at generating 250 billion units (BU) of electricity in the current fiscal under a performance pact inked with the power ministry. The target for revenue from operations is Rs 79,280 crore under the pact. The Memorandum of Understanding for 2017-18 between NTPC and the Ministry of Power was signed.

"As per the MoU, NTPC has generation target of 250 BU during the year under "Excellent" category. Revenue target from Operations under "Excellent" category is Rs 79,280 crore," NTPC said in a statement.

Parameters related to financial performance, operational efficiency, CAPEX, projects monitoring and HR Management are also part of MoU in line with guidelines of Department of Public Enterprises. NTPC is India's largest power utility with 51,635 MW installed capacity. It has presence in coal, gas, solar PV, hydro and wind power generation and coal mining.

Source : PTI, June 22, 2017

US ANNOUNCES $7.5 MILLION TO ADVANCE INDIA'S POWER GRID

The US will provide $7.5 million to help advance India's power gridBSE 1.84 % as part of their commitments to ensure access to affordable and reliable energy in both countries.

The Ministry of Science and Technology and industry will match the commitment of US' Department of Energy, bringing the total commitment to $30 million, officials said.

"This new consortium demonstrates the US and Indian commitments to ensuring access to affordable and reliable energy in both countries," Energy Secretary Rick Perry said ahead of Prime Minister Narendra Modi's visit here next week.

"We know that continued grid innovation will promote economic growth and energy security in the United States and India," he said yesterday. The initiative, part of America's commitment to fostering the reliable, resilient and secure delivery of electricity, was needed for the strong US national security, economic growth and global leadership, as well as furthering Department of Energy (DOE)'s collaboration with India under the US-India Partnership to Advance Clean Energy (PACE), officials said.

The US-India collaboration for smart distribution system with storage (UI-ASSIST) was selected as the new consortia for Smart Grid and Energy Storage under the US-India Joint Clean Energy Research and Development Center (JCERDC), the DOE said in a statement.

To help pave the way to a more advanced distribution grid that will allow greater use of distributed energy resources such as microgrids and energy storage, the new consortia will bring together experts from academia, DOE's national laboratories and industry, it said. Together with their counterparts in India, the center will conduct research and deploy new smart grid and energy storage technologies that will modernise the grids of both the nations to make them "smarter", while increasing resilience and reliability, the DOE said.

Through JCERDC, the US' world class installations and national laboratories will contribute their expertise and capabilities as India expands energy access to its remote areas, improves its grid reliability and resilience, and strengthens its energy security.

The US participants will gain insight from India's grid modernisation efforts - a potential export market for US equipment worth billions of dollars - and promote researcher access to India's grid operational experience, it said.

UI-ASSIST's US team, led by Washington State University, is comprised of MIT, Texas A&M University, University of Hawaii, Idaho National Laboratory, Lawrence Berkeley National Laboratory, Snohomish County (WA) Public Utility District, Avista, Burns and McDonnell, ETAP Operation Technology, ALSTOMBSE -2.73 % Grid/GE Grid Solutions, Clean Energy Storage, ABB, Philadelphia Industrial Development Corporation, and the National Rural Electric Cooperative Association (NRECA).

The Indian team, led by the Indian Institute of Technology (IIT) Kanpur, includes partners from IIT Delhi, IIT Madras, IIT Roorkee, IIT Bhubaneshwar and The Energy and Resources Institute (TERI) New Delhi.

Source : PTI, June 22, 2017

International Council on Large Electric Systems (CIGRE)

International Headquarters:

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

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

Aims and Objectives:

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

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

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

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

Establishment of Indian Chapters:

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

Membership:

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

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

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

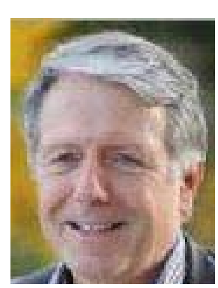
(IV) Young Members (Below 35 Years of Age) -
(In the engineering, teaching or research professions as well as of other professions involved in the industry (Lawyers, economists, regulators...)

CIGRE - HQ

President
Rob STEPHEN (SA)

Chairman TC
Mark WALDRON (UK)

Treasurer
Michel AUGONNET (FR)



Secretary General
Philippe ADAM (FR)

CHAIRMEN OF CIGRE NATIONAL STUDY COMMITTEE (NSC)

2016 - 2018

S.K. Negi
MD, GETCO &
Chairman CIGRE NSC C4

S.K. Soonee
Former CEO, POSOCO &
Chairman CIGRE NSC C5

Oommen Chandy
ED, Powergrid &
Chairman CIGRE NSC B4

Seema Gupta
ED, Powergrid &
Chairman CIGRE NSC C1

K.V.S. Baba
CEO, POSOCO &
Chairman CIGRE NSC C2

Subir Sen
ED, Powergrid &
Chairman CIGRE NSC C6

M. Vijayakumaran
Alstom T&D &
Chairman CIGRE NSC A2

Prakash Nayak
MD, PENA Power E&A .&
Chairman CIGRE NSC D2

Jithin Sunder
ED, BHEL &
Chairman CIGRE NSC D1

Gopal Ji
Former GM, Powergrid &
Chairman CIGRE NSC B2

D.K. Chaturvedi
AGM, NTPC
Chairman CIGRE NSC C6

Rajil Srivastava
AGM, Powergrid &
Chairman CIGRE NSC B3

Anish Anand
AGM, Powergrid &
Chairman CIGRE NSC C3

Subhas Thakur
AGM, NTPC
Chairman CIGRE NSC B5

R.K. Tyagi
AGM, Powergrid &
Chairman CIGRE NSC A3

Deepal Shah
Pfisterer
Chairman CIGRE NSC B1

THE COMMITTEE FOR INTERNATIONAL COUNCIL ON LARGE ELECTRIC SYSTEMS (CIGRE) - INDIA

Governing Body of CIRGE - India

President
I.S. Jha
CMD, POWERGRID

Chairman – Technical
R.P. Sasmal
Director, POWERGRID

Vice Chairman – Technical
N.N. Misra
Former Director, NTPC

Vice President
K.K. Sharma
Director, NTPC

Vice President
Amitabh Mathur
Director, BHEL

Secretary & Treasurer
V.K. Kanjlia
Secretary, CBIP

Director In charge
P.P. Wahi
Director, CBIP