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Union budget 2015-16 aimed at high growth, seeks to boost investment. Domestic and international investors are keen to invest with renewed interest. A creation of a national infrastructure investment fund and doubling of coal cess in the Budget is positive for renewable energy industry. Budget has 1,75,000 MW target set for clean energy installations by 2022. This comprises 1,00,000 MW solar, 60,000 MW wind, 10,000 MW of energy from biomass and 5,000 MW from small hydroelectric projects. Currently, India's clean energy capacity is 33,000 MW.

The budget also envisions providing electricity by 2020 to 20,000 villages - still without access to electricity, including through off-grid solar power. There is also a proposed programme for faster adoption and manufacturing of electric vehicles for which, an initial outlay of Rs 75 crore for 2015-16 has been allocated.

"Budget has 1,75,000 MW target set for clean energy installations by 2022"

This issue has an interesting research writeup 'Kaizen and innovation challenges in new renewable environmental friendly energy sources' redefines kaizen and innovation process towards improving present and finding new renewable environmental friendly, safe, secure and sustainable high voltage power generating energy sources for future of the world and next generation with an integration plan for improvement, change and innovation process including transmission.

Transmission grid is used as a transport medium between generation and the load centers. While discussing control and protection philosophy the article 'Phase Shifting Transformers' reveals that such transformers can be used to control the active power flow in a complex power distribution network in a very efficient way.

Do send in your comments at miyer@charypublications.in

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CONTENTS

Vol 55 | No 3 | March 2015

Departments

Interview

56

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Transformer Technology and Improving Efficiency

> *Researchers have devised a way to manufacture transformers more efficiently, using a laser process*

Transformers efficiency is crucial and power distribution is critical for energy sector carrying high voltage power transmission to long distances. Michael Faraday built first transformer, although he used it only to demonstrate principle of electromagnetic induction and did not foresee the use to which it would eventually be put. The powerful transformers are used in electricity substations to convert high voltages of transmission grid into the standard AC power supply, delivered to households.

Researchers have devised a way to manufacture transformers more efficiently, using a laser process, to improve performance of electrical steel material used in transformer construction. Transformer market for large capacity transformers is highly dependent on the needs of electric power companies needing supply. An initiative 'Make in India' i.e. manufacturing in the country has set tone for activity on all fronts. India, gearing up for change under new government, would stimulate increase in infrastructure activity boosting power & energy sector.

All large transformers use oil for insulation and cooling, as is known; since this greatly reduces energy loss and improves reliability. Increasing focus on energy efficiency actions might also enforce a substitution of dry transformers with oil filled transformers. However, preventive maintenance is necessary to protect investment in equipment. Also, solution to transport big transformers to substations lies in adopting practice of on-site assembly system, wherein focus has to be, to minimize installation space and need for stable operation over long period. The latest apparatus supervisory system can support preventive maintenance systems. A new technology for transformer industry involves use of high temperature materials to provide a variety of economic, environmental & safety benefits to user.

Utilities are tilting towards advanced technology solutions that encompass voltage & power levels, while ensuring safety of people and environment. Statistics suggest, internal failure occurs on an average in about 15 of Norway's 3000 transformers every year. Moreover, new advancements include maximum protection from internal arcing faults, completely submersible applications, & improved efficiencies.

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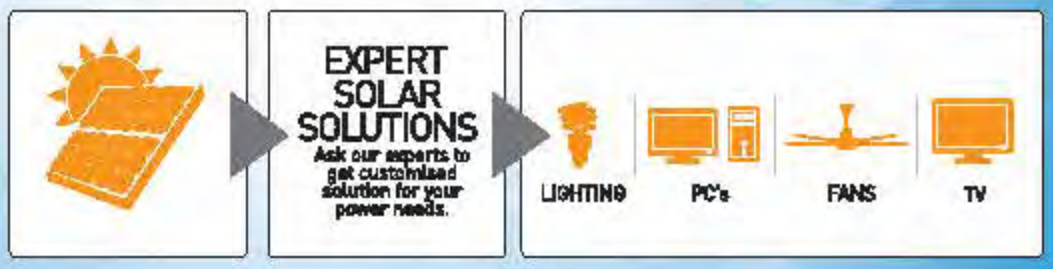

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Wind Industry: IWTMA supports MNRE to achieve 60 GW target by 2022

Indian Wind Turbine Manufacturers' Association, a announced its support to Ministry of New Renewable Energy (MNRE), in fulfilling the target of creating 60 GW of wind energy by the year 2022. The growth of Renewable Energy in India is enormous and Wind Energy proves to be the most effective solution to the problem of depleting fossil fuels, importing of coal, greenhouse gas emission, environmental pollution etc. Wind energy as a renewable, non-polluting and affordable source directly avoids dependency of fuel and transport, can lead to green and clean electricity. With an installed capacity of 21136.3 MW (March 2014) of wind energy, Renewable Energy Sources (excluding large Hydro) currently accounts for 13.86% of India's overall installed power capacity of 228721.73 MW.

Wind Energy holds the major portion of 66.7% (of 31707.2 GW total RE capacity) among renewable and continued as the largest supplier of clean energy. IWTMA sponsored a panel discussion titled 'Onshore Wind' at the first Renewable Energy Global Investors Meet & Government Expo. The conference was mainly focusing on policy, regulatory, financing and other major issues concerning wind power business in India and concentrate on building a comprehensive roadmap for achieving our targets. The panel consisted of members from manufacturers, project developers, investors, grid operators and bankers. Madhusudan Khemka Chairman IWTMA said, "We fully support the "Make in India Campaign" with our turbines of state-of-the-art technology which has almost 70% localization. We also aim at creating rural employment both direct and indirect during the project stage and employment for manufacturing and the estimated persons to be employed which will go up to 160,000 persons by 2022. Addressing these key challenges and issues we are confident of achieving 60 GW target". Indian Wind Turbine Manufacturers' Association (IWTMA), is formed to promote and harness wind energy in India and a key driver of the wind energy market. It is formed to promote and harness wind energy for an all-inclusive sustained growth-now and in the future.

BHEL commissions 270 MW Thermal Unit in Maharashtra

Bharat Heavy Electricals Limited has achieved one more milestone by successfully commissioning another 270 MW coal based thermal power plant in Maharashtra. The unit was commissioned at Rattan India Power Limited's (formerly Indiabulls Power Limited) upcoming thermal power project located at village Nandgaonpeth in Amravati district of Maharashtra. This is the third 270 MW unit commissioned by BHEL in Phase-1 of the project. The project is being executed in two phases, each of 1,350 MW. Notably, this in-house engineered 270 MW rating TG set establishes the engineering prowess of BHEL. The 210/250 MW sets of this rating class, supplied earlier by BHEL, today form the backbone of the Indian power sector and have been performing much above the national average as well as international benchmarks. BHEL has so far contracted 247 sets of this rating class including 31 of 270 MW rating. BHEL is the largest engineering and manufacturing organisation of its kind in the country. It is also among the world's few integrated power plant equipment manufacturers with the capability to manufacture the entire range / type of power equipment and also to undertake projects on EPC basis. It has achieved technological developments at par with the world's best through a blend of collaborations with global OEMs and in-house developments. BHEL supplied thermal sets fully meet the performance standards notified by CEA. As per a recent CEA study on the performance of installed power generating sets, BHEL supplied sets have demonstrated a better operating Heat Rate resulting in less coal consumption per unit of power produced.

Gamesa signs two new contracts for supply of 260 MW wind power

Gamesa, a global technology leader in wind energy, has recently signed two new agreements for supply of an aggregate 260 MW.

The first order, from Indian developer and independent power producer (IPP) Greenko, encompasses the supply, installation and commissioning of 80 of the company's G97-2.0 MW turbines (160 MW). Gamesa will install 30 turbines at Jaisalmer region, in the state of Rajasthan, and another 50 at Basavanabagewadi, in Karnataka. The turbines are slated for delivery during the first quarter of this year and the wind farms are expected to be commissioned by June 2015. The company will also operate and maintain all 80 turbines in the long term. This contract is included in a new framework agreement to commission 300 MW wind power projects in India, signed by Gamesa and Greenko. The second phase of 140 MW is expected to be secured during the second quarter of the year, in different wind farms located in the states of Karnataka and Andhra Pradesh.

The second order, placed by Indian developer CLP India, covers turnkey construction of a 100-MW wind farm at Chandgargh, Madhya Pradesh. The company, which will handle all of the infrastructure needed to install and operate the complex, will install 50 G97-2.0 MW turbines and also service them in the long term. The turbines are due for delivery during the first half of this year and the wind farm will be commissioned in December 2015. Both the 80 turbines will be its G97-2.0 MW Class S make, with a tower height of 104 metres, a new model specifically designed for low wind speed sites in the Indian market.

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NTPC Commits to add 10000 MW

NTPC presented the certificate of commitment to PM

NTPC committed to add 10,000 MW through Solar Projects at RE- Invest - 2015 in New Delhi. Dr. Arup Roy Choudhury, CMD, NTPC presented the certificate of commitment to Prime Minister, Narendra Modi in the presence of Piyush Goyal, Minister of State (Independent Charge) for Power, Coal and New & Renewable Energy and P K Sinha, Secretary, Power, GOI. Committed to the solar initiative NTPC has already floated Notice inviting tender for four Solar Project of 250 MW each in Andhra Pradesh, Madhya Pradesh, Telengana & Rajasthan and one Solar Project of 500 MW in Andhra Pradesh. The first 250 MW Solar project in Anantapur in Andhra Pradesh is expected to be awarded this FY. Availability of land and PPA arrangement are being explored in other states like Chhattisgarh, Uttar Pradesh, Puducherry, Gujarat etc. NTPC has already commissioned 8 MW scale solar projects in different parts of India totalling 110 MW, out of which Rajgarh Solar Project of 50 MW in Madhya Pradesh is the largest. NTPC generated more than 100 Million Units by RE during 2014-15.

Madhya Pradesh setting up largest solar power plant

Madhya Pradesh government in a joint venture with Solar Energy Corporation of India is setting up the solar plant in Rewa district, slated for inauguration on August 15, 2016. It will straddle five villages of Barseta and country will have world's largest 750 MW solar power plant which will be developed in three segments of 250 MW each. The expected cost of power production is pegged at Rs 5 per/unit lower than production costs in any solar project in the country. Gujarat occupies top solar power state with commissioned capacity of 930 MW out of the country's total capacity of around 3,000 MW. Rajasthan is second with 840 MW; Third is Madhya Pradesh-354 MW, then Maharashtra-287 MW and Andhra Pradesh-235 MW. It is stated that at least 20% power produced from the solar plant will be for Madhya Pradesh.

CIL gears up for one Billion Tonne Coal Production mark

Coal India Limited (CIL), the Maharatna coal mining company unveiled its roadmap, of strategies to be adopted, to attain the 1 Billion Tonne (BT) coal production mark by 2019-20. With the projected coal demand of the country hovering around 1,200 Million Tonnes (MTs) by 2019-20, at a growth rate of 7%, CIL is expected to chip in 1 BT, of which, 908 MTs is the expected contribution from the identified projects. S Bhattacharya, CMD, CIL stated further that the process of identification of projects to share the balance quantity, to top up the 1 BT mark, is underway.

Two CIL subsidiaries Sambalpur based Mahanadi Coalfields Limited and the Bilaspur based South Eastern Coalfields Limited are expected to play a pivotal role in CIL's quest of attaining the 1 BT production with 250 MTs and 240 MTs respectively , Bhattacharya added. Earlier, Anil Swarup, Coal Secretary said that coal ministry is committed to increase coal production in the country. CIL is introducing a number of systems improvements that would help the company in realizing its challenging target. Use of ICT, remote sensing geophysical technologies and proper monitoring and evaluation methodologies are the key features. Elaborating further, he said initiated actions involve creation of Coal Project Monitoring Group (CPMG) portal for regular monitoring of project related issues with different ministries and State Authorities. To overcome the hurdle of coal evacuation, CIL had decided to purchase 2000 railway wagons from its own kitty. He said that the strategies for future include Technology Upgradation in Opencast Mines with high capacity equipment, Operator independent Truck Dispatch System, Vehicle tracking system using GPS/GPRS, Coal Handling Plants (CHPs) & SILOS for Faster Loading and monitoring using Laser Scanners. As far as productivity improvement in Underground mines is concerned, Bhattacharya said that the steps taken by CIL will include introduction of Continuous Miner Technology in large scale, Long-wall Technology at selected places, Man Riding system in major mines and Use of Tele monitoring Techniques.

Companies commit 266,000 MW of clean power

Close to 300 global and domestic companies have committed to generate 266,000 mega watts (or 266 giga watts) of solar, wind, mini-hydel and bio-mass based power in India till next ten years. Renewable energy is one of the 25 sectors identified under 'Make in India' campaign. According to sources at ministry of new and renewable energy, 293 firms have shown interest to set up renewable power plants in the country. India's total renewable energy capacity is around 34,000 MW at present. In consonance with Make in India plan, assurances have been received for setting up close to 50,000 MW of manufacturing and EPC facilities for solar and wind power.

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Distribution Automation Market set to transform Global Electricity Distribution Efficiency

With power interruptions resulting in huge economic losses of up to $150 billion annually, distribution automation presents a viable solution to ensure effective asset management, minimal interruption, and enhanced efficiency in the grid network. As a result, distribution automation is quickly becoming a requirement for utilities. Power demand and grid complexity will continue growing and utilities across the globe are turning to advanced automated solutions to protect assets, enhance reliability, and minimize operations and maintenance costs. New analysis from Frost & Sullivan, Analysis of the Global Distribution Automation Market, finds that the market earned revenues of $7.32 billion in 2014 and estimates this to reach $10.33 billion in 2018. "Emerging countries hold significant potential for distribution automation vendors," said Frost & Sullivan's Energy & Environment Analyst. "In India, transmission and distribution loss is estimated at over 20% of produced power, while in Latin America, power distribution loss is estimated at over 16%. Hence, governments are urging utilities to adopt automation solutions and boost grid efficiency."However, the high initial costs of automation solutions restrain uptake. Integration of different types of vendors, including information technology providers, communication network suppliers and hardware suppliers is also crucial to create products that prepare automation companies to meet future demand. "Distribution automation is in the early stages of its lifecycle and investments in complementary technologies enabling two-way communication, better asset management, and improved efficiency will help capitalize on the full potential of the technology," explained the analyst. "The combination of technologies will yield significant benefits for all stakeholders." Lack of integrated demonstration projects & universal standards are dissuading utilities from investing in distribution automation, so demonstrating the superior operational benefits of these solutions is vital for market growth. Analysis of the Global Distribution Automation Market is part of the Energy and Power Growth Partnership Service program.

Cyber Security Solutions for the Energy and Utilities Sector

Wipro Ltd. a leading global information technology, consulting and business process services company and SRC Cyber, LLC, a company specializing in cyber security products and services, announced a global alliance. The two companies will jointly develop IT security products and provide consulting services that will serve organizations across the global energy and utilities industry value chain. According to industry studies, in 2014 nearly 70% of companies across more than 10 countries with large economies said that they "have had at least one security breach that led to the loss of confidential information or disruption to operations" in the past year. Wipro and SRC Cyber's joint value proposition is of strategic importance given this security environment. Wipro brings a wide-ranging set of IT solutions for the cyber security domain and cyber security best practices in addition to proven domain expertise in the energy and utility sector, to this alliance. The joint offering aims to provide customers with an entire gamut of solutions and services, ranging from strategy development, compliance adherence, operations optimization to project delivery. Wipro's global security consulting and energy domain expertise combined with SRC Cyber's leading edge products and services for the energy and utilities industries will deliver a comprehensive set of solutions that will help customers address current and emerging threats.

Solutions for Data Center Segment at Eaton Technology Day

Power management company Eaton hosted a Technology Day in Bengaluru for the data center segment. The Technology Day showcased Eaton's offerings that help in designing flexible and holistic data centers, increasing efficiency without sacrificing uptime and ensuring faster time-to-market. Technology Day is part of a global Eaton initiative that leverages these events to reach out to customers, influencers and end-users to enable effective market interactions across major regions and key industry segments. "Bengaluru is an important market for Eaton. This is the second Eaton Technology Day in the last six months in Bengaluru and this time we have hosted it exclusively for the data center segment, which is a focused segment for Eaton." said Nitin Chalke, managing director – India, Eaton. " We have been partnering with several leading players in this segment by providing solutions that help them build an agile and scalable infrastructure; drive real business benefits by ensuring optimum efficiency and low cost throughout the complete lifecycle of the data center." Eaton products are manufactured to meet the highest standards of efficiency, reliability and safety. Eaton's showcased complete Electrical business portfolio, which help address rising demands of the data center industry. At the Technology Day, Eaton showcased its robust range of uninterruptible power systems (UPSs) such as Power Xpert 9395 UPS with Hot Sync paralleling technology, which contributes to outstanding savings and unmatched green efficiency, and the 93PM UPS with advanced energy saving system technology that enables more than 99% energy efficiency. Also showcased were 93E UPS, 9PX PDUs, fire alarm panels and detectors, HT fuses, circuit breakers, push buttons, circuit breakers, MCB and contactors that support the constantly evolving data center segment.

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India-based Neutrino Observatory

INO Project is a multi-institutional effort aimed at building a world-class underground laboratory with a rock cover of approximately 1200 meter. The project is jointly supported by Department of Atomic Energy and Department of Science & Technology with DAE acting as the nodal agency. The objective of INO is to conduct basic research on the elementary particle called neutrino. Presently 21 research institutes, Universities and IITs from all over the country are involved in this project. INO is expected to galvanise interest in basic science research in the whole country and particularly in & around Theni and Madurai districts of Tamil Nadu. Science students across the country will have opportunity to pursue cutting edge research in the field of particle physics while being located in India. The observatory will be located underground so as to provide adequate shielding to the neutrino detector from cosmic background radiation. The project has all the required clearances from various Central and State Government authorities. A geotechnical studies was also carried out by Geological Survey of India. The operation of INO will have no release of radioactive or toxic substances. It is not a weapons laboratory and will have no strategic or defence applications.. Department of Atomic Energy states that INO laboratory will be used only for the purpose of basic science research in the field of neutrino physics. The underground laboratory, consisting of a large cavern of size 132m 26m 20m and several smaller caverns, will be accessed by a 1900 m long & 7.5 m wide tunnel.

Rolls-Royce & Kirloskar co-operate on Standby Power for NPPS in India

Rolls-Royce & Kirloskar Oil Engines Ltd, the Indian engine & genset manufacturer, signed a declaration of intent for exclusive cooperation on the building & commissioning of emergency gensets for Nuclear Power Plants in India. Rolls-Royce will supply MTU engines and key components, and take responsibility for basic engineering & genset configuration. KOEL, as a main contractor to Nuclear Power Corporation of India Ltd., will integrate the systems and assemble and test the gensets on site in India. "Working together with KOEL, we see good chances of gaining entry into the emergency genset market for nuclear power stations in India," said Dr Michael Haidinger, CSO of Rolls-Royce Power Systems. India is putting its focus on nuclear power to help meet its long-term energy requirements.Indian PM Narendra Modi has declared that nuclear power will form a mainstay of India's power supply. By 2050, nuclear power is to cover one quarter of India's power requirement. "This cooperation is enabling us to pool our own experience and expertise as a local supplier with the technological leadership of MTU in the area of NPP emergency gensets," said Rajendra R. Deshpande, Executive Director of KOEL, during his visit to Friedrichshafen. KOEL has already delivered 20 emergency gensets to nuclear power plants in India and today is the only Indian company supplying high capacity gensets to NPCIL. MTU has completed numerous projects in the field of nuclear power & its emergency gensets operate in several nuclear power plants in Europe, China and Russia.

Dr Michael Haidinger (in the middle), CSO of Rolls-Royce Power Systems, Andreas Götz (right), Head of sales and applications technology department for NPP and Gas MTU Friedrichshafen and Rajendra R. Deshpande (left), Executive Director Kirloskar Oil Engines Limited signed a declaration of intent at the end of January 2015 for exclusive cooperation on the building and commissioning of emergency gensets for nuclear power plants in India.

Solar Water Pumps for Agriculture Sector: Claro Energy receives USD 2 Million credit facility from RBL Bank

Claro Energy, a leading solar water pumping solution provider, today announced that it has received a first of its kind USD 2 million credit facility from RBL Bank to scale up its solar pumping business. Of this USD 1 million is a Direct Line of Credit to meet working capital needs and another USD 1 is a commitment from the Bank towards direct farmer financing for Claro Energy's solar water pumps. 'Solar pumping is the most useful application of solar energy in India as it is directly connected to farmer's income and food production. As MNRE expands the solar pump program across the country, millions of farmers are going to benefit from solar irrigation, said Soumitra Mishra, Director at Claro Energy. 'The credit facility shall be used for meeting our growing working capital needs and towards consumer financing for farmers who wish to buy our solar pumps but can't afford the upfront capex.

This credit facility comes at the right time as the solar pumping industry is witnessing explosive growth and with our extensive on-ground experience we're nicely positioned to capitalize on that. This will help solidify our leading position in the industry.' With a team of over 100, Claro Energy currently operates in 10 states across the country and has installed solar pumps from 1HP to 10HP across drinking water, irrigation, purification and aquaculture applications. 'RBL bank is committed to provide financial services for supporting sustainable energy efficient irrigation systems and renewable energy programs for farmers. 'Agriculture sector would be more profitable if the farmers have efficient irrigation system and optimised cost of fuel. With little maintenance requirements, the solar pump deployed on field by high quality system integrator will help farmers adopt this new system. As a bank we are continuously working with various stakeholders to support the sustainable models in renewable and clean energy especially solar energy sector.' The tie up comes even as the Union Government has announced a provision of Rs 1,000 crore for promoting solar energy in the country.

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Toshiba adds multi-purpose 4400 Series to Three-phase UPS Line

Toshiba International Corporation (TIC) launched a new 4400 Series three-phase uninterruptible power system (UPS). The next-generation UPS utilizes double conversion, all insulated-gate bipolar transistors (IGBT) technology and is available in power ranges from 15 to 80kVA. Ideal applications include small to mid-size datacenters, medical and healthcare, hotels, casinos, banking, retail, telecommunications, broadcasting, and light industrial. The 4400 Series UPS features include a digitally controlled IGBT input rectifier. This advanced technology allows for a .99 input power factor and a wide voltage and frequency input window without utilizing batteries, making it ideal for generators. The series incorporates an intelligent low harmonic IGBT pulsewidth modulation (PWM) output providing critical loads with continuous clean power. The state-of-theart IGBT DC to DC converter and the large robust DC capacitor

bank allows for battery longevity reducing total cost of ownership. The UPS includes an easy to navigate local touch screen interface with a large memory capacity. The 0.9 output power factor maximizes total available power, and the 100% load step and 100% unbalanced load capability is ideal for all critical load applications. "The 4400 Series was designed from the ground up with an emphasis on installation convenience and efficiency," said Greg Mack, Vice President and General Manager of the TIC Power Electronics Division. "The result is a multi-purpose UPS that is easy to install and customize for multiple markets and applications." The small footprint, total front access mechanical design requires zero rear clearance and includes features such as top, bottom, and/or side cable entry, standard sized air filter provisions, and lockable keyed doors. A variety of 4400 Series UPS models are available for application specific requirements, such as internal battery models and models with internal transformers for numerous input and output voltage requirements. The 4400 Series includes matching battery cabinets for extended run times and matching auxiliary cabinets for load distribution and maintenance bypass system configurations. Remote monitoring of the 4400 Series is capable with the Toshiba RemotEye® 4 multi-protocol UPS monitoring solution. Toshiba backs the reliability of the 4400 Series UPS with a 3-year onsite warranty.

Crestron extends next generation DM 3.0 4K Product Line

Crestron Asia Limited, the Asia headquarters of Crestron Electronics, Inc. (Crestron) being one of the world's leading manufacturers of advanced control and automation systems, continues to expand the DM 3.0 family of products with more standard-setting 4K products for every room, announced that it is now

shipping the following new products. What makes the 4K DigitalMedia Receiver & Room Controller w/Scaler (DM-RMC-4K-SCALER-C) unique is its exclusive scaler chip, developed in-house by Crestron. Other AV companies simply don't have this capability. It can convert any resolution and frame rate to any other resolution and frame rate, up to 4096x2160 at 60 Hz. Both Wall Plate 4K DigitalMedia Transmitter (DM-TX1-4K-C-1G) and Wall Plate 4K DigitalMedia Receiver (DM-RX1-4K-C-1G) are powered over DM, so all you need is a single cable. Using CEC, many devices can be controlled right through their HDMI connections, eliminating the need for serial cables or IR emitters. Available in both black and white, both devices utilize a standard electrical box for tidy, discreet installation. The 4K DigitalMedia Input Card (DMC-4K-C) and 4K DigitalMedia Input Card w/Downmixing (DMC-4K-C-DSP) provide a single DM or HDBaseT input with modular input card slots, and handles 4K and Ultra HD video resolutions.

Deploying more than 1,500 kWhs of Intelligent Energy Storage in California

Installation of over 1,500 kWhs of intelligent energy storage capacity that will be used to reduce the ongoing costs of demand charges on their electricity bil prompted a Power Efficiency Agreement, wherein, Californian schools and university have contracted with Green Charge Networks. These academics can expect to save up to 50% off their demand charges. Green Charge has coupled electric vehicle charging stations with each of these systems to mitigate increased demand charges while promoting the use of electric vehicles with students, faculty, and staff. By installing Green Charge's intelligent lithium ion-based battery storage solutions, these California schools are transforming the way - U.S. produces, distributes, stores, and uses energy. Aiming for net-zero carbon emissions, schools in California are integrating intelligent energy storage solutions and electric vehicle charging stations while reducing their energy bill. "California is home to more than 100,000 electric vehicles drivers. As the EV market continues to expand, the work of schools to provide more charging options for employees, students and visitors is an important part of our community's growth toward cleaner transportation solutions," said Jason Anderson, president and CEO of Cleantech San Diego, an organization that includes more than 100 local businesses, universities, and governments, working to advance sustainable solutions. "Energy storage is a critical complement of EV charging as it allows schools and businesses to control their energy use & reduce demand charges."

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SolarPulse 3.0 by MachinePulse Makes Solar Power Projects Smarter

MachinePulse, a Mumbai based Internet of Things (IoT) platform provider, launches SolarPulse 3.0, an analytics solution for the solar power industry. Catering to industrial, commercial and utility sectors, SolarPulse 3.0 is the new and improved version of its predecessor SolarPulse 2.0, which was introduced in 2013. The utility solution's scalable (horizontally and vertically) platform allows monitoring of multiple parameters through no node locking, allowing the user to find the root cause of performance issues easily. All devices are dynamically compared against the best performing device to enable users to spot performance issues through bird eye monitoring on a real-time basis. Users can define their own rules and notifications for benchmarking to a string level granularity. The geographical plant map feature enables quick fault detection through one single dashboard for viewing device performance through a color coded status. SolarPulse™ 3.0 for rooftop applications is offered through the erlxis™ cloud platform. The cloud solution offers features that equip solar plant owners with the right tools to achieve optimum performance of their power plants. It offers unification of all data on a single platform, all existing as well as upcoming roofs and an interactive platform for multi-roof comparisons and drill down.

Suzlon partners Brazil: adding 350 MW of wind energy capacity

Suzlon Group, the world's fifth largest* wind turbine maker has completed installing and commissioning of over 350 MW wind energy in Brazil over a period of 16 months ending Nov 2014 with bulk of 309 MW being added in Calendar Year (CY)2014. This combined capacity includes projects located in the high wind states of Rio Grande do Norte & Ceara in Brazil. The installations comprise of 150 WTGs (Wind Turbine Generators) of Suzlon's proven S9X product series – S95 & S97 and 18 WTGs of Suzlon work-horse of S88, both with a rated capacity of 2.1 MW. The above 168 WTGs were distributed amongst three major clients representing Banks/Financial Institutions/ Funds and EPC/Construction Companies in Brazil. Speaking on the project completion, Tulsi R. Tanti, Chairman, Suzlon Group said: "The successful completion of projects in Brazil bears testimony to Suzlon's value proposition and our customer's confidence and trust in our end to end solutions. We remain focused on high growth & emerging markets and Brazil is a key geography of our growth strategy. Suzlon is committed to contribute to Brazil's energy basket by reducing its carbon footprint and bridging the country's power needs." Suzlon machines across various wind farms in Brazil have delivered the highest Capacity Factor in Brazil over the years.

German Chancellor Angela Merkel visits Siemens' showcase digital factory

German Chancellor Angela Merkel visited Siemens' Electronics Factory in Amberg, Bavaria, and was briefed on current status of production automation as it moves toward Industrie 4.0. Key elements of the coming industrial world are already being used at the Amberg factory: Products communicate with machines and all processes are optimized and controlled via IT. 'Amberg is the best proof that high tech and top innovations can sustainably secure Germany's position as an industrial location over the long term,' said Joe Kaeser, President and CEO of Siemens AG. 'Our Electronics Plant is a prime example of a digital factory, and shows that Siemens is already implementing key elements of Industrie 4.0. The organizational model of the 'Digital Factory' as a Division, established during October, 2014, also reflects this development in our company.' The Amberg Electronics Factory showcases Siemens' concept for a "digital enterprise." The factory

From L to R: Prof. Dr. Karl-Heinz Büttner, Head of the Siemens electronics manufacturing plant in Amberg, Germany; Dr. Angela Merkel, Chancellor of the Federal Republic of Germany; Joe Kaeser, President and CEO of Siemens AG and Ilse Aigner, Bavarian Minister of Economic Affairs, Media, Energy and Technology.

already employs production methods that will be the standard in many manufacturing facilities in a number of years. Products in the plant control their own assembly by directly communicating their specific requirements and their next production steps via a product code to the machines. The Amberg factory has made substantial progress on the way to the future, where real and virtual worlds will be even more closely merged in production, and products will communicate with one another and the machines and optimize their own production process. In the future, factories will be far more flexible than today in producing individual products and achieving higher efficiency – faster, at lower cost and with highest quality. Production is largely automated: Machines and computers are responsible for 75 percent of the value chain, and employees handle the rest. The product is touched by a human hand only at the beginning, when the basic component – a bare printed circuit board – is placed on the assembly line. From then on, everything is run by machines. Yet humans remain indispensable – for developing products & production processes, for planning production, or for handling unexpected incidents. The factory produces around fifteen million Simatic products a year. This means that one product leaves the factory every second on 230 working days a year.

High voltage electrical installations tend to heat up before they fail. By monitoring HV-equipment continuously with thermal imaging cameras costly breakdowns can be avoided.

Thermal imaging cameras for substation monitoring

Electric power utilities are faced with an aging infrastructure, increasing risk of blackouts and brownouts. A brownout is a drop in voltage in an electrical power supply, so named because it typically causes lights to dim. Utilities also face costly unplanned maintenance and rising costs.

Utilities are looking for ways to address these issues in order to improve the reliability of electric power delivery while at the same time reducing costs.

By using FLIR thermal imaging cameras and automation software, impending equipment failures and security breaches can be detected anytime, day or night, at a remote monitoring location. The net effect is increased reliability and reduced cost.

FLIR A310pt
The FLIR A310pt pan/tilt has all the necessary features and functions to build single- or multi-camera solutions. The FLIR A310pt can pan +/- 360° continuous and tilt +/- 45°. It is ideal to cover large areas. Typical application examples are coal pile, waste bunker and sub-station monitoring, utilizing standard Ethernet hardware and software protocols.

The FLIR A310pt is a multi-sensor and includes a lowlight 36x zoom color CCD camera.

A300f / A310f
The FLIR A300f and A310f are thermal imaging cameras with an environmental housing protecting the A300 or A310 against dust and water. The housing increases the environmental specifications of the FLIR A300 / A310 to IP66, without affecting any of the camera features.

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Kaizen and Innovation Challenges in New Renewable Environmental Friendly Energy Sources

The research paper discusses of redefining the 'kaizen' and 'innovation process' towards improving present and finding new renewable environmental friendly, safe, secure and sustainable high voltage power generating energy sources for future of the world and next generation with an integration plan for improvement, change and innovation process.

Prof Bhargav SV Ramachandra,
Prof Vanitha R Bharagav, Sindhu V Dixith

The mankind has always been innovating new and newer technology when ever it has felt deeply the "need" of the human race & "emergency" of the requirement of such need to change the way the whole world lives & enjoys the life, health, communication, mode of transportation & most important is the sources of the energy and power (presently electrical power needs) which sets the world move in action for all the day and brightens the night into heavenly world of dreams, colors and joy.

With the availability of enough of nuclear, coal, crude oil and other sources of depleting sources of power generations today for the world, world & humanity being in comfort zone of power utility it is unable to appreciate the "urgency" to find a most cost effective, natural, environment friendly and reliable and high voltage quality power producing alternatives (depleting sources) to the coal, nuclear and crude oil and unreliable Hydro power sources (depends on the rainfall in the catchment area of river basin the source of Hydro power projects). As the "emergency to create a new alternative renewable energy source" is not deeply felt by the scientific and technological community (which is human race psyche) & the humanity. This situation as such is - leading to relaxed look & effort in bringing newer sources or to bring nuclear fusion reactors (research in on the way of producing magnetic thermally insulated invisible chambers for reaction base & control), matter – antimatter reactors and other unfounded and unfolded sources not known to humanity presently. The argument may look naïve and foolish but this brainstorming session is a must today, otherwise it may be too late when the crude oil and coal sources may slowly and steadily disappear from the world and there will no time to find the correct alternative to those sources of power generations.

But mindset of science and technology for any solution to the problems of power sector is always been now "only to find a better out of the alternatives available in the world" on the basis of the following parameters:-

- The safety & security needs of the world (nuclear)
- Least damage to the environment (green house effect) (greatest damage is from coal and crude oil)
- Cost effectiveness on the basis of the cost per unit of production of power in comparison to other alternatives (the

As the "emergency to create a new alternative renewable energy source" is not deeply felt by the scientific and technological community (which is human race psyche) & the humanity

nuclear, thermal and hydro power projects projects in comparison to solar and tidal)

- (least) Transmission and distribution losses
- The capability to produce high voltages (like nuclear, hydro and coal)
- Efficiency & effectiveness of the power generation system (least breakdown and consistency with reference to voltage, power factor and other quality aspects)
- Readability & quality of power produced (stable and consistent power supply)

The above list of parameters show a valid case where one type of power project will have an advantage over other power projects and any power technology can be argued as the best and useful for humanity. As the Gujarat example of power sector management systems there could be "integrated look and vision with regard to power sector & effective utilization of all sources of energy" towards the target goal to produce high quality power & enough electrical power for all needs of society such as industrial, agricultural, domestic, shopping, entertainment and market place, streets and highways, the railways & road transport-(electric buses), other establishments like religious and tourism spots.

Now the question is not just finding which is the best out of these looking to SWOT analysis of the strengths, weaknesses and opportunities and threats and one's inclination of non – conventional energy alternative to a particular sector as the best.

To give an example one research paper argues that the best is the nuclear power as it produces little or no greenhouse effect like coal and cheep, quality and reliable power could be produced and the researcher concludes blind folded that it is the best alternative among the present power production alternatives and India should establish many power projects to solve the problems of power requirement in the country. But it clearly appears dangerous when we remember the recent Japanese nuclear leakage because of the earth quake, flood and rains –(when the sea water started flowing with force and started destroying everything in its way because of incessant thunder showers and rains) creating nuclear disaster in Japan and yet the cities around that reactor is in higher degree of nuclear radiation exposure and its related damages and threats for health. The possibility of damage to nuclear reactor from natural disaster like floods, Tsunamis, tempest, earth quakes etc, or (the new threat from the black spot of present humanity) the terrorists (with their suicide bombers) cannot be ruled out and neglected or un-remembered with an attitude that" When such thing happen we take care and solve and very rarely such a thing can happens- so let us not worry" . Because recently the US where maximum nuclear reactors are there (around 100 and odd catering to near 20% of power requirement of their country) has proved the limitation man over nature and it is today we need to pull up the sockes and sit straight and find the correct matching alterative in their place. We see a need and urgency for redefining the sources of power by transforming the whole process of our mindset towards the innovation in new energy sources – by seeing the urgency for change in the whole process, technology and present sources of power generation (coal, crude oil, hydro, wind, solar, tidal).

The complete solution model of power management

The complete solution model of power management consists of five components of research areas.

- Part - I: The kaizen – the continuous improvement of the present system of power generations like hydro, nuclear, solar, tidal, waste heat gases based, bio-hydrogen from waste material and other similar already existing systems of power generation.
- Part - II: The innovation in the field of power generation – harnessing the power from entirely new entities of nature unfolded till day by science and technology
- Part - II: What is the need for kaizen and for innovation (of power generation which is totally environmental friendly and which can reverse the damage already mankind has done in the name of power generation.
- Part - IV: Implementation process – New TQM PPT model for change:
- Part - V: Integration process of change and innovation and final conclusions:

The complete solution model of power management consists of five components of research areas. Discussed in details

Part - I: The kaizen

The kaizen – the continuous improvement of the present system of power generations like hydro, nuclear, solar, tidal, wind, waste heat gases based, bio-hydrogen from waste material, and other similar already existing systems of power generation.

Following researcher on the way and making remarkable way of improvement of the present system in the area by way understanding the principles of quality management and

innovative and integrated methods for power loss and waste management. The prime areas in which researches have made enormous contributions and most are being documented in research journals and electric India and similar magazines. But only 20% are brought to the light and execution mode by the policy makers of the power management administration and government.

The main areas of research in this area are

- T&D loss management
- Captive power generation systems
- Efficient solar power reactors
- Hydro and river based small project plans
- Tidal projects
- Wind energy management
- Digital meters & electrical auditing systems for leakage power waste management
- Safe and efficient nuclear projects
- Solar power generation systems.

The technological community is ahead and macro and micro improvements are done day to day basis & very few are implemented. (as the policy makers fell that they are not economically viable though they are environmentally friendly).

Part - II: he innovation in the field of power generation

Harnessing the power from entirely new entities of nature unfolded till day by science and technology. This could be done by brain storming sessions in international communities by understanding that the innovation process is long journey like the Thomas watt innovation and can not be taken after the closure of fossil fuel, all coal and nuclear fuel erodes from the world. The scientific community can redefine their goals only by understating the emergency for change not other wise – why and what is the need for change is discussed in the part-III of the research paper.

Part - III

The "Emergency and Need for innovation of new-generation unfolded till-date power generation technology – Totally environmentally friendly and safe in case of earth quakes and natural calamities situations.

Part - III (a) The background of present science and technology and mode of power and energy generation of modern world

The science and technology has advanced our life style and smoothened every aspect of our life. It has provided fast and comfortable ways of communication and travel, good home, better means of education and better health with it's medical advancements. The science and technology in it's path of comforting human's life in all sense, has invariably using resources from mother earth for it's power (energy), construction and other requirements. It is yaksha prashna that can we proceed in the same path eternally. The environmentalists are making hue and cry about the great dams, mining, fossil fuel extraction, oil spilling in sea, de-forestation, and all aspects of human interventions of nature in the name of advancement towards better and better living life styles.

The Most Important Question is How Far and How Much?

- The question posed (in this research paper) is whether we have to re-align & re–design and re-orient our science and technology so that we make lesser & lesser interference with the natural way of existence of nature?
- Whether the natural calamities that have increased over the present century, in particular in the recent few decades have any thing do or have any roots in our interference with nature and our direct interventions with the nature?
- If so to what extent we have are being (responsible and cause) reasons for the calamities?
- Have we to reconstruct a new path of science and technology which is totally environmental based and have no or least interventions to nature?

The research paper part iii rather poses questions, than inferring based on the limited study made. But these very questioning will be begin a new look at the other side of the problems of which we might have been not given much attention to.

The research paper part iii poses:- The question is similar to the Shakespearean dilemma in Hamlet " TO BE OR NOT TO BE (is the question?)" with no answer as no alternative is in the offing before us. The scientific community shall speed up the scientific resources for new sources of energy like atomic fusion and other nature friendly supplements for our requirements of energy, housing, infrastructure, transportation, clothing, medicine, telecommunication and so on.

Part –III (b) There are main three aspects of this Part – III of research paper to find the need to change the mode of power generation and energy requirement of the world

- whether human interventions into the very style of existence of nature, that have been more from two centuries and increasing exponentially with the increase of population and advent of science to use nature for our comforts, have increased the occurrence of natural disasters on earth?.

  which interferences may listed as follows:
  - Extraction of Fossil Fuel and Gas (leading creation of vacuum – vacant spaces beneath earth surface) and burning of same creating poisonous fumes affecting environment. (power generation)
  - Coal, Steel & Other Mining Activities. (energy and infrastructure requirements)
  - Massive Dam Constructions. (power generation)
  - Diverting Rivers Courses. (power generation)
  - Massive Deforestation (energy and infrastructure requirements)
  - Poching of Wild Animals (leading to imbalance of vegetation v/s wild life in forests).
  - Urban Population and Urban Infrastructure. (leading to concentration of weight at some points on the surface of earth). (more demand for power and energy requirement fro city internal and city to village transportation)
- The natural disasters, which we are trying to find, whether their roots or increase of occurrences are with human interventions (listed above) are:
  - Earth quakes (major disasters)
  - Tsunamis (like the that happened in India, Japan recently)
  - Great unusual floods (rains)
  - Volcanic eruptions
- The information system & it's development over five hundred years:
  - Advent of printing machines
  - Advent of computers
  - Advent of Radio and TV
  - Advent of satellite communication
  - Advent of Internet and Intranet information resources for speedy information flow.

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Part - III (c) The mapping of emergency for change in science and technology (power and energy generation systems and management)

Here we also find out whether & is there really an increase in the occurrence of natural disasters over a period of time, more importantly the author wants to find out, between 1800 to 2006, when scientific innovation has taken a rapid leap and changed the way we live and changed the very earth on which we live. (human interventions of nature for fulfilling his requirements of fossil fuel, ores, forest materials, water, etc, for a comforting life style which the modern science has gifted to mankind.)

These comments shall not be mistaken as the author's opinion is against the scientific inventions and innovations. This is only a constructive criticism whether the trend of science and technology is environmentally friendly or not? (The very earth is our home and the only home we have) and if so, how we can re align and re design our course so that we enjoy the "better life style" that "the science and technology particularly for power generation and energy requirements other than coal, extraction of fossil fuel and using nuclear power reactors for energy requirements - is going to offer us in future and at the same time it's way is totally environmentally friendly and interventions which may be (if) leading to natural disasters and (if) changing the nature irreversibly (shall be) be stopped for ever

Part - III (D) Introducing earth quakes and tsunamis and research study part - III to map emergency for new innovation in power and energy systems and management:

The earthquakes basically occur because of crest movements and other important seismological reasons according to earth quake experts and scientists. The Reiter scale reads the earth quakes classifications as mild, moderate, medium and devastating. The classifications are based on the reading scale that could be attributed in general sense as Mild – below 2, moderate above 2 and up to 4, medium above four up to 6.5 and devastating above 6.5 on the Reiter scale.

The earth quake has got specific frequency and occur more in specific earth quake prone scientifically marked and tested areas, though it's timing and the exact epicenter point (place of happening) can not be predicted. According to seismological research major earth quake will happen once in a time duration (may be one year or so) any where in world, but most probably in specific marked prone areas for crest adjustments. Mild earth quakes are repeated phenomenon of earth ,most probably beneath the oceans. Major earth quakes that happen beneath ocean near to land may lead to great disastrous tsunamis.

The chance factor that the epicenter will be located very near to the populated – urban area, area of dam, area of atomic reactor etc, are very rare but can not be ruled out and can not be predicted and even predicted about its arrival it can not can be avoided and averted and the danger of damage is immense and miserable and the recent Japanese experience in 2014 should it self show the great urgency for change and innovation for new power generation ideas. Which bring lesser damage to my earth.

But we are also looking into whether the human interventions like Dams, Very heavy multi storied constructions (like Tokyo tower) and other similar human interventions cause earth quake happen or intensify the earth quake that is may happen or increase the frequency of happening of the same. Some researchers have not ruled out the possibility of correlation and opined possibility of the increase of occurrences of such disasters in earth quake prone Areas like Japan, Indonesia, etc. So it could be construed that the human interventions in a big way will have some changes made in the eco-system which may lead to the happening of negative aspects of nature (natural disasters) more often than ever before.

The tsunamis occur because of earth quakes that happen inside ocean and the tsunamis that India has faced two years before have never been heard in our peninsula before on time line. The recent incidents in japan in 2013 proves a typical case to prove emergency for change and need for new generation of power reactors which are safe even in breakdown conditions & disasters for example there is damage to any persons if solar panel collapses because of the situations like the recent torrential rains and power breakdown conditions in US (2013-14).

Part - II (e): Introducing information system and research study for urgency for change requirements

The occurrence of Natural calamities and disasters have been recorded by time-immemorial by our ancestors, in their scriptures, on stone carvings, palm books, poetries and literatures. Even biblical scriptures, vedic scriptures and puranas speak in length about earthquakes, deluges (great flood), volcanic eruptions, shaking of earth, breaking of earth, falling of meteorites, (fire from sky) etc. But fifteen century on wards we have clear cut explanations and recordings (with out religious distortions) of the natural disasters that have occurred in different continents with their approximate dates and loss that have occurred due to disasters. But definitely the small calamities with or without human loss away from major cities might have not been recorded between 1500 to 1800. But after 1800 with the advent and strengthening of British and other European colonial rule around the world and emergence of independent America, Australia & other countries with increased communication & transportation facilities between countries, the popularity of printing machine, with growth and popularity of English as world language, the world events were recorded by sailors and British ruling executives, historians, archeologists, moving around the world. In the 20th century the advent & growth of telephone network in the wake of the century and the mind boggling internet revolution by the turn of century brings all information to our desk top with no delay.

According to author the information system has stabilized from the beginning of the century though today we get minute & detailed information we had sufficient information at least about natural disasters happening or not happening from news paper, radio from 1900 and also from 1970's in tv's. To reduce the redundancy of the study the data previous to 1800 has not been taken here as the information system has not stabilized previous to 1800 and communication was broken, delayed and not authenticated. But from 1800 and definitely from 1900, we have had quality information and it has been properly recorded because of the advent of paper in today's form and printing technology. The advent of Radio has solved

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major information block between world citizens & countries, & Tv has ceased the difference between countries & internet has virtually integrated the world not as a global village, but as a global home.

The author has observed that if we analyse the frequency of all natural calamities like earthquakes, Tsunamis, volcanic eruptions, great and unusual floods happened in two centuries. It revealed that between 1800–1900 very major devastating calamities (MDC*) causing great human & property loss were few, between 1900 to 1940 - it's numbers have increased, between 1940- 1970 once in decade MDC have occurred (approx), between 1970 to 1990 once in five years (approx) and between 1990–2000 approximately once in two years, from 2000 approximately once in a year a MDC has occurred some where in the world. WHY? (Armenia, Bhuj, Latur Indonesia earth quakes, recent tsunami in Indian ocean, torrential rains at Texas, Mumbai and similar major disasters in US have been taken into account)

- Is it because we were not informed in the previous decades and only now we are connected by strong information network like Radio, TV. Internet. (Answer may be No!).
- Is it only because of traditional reasons like continental movements, ice melt, crest movements & other seismological reasons etc. (Then why the frequency of such occurrence have increased over recent decades.)
- Is it due to extraction of coal and fossil fuel & fuel's burning has exponentially increased over this century. (appears to have destabilizing the foundations where we live)
- Steel and other major mining activities (including sea mining)
- Deforestation
- Very big dams
- River course changes
- Population
- Other human interventions

Part - II (f): The suggestions and questions for scientific and technological communities which are highly relying on present systems for power generations and energy management systems in the world

We have to check whether above reasons are contributing to this increase in the frequency and whether we have to re align our science and redefine our science and technology in terms of totally environment friendly by immediately stopping rocketing way we are proceeding in the present style of science-tech-life and start inventing a new environmental based science and technology for energy (fusion & other technology in place of coal, nuclear & fossil fuel) and to fulfil other amenities we require for our present day life style.

Or whether we will not have our earth in the same beautiful and serene way we see today & will it become a place of greatet uncertainties and disasters.

(Letus Stop Medling Nature Beyond Limit Before It is Too Late - let us question our selves "how far and how much?" and have we crossed the limit –Lakshman rekha or we are well with in the limit of safety for ourselves and our only world).Even if the above finding is not true or even if we feel or find there it is a rare probable, but possible reason (could be assigned to these causes) for the disasters we shall have to pull up our socks and start working the direction mentioned below:

Part - II (g): Alternative solution for better planning of power and energy planning and lesser environmental interferences

- Stop urbanization: small packets of human habitations separated by well net communication facilities and but nature as it is in between them. They use lesser power than being in larger cities.
- Stop constructing very big dams: smaller dams and smaller power projects.
- Unfolded new- environmentally friendly research (fusion or some thing else we don't know till the scientist find it) as focus in the energy front: (and non conventional – reusable environmental friendly energy resources)
- Deforestation & planting trees every where. Where ever possible to protect world from green house effects and the uncertain rains effecting the hydro power projects which are highly environmentally friendly.
- Stop poaching wild animals like tigers, lions, etc, with greater awareness programs than just by laws & enactments fro ecological balance (and also to show them to next generations as better entertainment options then the malls, theatres and others which consume more power requirements)
- Have scientific consensus before any river course are changed or rivers are joined just to have big hydro power projects and big dams which might create imbalance to the earth surface because of heavy weights concentrated in some areas putting pressure and creating stress in earth environment. Planning for smaller dams and river flow utility for power generations in each villages is a must and need of the hour.
- Stop or reduce unwanted mining activities (shows great emergency to find new energy generating systems & science alternatives). National policy with international consensus for every nations participation in the whole conservation programme of nature as it is. (energy requirements)
- All nature's interferences and human interventions are questioned &scientifically tested whether they are affecting our earth in any way like global warming, green house effect, increasing calamities, un-seasonal rains, acid rains etc, and whether such interference is inevitable or an alternative course is available for progress with out nature's destruction is listed searched before proceeding further.

Part- III conclusions

These points show that the present science and technology should redefine themselves for and march towards finding new alternatives like solar, tidal, hydro systems and which are not based on fossil fuel, coal, nuclear fuel etc, to match the ever increasing need for more power and energy needs of the society.

Part- IV – Implementation process

Implementation process of new -technology

We are astonished always, why most of the recent & innovative new technology power sector systems and power management kaizens (continuous improvement baed projects with great advantages of power savings and power loss avoidance systems) and some innovative plans in the traditional environmentally friendly power generation systems like solar, tidel, hydro (river flow

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based), wind etc, are not being used and unfortunately becomes only part of research publications (any kept aside by policy makers as non-viable/economically or otherwise because of mindset and attitude problems) is addressed by the new implementation plan under the Dr. Bhargav's TQM-PPT model fro which a pilot survey has been done in Ksrtc, Karnataka with research scholar Ramamurthy controller, KSRTC. (one of the highest energy consumption organization for public transport systems in Karnataka)

The tentative conclusions based on the specific pilot survey conducted (at KSRTC) and arrived at generic conclusions could be applied in new technology and kaizen implementations in power sector research, management and implementation process (conducted in the first years of research) are as follows based on the questionnaire survey and the outcomes and findings of statistical study and its interpretations.

Part-iv-1: Findings

The research revealed that there is a must that the major change management inputs are to be addressed proper in any organization or department if the new – technology implementation to should shall have smooth slide without any resistance (or least resistance) and with better acceptability and cooperation

Part-iv-2: Findings

The research brought out that the need and significance of technology training as well as human resource based –

- Leadership training for implementers and ownership building exercise for managers.
- Technology training and site visits (already implemented areas) for executives in India and abroad for planners and top executives and selected managers.
- New-technology training for all managers and officers – implementers.
- New-technology training for all supervisors and other sub- officials. (subjected to new-technology) in batches and stages
- Human relations based training for all supervisors and other sub- officials. (subjected to new-technology) in batches and stages

Part-iv-3: Findings

The research unequivocally declared by way of research a requirement of good human relations between the implementers and the sub-officials by way of a clear cut policy of motivation, incentives, awards and promotion plans attached to proper cooperation and successful implantation of technology in their respective units of work, department and by self (himself / herself).

Part-iv-4: Findings

The research brought out the importance of feedback systems and that the proper corrective actions as the basis for successful implementation at all stages like initial planning, pilot implementation, 1st stage implementation, major cities, zones wise and district wise and whole state implementation

Part-iv-5: Findings

The research brought out that the feedback systems shall be in-place at all stages and all zones of new-technology implementation with reference to changing customer needs and aspirations with regard to the technology implemented, the changes required by them, the improvement in the speed of service (like bringing on-line, mobile and other mode of booking and reservations), the safety and security aspects, & finally customer friendliness and majorly technology failure situation handling issues being properly addressed with.

Part-iv- New model of "change management and new tech-implementation"

The research has suggested a integrated suggestion in from of new- model for successful implementation. The suggested new model of " change management and new tech-implementation" that is tested by the research is as follows and shown in the flow diagram.

The new model of change management inputs for new-tech-implementation is a PPT Approach – people – process & technology.

In new technology implementation scenario in power sector management and innovation and kazien implementation plans for success and social contribution of the research to research to reach the common man and humanity as a whole the above generic model can be used with some modifications

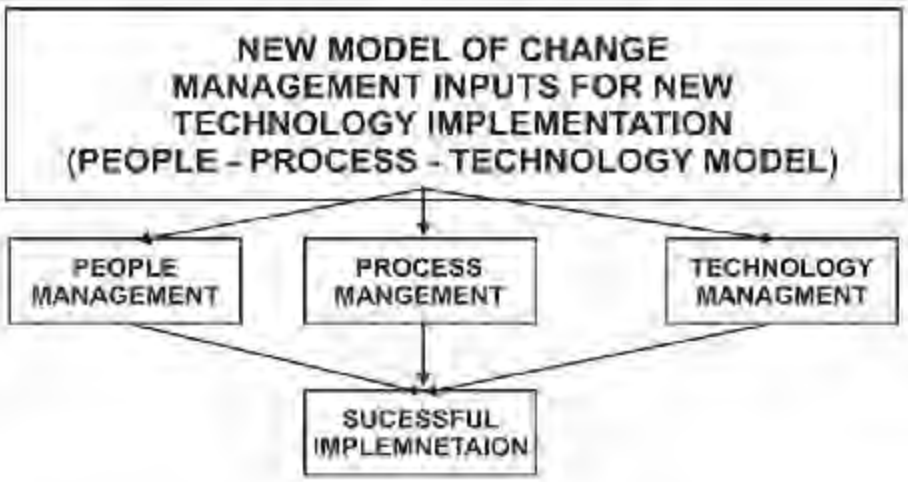
Part- V

Integration process and innovation , change and implementation process

Model for the weightages, for the five force components, for redefining the technology and science "kaizen and innovation process

- Part - I: the kaizen the continuous improvement of the present system -weight age – 20%
- Part - II: the innovation in the field of power generation – weight age – 40%
- Part - II: the need analysis and change plan for kaizen and for innovation weight age– 10%
- Part - IV: implementation process for kaizen as well as innovation power – New TQM PPT model for change -20%
- Part - V: integration process of change, improvement(kaizen) and innovation – 10%

The policy makers and scientific and technological community should see the present damage to the nature and world by present science and technology implementations and in the above mentioned and concluded weightage of attention and commitment will



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Conclusions

We conclude after looking at innovation and implementation challenges that by only feeling deeply the emergency for change and innovation humanity and human race can with their scientific and tecnological expert teams across the world joining together for the redefining the 'kaizen' and 'innovation process' towards improving present systems of electrical sources effectively and efficiently & in finding new renewable environmental friendly, safe, secure and sustainable high voltage power generating energy sources for future of the world and next generation'.

Profile

Dr Bhargav S V Ramachandra,

Director and processor, Total Quality Management school, has graduated in science and with post graduation and doctorate in management from university of Mysore. He has published several research papers in international journals and accredited as chief guest and guest of honour and has chaired several sessions in national & international conferences in India & abroad. Presently he is involved in four years research private project on "change management requirements in new technology implementation scenario".

Dr Vanitha R Bhargav

HOD and professor, Total Quality Management school, Mysore. Graduated in science with post graduation in development, planning and management from university of Mysore, doctorate and fellow in management. Her doctorate is on TQM and presently involved in research on 'kaizen & innovation process "as part of academic progress. She is guiding many research scholers in Bharathiar university, Coimbatore towards doctorate degree in management and allied subjects in foreign universities.

Sindhu V Dixith

Research associate and Electrical technology student, National Institute of Engineering, Mysore has given required support for the research paper design and is part of Total quality management research team – student wing for finding new methods & processes through brainstorming sessions.

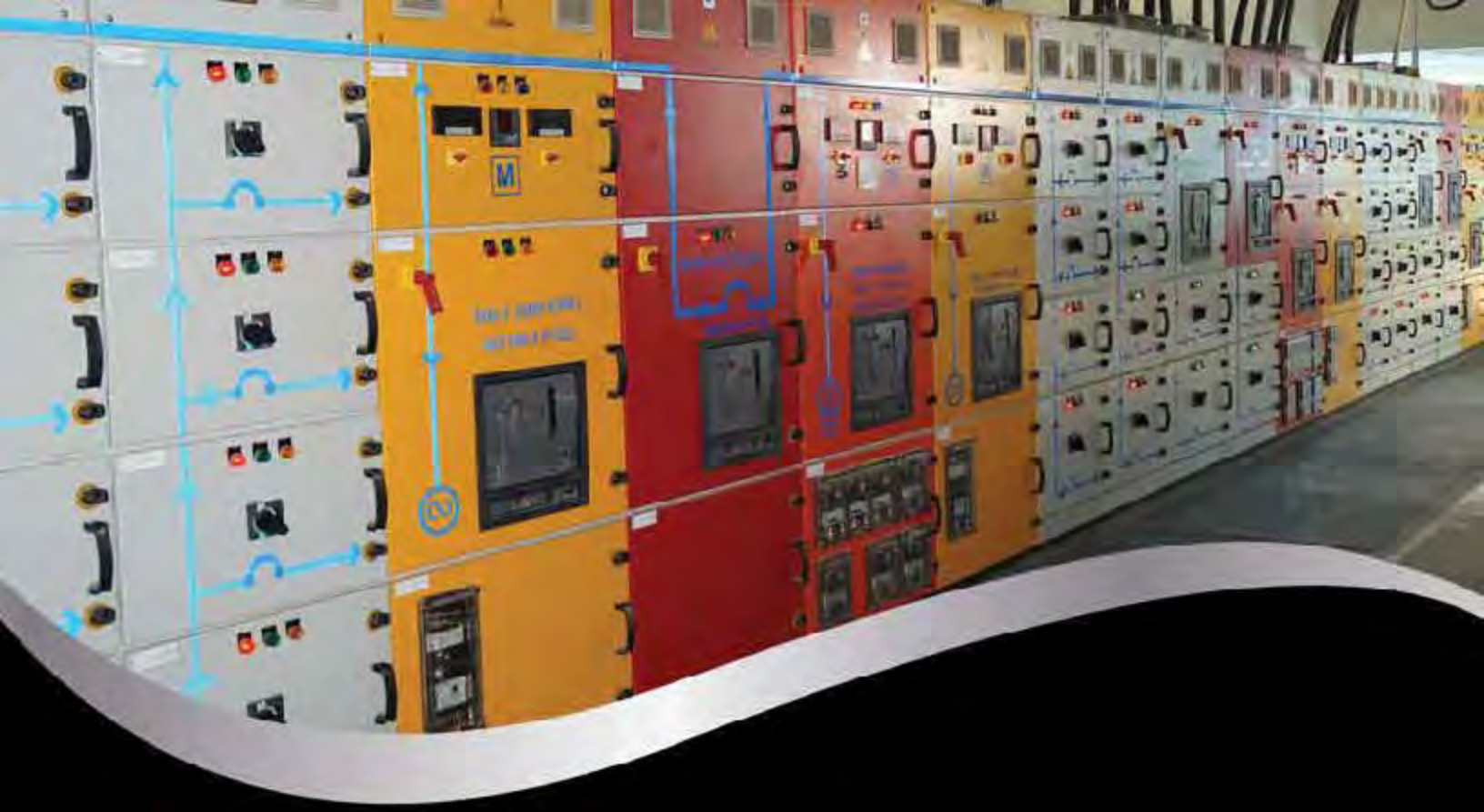
NTPC to Contribute to the Improvement of Indian Power Sector

Appreciating NTPC's performance and contribution to the Nation, Piyush Goyal, Minister of State (Independent Charge) for Power, Coal & New and Renewable Energy said the company has still bigger goals by aligning with the national mission. Addressing NTPC's International Power Plant Operation and Maintenance Conference in New Delhi with theme 'Fuel Adequacy' to commemorate commencement of service from its first ever generating unit at Singrauli, on the same day in 1982, he said NTPC has seen turbulences & crisis and evolved as a better organization over a period of time. Goyal added, that it is his target to make NTPC the world's most valuable company in next 5 years and urged all the employees to take this as a challenge and personal commitment by providing cheap and quality electricity to the masses.

D V Kapoor, Founder Chairman of NTPC, A S Bakshi, Member Central Electricity Regulatory Commission & former Chairperson Central Electricity Authority, Dr Arup Roy Choudhury, Chairman and Managing Director, NTPC & K K Sharma, Director (Operations), NTPC Ltd also spoke during the inaugural session. In his address, D.V. Kapoor said, that NTPC was created to escalate power generation at the time when India was suffering from acute power shortage. NTPC took up the challenge and emerged as most efficient company that set benchmarks for the sector, he added. He appreciated the role of Finance and HR for the success of the organization along with Engineering. A.S. Bakshi in his address called NTPC Nation's Pride which has brought innovative practices in the sector. He said, the purpose of the conference is to share and learn from each other.

Dr. Arup Roy Choudhury, CMD NTPC emphasized on the need for improvement in efficiency to bring down cost of generation. He said, fuel and water are scarce and a judicious use of these two is important and need retrospection in forums like these. He spoke about the need to weed out old redundant practices with new and more efficient ones at all power stations. K. K. Sharma assured the gathering of NTPC's commitment to efficient generation while naming environment and fuel as the biggest challenges.

The conference is being attended by over 300 delegates with power industry representatives from USA, Germany, China, Japan, Australia as well as from domestic players like TATA Power, Adani group, GMR group, and many State Sector Power companies.



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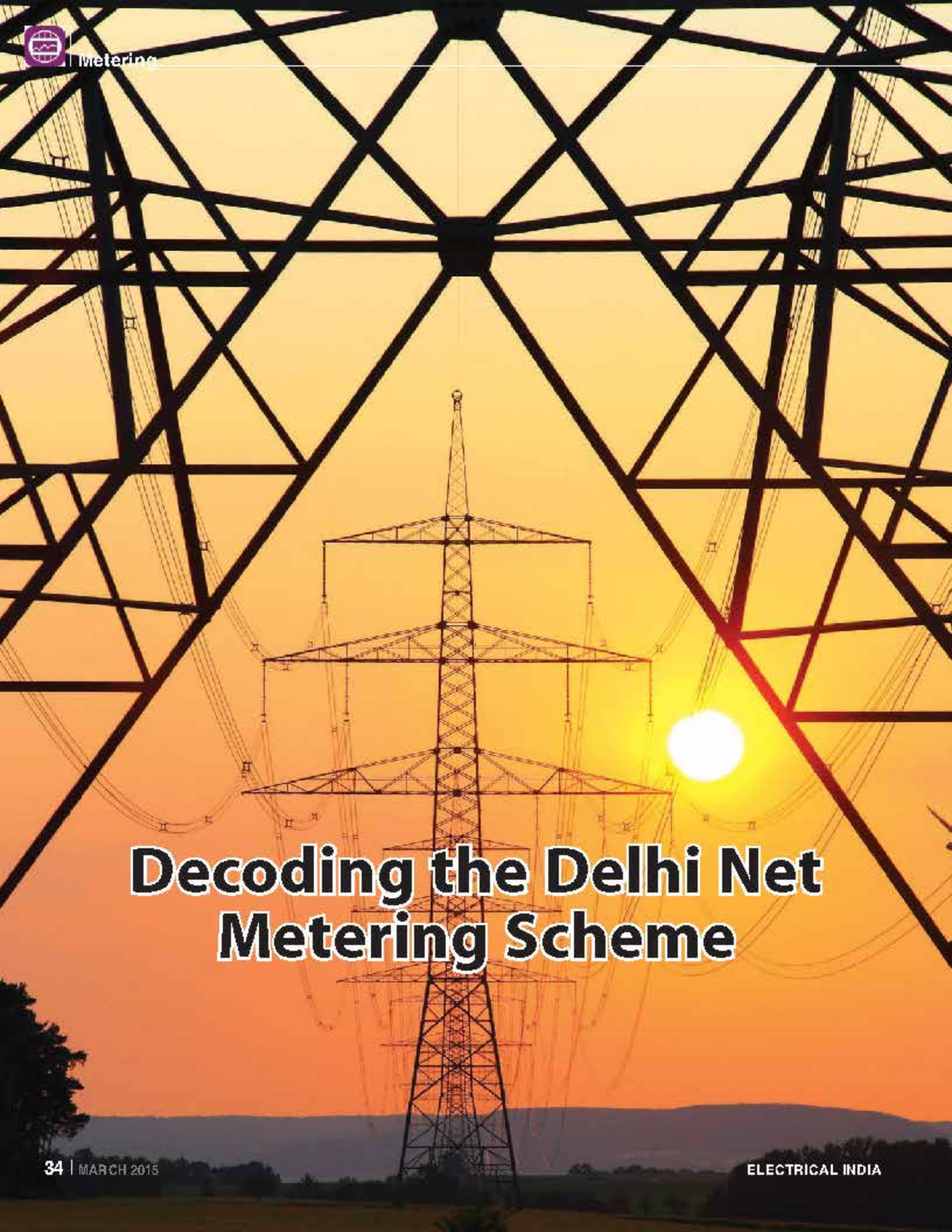

Decoding the Delhi Net Metering Scheme

Across the country, there is a growing interest in deploying Solar PV Rooftop technology. Solar PV rooftop segment is growing to look promising owing to the advantages it offers. Also industry has realised need for a complementary metering mechanism that can be a game changer for the large scale implementation of these systems.

Metering plays an important role in helping us to understand the performance of solar energy systems. Net metering, a metering arrangement where only 'excess' solar electricity is sent to the grid and its amount recorded. The saving reduces consumer's electricity bill in two ways, it results in a lower use of electricity from the network, and adequate payment for the exported amount. Net-metering approach to Solar PV Rooftop promotion is ideally suited for India, since it is socially equitable, economically viable, and environmentally sustainable. Since 2013 India places emphasis on net metering. Looking at the advantages net metering mechanism offers, it has received a strong policy support at central and state level. States like Tamil Nadu, Uttarakhand, Delhi, Punjab, and Andhra Pradesh have issued final guidelines for the implementation of net metering policy; others states like Haryana, Karnataka have only issued draft regulations. Following are the highlights of recently released net metering policies & regulations of different states.

Delhi took a huge leap in renewable energy generation when Delhi Electricity Regulatory Commission (DERC) announced regulations for net metering of renewable energy, giving Delhiites a chance to become renewable energy suppliers. The regulations are enforced by the guidelines issued for implementation of net metering in Delhi. While these net metering regulations apply to all forms of renewable energy like solar, hydro and wind, a recent study by 'Greenpeace' and 'BridgetoIndia' has estimated that in Delhi, only solar generation is feasible.

Although this net metering system will help consumers to reduce their electricity bill by allowing them to feed the excess power generated by their renewable energy system into the grid, the actual benefits are still undetermined as there is no clarity on how consumer will be paid for surplus power. As per the Delhi Net Metering guidelines, the Consumer shall be paid at the rate of Average Power Purchase Cost (APPC) of the Distribution Licensee for the respective year for net energy

Particulars	Punjab	Delhi	Haryana	Uttarakhand	Andhra Pradesh	Kerala	Tamil Nadu
Eligibility	All consumers	All consumers	consumers who intends to install or has installed solar rooftop plant	All consumers	consumers with three phase supply will be preferred	All consumers	HT Tariff II-A, HT Tariff III, LT Tariff IA, LT Tariff I-C, LT Tariff II-A, LT Tariff II-B, LT Tariff V as specified in the commission's retail tariff order
Cap on banking surplus power	Up to 90% of the electricity at the end of settlement period	Not specified	Up to 90% of the electricity at the end of settlement period	Not specified	Up to 90% of the electricity at the end of settlement period	Target Capacity	Up to 90% of the electricity at the end of settlement period
Restriction on Grid penetration	30% of distribution transformer capacity	20% of the distribution transformer capacity	15% of the peak capacity of the distribution transformer	Not specified	50% of the rated distribution transformer capacity	50% of the rated distribution transformer capacity	30% of the local transformer capacity
Eligibility for RECs	Not Eligible	Not specified	Not specified	Not specified	Not specified	Not specified	Not Eligible
Maximum system size	80% of the sanctioned load of the consumer	Will depend on feasibility of interconnection with the grid and Sanctioned load of the consumer	1MWp	100KW for projects with battery backup and 500 KWp for projects without battery backup	3 KW for single phase consumers	3 MW	Not specified
year of order	2014	2014	2014	2013	2013	2013	2013
Order status	Final	Final	Draft	Final	Final	Draft	Final

Source: State Net metering guidelines

credits which remain unadjusted at the end of the financial year on provisional basis but the poor financial health of the Discoms makes aspiring consumer suspicious about any such payment from Discom. Instead of complying Discoms to pay for this surplus power, commission could have devised incentives like reduction in tariff for the consumers generating surplus power or could allow the carry forward of these net energy credit to next settlement period. These steps will encourage consumers to go for probable adoption of renewable systems in the capital.

There is also a restriction on the level of grid penetration. Scheme states that the Distribution Transformer level capacity to be offered for connecting Renewable Energy System for Net Metering by the Distribution Licensee is 20%, which is considerably low in comparison to the southern states like Andhra Pradesh and Kerala, where it is as high as 50%. The higher the restrictions on the level of grid penetration, the lower will be the potential for the grid connected solar PV rooftop projects in the state. It is possible to replace existing transformers with highly efficient one that can handle a high level of distributed generation. The maximum size of system that a consumer can go for is also not specified in the guidelines. While capacity of solar plant is subject to sanctioned load of the consumer, consumer can extend this capacity beyond his sanctioned load on payment of SLD charges. Also while many states like Punjab, Tamil Nadu, and

The regulations are enforced by the guidelines issued for implementation of net metering in Delhi. While these net metering regulations apply to all forms of renewable energy like solar, hydro and wind, a recent study.

Uttarakhand have put a cap on surplus power, DERC net metering scheme doesn't contain any such provision that sets limit on the injection of surplus power to the grid. While this gives freedom to Delhi consumers to go for higher capacity Renewable systems, the downside of this non clarity is that customer wouldn't be sure about the evaluation of surplus power they are feeding into the grid and thus will prevent them going for higher capacity systems. States like Punjab, Haryana have capped the electricity generated from a solar PV rooftop system at 90% of the power consumption by the eligible consumer by the end of the settlement period. This clause favours discom but will discourage individual customers from the early adoption of solar PV rooftop as consumer won't be able to utilize his large available roof space and somewhere, he will have to rely on grid power. The eligibility of grid connected solar PV rooftop projects supported by net meters for renewable energy certificates (RECs) in these state net metering guidelines is also unstated. An explicit provision is needed with regard to the eligibility of such power for renewable energy certificates. This along with net metering will act as an incentive for solar PV rooftop adoption.

The Primary challenge is spreading awareness about regulations and policies at the local level. Just announcing a policy is not enough. A framework of processes needs to be created for its implementation. However, this has not been insured in most scenarios. State governments that have announced net metering guidelines have not done enough to educate local utility officials and the public in general about the regulation and how they would be implemented. Another major concern is that the grid in most parts of the country is not stable. For net metering to work effectively, the grid should be stable and available all the times. The net metering system will make solar PV rooftop projects more attractive to individual households and small industry setups, especially in new towns and cities where the rooftop project is implemented on a large scale. Net-metering is economically viable for consumers with high levels of energy usage and high avoided tariffs, and further provides cost certainty over the lifetime of the project. BridgetoIndia in its recent report, "India Solar Rooftop Map 2015", has presented a positive outlook for the Indian solar rooftop industry. According to the report, the pace of rooftop adoption is set to accelerate post 2016, owing to net metering benefits expected after other states also draft and implement this policy. This would be a driving factor in making solar rooftop a viable option.

NEWS

BHEL conferred the prestigious National e-Governance Gold Award for 2014-15

Bharat Heavy Electricals Limited (BHEL) has been conferred with the prestigious National e-Governance Gold award by the Union government for 2014-15. The award was given in the category - 'Innovative use of ICT by Central Government PSUs', for the project 'SAMPARK – Online Integrated Employee Centric services Portal', developed by BHEL, Bhopal. The Gold award carries prize money of Rs. 2 lakh, a trophy and a certificate. The award was presented by the Chief Minister of Gujarat, Ms. Anandiben Patel, in the presence of Sh. D J Pandian, Chief Secretary, Govt of Gujarat, Alok Rawat, Secretary, DARPG-GoI, R S Sharma, Secretary, DeitY-GoI & R Chandrashekar, President, NASSSOM.

Profile

Abhinav Gupta

Founder & CEO, SunSwitch India Pvt Ltd., is BSc, Mechanical Engineering from University of Illinois, Urbana Champaign U.S.A., and director. He was also an integral part of his University's Solar Decathlon team in the US -held every second year in Washington DC.

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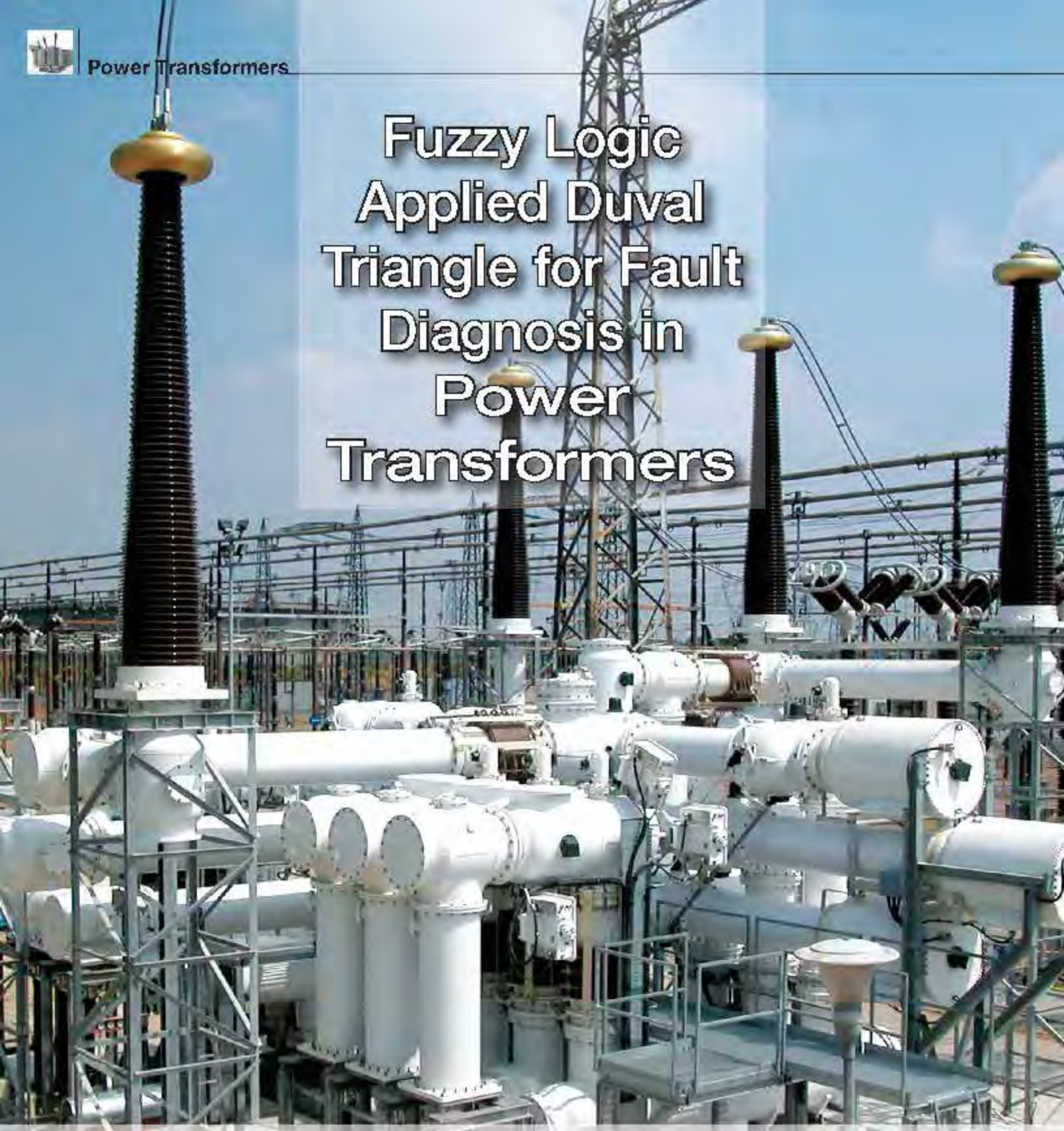
Fuzzy Logic Applied Duval Triangle for Fault Diagnosis in Power Transformers



The accuracy and uncertainties of diagnosis with dissolved gas analysis (DGA) is not satisfactory through conventional diagnostic techniques in power transformers. On other hand computer' applications have found wide spread applications 'human-like' capabilities to make judgments, guesses, change of opinions.

Sukhbir Singh and Dheeraj Joshi

In this article, fuzzy logic approach on Duval triangle 1 for fault diagnosis besides the diverse gas content of transformer oil has been presented. For this simplified approach the numerical zone boundaries of seven fault coordinates of Duval triangle 1 are assigned with percentages of the gases methane, ethylene and acetylene. These percentage zone boundaries of faults are used to make the membership functions and fuzzy rules. Finally, conventional interpretations techniques' fault diagnostic reports available from various organizations are compared with proposed fuzzy logic Duval triangle technique. Results reveal the increased in accuracy and reducing the uncertainties between the fault boundaries those can be improved further more and more by adding the experienced based fuzzy rules.

Transformer is one of the most important but complex component of electricity transmission and distribution system. The trend toward a deregulated global electricity market has put the electric utilities under severe stress to reduce operating costs, enhance the availability of the generation, transmission and distribution equipment and improve the supply of power and service to customers. Much attention is needed on maintenance of transformers in order to have fault free electric supply and to maximize the life and efficiency of a transformer. Thus, it is important to be aware of possible faults those may occur. It is equally important to know how to detect them early.

Formation of Gases in Transformer Oil

The faults that occur within the transformer protection zone are internal faults. Transformer internal faults can be divided into classification: internal short circuit faults and internal incipient faults. Incipient fault detection in power transformer can provide information to predict failures ahead of time so that the necessary corrective actions are taken to prevent outages and reduce downtime. Incipient faults can produce hydrocarbon molecules and carbon oxides due to the thermal decomposition of oil, cellulose, and other solid insulation.

Because the insulating oil used in power transformer is organic (i.e. composed primarily of hydrocarbons), certain fingerprint gases are generated at specific temperature ranges therefore, allowing the traditional methods to identify a possible fault temperature range and therefore the possible fault type. In the normal operation of the transformers, the released gases: Hydrogen (H_2), methane (CH_4), ethane (C_2H_6), ethylene (C_2H_4), acetylene (C_2H_2), carbon monoxide (CO), carbon dioxide (CO_2) and so on are small in quantities as ageing effects. When there is an abnormal situation, as occurring a fault, some specific gases are produced more than in normal operation and the amount of them in transformer oil increases. This decreases the insulation properties of the transformer oil.

Transformer is one of the most important but complex component of electricity transmission and distribution system

Dissolved Gas Analysis

The faults in power transformers can be detected and monitored for abnormal conditions with dissolved gas analysis (DGA). Throughout the world, different countries/utilities are using different fault interpretation techniques/tools to diagnose the faults; According to the pattern of the gases composition, their types and quantities, the conventional interpretation approaches below for dissolved gases are extensively followed as:

- IEEE Gas Guide C57.104™- 2008
- IEC Standards 60599
- IS 10593: 1992 Standards.

At first a sample of transformer oil is taken and calculations for sampling intervals can be decided between typical and pre-failure values (e. g. every year for transmission transformer and every six months for nuclear transformers/ power transformer), dissolved gases concentration requiring monthly, weekly, and daily sampling. Then the dissolved gases are extracted, separated and measured by means of chromatography. In order to interpret the results of experiment a data in suitable form to diagnose the faults is produced. The forming of the data is based on different standards.

Duval Triangle 1 Fault Interpretations

Conventional Duval triangle 1 technique used in fault diagnosis through dissolved gas analysis (DGA) in a power transformer is shown in Fig. 1. The faults have been divided in seven zones in an equilateral triangle. There are two different procedures to find the faults by the use of Duval triangles:

- By using total accumulated gas
- By using total increase between conjugative samples.

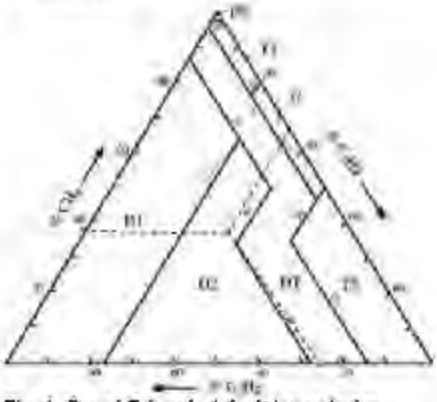


Fig. 1: Duval Triangle 1 fault boundaries

The following DGA interpretations are made in Duval triangle 1 for typical faults detected in power transformers given Table 1.

This Dissolved gas analysis involved percentage of these gases only in three dimensional arrangements: Methane (CH_4), Ethylene (C_2H_4) and Acetylene (C_2H_2) in Duval triangle 1 where:

$$\%CH_4 = \frac{100x}{x+y+z}$$

$$for,\ x = [CH_4]\ in\ ppm \qquad (1)$$

$$\%C_2H_4 = \frac{100y}{x+y+z}$$

$$for,\ y = [C_2H_4]\ in\ ppm \qquad (2)$$

$$\%C_2H_2 = \frac{100z}{x+y+z}$$

$$for,\ z = [C_2H_2]\ in\ ppm \qquad (3)$$

First calculate the sum of these three values: $(CH_4 + C_2H_4 + C_2H_2) = S$, in ppm, then, calculate the relative proportion of the three gases, in %:

$X = \%\ CH_4 = 100\ (A/S)$,

$Y = \%\ C_2H_4 = 100\ (B/S)$,

$Z = \%\ C_2H_2 = 100\ (C/S)$.

X, Y and Z are necessarily between 0 and 100%, and (X + Y + Z) should always = 100%.

Symbol	Fault	Examples
PD	Partial discharges	Discharges of the cold plasma (corona) type in gas bubbles or voids, with the possible formation of X-wax in paper.
D1	Discharges of low energy	Partial discharges of the sparking type, inducing pinholes, carbonized punctures in paper. Low energy arcing inducing carbonized perforation or surface tracking of paper, or the formation of carbon particles in oil.
D2	Discharges of high energy	Discharges in paper or oil, with power follow through, resulting in extensive damage to paper or large formation of carbon particles in oil, metal fusion, tripping of the equipment and gas alarms.
DT	Thermal and electrical faults	Mixture of thermal and electrical faults
T1	Thermal fault, T<300°C	Evidenced by paper turning brownish (>200°C) or carbonized (<300°C).
T2	Thermal fault, 300<T<700°C	Carbonization of paper, formation of carbon particles in oil.
T3	Thermal fault, T>700°C	Extensive formation of carbon particles in oil, metal coloration (900°C) or metal fusion (>1000°C).

Table 1: Transformer faults by Duval triangle 1

Fuzzy Logic for Proposed Technique

A fuzzy set F of a universe of discourse X= (0, 1) is defined as a mapping, $\mu_F(x)$: $X \rightarrow (0, \alpha)$, by which each x is assigned a number in the range $(0, \alpha)$, indicating the extent to which x has the attribute F. if x is say 'small' a value of fuzzy variables from the range of '0 to ∞', then $\mu_{small}(x) \in (0, \alpha)$ is called a 'membership function'. A membership function is normalized (ie., $\alpha = 1$), thus $\mu_F(x) : X \rightarrow (0,1)$, fuzzy logic is called 'normal'. The normalization of fuzzy set $\overline{F}$ is expressed by $\overline{F}$

$$\sup \mu\overline{F}(x) = 1 \qquad (4)$$

Where $x \in X$, normalization of a set of numbers is achieved by dividing each number of the set by the largest one, the supermum. Where, X be a time-invariant set of objects x. a fuzzy set $\overline{F}$ is X will be expressed by a set of ordered pairs:

$$\overline{F} = [(x, \mu\overline{F}(x)) \mid x \in X] \qquad (5)$$

Where, $\mu\overline{F}$ is the membership function that maps X to the membership space M (i.e. 0 to 1) and $\mu\overline{F}(x)$ is the grade of membership (degree of truth) x in $\overline{F}$.

Methodology Used for Fuzzy Logic Approach

Step 1: In this research work, firstly, polygon coordinates for the numerical zone boundaries of seven key faults of Duval Triangle 1 have been generated in terms of percentages of CH_4, C_2H_4 and C_2H_2, from 0% to 100% respectively shown in Table 2.

Area	Points	%CH_4	%C_2H_4	%C_2H_2
PD	PD1	98	2	00
	PD2	100	00	00
	PD3	98	00	2
D1	D11	0	0	100
	D12	0	23	77
	D13	64	23	13
	D14	87	00	13
D2	D21	00	23	77
	D22	0	71	29
	D23	31	40	29
	D24	47	40	13
	D25	64	23	13
DT	DT1	00	71	29
	DT2	00	85	15
	DT3	35	50	15
	DT4	46	50	4
	DT5	96	00	4
	DT6	87	00	13
	DT7	47	40	13
	DT8	31	40	29
T1	T11	76	20	4
	T12	80	20	00
	T13	98	2	00
	T14	98	00	2
	T15	96	00	4
T2	T21	46	50	4
	T22	50	50	00
	T23	80	20	00
	T24	76	20	4
T3	T31	00	85	15
	T32	00	100	00
	T33	50	50	00
	T34	35	50	15

Table 2: Numerical fault zones in percentage on vertexes

Step 2: Fuzzy Diagnosis System, The fuzzy logic analysis involves three successive processes; namely fuzzification, fuzzy inference, and defuzzification. Fuzzzification converts the crisp the gas percentage into a fuzzy input membership. The fuzzy inference system (FIS) is responsible for creating the knowledge-based fuzzy rules set of If-Then linguistic statements. Defuzzification then converts the fuzzy output values back into crisp output actions.

Fuzzy inputs-gas percentages

In this diagnostic each crisp value of gas percentages (CH_4, C_2H_4, C_2H_2) from Table 2 changed to triangular fuzzy-membership function ranges (i.e. A.....L, A1.....G1 & A2..... H2 respectively), given in Table 3. Fuzzy-membership function for %CH_4 obtained in MATLAB fuzzy-box tool is illustrated in Fig. 2.

CH_4		C_2H_4		C_2H_2	
A	0-10	A1	0-1	A2	0-1
B	25-35	B1	0.5-5	B2	0.5-5
C	35-45	C1	5-15	C2	10-20
D	45-55	D1	15-25	D2	25-35
E	55-65	E1	30-40	E2	50-55
F	65-70	F1	35-45	F2	60-65
G	70-80	G1	90-100	G2	85-95
H	80-85			H2	95-100
I	85-90				
J	85-95				
K	95-98				
L	90-100				

Table 3: Triangular fuzzy-membership ranges

Fuzzy-rule base

The set of fuzzy inputs (% three gases) with their respective membership function form the integral part of fuzzy logic analysis. The fuzzy rule set (If-then linguistic statements) with AND operator for minimum and OR operator for maximum fault conditions is then used form 'judgement' on the fuzzy inputs derived from the 3 gas percentages, whose sum is always 100%. For example,

Rule 10: If (CH_4 is E) and (C_2H_4 is E1) and (C_2H_2 is D2) then (FAULT is D24)

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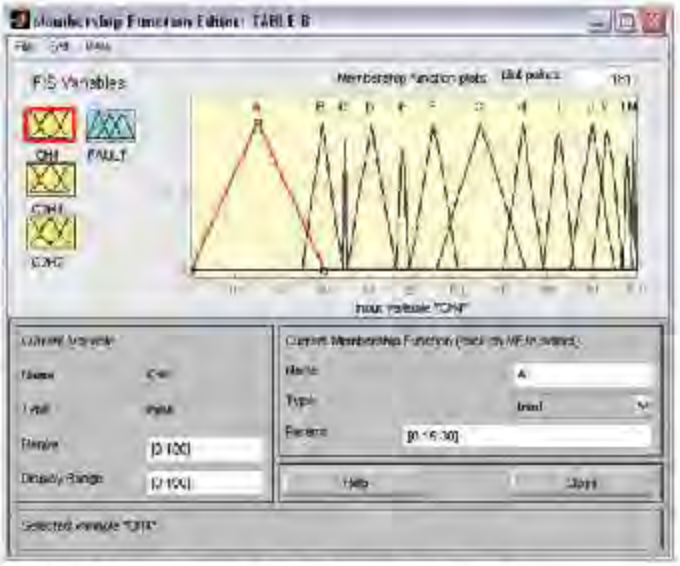

Fig. 2: %CH_4 membership function in MATLAB toolbox

All such 32 fuzzy rules just derived from Table 2 for mapping the fault types and screen shot of these rules is shown in Fig. 3 in MATLAB environment. Although these faults are defined strictly for the percentages of the zone boundaries of 7 faults in Duval triangle 1 coordinates. These 34 rules are just mapped on the joining points of the numerical zone boundaries of the faults in Duval triangle 1 coordinates. Membership function plot of the faults is also illustrated in Fig. 4 in MATLAB environment.

1. If (CH4 is M) and (C2H4 is A1) and (C2H2 is A2) then (FAULT is PD2) (1)
2. If (CH4 is L) and (C2H4 is A1) and (C2H2 is B2) then (FAULT is PD3) (1)
3. If (CH4 is A) and (C2H4 is A1) and (C2H2 is H2) then (FAULT is D11) (1)
4. If (CH4 is A) and (C2H4 is D1) and (C2H2 is G2) then (FAULT is D12) (1)
5. If (CH4 is G) and (C2H4 is D1) and (C2H2 is D2) then (FAULT is D13) (1)
6. If (CH4 is J) and (C2H4 is A1) and (C2H2 is D2) then (FAULT is D14) (1)
7. If (CH4 is A) and (C2H4 is D1) and (C2H2 is G2) then (FAULT is D21) (1)
8. If (CH4 is A) and (C2H4 is H1) and (C2H2 is F2) then (FAULT is D22) (1)
9. If (CH4 is B) and (C2H4 is E1) and (C2H2 is F2) then (FAULT is D23) (1)
10. If (CH4 is E) and (C2H4 is D1) and (C2H2 is D2) then (FAULT is D24) (1)
11. If (CH4 is G) and (C2H4 is D1) and (C2H2 is D2) then (FAULT is D25) (1)
12. If (CH4 is A) and (C2H4 is G1) and (C2H2 is F2) then (FAULT is DT1) (1)
13. If (CH4 is A) and (C2H4 is H1) and (C2H2 is E2) then (FAULT is DT2) (1)
14. If (CH4 is C) and (C2H4 is F1) and (C2H2 is E2) then (FAULT is DT3) (1)
15. If (CH4 is D) and (C2H4 is F1) and (C2H2 is C2) then (FAULT is DT4) (1)
16. If (CH4 is K) and (C2H4 is A1) and (C2H2 is C2) then (FAULT is DT5) (1)
17. If (CH4 is J) and (C2H4 is A1) and (C2H2 is D2) then (FAULT is DT6) (1)
18. If (CH4 is E) and (C2H4 is E1) and (C2H2 is D2) then (FAULT is DT7) (1)
19. If (CH4 is B) and (C2H4 is E1) and (C2H2 is F2) then (FAULT is DT8) (1)
20. If (CH4 is H) and (C2H4 is C1) and (C2H2 is C2) then (FAULT is T11) (1)
21. If (CH4 is I) and (C2H4 is C1) and (C2H2 is A2) then (FAULT is T12) (1)
22. If (CH4 is L) and (C2H4 is B1) and (C2H2 is A2) then (FAULT is T13) (1)
23. If (CH4 is L) and (C2H4 is A1) and (C2H2 is B2) then (FAULT is T14) (1)
24. If (CH4 is K) and (C2H4 is A1) and (C2H2 is C2) then (FAULT is T15) (1)
25. If (CH4 is D) and (C2H4 is F1) and (C2H2 is C2) then (FAULT is T21) (1)
26. If (CH4 is F) and (C2H4 is F1) and (C2H2 is A2) then (FAULT is T22) (1)
27. If (CH4 is I) and (C2H4 is C1) and (C2H2 is A2) then (FAULT is T23) (1)
28. If (CH4 is H) and (C2H4 is C1) and (C2H2 is C2) then (FAULT is T24) (1)
29. If (CH4 is A) and (C2H4 is H1) and (C2H2 is E2) then (FAULT is T31) (1)
30. If (CH4 is A) and (C2H4 is I1) and (C2H2 is A2) then (FAULT is T32) (1)
31. If (CH4 is F) and (C2H4 is F1) and (C2H2 is A2) then (FAULT is T33) (1)
32. If (CH4 is C) and (C2H4 is F1) and (C2H2 is E2) then (FAULT is T34) (1)

Fig. 3: Fuzzy DGA rules

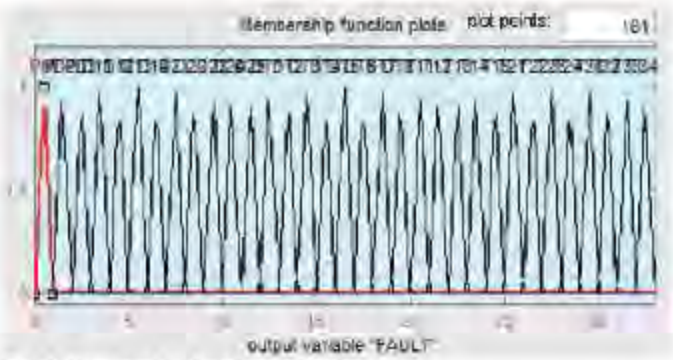

Fig. 4: Membership functions of faults

Fuzzy Inference System (FIS)

FIS involves the operation between input fuzzy sets as shown in figure 5, known as 'Mamdani' type. This derives output fuzzy sets 'judging' all the possible fuzzy rules by finding the membership for the fault types as represented by 34 fuzzy output rules. The solution is reached by weighted average of the fuzzy inputs. The spikes in the figure denoting probabilities between 0 and 1 are the outputs from each fuzzy rule, which denotes the fault type. Thus each rule is a row of the plots and each column is variable.

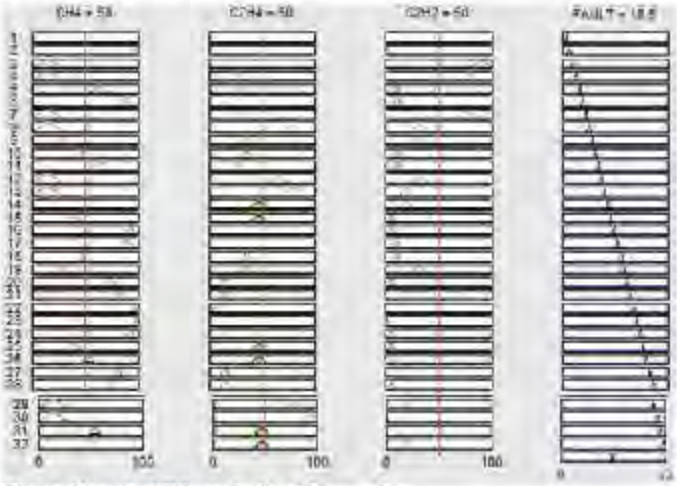

Fig. 5: Mamdani FIS analysis of fuzzy rules

Results and Discussions

In order to evaluate the performance of the proposed fuzzy logic for fault diagnosis in power transforms through DGA, transformers' fault analysis reports collected from different utilities and authorities are tested. Reported faults by different conventional diagnostic tools such as IEEE C-57, 104TM 2008, CIGRE, IEC Key gas ratios, Roger's gas ratios, Doernenburg' gas ratios and others are reconfirmed with fuzzy logic Duval triangle 1 based diagnosis. This fuzzy logic Duval triangle approach is also compared with other specifically generated MATLAB based Duval triangle 1 diagnostics tool. This has been achieved by forming different sets of fuzzy inputs and output rules on experiences (fault analysis reports) basis and by changing the FIS for inputs. Results are tabulated in Table 4. Results are found more specific & crisp. Result table has been prepared for integers (round up values) and nearer numerical values at the fault zones for three input gas percentages. Duval triangle 1 approach is cross

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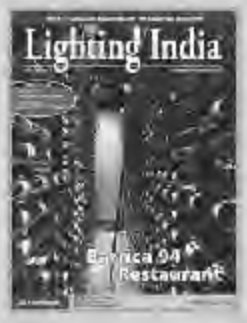

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Sr. No	Transformer Ratings		GASES (ppm)			Gases (%)			DGA Fault Diagnosis/Comments				Duval Results	
	MVA	KV	CH_4	C_2H_4	C_2Hv	CH_4	C_2H_4	C_2H_2	CEBG	IEC, CIGRE	IEEE/ Reco.	Comnts:	Software	Fuzzy logic
1	315	400/220	79	89	0	47.02	52.98	0.00		300-700^{0}C	<700^{0}C		T2	T21
2	250	16/420	40	10	0	80.00	20.00	0.00	200-300^{0}C	NF	200-300^{0}C	Ind. Gases	D1	T12
3	16	132/33	3	64	42	2.75	58.72	38.53			OH	OH	DT	D22
4	6.3	33/11	2	28	0	6.67	93.33	0.00			OH	OH	T3	T32
5	200	420/21	1	1	0	50.00	50.00	0.00	PD	NF	N	IG	T2	T22
6	16/20	132/33	17	17	0	50.00	50.00	0.00			T	OH	T3	T33
7	75	NG	14	0	0	100.0	0.00	0.00	PD	PD, D1, T1	N	H_2, CO_2	PD	PD2
8	16	NG	50	61	43	32.46	39.61	27.92	N	D1, D2	SRQ		D2	DT8
9	250	NG	547	530	ND	50.79	49.21	ND		300-700^{0}C	Cir. C		T2	T22
10	50	NG	92	120	4	42.59	55.56	1.85	>700^{0}C	D2,T3	N	H_2, C_2H_2	T3	T33

Table 4: Comparative table for reported faults in power transformers with fuzzy logic Duval triangle 1 approach

Cir. C	Circulating Current
NF	No Fault
Ind.	Individual
PD	Partial Discharge
N	Normal
SG	Gases
IG	Individual Gases
S OK	Sample OK
NA	No Abnormality
DZD	Denominator Zero Diagnosis
DZD B	DZD Bypassed
MF	Mixed Fault
CO	Conductor Overheating
DUVAL	Duval Triangle
SRQ	Sample req. quarterly
T	Testing Required
Reco.	Recommendation
AD	Arc Discharge
Comnts	Comments
NI	Not Identified
NG	Not Given
TF	Thermal Fault
DA	Discharge Arcing
OH	Overheating

Table 5: Special Abbreviations used in above result

verified to provide more than 90% accurate results applied to the available fault reports. In some cases this DGA method could not provide the results, reasons are unclear fuzzy rules and the membership functions. This approach is more effective in case faults are ambiguous on zone boundaries. Table 5 has been tabulated to use these abbreviations/shorten forms in the result Table 4 only.

Conclusions

In this article, fuzzy logic Duval triangle 1 is applied for the interpretation of faults keeping in view that Duval Triangle 1 to Duval Triangle 5 needs three gases only. This approach can be explored to improve the incipient fault diagnosis technique by adding more and more fuzzy rules and adding membership functions. Fuzzy rules can be mapped for possible real number input percentages. Fuzzy logic is applied as the practical representation of the relationship between the fault type and the dissolved gases percentages with fuzzy membership function. To increase the accuracy of this method, more transformers fault reports should be analysed to compare the actual faults. In addition, appropriate membership functions and fuzzy rules are necessary to obtain the acceptable accuracy and to reduce the ambiguity between the faults.

Profile

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Received degree in Electrical Engineering and Master of Engineering (C&I) in (Delhi College of Engineering, Delhi, (D.U.) & PhD from NIT Kurukshetra. He has worked in Indian Air Force for 15 years in the engineering field and since 1993 onwards in teaching in India and Abroad. He has an interest in Fuzzy and Neural Networks.

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Nitrogen Injection Fire Prevention and Extinguishing System for Oil Filled Transformers

Different types of Transformers are used in power system. Commonly used power transformer is oil filled power transformer. In the oil filled power transformer oil act both as insulating and cooling media. During an internal fault resulting in an arc will cause fire. The fire may spread resulting from ignition of oil, causing explosion of tank, rupture of tank, core and winding and also burning the neighbouring equipment's.

Kiran Kumar R B

The "Nitrogen injection and drain method" is one of the best fire prevention and extinguishing system for oil filled transformers for indoor/outdoor use. This system is fully automatic and unattended, Maintenance free and low cost compare to other systems.

Fire - Anatomy & Classification

What is Fire?

Fire is an exothermic chemical reaction in which combustible material combines with oxygen in the atmosphere to give out heat and flame. But once fire has begun, the heat produced may often be sufficient to support or even accelerate the process. The materials involved in the combustion process may be in solid, liquid or gaseous state. They are also identified as two or three-dimensional

- Two-dimensional fires are those where fire and fuel are on a single plane or flat surface. Ground fire or trench fire fall in this group of fires.
- Three - dimensional fires are complicated fires of falling liquid streams or fuel under pressure escaping from a container. Fire resulting from leak of transformer oil falls under this category.

Fire is not happen by their own self. It require some elements,Four factors/ Elements must be required in order before combustion occurs. They are,

- Heat-Sufficient to raise the temperature to ignition point
- Oxygen at sufficient quantity
- Fuel
- Chemical Chain reaction of above three mixtures.

The Fire Triangle/ Fire Tetrahedron

Nitrogen injection and drain method is one of the best fire prevention and extinguishing system for oil filled transformers for indoor/outdoor use

These Four elements may be represented in the form of a Tetrahedron.

Just as removal of one or more sides of a tetrahedron causes its breakdown, the removal of one or more factors causes the fire to cease.

Stages of Fire

Except explosion, most fires have humble starting and grow through the following four stages of combustions:

- **Incipient stage:** At this stage decomposition is occurring at the surface of the fuel due to the influence of some form of heat. Products of combustion given off at this stage are invisible to the eye.
- **Smouldering Stage:** At this Stage, up to 10% of the decomposing products released at the surface of the fuel are visible.
- **Flaming Stage:** Vapours from the decomposing fuel have ignited and are at the stage where flames are self-propagating.
- **Heat stage:** At this stage the burning has progressed to the point where the fire is still small but generating sufficient heat to warm the air immediately around the fire sending warm products of combustion upwards by convection. The above principle is used for the selection of fire detectors.

Classification of Fire as per Bureau of Indian Standards (BIS)

Combustible substance can be present in three states - solid, liquid and gaseous state. The burning of most materials produces a flame, this occurs when vapour or gas given off by the liquid or solid materials is ignited. Depending upon the nature and state of the burning material, fires are generally classified into A, B, C or D type.

Class - A: Fire

These are fires involving solid materials, normally of carbon compounds in which combustion.

Generally occurs with the formation of glowing embers.

These types of fires are most common. Examples of Class A - fires are fires involving wood, rags, paper, plastic coal etc.

Class - B: Fire

These fires involve flammable liquids or liquefiable solids. That is, fires occurring in vapour-air mixture over the surface of flammable liquids such as gasoline, oils, paints & thinners. These types of fires occur in storage tanks and chemical storages.

Class - C: Fire

These are fires involving liquefiable gases like propane, butane, LPG, H2, etc.

Class - D: Fire

These are fires that occur in combustible metals such as magnesium, Titanium, Sodium etc. For Controlling such fires, special extinguishing agents/equipment and techniques are to be used.

Electrical Fires

As per latest classification of Bureau of Indian Standards, electrical fires do not constitute a Particular class. The normal procedure is to cut off electric supply and extinguish the fire using Equipment & medium appropriate for the burning material (burning material may be PVC Insulation around the conductors or the conductor material themselves such as aluminium and Copper). Extinguishing agents which are non-conductors & non-damaging to the equipment should be used. In case of doubt positive isolation of electric supply should be done.

Important Properties of Flammable Materials

Flash Point

Flash Point of a liquid is the minimum

temperature at which sufficient vapour is given off to form an ignitable mixture with the air near the surface of the liquid. By Ignitable mixture is meant a mixture that is within the flammable range and that is capable of propagation of flame away from the ignition source. Although vapours are evolved at temperatures below the flash point, the concentration is not sufficient for ignition to occur.

Flash point of transformer oil is 146^{O}C

Fire Point

The lowest temperature of a liquid at which vapours evolved is hot enough to support continuous Combustion is its fire point.. This temperature is usually a few degrees above the flash point.

Auto Ignition Temperature

Auto-ignition temperature is the minimum temperature required to initiate self-sustained combustion in a substance without any apparent source of ignition (spark or flame). The substance may be solid,liquid or gaseous. Thus auto ignition is the ignition of a combustible material without initiation by any external agency like a spark or flame - when the material has been raised to the auto ignition temperature.

Auto ignition temperature of is transformer oil 340^{O}C

Vapour Pressure

When a petroleum product is transferred into a container, it commences to vaporise, that is, it liberates gas into the space above it. There is also a tendency for this gas to re-dissolve in the Liquid and equilibrium is ultimately reached with a certain amount of gas evenly distributed throughout.

Fire Extinguishing Methods

For the purpose of extinguishing fires, we have to basically limit or eliminate one or more elements of the fire triangle/ tetrahedron namely fuel, source of ignition, oxygen (air) and chain reaction for stopping the combustion process. Whatever may be the equipment or the extinguishing media used for fire fighting, they follow the following four basic mechanisms for fire extinction. These are the commonly adopted methods of extinguishing fires:

- Starvation - Elimination of fuel.
- Smothering - Limitation of Oxygen.
- Cooling - Removal of temperature (Ignition Source).
- Inhibition - Breaking the chain reactions.

Starvation

Starvation can be brought about in 3 ways:

- By removing combustible material from the vicinity of fire such as transfer of fuel from burning transformers, isolating or closing off valve on oil or gas line leading to fire, taking material out of the ware-house etc.

Smothering

If the oxygen or air source to the burning material can be minimized or limited, the combustion will tend to retard. This method of extinguishment is accomplished by covering a burning surface with a wet blanket, Sand, DCP, Foam, etc.

Cooling

If the heat generated during combustion can be dissipated at a faster rate than generation by some means, the combustion cannot sustain. By proper cooling, the heat of combustion is removed at a Faster rate thus reducing the temperature of the burning mass, continuously. In due course of time,the heat lost will be more than the production and the fire will die down. Application of water jet or spray for this cooling purpose is based on this method and principle. The efficiency of an extinguishing agent as a cooling medium depends upon specific and latent heats, as well as the boiling point. For these reasons, water is a good cooling medium as its specific and latent heats are higher than those of other common extinguishing media.

Chemical Chain Inhibition

Combustion consists of rapid chain reactions involving hydrogen atoms and other active substances.

Reasons for Fire in Oil Filled Transformers

Fire due to Internal causes

Those faults that arise within in the transformer are called internal faults. These faults are very severe and there is always risk of fire.

- Line to ground fault or line to line fault on HV and LV external terminals.
- Line to ground or line to line fault on HV and LV windings.
- Short circuit between turns of HV and LV windings.
- Due to break down of insulation of lamination bolts etc, a poor electrical connection of conductors which causes arcing under oil.
- Coolant failure, which will cause a risk of temperature rise even below full load operation.
- Bad load sharing between transformers, in parallel, which can cause overheating due to circulating current.

Fire causes due to external causes:

Faults which occur in other part of the system outside the transformer, are called external faults.

- Bushing failure.
- OLTC fire.
- Spread of fire from surroundings.

All the above will cause internal break down of insulating material in the transformer and the resulting arc energy causes rapid rise of oil temperature. Due to rising of oil temperature the hot oil having exceeded the flash point temperature coming contact with oxygen from the external atmosphere, causes fire in the oil filled transformer.

Damages caused due to the fire in Oil filled Transformers

- Explosion of tank.
- Rupture of tank, Winding and core.
- Personnel injury.
- Neighboring equipment's such as CT's, Lightning arrestors, power cables, marshaling box etc, catching fire.

Due to fire in the oil temperature rises rapidly and it will exceed flash point temperature. Hence pressure in the transformer tank rises rapidly PRV acts or even in some cases tank rupture.

Extract From Indian Electricity Rules 1956 (Second Amendment 2000)

Section NR 64(2) (e) (page No-41)

Where a substation or a switching station with apparatus having more than 2000 liters of oil is installed, whether indoor or outdoor, the following measures should be taken namely

- Provisions shall be made for suitable oil soak pit and where use of more than 9000 liters of oil in any one oil tank, receptacle or chamber is involved, provision shall be made for the draining away or removal of any oil which may leak of escape from the tanks receptacle or chambers containing the same special precautions shall be

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taken to prevent the spread of any fire resulting from the ignition of the oil from any cause and adequate provision shall be made for extinguishing any fire which may occur.

Section WR 64(2) (f) (page No-42)

- Without prejudice to the above measures, adequate fire protection arrangements shall be provides for quenching the fire in the apparatus.
- The transformer shall be protected by an automotive high velocity water spray system or by Carbon–dioxide (CO_2) or BCF (Bromo chloro – difluro methane) or BTM (Bromotri fluro methane) fixed installation system or nitrogen injection and drain method."

Nitrogen Injection & Drain Method

General description

It Consists of fire extinguishing cubicle near the transformer, control box in control room, fire detector on transformer tank top cover, specially designed non-return valve in conservator pipe between buchholtz relay and conservator tank, and signal box placed on transformer. Fire extinguishing cubicle is connected to transformer tank by pipes for oil drain and nitrogen injection. Cable connections are provided from signal box to Control box and from Control box to Fire Cubicle.

Nitrogen injection fire prevention and extinguishing system designed for oil filled transformer, shall prevent, tank explosion and the fire during internal faults resulting in an arc where tank explosion will normally take few seconds after arc generation and also extinguish the external oil fires on transformer top cover due to tank explosion or external failures like bushing fires, due to OLTC fires and fire from surrounding equipment's.

The system shall work on the principle of "DRAIN AND STIR" and on activation, shall drain a predetermine quantity of oil from the tank top through the outlet valve, to reduce the tank pressure and inject nitrogen gas at high pressure from the lower side of the tank through inlet valves to create stirring action and reduce the temperature of top oil surface, below flash point to extinguish the fire.

Conservator tank oil shall be isolated during tank explosion and oil fire, to prevent aggravation of oil fire.

Transformer isolation shall be an essential precondition for activating the system.

The system shall be designed to operate manually, in case of failure of power source.

System Equipment's

- Fire **extinguishing cubicle:** With base frame and containing oil drain assembly, nitrogen cylinder, electromechanical control unit for oil drain and nitrogen release, pressure monitoring switch for backup protection for release of nitrogen, detectors necessary for monitoring system, flanges with gate / butterfly valves on top panel for connecting pipe connections from transformer, panel lighting etc.
- Fire extinction period
- On commencement of N2 injection → Maximum 30 seconds
- On system activation up to post cooling → Maximum 3 minute.

Control box: For monitoring system operation, automatic control and remote operation, with alarms, indication light switches, push buttons, audio signals, line fault detection suitable for tripping and signaling on station battery DC supply.

Pre-stressed non-return valve (PNRV): Working mechanically on transformer oil flow rate, with proximity switch for remote alarm indication and with visual position indicator.

PNRV setting for operation → Minimum 60 liters per minute

Fire detectors: The required number of fire detectors rated for 141°C for heat sensing fitted on the top of the transformers.

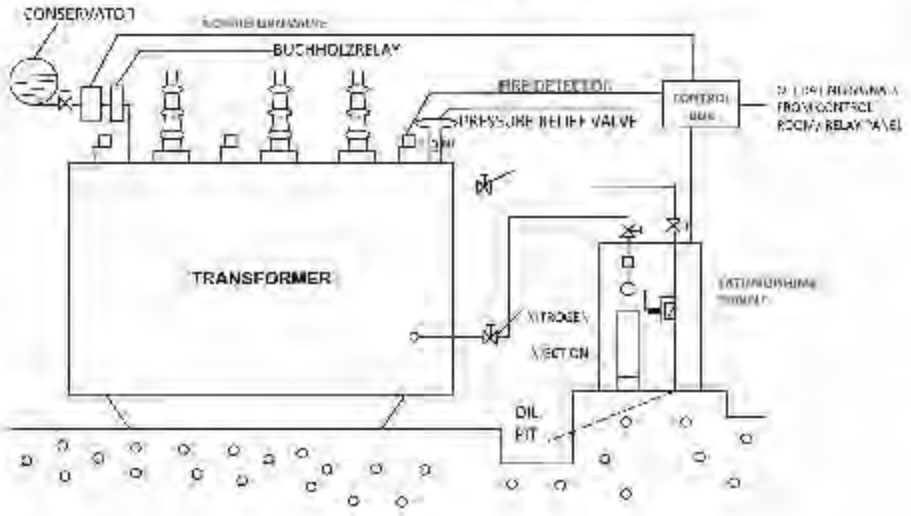
Heat sensing temperature → 141°C

Heat sensing area → 800 mm radius

Signal box: For terminating cable connections from PNRV and fire detectors.

Connection Details

Schematic arrangement of Nitrogen injection fire prevention & extinguishing system for oil filled power transformers.



- Fire extinguishing cubical (FEC) to be placed on plinth at about minimum 5 mtrs away from the transformer it consists of
  - Nitrogen cylinder with regulator and falling pressure electrical contact manometer.
  - Oil drain pipe with mechanical quick drain valve.
  - Electromechanical control equipment's for oil drain and pre-determined regulated nitrogen release.
  - Pressure monitoring switch for backup protection for nitrogen release.
- Control box with activating, monitoring devices and line fault indicators, (to be placed in control room).
- Pre-Stressed Non-return Valve (PNRV) to be fitted in the conservator pipeline; between conservator and buchholtz relay operating mechanically on transformer oil flow rate with electrical signal for monitoring.
- Fire detectors fixed on transformer tank top cover for sensing fire.
- Signal box fixed on transformer side valve for terminating cable connections from fire detector and PNRV.

Other connection requirements for system installation

Product Range for Nuclear\Power

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10	OPzS	1000
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24	OPzS	3000

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- Oil drain and nitrogen openings with gate valves on transformer tank, flanges with dummy piece in conservator pipe and fire detectors brackets on transformer top cover.
- Spare potential free contacts for system activating signals that is differential relay, buchholtz relay, and pressure relief valve for transformer isolation.
- Pipe connections between transformer to fire extinguishing cubicle & fire extinguishing cubical to oil pit.
- Cabling on transformer top cover all fire detectors to be connected in parallel and inter cabling between signal box to control box and control box to fire extinguishing cubicle.
- Plinth for fire extinguishing cubicle, oil pit with capacity as 10% of total oil quantity of transformer.

Operation

During fire due to internal or external faults in the transformer the fire detector senses and gives activating signals to the system, Transformer is isolated from the supply and a predetermined quantity of oil drain commences, Simultaneously Nitrogen injected under pressure at a predetermined flow rate creates stirring action & temperature of top oil surface is brought below ignition point and fire extinguishers within 30 seconds. Nitrogen gas occupies space created by oil drain and act as an insulating layer between tank oil and fire on top cover. Pre-stressed non-returned valve blocks oil passage. Also isolates conservator tank oil and prevents escalation of fire.

Comparision				
Sl. No.	Item	Nitrogen	Water	CO_2
1.	Purpose	Fire Prevention, Fire Extinction	Fire Extinction	Fire Extinction
2.	Principle	Release of excess pressure by oil drain cooling of top oil surface below flash point by stirring	Cooling O_2 Seal off	Reduction of O_2 contents
3.	Installation	Indoor / Outdoor	Outdoor	Indoor
4.	Space requirement	Small	Great	Great
5.	Civil Work	Minor	Major	Medium
6.	Climatic influence	None	Freezing of water	None
7.	Human Danger	None	None	Suffocation
8.	Secondary damages	No secondary damages	Paper insulation Transformer burnt out	Contamination by carbon components
9.	Investment	Low	Very high	High
10.	Maintenance	Very low	Extensive	Low
11.	Running cost	Practically nil	Very high	High

Comparison of different fire protection systems

System activating signals

For Prevention: Differential relay trip + buchholtz or pressure relief valve trip + circuit breaker trip (Transformer isolation).

For Extinction: Fire detector operation + buchholtz or pressure relief valve trip + circuit breaker trip (Transformer isolation).

Maintenance

Practically Nitrogen Injection and Drain method of Fire Protection and Extinguisher system is maintenance free.

It is recommended for monthly visual inspection for about 15-20 minutes and annual operational test schedule.

Advantage of Nitrogen Injection & Drain Method of Fire Protection

- Low investment cost as compared to other conventional system.
- Very low post fire and no secondary damages.
- Minimum maintenance and running cost.
- No climatic effects.
- Suitable for indoor / outdoor installation.
- Minimum space requirement.
- Multi signals for activation, eliminates false alarms.
- Allows system testing on operational transformer not possible with conventional fire system.
- No moisture absorbing in inside the transformer due to presence of nitrogen.
- Great saving in cost, due to absence of moisture.
- Fully automatic, unattended and a fool proof system.
- It can be operated manually / automatically, local / remote control.
- No water reservoir or major civil work required.
- Prevents transformer explosion ensuring system remains functioning.
- Prevention of unplanned outages.
- Considerable savings.
- Improves overall power system reliability.

Conclusion

The 'Nitrogen injection & Drain method' to protect the Power Transformer from catching fire is a best method technique suited for Indoor/Outdoor application because of its low investments, low maintenance & with practically no running cost beside assuring 'Fool proof operation' & is being satisfactorily adopted by many state electricity Boards.'Fire is good servant but bad master' safe way is best way.

Kiran Kumar R B

MTech (Energy System & Management) presently working as Assistant Engineer (Elect) in Meter Testing Division, CESC (Mysore region Electricity Supply Company) has experience in the field of Power Transmission & Distribution sectors. He also worked in 220kV Receiving station of Karnataka Power Transmission Corporation Limited.

Profile

Interview

"Main offer at intelect was providing street light automation"

L Anil Kumar Kadam,
Senior Manager Solution, Energy Business
Schneider Electric

Schneider Electric, transformed from steel in the 19th century, to electrical distribution and automation in the 20th and energy management in the 21st, has always been driven by an international, innovative and responsible mind-set to shape the transformation of the industry it was evolving in. In an one-on-one interview with **Electrical India,** on the sidelines of intelect conference and expo **L Anil Kumar Kadam,** Architect & Marketing-smart Utility and smart Cities, remarks to Gopal Anand that in the next five years, we would be having quite a few cities operating smartly.

How do you find the intelect Exhibition?

We were expecting much but it is less than one-third of Elecrama or say, 20-25% of Elecrama. But the response picked up in the afternoon. I see a lot of electricity department people coming in. Lot of people from the electricity board, like Tata power, people from North East electricity board visiting the booth.

What according to you is the Scope of Energy in India?

Scope of energy is a very broad topic. But we are actually sitting on a very big installed base, we have to acknowledge, 240 MW installed based we are sitting on, that's lots of energy. Still out of 1.2 billion population, close to only 3 million or 4 million have access to energy, that's because they don't have a corridor to supply energy & most of them include very fast growing cases. So I would say as India we should give higher priority to first give energy to everyone. Electricity to all should be the mandate of government of India. That's my top priority, if you ask me. Next is the allocation of coal, the problem of coal & lot of imports, this has to be sorted out in a very majestic way which the new government is anyway doing for us - to be more secure on the energy front. But if we want to be a big hit we should really sort out the coal problem.

What are the products you are displaying over here?

The theme of this particular time is a smart city. There are five verticals in a smart city that we are showing. Starting from the smart grid, electricity of a distribution company making it smart, the whole theme is efficient, we want to make them efficient, we want to bring them in a sustainability path, give initiatives and sustainable, and that's how we want to make the life of the residential people more livable by providing them more efficiency. One is energy, another one is water. We are bringing technology and process changes in water so that people get quality water at a lower cost and water can reach every person on time with the right quality. We don't have the technology to see

if the water is of high quality or not. So we automate the water reservoirs, we automate the water pumping stations, we do an energy audit and water audit online, for all the circuits in the city and we reduce the wastage of water that has happened, Indirectly the wastage of energy and the wastage of natural resources. Today 45-55% of water coming into the city is wasted. When I say mobility it means transportation. When I say transportation, how do I make transportation smarter? Today traffic signals are timed. One minute for this road, one minute for that road. Can you change it dynamically with the density of traffic coming on the road? That's one of the ideas. So our solution does that. Can I have a camera looking at the traffic and anybody violating the traffic rule gets captured and its number plate is recognized and his face is recognized. Next is can I see the ambulance coming and can I exactly pinpoint that the ambulance is coming on this road and I give more time for the corridor to pass on, so can I create a green corridor for the emergency activities, can I create a green corridor for a VIP movement instead of having police standing all the way and talking on the wireless can the system do it from the command and control center and CCTVs at junctions. It's all about data and analytics and getting the right insights and getting the right decision at the right time.

➢ **What are the offerings you provide in smart public service city?**

One of the main offers that we provide is street light automation. If you manage street light properly, it straight away reduces 50% of your energy consumption. For example, street light is lit in the day also, nobody bothers to switch it off. It wastes India's money. Second is, street light is always at the same intensity whether a person is there or he is not there. Can you change the intensity of lighting based on the person occupancy. Second is video surveillance. Can I have the whole streets covered with video surveillance, can I avoid terrorism, can I make out where is a mob or if there's a problem happening. Can I do an analytic? Can I immediately inform the police so that the police go there? Form some alerts! So these are the smart public services that come in and weather services. All these infrastructures needs weather services. What is the weather today in terms of intensity, wind speed, in terms of light, the radiation levels, the humidity, the precipitation we can give info, we are actually a weather solution providers. In UK, US, even in India we have whether solution providers We provide information to critical infrastructures which needs weather data for its processing. Example, Smart energy needs weather data to forecast the energy needed for tomorrow, day after tomorrow and based on that forecast they purchase energy properly from the generation company and plan well otherwise per purchase of energy is still expanded for the utility. And the utility has to still supply for 4 rupees even when you have to purchase it at 15 rupees. But if it does proper forecasting, using the weather data, you can still buy it at 2 rupees, 3 rupees and supply it at 4 rupees so you get a profit which you can put in further development. So we provide weather data for transportation, water, & travel information system. We provide data to the metropolitan bus network or the maps or the metro rail. On their portal they say this is the today's weather, for connecting from this station to this station you can take bus from here to here etc. Now that's an extended traveler information system what a metropolitan area bus network can be provided to the people & the data for that comes from our system. It is localized, it is authentic, and it lets you take decision very easily.

➢ **What if the system gets disrupted?**

See there is a fall back mechanism, first of all there is a lot of redundancies that you establish in such critical situations. Redundancies in terms of communications, redundancies in terms of processing electronics, redundancies in terms of software, a lot of level of redundancies is built everyday plus, if the system is totally down, there is always an alternative for it because there is distributed intelligence always, It is not that the command and control centre is always controlling the traffic signal. It is already told in the traffic signal that you work in this status. Whatever is happening today will continue. The only thing is you will move gradually into your efficiency.

➢ **What is the concept of smart electricity from Schneider's point of view?**

Well! From Schneider's point of view properly managed for making the most out of whatever you generate is smart. For example every 1 unit used is 3 unit of primary fuel is burned, so there is inefficiency in your dollar system, there is inefficiency in your generation, inefficiency in your transformation, there is inefficiency in your distribution. If you block this inefficiency to some extent you are actually generating electricity and maximizing it so how will I make the system and the value chain more smart or more efficient more sustainable and more livable is what energy is. So smart electricity is how can I be more efficient, how can I be more sustainable with green power and how can I make people using my energy more livable. These are three definitions for me to be smart.

➢ **What is the role of Schneider for renewable energy in smart city?**

Schneider manufactures end to end renewable offerings. We are in single phase applications and three phase applications. Schneider does complete gamut of renewable, and we have lot of advanced application software and smart systems, which can help them integrate better into the renewable. Because renewable has its own challenge. You have a present distribution company or a generation or transmission company any renewable technology comes in, so this will produce when there is sun or when there is wind, but AC cannot be stored, Alternative current cannot be stored, it has

to be used. So production=loss + consumption, that's the definition, consumption+loss=production. But what will you do without energy if you don't want it. It is morning 10 am, and I need energy, everybody is using energy here, but if there is a cloud passing on the top of your city and there is no energy produced, what's the use, so how can you better manage that. Storage is one option. There is a smart way managing, it's called demand response, next is it's a power electronic, okay, there are conditions, where you over produce and still do not have the load, these are all power electronic devices, with controllers inside, and can send signals to reduce the loads. So smartness is all about doing that and integrating. Next is you can have a smart grid transformer which can change the output of the transformer, irrespective of the input by changing the tap automatically so in renewable, whenever the output goes low, the voltage falls. Else, it can trip. Instead of helping the grid it will create more problems in the grid so we should have smart system to manage it.

➢ **How do you find the response, like you have already said there are inquiries coming, what the visitors at your booth inquire about?**

Lot of utility wants to simplify the way they operate their system, want to have more of data management, knowledge management, & want to have more suggestions from technology. All the time they talk on the brand, they would want to generate more revenue, make profit and invest back, so they are more looking at technology from efficiency perspective. The most of the people I have spoken to are not even electricians, and lot of people are specifically talking about sustainability and increasing power, but more are talking how can I have a Schneider, what can Schneider do, can I control from there, okay, my person can do a good job; a better job, he need not go all the way there and do it.

➢ **What do you think about motive of 'intelect' & about this initiative of IEEE?**

It's a good initiative of Elecrama, Elecrama is two years once, I think we need this one, it's a good initiative, it brings in lot of industry players together, and it is a very good forum also for exchange of ideas, what happens is until and unless you get a forum you can't, you can do one on one but how much will company will do one on one. IEEE is a standard body and they most often collaborate with companies like IEEMA, to bring in awareness on technology front. So smart city and smart energy is a new topic, and NEMA and IEEE being standardization, they would want to encourage the corporation in the stakeholders so that somewhere it is still helping the technology. Even today if you see any of the electrical equipment, all are of IEEE standards EC or NEMA standards.

➢ **What is your role in Schneider?**

I work as a solution architect, for smart grids mainly and smart cities generically. My main role is to understand the problem statement of a customer and try to come up with a solution so that he comes out of that problem. It's more of a problem solution statement. So example, if XYZ customer says, what I will do to reduce outage to my consumer. So I understand what is the type of outage, how much is your consumer affected, what is the industry standard, and then I go to the root cause to say where is this outage coming from, why is it coming. And then I come up with say, we could probably do this, or it could be just a process change, even after all this it could be a small infusion of technology, or an efficient use of technology which the consumer already has. The customer sees me as a solution architect for his problems. So that's how I work for Schneider, actually working for the consumer.

➢ **What do you think in respect of Make in India as an initiative?**

Make in India concept is a noble cause from two angles. 1 is improving the economy of India. It helps the entrepreneurs to come up. And you would need a lot of critical mass. When we are developing our, there is requirement of lot of material, manpower, preservatives, and if it comes from India it is made in India, from the complete life cycle perspective. For the economy its good, you get the money out of India, point no one, point no two is you employ people in India, you improve the lifestyle, point number three is you are logistically moving fast and you are faster on your technological part so it's very good to make in India. I really appreciate the make in India concept.

➢ **What is the vision in the next two years?**

It is very ambitious. India is known to live for whatever initiative it takes. We have just taken 50 years to reach here, where we are. Our brothers outside India have taken 100 years 150 years to reach where ever they are, so I think two years is a short time but in the next five years we would be having quite a few cities operating smartly. And people would be in more reliable, livable space then.

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Phase Shifting Transformers

Control and Protection Philosophy

The Indian economy is growing at a rapid pace and so in Indian power system. The installed capacity of 2.03 GW is planned by the year 2011-12 and the estimated peak demand is expected to grow to 150300 MW in the year 2011-12. With the result, the transmission & distribution is increasing many fold. However, the use of existing infrastructure to their optimal capacity rather than providing additional corridor is essential in order to have economical operation of grid.

Dinesh Pawar

Transmission grid is used as a transport medium between generation and the load centers. The grid can be segregated in to physical group of alternate paths i.e. transmission sub-systems between the generation and the load center. The loading of parallel transmission sub-systems is governed by their impedances. The impedances are essentially determined by the type of conductor, its configuration and tower geometry. The line with the smaller impedance carries more power and vice versa. Due to uneven loading of the sub-systems in a meshed network, the total power transmission from generation to load is lower than expected.

Phase shifting transformer (PST), which is a member of FACTS family, can be used to control the active power flow in a complex power distribution network in a very efficient way. It provides a well defined phase shift between the primary & the secondary terminals. The purpose of this phase shift is usually the control of power flow over transmission lines. Both the magnitude and the direction of the power flow can be controlled by varying the phase shift.

This phase shift can be varied during operation in definite steps by use of an on load tap changer or a static tap changer and the sign of phase shift can be inverted from advance to retard and vice versa as well. The principal use of PSTs is at major inter-tie buses where the control of active power exchange is especially important.

Phase Shifting Transformers

Thus there are two main applications of PSTs: – one is to re-distribute power in parallel lines (both ends are at same voltage level) & another is to direct power from one voltage level to another (auto-transformer + PST).

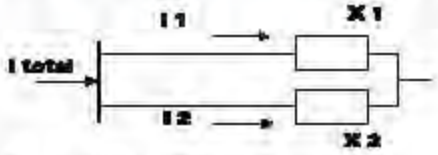

Fig. 1a: Without PST

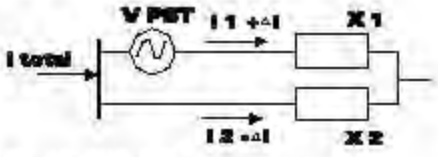

Fig. 1b: With PST

The current distribution between two parallel lines will be in inverse proportion to their impedance. For example in Fig. 1a, the current distribution:

$I_1 = I_{total} (X_2/(X_1+X_2))$ and

$I_2 = I_{total} (X_1/(X_1+X_2))$

Because the main part of the line impedance is inductive reactance, inserting a voltage in phase with or opposite to the line voltage (changing the magnitude of the voltage) will have an impact mainly on the reactive part of currents (i.e. reactive power flows). The boost voltage with a phase angle perpendicular i.e. quadrature to the line voltage (creating a phase shift) influences mainly the real part of currents (i.e. real power flows). Thus the PST helps to vary the load as desired. Fig. 1b shows the load distribution by use of PST.

For the real power flow influence the most often used is the quadrature symmetric or the quadrature non-symmetric PST's. A quadrature type PST is a unit where the boost voltage, which creates the phase shift between source and load terminals, is perpendicular to the line voltage at one terminal. This regulates the active power flow.

Design of Phase Shifting Transformers

The PST consists of two separate transformers: a shunt unit and a series unit. The shunt unit has its winding terminals connected so as to shift its output voltage by 90 with respect to the supply. The output of shunt unit is then applied as input to the series unit, which, because its secondary winding is in series with the main circuit, adds the phase-shifted component. The overall output voltage is hence the vector sum of the supply voltage and the 90 quadrature component. Tap connections on the shunt unit allow the magnitude of the quadrature component to be controlled, and thus the magnitude of the phase shift across the PST.

In an ideal un-loaded power transformer, the source side voltage and load side voltage are in phase. On loading the transformer, the angle between voltages (load angle) changes based on the transformer impedance and load. The difference between PST from a normal power transformer is of the non-standard phase shift angle between the source side and load side no-load voltages (phase-shift angle). There is an additional shift between source and load side voltages during load (transformer load angle). In PST there is a phase angle difference between currents of source and load side, unlike a power transformer.

Typical Arrangement of a PST in Grid Substation

Phase shifting transformer in a typical arrangement consists of a shunt unit and a series unit. The shunt unit is similar to interconnecting transformer with a control winding in addition to normal three windings (Primary, Secondary and Tertiary). The series unit is connected in conjunction with the shunt unit via its control winding so that boost voltage can be injected in quadrature. The above arrangement is supplemented with the disconnectors to offer flexibility in operation. The disconnectors are provided to ensure that the PST can also work as normal inter connecting transformer.

Figure 2 below shows the typical arrangement.

Here,

PSTSH = Shunt Unit

PSTSE = Series Unit

89TD = Disconnector for control winding

89TC & 89T = Disconnector for Series Unit

89TB = Disconnector for Bypassing PSTSE

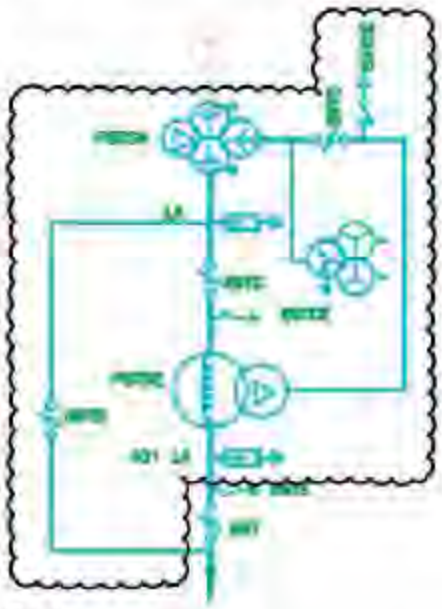

Fig. 2

Control of PST

Under normal conditions when the power flow is as intended, the series unit is kept in a bypass mode. In order to bypass PSTSE, disconnector 89TB is put ON and 89TC, 89T and 89TD are put OFF. This way only the PSTSH is in the circuit which acts as a normal power transformer interconnecting the two switchyards working under different voltage levels.

Under abnormal conditions when we want to have real power control from/ to switchyards connected at the either end of the PST, the bypass arrangement is no more used. And by putting OFF 89TB and putting 89TC, 89T & 89TD ON, the PSTSE is put under service. Due interlocks are taken care while operating these disconnectors as they are to be operated under no-load condition.

The on-load tap changer (OLTC) installed in the control winding is then used to control the boost voltage. This boost voltage after being injected to the line voltage in quadrature creates the phase shift between source and load terminals. For every step of tap changer, there is a definite voltage boost and corresponding phase shift. Thus every step contributes to a definite real power control. The phase shift with every step change is provided in the Rating and Diagram (R&D) plate of the PST.

Control winding is provided with a VT so that the injected voltage into the series transformer primary can be measured with voltmeter. This VT is also used for providing input to overfluxing protection.

Protection Philosophy for PST

In our typical arrangement of PST, there are two transformers, one Shunt and another Series. The protection philosophy of such an arrangement is to cover all the zones. Protection covered for each transformer can be similar to a normal transformer viz differential protection, over current protection, restricted earth fault protection, back-up earth fault protection and over fluxing protection.

Difference lies in differential protection adopted for PST. Standard transformer differential protection can not be used due to variable phase angle shift across the PST. Thus if a numerical power transformer differential relay is directly applied for the differential protection of PST, and set for Yyd vector group compensation the differential relay will not be able to compensate for variable phase angle shift θ cause by position of on-load tap changer (OLTC) installed in the control winding. As a result a false differential current would exist which will vary in accordance with phase angle shift across the PST. However in order to apply the standard numerical transformer differential protection on a PST the following compensation shall be provided -

- Primary current magnitude difference on different sides of the protected PST.
- Phase angle shift difference across PST.
- Zero sequence current elimination.

Current magnitude difference on the two sides of PST will occur during OLTC operation and is thus variable because of different OLTC positions. Latest Differential protection relays designed has the unique feature of online OLTC position monitoring (via BCD coded binary signal) which enables the differential protection relay to automatically compensate for transformer turns ratio changes caused by OLTC movement.

Hence the standard differential relays are able to compensate current magnitude differences caused by different OLTC positions but the relay is not able to compensate for non-standard phase angle shift caused by OLTC movement in PST operating mode.

In the algorithm for differential current calculation, matrix for differential current calculation can be modified to obtain coefficients for the matrix which is variable with the phase angle shift. Every OLTC position is associated with a phase angle shift between no-load voltage on either side. This phase angle shift vis-a-vis OLTC position is depicted in rating diagram plate of PST. Relay programming is done to ensure coefficients changes with

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Device No	**Function**
99	Over Fluxing Protection (Built in Function of Num, Diff, Relay)
87T1, T4	Numerical Differential Protection Relay
67/67N/51N	Directional Overcurrent & Earthfault Protection Protn.
64	Numerical Restricted Earth Fault Protection Relay
63TX	Buchholz Trip Aux Relay
63AX	Buchholz Alarm Aux Relay
63OLTX	Oltc Buchholz Trip Aux Relay
63PTX	Prv Trip Relay Aux Relay
50/51/51N	Numerical Over Current & Earth Fault Protection Relay
49OTX	Oil Temp Trip Aux Relay
49OAX	Oil Temp Alarm Aux Relay
49WTX	Winding Temp Trip Aux Relay
49WAX	Winding Temp Alarm
21/21HV/21LV1	Numerical Backup Impedance Relay with Inbuilt Dir O/C, E/F Protn.
OLAX	Low Oil Level Alarm Aux Relay
V	Voltmeter
VS	Voltmeter Selector Switch

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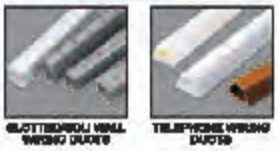

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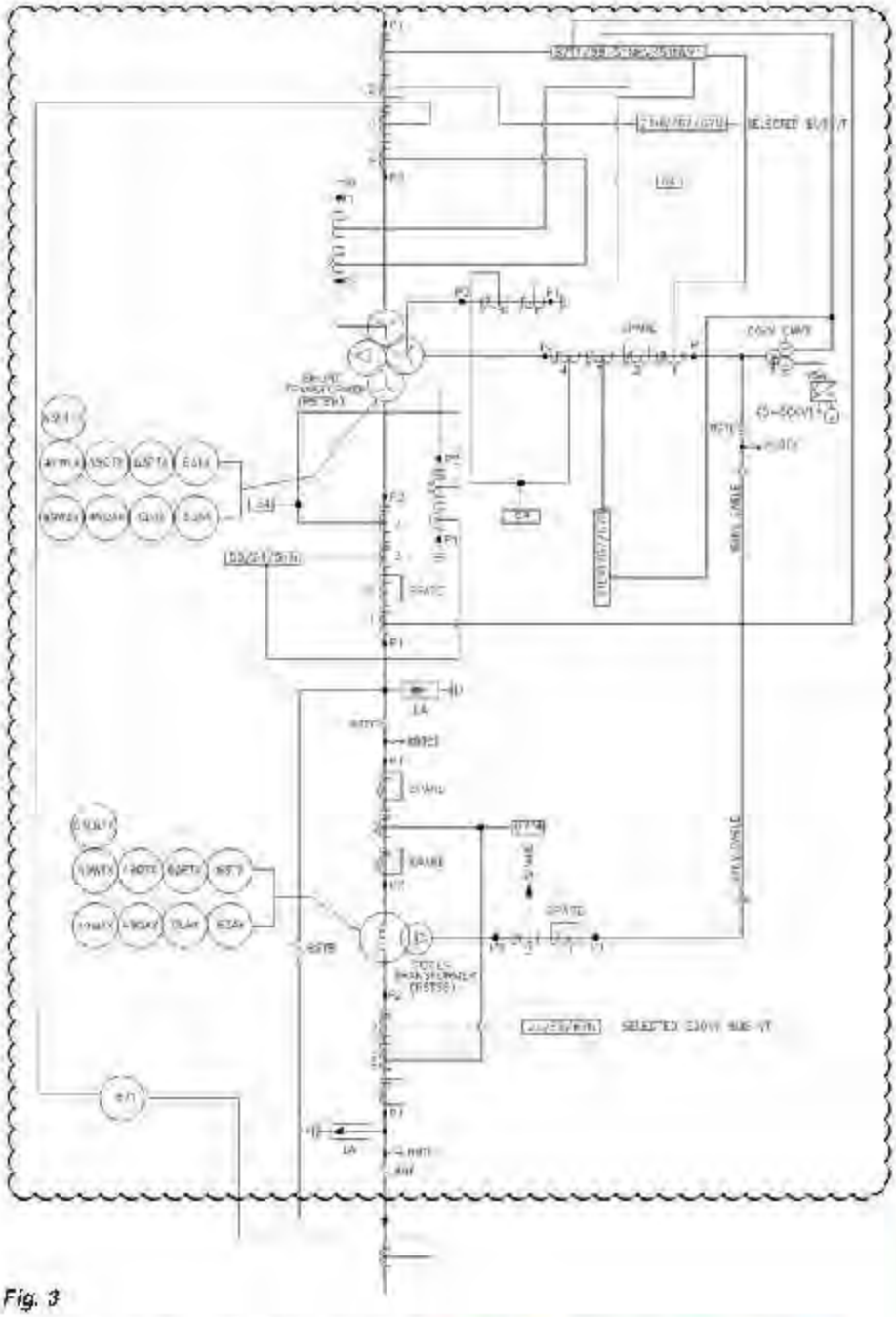

Fig. 3

change in phase angle shift and hence differential current calculation matrix changes with each OLTC position. Thus it seems to be fully feasible to provide online compensation for actual PST phase angle shift due to OLTC movement. Zero sequence current suppression is done by providing unloaded delta tertiary winding. Due to this delta tertiary winding, the zero sequence currents from the 400KV & 220 KV side must be always excluded from the differential current calculation.

Major Protections deployed in PST

Protection is more an art than science, every individual may think differently when it comes to deploy protection scheme to a system but objective is same to protect the equipment under fault condition. Fig. 3 depicts the various protections deployed on each transformer.

- Overall Differential Protection.
- Backup Impedance Protection.
- PSTSH Differential Protection with built-in over fluxing.
- PSTSH HV winding Restricted Earth fault protection.
- PSTSH HV winding Directional Overcurrent and Earth Fault Protection.
- PSTSH LV winding Restricted Earth fault protection.
- PSTSH LV winding Overcurrent and Earth Fault Protection.
- PSTSH Control winding Restricted Earth Fault protection.
- PSTSH Control winding Directional Overcurrent and Earth Fault Protection.
- PSTSE High Impedance Differential Protection for series transformer.
- PSTSE Directional Overcurrent and Earth Fault Protection.

Conclusion

Phase Shifting transformer is the most economic approach to power flow management. In the coming future application of PST is going to increase manifold in India. Control and protection pf phase shifting transformer is vital from the perspective that PST is going to cost more that double the cost of normal power transformer. This article gives an overview of control and protection for a PST which will definitely be useful in this area.

Major thrust is given on differential protection which involves on-line reading OLTC position and provides online compensation for PST non-standard & variable phase shift. In practice one OLTC step means PST phase angle shift change by one or two degrees which can be easily corrected cyclically inside the modern numerical relays available now-a days.

Profile

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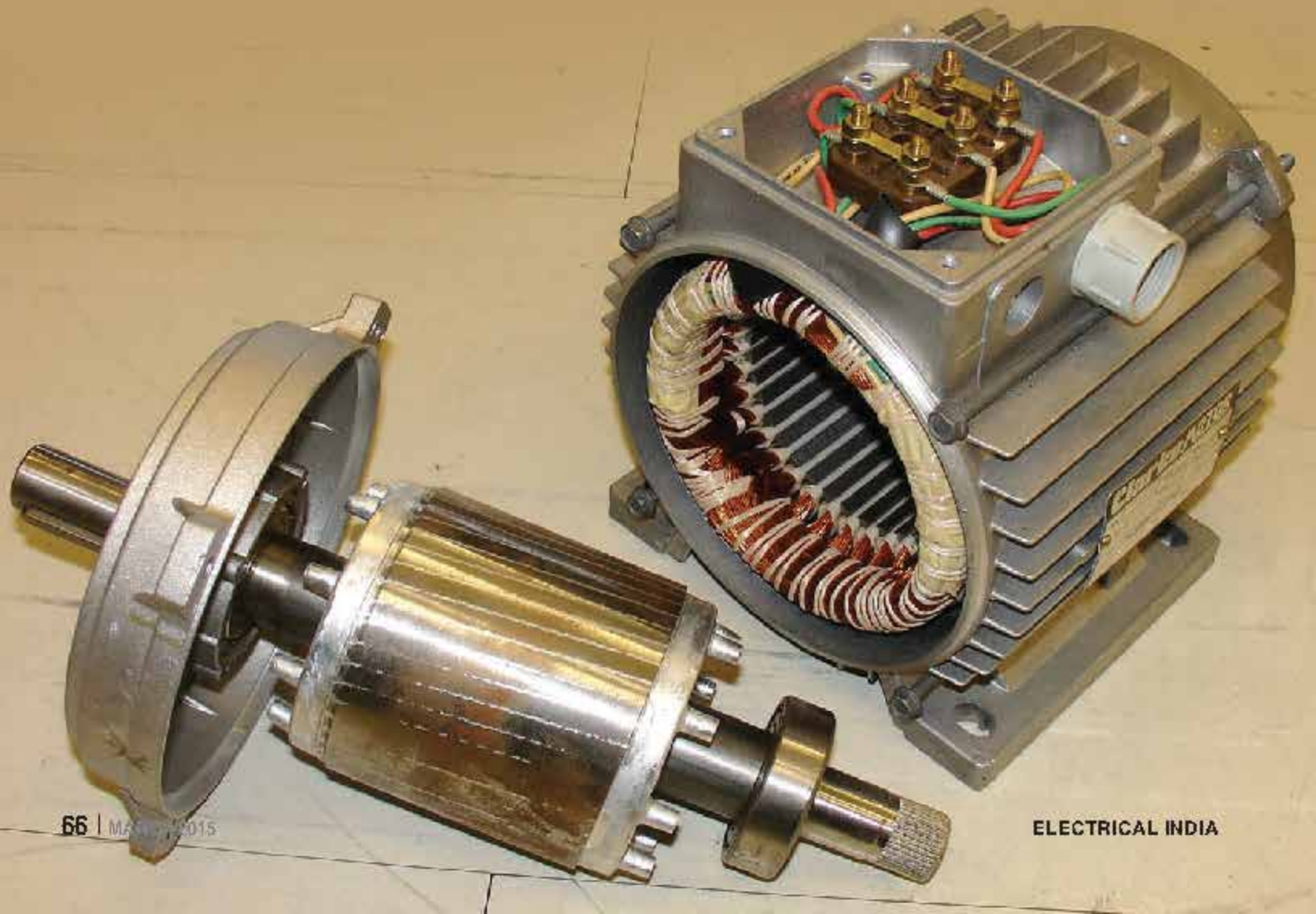
Solid Rotor Alternator

An alternative to traditional system

The growing use of electrical energy in the world leads to new problem concerning the generation of electrical energy. The advent of turbo generators opened a new era in the state of the art of alternator design. High centrifugal forces developed due to higher speed will be a threat to the laminations of the rotor. In addition to that, the traditional rotor is not adaptable for large rating synchronous generators as it is difficult to build with acceptable mechanical stress, rigidity and critical speeds. In order to overcome these drawbacks a Solid Rotor Alternator (SRA) is evolved.

Dr G Suresh Babu & T Murali Krishna



Indian electrical industries supply industrial alternators for rectifier loads, arc furnace loads & thyristor load applications to various customers. Such synchronous machines along with rectifier loads are used in HVDC system & AC exciters. In such cases the harmonics will be injected into the supply side of the alternator making the generator line current distorted to trapezoidal waveform. This harmonics increases the losses in stator conductors. Negative-sequence currents which are due to load imbalance will also induce even harmonics in the field and damper windings. The solid iron rotor in case of large synchronous machines will also have induced currents which cause additional losses and temperature raise. Ease of manufacture, high torque per ampere at standstill, withstanding capability of high rotational stresses and operating in unusual environment made SRA more suitable for high power ratings.

State of Art

The analytical description of synchronous machines having solid rotor, as a means of treating their behaviour during abnormal operating and fault conditions is a contemporary problem of undiminished importance. It is needless to say that the SRA is more adaptable for high power and high speed applications. The study of operational behaviour becomes difficult for academia as all available alternators are invariably laminated rotors. Hence this constraint motivated to develop a prototype model indigenously.

A three phase 400V, 4-pole, 50Hz, 1500 rpm induction motor is considered, keeping its stator unaltered as shown in Fig. 1 its squirrel cage rotor is replaced by solid rotor. The solid rotor is designed as per specifications, machined in a lathe machine for 16 slots as shown in Fig. 2. The rotor is inserted in the stator and is assembled with end rings, slip rings, and brushes as shown in Fig. 3.

Materials Perspective

The material used for rotor is chromium nickel steel. Core and shaft are forged together as one piece in the workshop which is exception in very large sizes. Two thirds of rotor is wound and the rest one third is left without slots. This unwound portion forms the so called large tooth through which the main part of generator flux passes. In case of turbo alternators Manganese bronze or steel wedge is driven into the mouth of each slot for the purpose of keeping the winding in place. Hardened Glass Laminations are used as wedge material. The field winding coils are concentric. Generally the windings used in synchronous machines may be single layer or double layered type. Machines having large values of flux per pole have small number of turns per phase and therefore a double layer bar winding is used for them. The slip rings are made of steel and are shrunk over cast iron sleeve with mica as insulation between the two. The electro graphite brushes are used here.

The solid rotor alternator output is tested. As the output waveform of the SRA is not sinusoidal as shown in Fig. 4, a redesigning is recommended. To achieve this objective two alternatives arrived.

- Increasing the number of slots of rotor such that slot harmonics will be reduced.
- Increasing the length of airgap (By reducing the diameter of rotor)

As the former is not possible in this case, the latter is preferred in redesigning as shown in Fig. 5. After redesigning and assembling, the output waveform found better as shown in Fig. 6.

Fig. 1: Stator Core

Fig. 2: Slotted armature core

Fig. 3: Spare parts of SRA

Fig. 4: Output waveform before redesigning

Fig. 5: Chamfered rotor

Fig. 6: Waveform after redesigning

Experimentation

Various tests such as Open Circuit Characteristics, Short Circuit Characteristics, load test, heat run test, three phase balanced load and unbalanced load test, three phase bridge rectifier load test, three phase short circuit test, line-line short circuit test and additional loss test have been performed to analyze the behaviour of the machine.

The impedance of a generator feeding a rectifier invariably affects the operation of the rectifier. The reactance of the machine not only influences the commutation of the bridge elements, but also affects the bridge output voltage, the operating power factor of the generator and eventually the capability of the

generator to supply the rectifier loads. All the voltages, currents, powers, overlap angles and waveforms are the consequence of the three external constraints viz. speed of the generator, field voltage Vf, load resistance RL, and the constants of the machine.

An experiment is conducted on the MG Set as shown in the Fig. 7, by observing the input voltage and current of DC motor while SRA is fed with same amount of AC load and DC load. The difference in the two cases resulted into Additional losses of SRA. The additional losses due to harmonics were observed to be 2.36W which are 0.42% of the total losses. The SRA developed here being a low rated one these losses are not predominant.

Fig. 7: Experimental setup of MG set connected to rectifier load

Behaviour of SRA During Fault Conditions

Before performing the test the machine should be carefully inspected to see that the bracing of the stator coil ends is satisfactory, the foundation is in good condition and the holding down bolts are tight. The rotor should also be inspected to see that all keys, bolts are in place and properly tightened. Generally oscilloscope readings are taken to determine the reactance. It is, therefore, necessary to short-circuit the machine by a circuit-breaker which closes all three circuits at almost exactly the same instant to avoid errors due to single phase action at the beginning of the short-circuit. Precision shunts are used for recording the currents on oscilloscope. It must not be forgotten that the shunts have to be earthed.

The major effects of short circuit are increase in armature current which in turn result in large electro dynamic forces. These forces may either be in between the winding head and iron or in between the winding heads of different phases. The large electro dynamo forces can result in a displacement of the end portions of the stator coils against one another. These displacements can result in failure of the insulation of the winding and hence shut down of the machine. The end portions of the coils must, therefore, be specially braced. Besides the forces in the end portions of the coils, sudden short circuits by a synchronous machine result in torque pulsation.

Fig. 8: Experimental setup for 3-phase short circuit fault

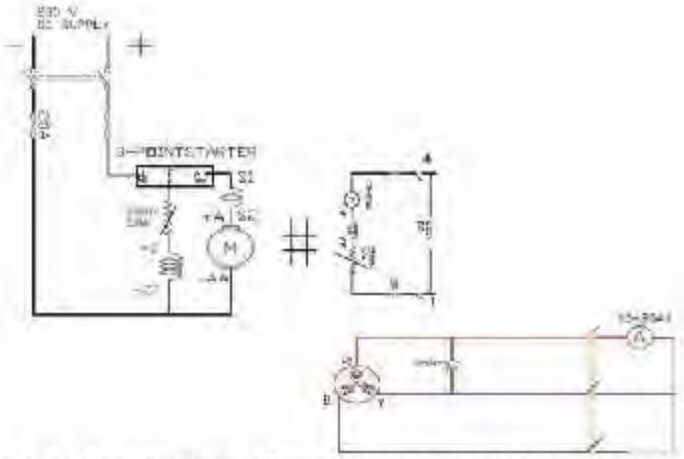


Fig. 9: Circuit diagram of SRA under three phase short circuit fault

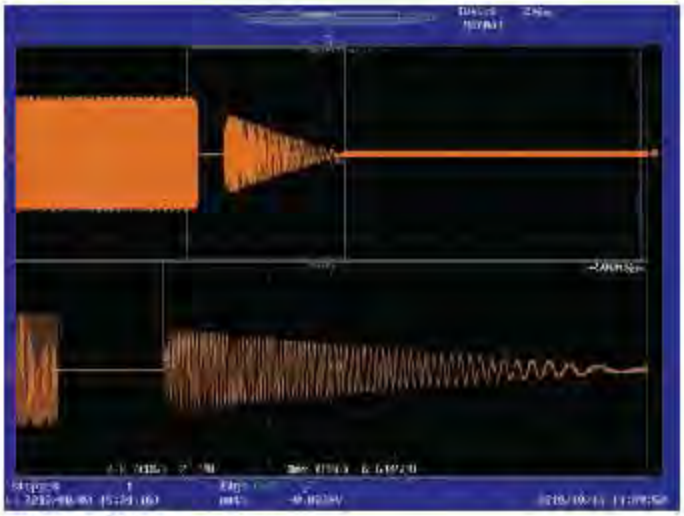


Fig. 10(a): Voltage waveform

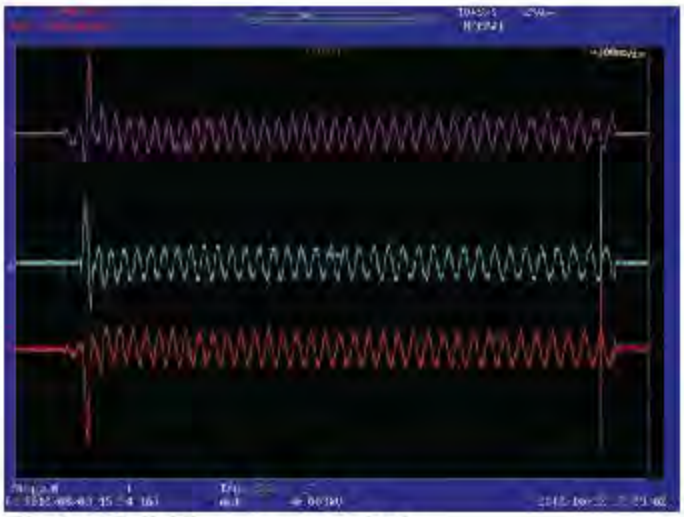


Fig. 10(b): Three phase current during fault

As a result of these torques of high magnitude, the casing, the shaft and the foundation must be designed to withstand the stresses. The huge values of armature currents cause I2R losses in the machine which in turn results in increased heating of the machine. Since the sudden short circuits are switched off with in a very short time, the heating in the machines due to them is generally not appreciable. The experimental setup is shown in Fig. 8.

The circuit diagram for the above test is shown in Fig. 9 and the waveforms captured in the sophisticated and high resolution instrument Scopecorder DL-750 are shown in Fig. 10(a)& 10(b). Fig 10(a) depicts the behaviour of voltage before, during and after three phase short circuit fault on SRA.

From the above test the sub transient, transient and steady state reactances have been calculated and found as 0.1 0.22 and 1.1 p.u. respectively. As this SRA does not have damper windings and also because of reduced wedges the sub transient current is no longer.

Conclusion

By reducing the diameter of solid rotor, the output waveform of three phase alternator is improved to a certain degree. The temperature raise at different parts of the machine has been noticed and found that machine is within tolerable limits. Saturated machine constants are obtained from three phase symmetrical short circuit test where as unsaturated machine constants are obtained from line to line short circuit test. Additional losses of this machine are found as 2.36W.

The analysis of SRA is carried out based on equivalent circuit approach in this experiment. The same can be extended using electromagnetic field approach.

Profile

Dr G Suresh Babu

Working with department of EEE CBIT, Hyderabad, Telangana for the last 16 years. He has guided 15 M.Tech projects, published 10 technical papers in various international journals & conferences. His interests are Industrial Drives, Energy Management & Renewable Energy Systems. He is a core member of Energy Conservation Mission of IE(I), Hyderabad & founder coordinator Energy Savers' Club in CBIT.

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EPRO TMS with Block Diagram

Loss Measurement Accuracy as Key Factor for Energy Saving Programs

Efficiency programs of most of the governments are focusing on reducing the energy losses in the distribution network, and for some of them even give metrics for these improvements. A big amount of these losses is coming from the distribution transformers and the manufacturers are encouraged to improve the efficiency of their designs. These improvements are often managed with the use of better materials and then increase the costs of the transformers.

Christoph Denk

The needs for accurate loss measurements are therefore increased, if the manufacturers don't want to see their efforts under coming in the measurement uncertainties of a measurement system. Proving a small improvement in efficiency, even at high costs for the manufacturer will be difficult if the measurement system can't measure this improvement accurately. Accuracy of measurement systems and comparison of these accuracies are of the biggest importance, and have been a subject of discussion between experts since long time. The article will describe how a modern measurement system can be accurate, assess its accuracy for every measurement performed and set confidence over the time about the stability of its accuracy. In this approach, not only the measurement is important, but also the complete chain, data management, reporting & accuracy assessment of the measurement have to be automatically computed for the end user.

It is stated in many studies and articles that the general losses of the transmission and distribution network is around 9% of total

Analysis of current situation

Transformer loss measurement is a well known field. All manufacturers of transformers have to do loss measurement tests for proving the technical data of their products especially in load losses and no load losses. It is stated in many studies and articles that the general losses of the transmission & distribution network is around 9% of total. The losses generated by transformers are the second biggest part of the total distribution and network losses. It is stated that the losses caused by transformer load and no load losses have an approximate value of 300 TWh per annum, this is for compares approx. 2 times the annual consumption of Poland . Efficiency programs worldwide are trying to force manufacturers in investments in R&D and production to reach lower losses. Speaking about losses we have to state that the efficiency values at transformers already are in a quite high range. Fig. 1 shows the efficiency values for liquid filled transformer tiers.

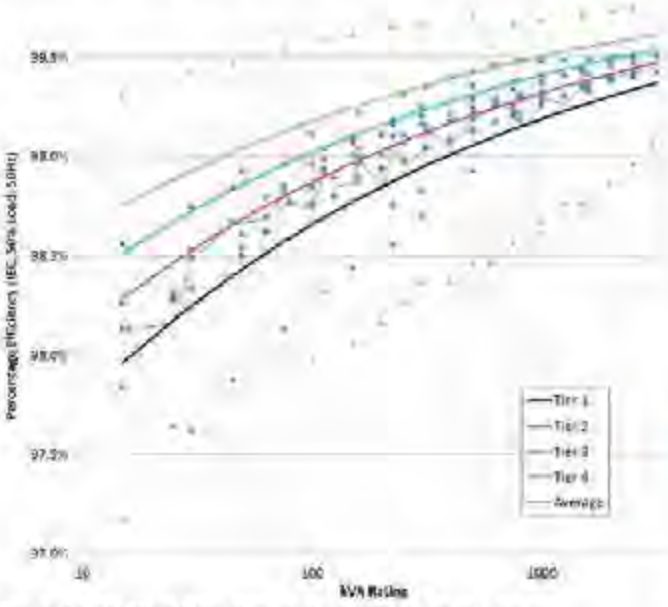

Fig. 1: Liquid filled Transformer tiers - efficiency values

Fig. 2 Shows a variety of international programs for energy efficiency and illustrates a trend for the future. Hardly all countries will propose programs like this to force transformer manufacturers to optimize the losses of their products.

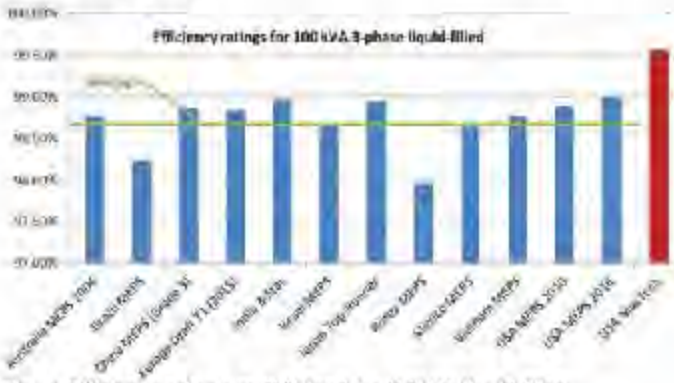

Fig. 2: Efficiency criteria at 50% load for 100kVA liquid filled transformers in different countries

These overview data shows the importance of high efficient transformer materials and the necessity in optimizing each single part in the transformer. But just on the second sight it points out very clearly a major question for reaching these goals. What is with transformer testing and the measuring uncertainties involved in this testing process?

All efforts done by transformer manufacturers are for nuts if the expensive improvements are eaten by measurement uncertainties of the transformer testing equipment. Thinking this statement to an end it reduces in two main issues:

- The measurement uncertainty has to be as small as possible
- The measurement uncertainty has to be known. And to be known means not having the information on the general (theoretical) uncertainty of a test system, it means that the actual uncertainty at each measurement has to be known and stated in the test report.

In order to have an idea about the impact of the accuracy and uncertainty of the measurements on the efficiency measurement, we can consider the example given in 6 Chapter 3.2. In this example, applying a system accuracy of 0.1% on measurement losses (including uncertainties to illustrate clearly this example) will yield automatically to a 0.03% tolerance on the transformer efficiency itself. This easy calculation really illustrates the importance of the loss measurement system in this efficiency improvement process.

Measurement uncertainties in Loss measurement system

The measurement uncertainties have been studied and discussed for years since the first well known publication5 of the National Bureau of Standards in the eighties. This publication had already stated the problematic of efficiency improvement and the needs of accurate loss measurements in order to assess correctly these improvements. Even if

the problematic is not new, the IEC has only published its part IEC 60076-19 about the determination of uncertainties in loss measurement for transformers and reactors in 2013.

The NBS publication has pointed out in the eighties that a measurement uncertainty statement in such systems can only be made efficiently if the measurement chain is reduced to its minimum. Every part of the chain brings its uncertainties, and these uncertainties are combined as a sum for a worst case study, or as RSS (root square of the sum). Even with low mathematical background, it is obvious that low part count in the measurement chain may bring less uncertainty as a bigger amount of uncertainties factors.

System calibration and longtime stability

All calibration methods are based on a standard alignment of the measurement system to higher level standards in order to keep measurement traceability. The alignment on the standards provides a very good accuracy at the time of the calibration, but the question remains on the longtime stability of this calibration. Can a measurement system manufacturer prove that a system will be enough stable to stay in the specifications it has given? And with which measurement uncertainty can this assumption be assessed?

This long term stability implies some basic principles for a measurement system. All components of the system must show:

- A very high long term stability that is proven and accepted in the industry, such as passive inductive transducer for voltage and current which are known for being very accurate and stable and therefore require very long calibration intervals
- A well-known variation that has to be proven using statistical methods and that can be compensated during the measurements. This is mostly the case of electronic front-end in the measurement chains, that are subject to change with temperature or other environmental aspects

The loss measurement methods and its accuracy

The evaluation of the accuracy of power measurements for the losses has been described in the standards since a long time, and is still of the first importance.

The basic calculation of the power measurement is given (1) in and is composed of the different measurement uncertainties of each measured quantity.

As described in the standards, the accuracy of measurement is of first importance for the voltage and current, but the most important factor for power measurement is the phase angle or power factor measurement.

The measured power losses are expressed as

$$P = U \times I \times \cos\varphi \qquad (1)$$

For the composite relative error the formula gives:

$$\frac{\partial P}{P} = \frac{\partial U}{U} + \frac{\partial I}{I} - \frac{\sin\varphi}{\cos\varphi} \times \partial\varphi$$

Modified, this equation shows that when the phase angle is small due to the inductive nature of the equipment under test, the power measurement error, which varies with the inverse of the power factor, will increase.

Analyzing the first terms of current and ratio, another term comes into account as the loss measurement usually deals with high voltages or high currents. This term is the ratio of the divider used during the measurements. Reducing the uncertainty of voltage and current measurements is mandatory. But, as explained in the standards the ratio of the measurement transformer can be compensated in the calculations of power to improve their accuracy. In order to compensate these ratios, the ratio deviation must be known exactly with the best accuracy and last but not least, must be very stable, not depending from temperature or humidity or electromagnetic noise for example.

The phase angle between current and voltage or the power factor must be measured accurately to reduce the uncertainty of the power. The Phase or power factor measurement errors are impacting the active power measurement very fast, applying the equations from (1) directly leads to curves like the Fig. 3 given below.

The typical curve of the Figure was obtained by assuming current and voltage at ±200ppm and a phase error of maximum 0.4 min.

Parameters that degrade the accuracy

Electromagnetic noise

Because of its random nature, electromagnetical noise is for sure the most difficult source of error in the loss measurements. Many laboratories are using electronic power supplies for their tests in order to get flexible power conditions like higher frequencies, but motor used in the factories and their frequence converter can also be important sources of noise.

These electronic power supplies are switching power supplies and are emitting a wide spectrum of electromagnetical noise. This noise at high frequencies can be coupled on the measurement devices themselves or on the connecting cables. A modular system with front-end and digitizing as near as possible from the measurement transformers reduces the coupling of noise.

Electronic instability like range switching

An important aspect to reduce the measurement uncertainty is the stability of the measurement setup, and once the transducers are considered, the focus comes on the electronic front-end. Changes in the measurement setup directly impact the uncertainty of the measurements. The

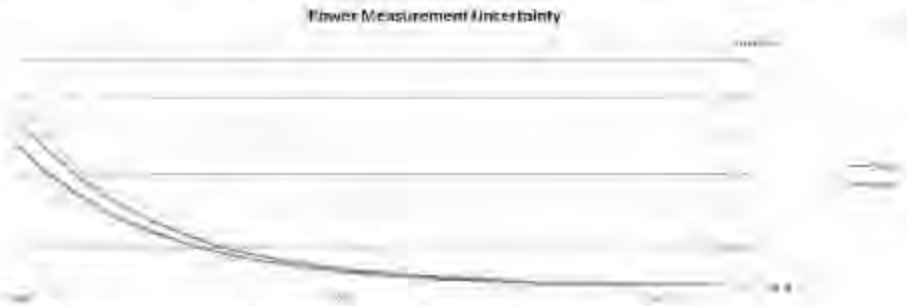

Fig. 3: Power measurement uncertainty in relation to the power factor

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predictable behavior can be compensated such as the temperature variation, but the non-predictable components in the system have to be avoided.

For example, measurement devices including range switching with relays influences the impedance in the measurement circuits and then brings an additional uncertainty to the measurements. Even the best measurement front end will be inaccurate if its setup is changed during the measurements.

It is of the first importance that the electronic contains a system of self-verification to ensure that the measurements are still made with the best accuracy. The verification and the calibration must be made in a way that shows a very low uncertainty. Using for example electronic front-end clearly identified with a conventional voltage or current, can allow a quick verification at any time with power standard devices on the market. For example, if the front end for current measurement is working on a range 0-10A it can be calibrated or verified with a common power standard like Fluke 6105 for example, leading to combined measurement uncertainties of less than 50 ppm.

Important but forgotten points to accuracy

As soon as a measurement discussion starts, it ends quickly to accuracy assessment. During these discussions, the metrological point of view is immediately on the scene, but some points are often forgotten, even if they can affect dramatically the accuracy of any measurement, and in the worst case make the measurement unusable.

Effect of the system user

The use of digital measurement devices has reduced the uncertainties due to the user against the old measurement devices with arrows. The "reading" errors have been eliminated. The measurement operator can still make mistakes during the test, especially if the user is not experienced or trained to these types of measurements.

The use of the latest man machine interfaces with touch screen or other displays guides the user during the tests in order to avoid any failure during the measurements. The use of intuitive graphics is of first importance to terminate through the requirements of the standards, without forgetting any measurement or action.

Fig. 4: State of the art man machine interface for measurement system

Equipment quality

As seen above, the measurement equipment directly impacts the measurement uncertainty of the power, not only with the initial accuracy, but mainly from their stability.

Inductive standard transformers offer the highest level of accuracy in voltage/current measurement and also in phase angle. Really state of the art standard transformers should offer accuracies between +/-0,005 & +/- 0,01% and a phase angle uncertainty of not more than 0,5-1,0min depending on the height of the rated voltage/current.

Including electronic in the transducers must be made very carefully, as the electronic can have direct drawbacks on the measurement quality. First, the power supply needed by the electronic can carry conducted electromagnetic noise from external sources, and second will bring its own uncertainties in the uncertainty of the equipment. Keeping the transducer simple is still the most efficient.

Fig. 5: State of the art standard voltage transformer, 40kV rated

The measurement system can compensate the transducers ratio and phase displacement only if the long term stability is proven, it can otherwise even add some errors to the measurements.

Temperature measurement

A very good example of the most neglected parts of the loss measurement, maybe because it is not directly related to the power loss measurement, is the temperature measurement. Every standard gives a method to correct the measured losses, depending on the materials composing the transformer or the reactor. Most of the laboratories take an approximated measurement of the temperature to correct the loss according to the standards.

The following example shows how important are the accuracy of temperature measurement in the final results of the loss measurements.

Considering the Load Losses in W as defined in the standards, the temperature correction applied to these losses is calculated using the following formula:

$$P_{LL} = P_j(I_r, T) \times \frac{T_k + T_r}{T_k + T} + P_a(I_r, T) \times \frac{T_k + T}{T_k + T_r}$$

Where

$P_j(I_r, T)$: Ohmic losses at I_r and T.

T: Temperature measurement, in ^{O}C.

$P_a(I_r, T)$: Additional losses at Ir and T.

I_r: EUT assigned current, in A.

T_k: Temperature coefficient of EUT windings

P_{LL}: Load losses, in W.

T_r: Assigned temperature, in ^{O}C.

Taking a small academic example to calculate the consequences of a bad temperature measurement uncertainty gives the following with:

$T_r = 75^0C$, Assigned temperature, in ^0C.

$I_r = 10A$, EUT assigned current, in A.

$T_k = 235$ (Copper), Temperature coefficient of EUT windings.

$R_{Tr} = 0.715\ \Omega \pm 0ppm$ EUT windings resistance at T_r

Measurements		Calculations	
P	T	R_T	P_{LL} (W)
90W ± 291ppm	70^0C ± 0^0C	0.727Ω ± 0ppm	88.55W ± 435ppm
	70^0C ± 0.3^0C	0.727Ω ± 984ppm	88.55W ± 926ppm
	70^0C ± 1^0C	0.727Ω ± 3279ppm	88.55W ± 2757ppm
	70^0C ± 5^0C	0.727Ω ± 16390ppm	88.55W ± 13620ppm

Fig. 6: Effect of temperature uncertainty to measurement uncertainty

Fig. 7: Live accuracy and printout of uncertainty in modern measurement system

This example shows the importance of the temperature measurement in the computed results. It is obvious from these results that a measurement system must include an accurate measurement of the temperature, synchronized with the power measurement. This ensures that during the averaging time of the loss measurements, the measurements are always corrected with the right temperature.

Live accuracy assessment

After reviewing the characteristics that can bring or avoid uncertainties in the measurements, a statement must be made for every measurement. Every measurement engineer has faced the difficulties of calculating the accuracy of measurement and their uncertainty.

Arising thanks to modern data processing possibilities, it is of best practice for a measurement system to provide directly the accuracy of every measurement. These assessment are then stated through the calibration documents and traceable to the national standards.

Conclusion

This Article shows that modern measurement centers are complex systems. The task of measuring transformers is not easy and brings various tradeoffs. Modern measurement centers are able to minimize the total uncertainty of the measurement process. Therefore some abilities should be guaranteed, the architecture of the measurement system can help minimizing tradeoffs and uncertainties. The Architecture of a combination of electronics and automation in combination with well proven inductive measuring devices brings advantages of two worlds together. The end user has to focus on easy handling, security and accuracy. All these points are important and are having a big influence on the process and therefore on the productivity of a lab.

The efforts that transformer manufacturer will do for the efficiency improvement of their designs must be secured by very accurate and defined measurement uncertainties measurement systems. The trend of efficiency improvement will live, only if this improvement can be quantified with the highest degree of confidence.

Christoph Dank

Completed Engineering in 2003 and Economics in 2005. Worked in several specialized companies in mechanics. At present he is director of sales and marketing at EPRO Gallspach GmbH in Austria. One of his most important focus is the topic of automated routine testing for transformers, instrument transformers and shunt reactors.

Profile

Control Coordination of a Team of Underwater Vehicles

Research on autonomous underwater vehicle (AUV) is motivating and challenging owing to their specific applications such as defence, mine counter measure, pipeline inspections, risky missions e.g. oceanographic observations, bathymetric surveys, ocean floor analysis, military uses, recovery of lost man-made objects. In many applications, a group of AUVs are required to follow a predefined trajectory while maintaining a desired spatial pattern.

Bikramaditya Das, Bidyadhar Subudhi and Bibhuti Bhusan Pati

Moving in formation has many advantages over conventional systems, for example, it can reduce the system cost, increases the robustness and efficiency of the system while providing redundancy, reconfiguration ability and structure flexibility for the system. A number of control complexities are encountered for AUVs motion control. These motivate to develop new and efficient control algorithms such that accurate path following task and effective group co-ordination can be achieved in face of parametric uncertainties, disturbances and resolving the difficulties encountered in communication constraints in underwater medium.

Autonomous underwater vehicle (AUV) is an unmanned mobile robot which travels under water. Based on design, control and utility, AUVs are classified as unmanned underwater vehicles (UUVs) and remotely operated underwater vehicles (ROVs). Above last two decades the AUV and group of AUVs forming the formation or cooperation, play crucial roles in different important cases as shown in Figure 1.

As the importance of energy sources increases, the area of finding that is also

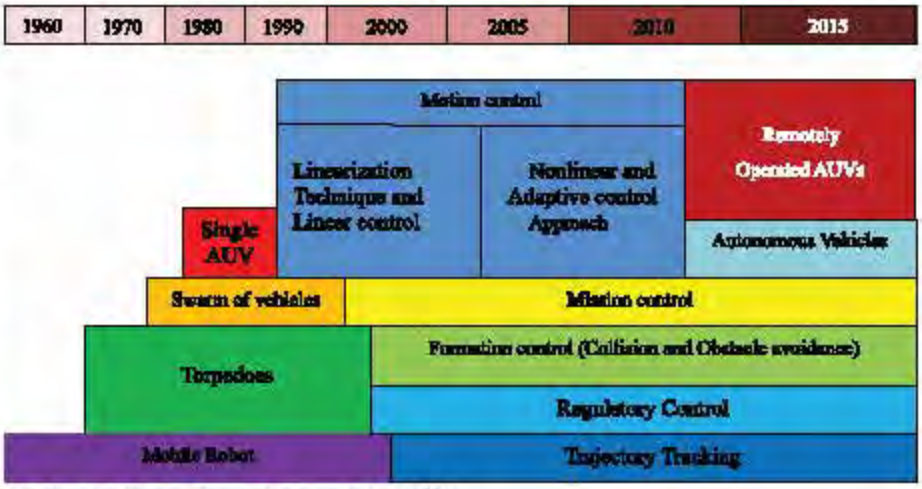

Fig. 1: Studies on Formation control of AUVs

increases and is extended to the deep sea areas. For getting that, competition among different countries increases. Exploring and developing deep sea areas needed different kinds of sensors and devices. Remotely operated vehicles (ROVs) and AUVs are directly fulfilling these requirements. AUV plays an important role in case of high resolution seabed mapping and commercial survey. In aquaculture, AUVs are used to feed the fishes.

In case of exploration and exploitation of resources located at deep oceanic environment, AUVs play important roles. The AUVs are used in risky and hazardous operations such as bathymetric surveys, oceanographic observations, recovery of lost man-made objects and ocean floor analysis etc.

Cooperative Control of Multiple AUVs are classified as formation control and flocking control of multiple AUVs. Formation control is an important research topic of the cooperative control within the recent fields of multi-AUV systems. It has broad applications and so it is recognized to occupy the seat of an active research topic in the recent years. Shortly the formation control referred as the problems of controlling the relative positions and orientations of robots in a group while allowing the group to move as a whole.

The step-by-step problems of formation control are (a) assignment of feasible formation (b) moving in formation in ocean current disturbances (c) maintenance of formation shape (d) switching between formations. Flocking is the flying behaviour of a group of birds. This is applicable to control a group of multiple AUVs to perform a desired task. Flocking control of multiple AUVs is similar to that of formation control with only difference is that there are no constraints on distance among AUVs.

Applications of AUVs

- Recently AUVs have been used for a limited number of tasks dictated by the technology available. With the development of more advanced processing capabilities and high yield power supplies, AUVs are now being used for more and more tasks with roles and missions constantly evolving. Autonomous Underwater Vehicles (AUVs) are playing a crucial role in exploration and exploitation of resources located at deep oceanic environments such as oceanographic observations, bathymetric surveys, ocean floor analysis, military applications, recovery of lost man-made objects, etc.. Other applications of formation control are security patrols, search and rescue in hazardous environments.
- The oil and gas industry uses AUVs to make detailed maps of the seafloor before they start building subsea infrastructure; pipelines and subsea completions can be installed in the most cost effective manner with minimum disruption to the environment as shown in Figure 2. The AUV allows survey companies to conduct precise surveys or areas where traditional bathymetric surveys would be less effective or too costly. Also, post-lay pipe surveys are now possible.
- In military missions, a group of AUVs are required to keep in a specified formation for area coverage and reconnaissance. A typical military mission for an AUV is to map an area to determine if there are any mines, or to monitor a protected area for new unidentified objects. AUVs are also employed in anti-submarine warfare, to aid in the detection of manned submarines.
- Scientists use AUVs to study lakes, the ocean, and the ocean floor. A variety of sensors can be affixed to AUVs to measure the concentration of various elements or compounds, the absorption or reflection of light, and the presence of microscopic life. Researchers conjecture that platoons of cooperating mobile robots or autonomous vehicles provide significant benefits over single- unit approaches for a variety of tasks.

Fig. 2: Survey of oil and gas pipelines by AUVs

Formation Control Sub-Problems

There are several complexities accompanied with formation control of multiple AUVs. These are collision and obstacle avoidance, movement of formation and communication constraints. These are briefly explained below.

Collision and Obstacle Avoidance

When a group of multiple AUVs move in formation, it is necessary to avoid collision between themselves as well as avoid collision with the solid obstacles intersecting the formation path to be travelled by the group. Obstacle avoidance is highly essential sub-problem in formation control of AUV as shown in Figure 3. The obstacle may be static or dynamic.

Movement of Formation

The shape of the formation structure is generated according to situation of the surrounding environment as well as the communication topology used. Graph theory considering the AUVs as the nodes and the communication vectors as the links play an important role for the generation of formation shapes. The formation controls of multiple AUVs may be maintained in different situations of the formation regions separately. The formation shapes are generated by a team of AUVs according to required conditions using appropriate mathematical functions as shown in Figure 4.

If there is no disturbances appear in the formation environment, the formation shape maintains a rigid shape or the graph rigidity is maintained throughout the motion. But in certain cases it is necessary to change or to

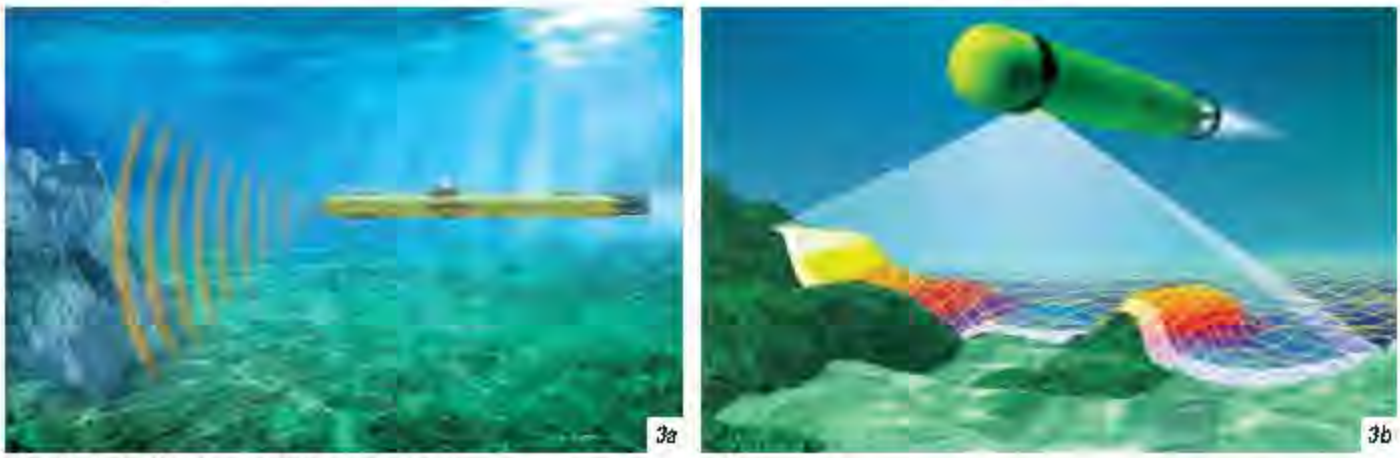

Fig. 3 (a & b): Collision and Obstacle Avoidance

split the shape of the formation according to requirements. It may happen due to change of environmental conditions such as presence of some uncertainties, entrance of heterogeneous vehicles, presence of solid obstacles, narrowness of formation track, communication failure between AUVs due to attenuation and suppression of strength of communication signals etc. In case of malfunctions and failure of formation due to missing or mechanical disturbances of one or many AUVs, the formation structure is disturbed. It is necessary to recover the formation shape again to the fundamental shape. This is possible by mean of ignoring the missing AUV and rejoining the other AUVs with establishing communication among them.

Communication Constraints

When moving in formation, the AUVs should communicate each other or to a central hub or mother vehicle according to the control and coordination strategies of the system as shown in Figure 5.

In other words, there should be communication channels for information exchange among AUVs in formation. The maximum distance up to which communication between two AUVs is still possible is the communication range. For AUV communication acoustic signals are used instead of electromagnetic waves which are in terrestrial communication. Keeping communication in underwater environment is difficult due to the following reasons. The chances of multipath propagation due to formation of distinction of sea layers, small available band width which tends to use time-division multiple-accesses (TDMA) techniques to share available information, uncertainty or time variation in channel of propagation, strong attenuation of signal in travelling medium, high latency due to the low speed (1500 m/s) of sound in water.

The speed of sound varies due to wavering in salinity and temperature, etc. One strong demerit of acoustic communication is the transmission of low data rate as compared to terrestrial communication which limits the amount of data flow. Instead of continuous time, discrete time based signals are used for AUV communication it is because the discrete time communications are more practicable and feasible for formation control of multiple AUVs in unreliable and narrow band width acoustic communication underwater environment. Sustaining of formation of multiple AUVs and simultaneously enabling cooperation among them is a very difficult task. To overcome the limitations of underwater environment and to create the efficient cooperation among the multiple AUVs, a special type of system DELPHIS may be used. It has an architecture that allows efficient communication between AUVs in ocean environment where the communication is very difficult. This DELPHIS system does not rely on any centralized task allocation but the

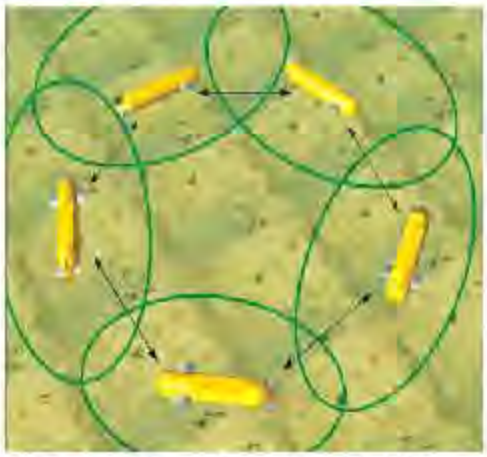

Fig. 4: Formation controls of multiple AUVs using predefined shape

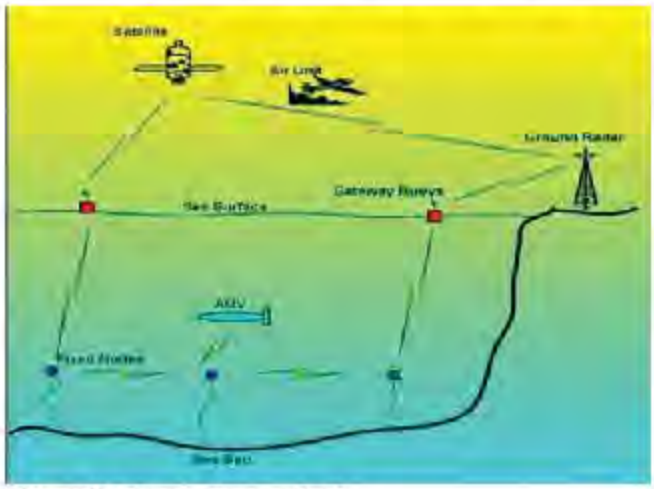

Fig. 5: Underwater Communication

total plan is completely distributed uniformly among all AUVs. The localization of AUVs is possible by measuring the inter-vehicular propagation delay and by exchanging localization map within water. To use efficiently the low data rate acoustic communication AUVs underwater, a special type of communication protocol i.e. Compact Control Language, or underwater acoustic MODEM are used. A central node is necessary to communicate the AUVs cooperating in the group.

Conclusions

An extensive review on formation control of a group of multiple AUVs along with different sub-problems of formation control is presented. The review provides a brief survey on effectiveness of the reported coordination control strategies and thus will motivate researchers in the area to focus on some issues highlighted in future control development of the AUVs.

Profile

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Specifying Current Transformers *Realistically*

Current transformer is an important link in power system that helps us to measure, monitor & protect the power system. As such, the correct selection and specification of a current transformer also becomes a very important task. Unfortunately, not much attention is paid to correctly specify the CTs.

K Sivakumar

This article aims to look into the significance of some of the CT Specifications and the effects of wrong specification – particularly with respect to application in Switchboards.

CT Specifications: Some of the vital CT Specifications are:

- Ratio
  a. Rated Primary Current
  b. Rated Secondary Current
- Accuracy Class
- Burden
- Accuracy Limit Factor

Rated Primary Current: Vide Clause 11.2 (Table-11) of IEC 60044-1:

Accuracy Class	+/- Percentage current (ratio) error at percentage of rated current shown below			
	5	20	100	120
0.1	0.4	0.2	0.1	0.1
0.2	0.75	0.35	0.2	0.2
0.5	1.5	0.75	0.5	0.5
1.0	3.0	1.5	1.0	1.0

Table 1: Limits of current error and phase displacement for measuring current transformers (Classes from 0.1 to 1)

Vided the above, according to Standards, the declared accuracy of a CT can be guaranteed only between 100% to 120% of Rated Primary Current. If the actual primary current is less than 100%, the error will increase. So much so that at 20% of primary current, the error doubles and at 5% or primary current, it quadruples for a Class 0.1 Measurement CT.

And, vide Clause 11.2 (Table-12) of IEC 60044-1:

Accuracy Class	+/- Percentage current (ratio) error at percentage of rated current shown below				
	1	5	20	100	120
0.2S	0.75	0.35	0.2	0.2	0.2
0.5S	1.5	0.75	0.5	0.5	0.5

Table 2: Limits of current error and phase displacement for measuring current transformers for special application

Note: Even with the special Class 0.2S & Class 0.5S CTs, the declared accuracy of the CT can be guaranteed only between 20% to 120% of Rated Primary Current. If the primary current is less than 20%, the error will increase. So much so that at 5% of primary current, the error doubles approximately and at 1% or primary current, it quadruples for a Class 0.2S Measurement CT.

This is of particular importance is CTs connected to Tariff Metering Applications.

In the case of Protection CTs too, the increased errors at reduced primary currents would greatly affect the performance of the protection schemes, thereby compromising on the very purpose of protection.

When selecting the rated primary current of the CT, the above fact shall be kept in mind. The CT Primary Rated Current shall be selected as close as possible to the actual load current anticipated in the location, where the CT is installed. If the CT primary current is not properly chosen and the actual primary current on the CT is a very low percentage of the rated primary current, then it would increase the error of the CT. If the present load of the installation is low, with anticipation of increased load in future, one can always opt for multi-ratio CTs, so that the CT tapping can be varied to choose the appropriate ratio, based on the requirements.

Rated Secondary Current: For the same ratio, accuracy class & burden, the size & cost of a CT with a 1A Secondary will be higher than a CT with a 5A Secondary. For switchboard

applications, where space is a constraint and also as the lead burdens are not very large, CTs with 5A Secondary will serve the purpose. Only where long lead lengths are involved (e.g.) CTs installed in outdoor switchyards with long secondary leads for loads located in distant control rooms, should one opt for CTs with 1A Secondary.

Accuracy Class: The required accuracy class also shall be chosen judiciously. Going for a finer accuracy class when not needed, would only increase the cost unnecessarily. Also, the accuracy class of the CT shall perfectly match with the accuracy class of the meters connected. For example, there is no point in going for a Class 0.2S Measurement CT, if the meter connected is also not of Class 0.2S.

Burden: Vide Clause 11.2 of IEC 60044-1, "for classes 0.1, 0.2, 0.5 and 1, the current error and phase displacement at rated frequency shall not exceed the values given in table 11 when the secondary burden is any value from 25 % to 100 % of the rated burden". "For classes 0.2 S and 0.5 S the current error and phase displacement at the rated frequency shall not exceed the values given in table 12 when the secondary burden is any value from 25 % and 100 % of the rated burden".

Thus, as per Standards, the declared accuracy is guaranteed only when the actual secondary connected burden is between 25% and 100% of the rated burden of the CT. If the actual connected burden is lesser than 25% of the rated burden, the error will increase. In earlier days, when measuring instruments and protective relays were of electromagnetic type, they imposed a huge burden on the CT cores. When a number of such devices were to be connected in series with a CT secondary, it was practical to specify CT Metering Cores as well as Protection Cores with rated burdens of 15VA or 20 VA or even 30VA.

But, with the advent of digital meters and digital protective relays, the burden imposed by these devices on the CT Secondary is greatly reduced. For example, the burden of the current coil of a conventional analogue, electro-magnetic, energy meter was about 5VA. Compare this with the burden of the current coil of modern day digital Trivector meter, which is less than 0.5VA. Similarly, the burden of an electro-mechanical over current relay is about 5VA, whereas the burden of a digital microprocessor based over current relay is less than 0.25VA. Say, for a tariff metering application with a digital Trivectormeter, if one chooses a CT with a rated burden of, say, 20VA, then the actual burden connected on the CT will only be a very low fraction – about 2.5% - of the rated burden of the CT. Thus, as per Standards, at such a low burden connected to the CT Secondary, the error will multiply many fold and the tariff meter will not record the measurements accurately. Even when one goes for an accurate & costly Class 0.2S Meter, it will still measure inaccurately only.

In case of protection CTs, apart from affecting the relay operations due to increased errors, connecting a lesser burden to a CT with a higher rated burden, would increase the actual Accuracy Limiting Factor of the protection CT. The ALF of a CT is inversely proportional to the actual burden connected. For example, if one has a protection CT of Class 5P10 & a rated burden of 15VA, the actual ALF of the CT will be 10, only when 15VA burden is connected to the CT Secondary. If the actual burden connected is, say, only 5VA, then the ALF will increase to about 17. This will not only affect the operating performance of the protective relays connected, but also might damage the CT Secondary Winding Insulation and the equipment connected to the CT Secondary.

More and more systems are updated with these sophisticated electronic measuring instruments as well as digital protective relays. But, unfortunately, while specifying the CT burden it is not paid due consideration. Customers specify CTs with the earlier 25VA or 30VA, perhaps thinking that as a factor of safety or cushion. But, as we have seen earlier in this article, such practice of over-specifying CT burdens will only be harmful to the system as well as the CT itself, thereby totally negating the factor of safety concept itself.

Also, specifying a CT with a higher rated burden than the actual connected burden will increase the size & cost of the CT.

Contrarily, CTs with lesser burden will also be smaller in size and also cheaper. So, customers can have the added benefit of precious space saving as well as economy. More importantly, operational hazards too are minimized. And, reference is drawn to IS 4201:1983 (The Indian Standard Application Guide for Current Transformer), wherein it is stated that

Cl. 6.1 (Measuring CTs):" the rated output should be as near to in value but not less than to the actual output at which the CT is to operate. Ordering a CT with a rated output considerably in excess of required output may result in increased errors."

Cl. 9.5 (Protection CTs): "Normally, the standard VA rating nearest to the burden computed shall be used."

Accuracy Limit Factor

The accuracy limit factors recommended in the Standards is 5, 10, 15, 20 & 30. The ALF of a protection CT shall be chosen realistically, duly considering the maximum anticipated fault current at the location of the CT. Selecting a CT with a higher than necessary ALF, will increase the size & cost of the CT. Alternately, selecting a CT with a lesser than necessary ALF, will affect the performance of the CT and might even cause irreparable damage to the CT.

Conclusion

Going by the above few paragraphs, it is prudent to select and specify current transformers judiciously, particularly for switchboard applications. Apart from optimizing the performance of the CT and of the connected equipment, such a measure would also optimize the size & cost of the CT as well as that of the switchboard as a whole.

Profile

K Sivakumar

Electrical Engineer, presently working as Manager-Design & Training, with Megawin Switchgear P. Ltd., Salem, looking after design & engineering of Medium Voltage Switchgear & switchboards and conducting training programmes. He has 8.5 years working as a Manager – Design & Training, with Larsen & Toubro Ltd.

Deal V/s Non-Violent Democracy

Since the Indo-US Nuclear deal inked by the then Prime Minister of India, Manmohan Singh, the NPCIL has embarked on a rather ambitious plan to expand the Nuclear power generation from 5,308 presently to 63,000 MW by 2032. The track record of NPCIL is anything but reassuring that this target will be met. The democratic resistance by the villagers of MithiVirdi area have raised very basic questions regarding the functioning of NPCIL which has flouted the norms and procedures to ensure safety of a nuclear power plant. With the renewed commitment arrived at between the present Prime Minister of India and President of US, NPCIL has received new enthusiasm.

Krishnakant Chauhan

People's resistance against nuclear power is not a new thing. With the signing of the Indo-Us Nuclear Deal the Indian Government expects to have its Nuclear Power Generation capacity from the presently 5,308 MW to 14,600 MW and 63,000 MW by 2032. However as is a case with the NPCIL and the Nuclear establishment in India, they have rarely achieved their projected targets. The case of MithiVirdi is one more story of the casual approach of the NPCIL.

A 6000 MW Nuclear power park with 6 reactors to be imported from WestingHouse USA is proposed in the MithiVirdi area of Bhavnagar district. The proposed site is just adjacent to the Alang Ship Recycling Yard. The proposed project is facing a stiff resistance from the local villagers and also the Alang Ship Recyclers. However determined to push the project the NPCIL has resorted to flouting the basic norms and procedures, also overlooking serious security issues. The whole process of preparing Environmental Impact Assessment (EIA) Report was carried out in violations of the basic procedures and norms prescribed by the Environmental Laws.

The first and foremost things is that the EIA is prepared by a consultancy – Engineers India Limited which does not have the mandatory certification from QCI-NABET. Moreover the EIA has overlooked very basic and serious issues that would have bearings on the stability of the proposed power plant.

'Unconstitutional and Illegal' Environment Public Hearing conducted in the 'Atmosphere of Terror' for the Nuclear Power Plant

The "Environment Public Hearing Committee" of the Bhavnagar District had not followed the bare minimum basic procedural norms while conducting the EPH on March 5, 2013 at Navagam (Nana) for the proposed 6000 MW Mithi Virdi Nuclear Power Plant.

Just prior to the EPH proceedings, A. V. Shah, the member secretary of "Environment Public Hearing Committee" of Bhavnagar District had reassured activists that the Sarpanchs of ten villages (Jaspara, Mithi Virdi, Paniyali, Khadarpar, Mandva, Sosiya, Navagam (Nana), Goriyali, Rampar (Garibpura), Bharapara) would be allowed to raise procedural issues after the opening remarks by the collector and the GPCB's.

The Sarpanchs had already prepared a written submission documenting procedural lapses in the EPH hearing as directed by the authorities. But when the EPH proceedings started, the first violation of the procedures happened, when authorities reneged on their assurances to the Sarpanchs of the affected villages.

Jaspara village Sarpanch Shaktisinh Gohil started making the point on procedural lapses soon after the opening remarks, but was prevented by the collector V. P. Patel himself saying that Shaktisinh Gohil could hold the floor only after the NPCIL presentation.

The main points of the written submission of the Sarpanchs were "The EIA Report for NPCIL has been prepared by Engineers India Limited. According to EIL's own admission it does not have the requisite Ministry of Environment and Forest accreditation to undertake the Environmental Impact Assessment. The EIA Report is therefore illegal.

The EIA Report has not been prepared as per the Terms of Reference (TORs) determined by MoEF. The EIA Report is therefore incomplete. Any public hearing based on such incomplete report would be illegal.

> *Mithi Virdi-Jaspara region as Nuclear Free Zone. The resolution to declare the region Nuclear Free Zone was passed unanimously*

Only 24 villages in a radius of 10 km from the project have been considered "affected" by the project. A total of 128 villages falling in the 10 to 30 km radius have not been considered "affected". The public hearing therefore cannot be construed to be legal.

The High Court judgement dated 28th May 2010 in the matter WP (C) No. 9317 of 2009 and Supreme Court Order of 2011 stipulate that all citizens, including those not directly affected by a project should be allowed to participate in environmental public hearings. Therefore your opinion that such citizens cannot be allowed to speak at public hearings would be a violation of the Honourable Supreme Court and High Court orders."

This was the second violation because the collector should have first read the written submission on the procedural lapse and opined on it before proceeding with the hearing. About 6000 villagers present in the EPH, left with no choice but to leave the venue and keep them away from such illegal and unconstitutional Environment Public Hearing.

The entire exercise of the illegal EPH was further rendered futile as the collector did not even go through the basics of the procedural norms and did not give ear to democratic representations. The NPCIL presentation should have been held only after the collector had read the Sarpanch's representation, opined on it, and not otherwise.

The third violation happened with the collector's complete disregard for the Delhi High Court Judgement, about which he was informed through A. V. Shah in oral discussions. This is in clear violation of the Delhi High Court order in the case of Samarth Trust and Other v Union of India & Others W.P. (C) 9317 of 2009, where it has opined that"....Prima facie, that so far as a public hearing is concerned, its scope is limited and confined to those locally affected persons residing in the close proximity of the project site. However, in our opinion, the Notification does not preclude or prohibit persons not living in the close proximity of the project site from participating in the public hearing – they too are permitted to participate & express their views for or against the project."

The fourth violation happened when the collector did not again read the Sarpanches' written submission on procedural lapses, which included the Delhi High Court judgement during the entire EPH, even after the villagers' walkout, and neither did he express any opinion on it. The collector thus ignored the Delhi High Court judgement, which was a vital point in Sarpanchs' representation during the entire EPH.

The EPH environment was coercive and terror-filled. Villagers were prevented from making free and fair representation. Not only was there a heavy posse of police force but also private security guards were hired at the EPH site, frisking and checking every entrant, and at places questioning villagers and participants about their antecedents.

There were unnecessary barricades and iron wire fencing between the collector's dais and the participants area, a first-ever arrangement during the EPH in recent times in Gujarat. The authorities had created an atmosphere of coercive tactics that invoked state control and fear over the proceedings of grave public concern.

Also, the collector allowed songs and recordings in favour of the NPCIL and benefits of nuclear power plant to be broadcast from the public address system arranged by the collectorate. These recordings continued to be played till the EPH proceedings began formally. This is a clear violation of the neutral approach that the collector should have taken on the issue and instead made clear his predisposition on behalf of the NPCIL. On the contrary, the villagers were not only prevented from making free and fair representation; their representations on procedural issues were also ignored during the EPH.

Also, the NPCIL made an audio-visual pre-recorded presentation during the EPH, with no NPCIL official making any opening remarks officially except for switching on computer and other accessories.

Heavy Police presence to create intimidating atmosphere during Environment public hearing 5th March 2013

Also, there were at least thirty odd people sitting on dais on both the sides of district collector during the EPH, whose presence and background went unaccounted with no one introduced or briefed about who they were and in what capacity they sat there. Their presences are not even marked in the minutes of the EPH. It is also a crucial issue that there be transparency regarding which capacities they were sitting on dais. The villagers and their elected representatives on the other hand got no such chance and instead were frequently frisked and subjected to irritating queries. The villagers were sitting behind the iron barricade at a long distance of the dais.

The additional district collector was sitting on dais next to the Bhavnagar district collector who had convened the EPH, which is strictly against the rules. Additional district collector can sit on dais and chair the EPH if the collector deputes him/her in his absence. The fact that the additional district collector was sitting sharing the dais with the district collector is also not mentioned in the minutes of the EPH.

The EPH was illegal to begin with as it was held based on incomplete, illegal EIA report, prepared by non-accredited company, the procedural lapses point out that the manner in which it was conducted is also illegal and unconstitutional. The collector, the chairperson of EPH, GPCB regional officers, the member secretary of EPH, the additional collector as well as those on dais who were overseeing the proceedings and representations is responsible for these illegalities by violating environment laws and the Constitution of India.

Even the Gujarat Coastal Zone Management Authority (GCZMA) acted in collusion with the illegal practices of NPCIL. While giving the so-called CRZ clearance / recommendation for CRZ clearance to the NPP, the Gujarat Coastal Zone Management Authority (GCZMA) stated that "The Authority deliberated the proposal of Nuclear Power Corporation of India Limited and after detailed discussion, the Authority decided to recommend to the Ministry of Environment and Forests, Government of India to grant CRZ clearance for construction of intake, outfall facilities, jetty and Desalination plant at Village: Mithi Virdi, District Bhavnagar by M/S Nuclear Power Corporation of India Limited, only after submission of the following details to this Department:

- Detailed note regarding the safety aspects and site selection criteria along with its advantage for this site and submit to this Department.
- A site visit should be carried out by GCZMA Member."

This clearly means that the Gujarat Coastal Zone Management Authorities is not serious about the CRZ clearance because they have casually given this clearance / recommendation for CRZ clearance without asking for and reading the note on safety aspects, site clearance report and without undertaking the site visit. GCZMA has not taken in account the basics, for instance eventualities like population increase in the immediate vicinity of the proposed plant.

It is unclear if the GCZMA is a victim of the non-transparent and secretive approach of NPCIL, which did not bother to attach the report dated 28 June 2007 of Site Selection Committee even in the EIA document.

It would be important to note that the EIA for the project could devote only a page for the Cost-benefit analysis of the project.

Co-ercive practices of the Gujarat Government & NPCIL to obtain forest land

NPCIL needs 81 hectares of forest land in addition to the other land for the nuclear power plant. To facilitate this the Taluka Development Officer (TDO) of Gujarat State sent a letter dated July 15, 2013 to Sarpanch of Jaspara directing him to pass a resolution on the lines of the copy that he had sent, so as to have the village body's stamp of approval for the state government transfer of forest land to the NPCIL. In this letter the TDO instead of seeking the opinion of Gramsabha as per the law for the land transfer, illegally and unconstitutionally orders the Sarpanch to pass the readymade resolution. Thus undermining the institution of Panchayati Raj.

The Gramsabha of Jaspara unanimously condemned & rejected such an unconstitutional letter of TDO. The Gramsabha unanimously resolved not to hand over the forest land for non-forest use to the NPCIL.

Villagers Asserting their Democratic rights non-violently

281 farmers and farm workers who would be directly affected by losing land and livelihood have expressed their dissent on oath by submitting affidavits.

The affidavit says "In this area, following a nuclear deal Indian government, the US government and US-based Westinghouse Company, the NPCIL proposes to set up a nuclear power plant. I strongly protest the land

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Villagers showing their affidavits

Villagers of MithiVirdi raising slogans after adopting Nuclear Free Zone Declaration

acquisition of my farm land mentioned above', it says, adding, "I solemnly affirm that I refuse to sell my above mentioned land at any price to the Government of Gujarat, Government of India or NPCIL". A similar affidavit has been signed by those working labourers in the farms associated with the villages, saying these farmlands are their only source of livelihood.

Village Panchayat' meeting turns Mithi Virdi-Jaspara area into Nuclear Free Zone

On 9 March 2014 the gram panchayats of five villages have passed a resolution declaring the entire "Mithi Virdi-Jaspara region as Nuclear Free Zone." The resolution to declare the region Nuclear Free Zone was passed "unanimously", and a copy of the resolution was sent to President of India Pranab Mukherjee, the then Prime Minister Manmohan Singh, the then Gujarat Chief Minister Narendra Modi, and secretary-general, United Nations, Ban Ki-moon.

The resolution clearly states "Orchards of mangoes, chikoos, coconut trees, lush greenery, sea and ships passing by, describe aptly the Mithivirdi-Jaspara area in the Talaja block of Bhavnagar district. This lush green area is the irrigated region of Shetrunji dam. At a time when Special Investment Region has become the most lobbied term in the state of Gujarat, this region too should be announced as SAR (special agricultural region) for agricultural purpose." The resolution added, "Situated on the Saurashtra sea coast, one would assume that the land is barren and un-inhabited, but a visit here belies all these assumptions. It is perhaps from this mistaken presumption that the proposal for a 6000 MW nuclear power plant spread over 777 hectares on this green lush land must have taken place." The statement further said, "Presently on this 777 hectare of land spread in Jaspara, Mithivirdi, Khadarpar, and Mandva stand 50,000 fruit trees. Also, bajra, cotton, groundnut, onions and other crops are sown year round due to irrigation facilities. This area is therefore aptly called Bhavnagar's vegetable basket a reason, why local villagers who stand to lose not only their land and livelihood but also a potential environmental risk if the nuclear power plant were to come up here."

The resolution suggests "people's desire to keep the neighbourhood nuclear power free." The resolution is significant, in view of the fact that the environmental public hearing of the proposed nuclear plant ran into controversy, as it was held on the basis of an illegal, incomplete environmental impact assessment study by an unaccredited agency, inviting strong protests from the local community.

Important salient points of resolution are:

- The production of nuclear weapons or of nuclear power shall not be allowed in the city/ village/ municipality. No facility, equipment, components, supplies or substance used for the production of nuclear weapons or nuclear power shall be allowed in the city/ village/ municipality.
- No person, corporation, university, laboratory, institution or other entity in the city/village/municipality knowingly and intentionally engaged in the production of nuclear weapons or with respect to nuclear electricity generation shall commence any such work within the city/ village/ municipality after adoption of this chapter.
- Nothing in this chapter shall be construed to prohibit or regulate the research and application of nuclear medicine or the use of fissionable materials for smoke detectors, light-emitting watches and clocks and other applications where the purpose is unrelated to the production of nuclear weapons or nuclear power.
- Nothing in this chapter shall be interpreted to infringe upon the rights guaranteed by the Indian Constitution.

The statement concludes, "We are opposed to all aspects and parts of the so-called nuclear fuel cycle and expressly forbids the production of nuclear energy, the presence of any equipment and materials related to the carrying out of any part of the fuel cycle and opposes any storage of nuclear waste."

The villagers have also raised questions on why the government has not been considering other sustainable and less hazardous options for electricity generation.

Democratic struggle v/s illegal and undemocratic means of NPCIL

Thus while the people to be affected by the NPCIL project for proposed 6,000 MW MithiVirdi Nuclear Power Park have continued to adopt democratic and non-violent means to protest against the unconstitutional means of NPCIL.

The government enterprise while rhetorically claiming to have taken utmost scientific approach and measures for security has ensured to flout many of the legal procedures overlooking hazardous nature of the Nuclear technology.

Krishnakant Chauhan

The author is an voluntary worker and activist of Paryavaran Suraksha Samiti. Paryaveran Suraksha Samiti is supporting the Villagers struggle to save their prime agricultural land against the proposed MithiVirdi Nuclear Power Plant

Profile

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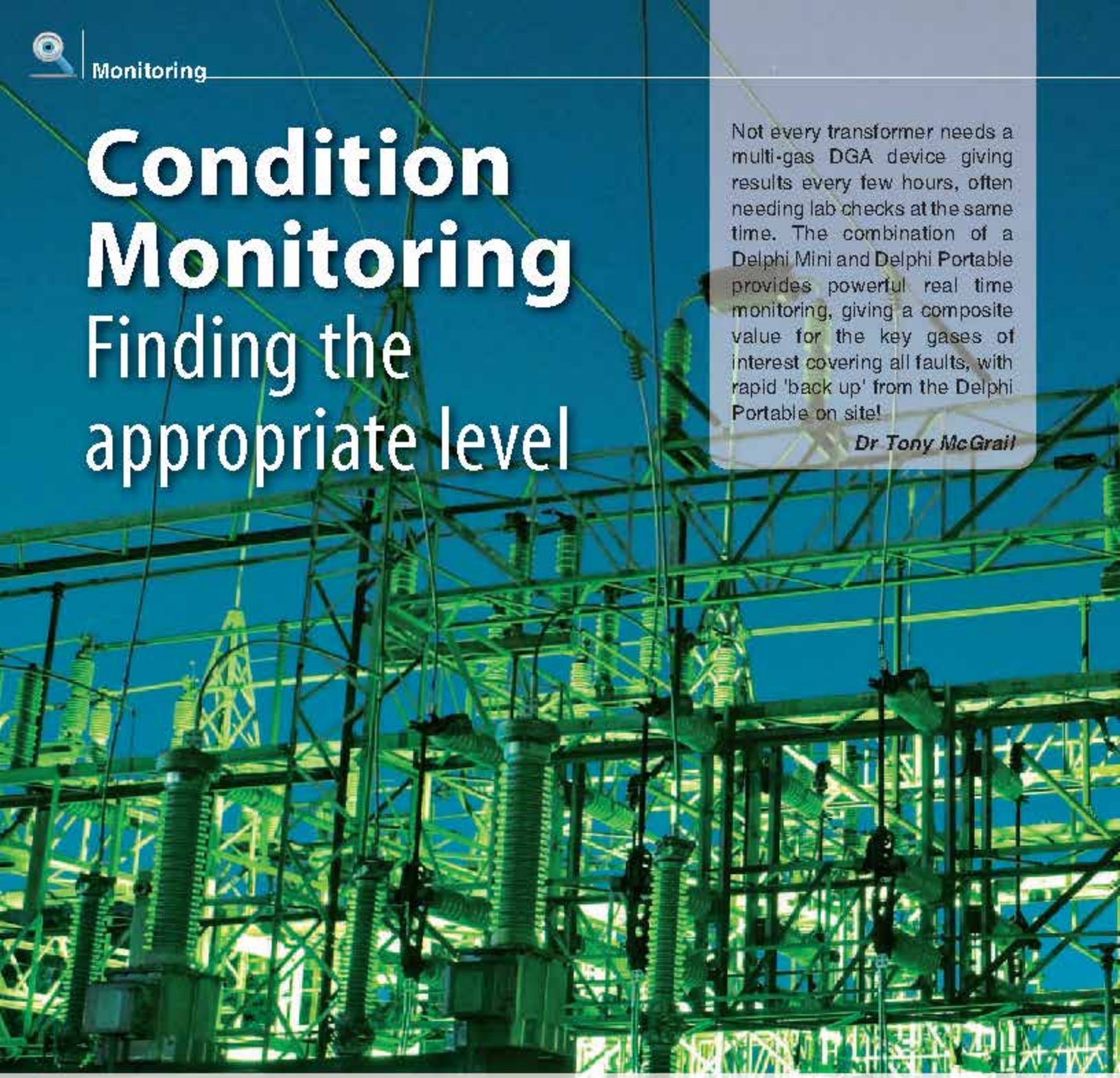
FORECAST

Condition Monitoring

Finding the appropriate level

Not every transformer needs a multi-gas DGA device giving results every few hours, often needing lab checks at the same time. The combination of a Delphi Mini and Delphi Portable provides powerful real time monitoring, giving a composite value for the key gases of interest covering all faults, with rapid 'back up' from the Delphi Portable on site!

Dr Tony McGrail



There are some general rules as regards to the application of condition monitoring which cover not just power transformers, but many large assets:

- What is the failure rate?
- What decisions do you need to make?
- What information do you need to support those decisions?
- Will a monitor give data in a timely manner?
- Is it worth it - what is the value?

Answering these questions helps determine the appropriate level of condition monitoring for a particular application. This paper looks at these elements and makes recommendations for some power transformer applications.

What is the failure rate of the asset?

It is unlikely that the asset in question has no failure mode; power transformers, for example, may fail through dielectric, thermal and mechanical causes. A study by HSB insurance company, and reported at the Doble Client Conference in 2012 reviewed causes and noted that the failure rate of power transformer is likely to increase in coming years. Failure rate may be closely related to individual manufacturer or designs, and may also depend on operation regimes. However, a failure rate

of less than 1 per year is commonly achieved in practice by electric supply industry organizations.

Decisions to be made

The most common condition monitoring decision is to decide the fitness for purpose of the transformer. This may seem obvious - but the decision will be made in context of available information: maintenance history, manufacturer/design, effect of any through faults. Is there anything in the performance of the transformer which is anomalous and leads us to believe that there is deterioration outside of expectations? Particular transformer families may need more attention; those which are suspect may require condition monitoring to provide more frequent data for ongoing review.

Information needed

Over the decades, many technical papers have shown that dissolved gas analysis (DGA) of transformer oil is a cost effective and comprehensive technique to support transformer health decisions; when a fault develops in a transformer, it is usually accompanied by development of fault gases - the individual gases will be dependent on the type of fault - thermal faults, partial discharge (PD) or power arcing. Sampling of transformers for lab testing is performed by most transformer owners, with the frequency of sampling related to the size of the unit. GSU's and transmission transformers may be monitored annually, or every 6 months; smaller units and less critical units may be tested every couple of years. The actual details are dependent on the individual organization. Online condition monitoring bridges the gap between regular lab samples and provides a greater opportunity to detect incipient faults in a timely manner. Other tests include partial discharge testing, bushing leakage current monitoring, temperature and infrared tests.

It is not necessary to have complete DGA details from a monitor to detect a developing problem. The Doble Delphi Mini, for example, provides a single value which is a composite indication of the key gases hydrogen, acetylene, ethylene and carbon monoxides. These gases are present in each of the common transformer faults detectable by DGA - thermal, PD and arcing.

> ***Most common condition monitoring decision is to decide the fitness for purpose of the transformer. This may seem obvious - but the decision will be made in context of available information: maintenance history, manufacturer/design, etc.***

When the Delphi Mini shows rising DGA levels, perhaps through an alarm setting via SCADA, a sample can be taken for analysis. This analysis may be performed at a lab, or using a Portable Delphi on site, which gives a reading for each of the 7 key diagnostic gases plus moisture. The advantage of the Delphi Portable approach is that it gives confirmation of dissolved gases in a very timely manner - no need to wait for a lab to respond!

Timeliness of Information

The nature of transformer design is such that it takes time for the byproducts of the faults - the dissolved gases - to mix in the oil and arrive at the sensor itself: consequently there is a natural time lag in information received, which may amount to several hours. The likelihood is, however, that well mixed oil will arrive at the sensor which is characteristic of the fault.

Online DGA through a Delphi Mini provides information in real time - continuously giving absolute DGA level and rate of change. Devices which provide 7 gases plus moisture take more time to process a sample - and they also need to be 'backed up' with a lab sample should they indicate a problem within the transformer. It is common to set a multi-gas online DGA device to measure every 12 or 24 hours, and then increase the frequency if there is a rise in DGA levels; this is reduced to a reading every few hours if the situation continues to deteriorate. One reason for this gap in sampling is that the multi-gas monitors require more maintenance and attention the more they operate; in addition, it takes time for each sample to run. This is the trade off with a multi-gas device - more information, but less frequently.

Value

Is it worth putting a more expensive multi-gas DGA device on every transformer? The short answer is 'No!' A Delphi Mini gives good general indication of deterioration in transformer health, in real time, which can be backed up using a Delphi Portable. The multi-gas device absolutely has its place with the large units and hyper-critical units, and comes with a cost associated - more investment in installation and upkeep and it is still recommended that a lab sample be taken should the multi-gas go into alarm.

It should also be noted that any condition monitoring will provide the possibility of both false positives and false negatives; depending on how the alarm levels are set. Managing the possibilities is an asset management decision - as is planning a response when an alarm happens!

Conclusions

When considering appropriate Online DGA condition monitoring, care must be taken to look at the individual application - multi-gas DGA devices have their role for large transformers and hyper-critical units, but a combination of a Delphi Mini for general DGA indication, with a Delphi Portable for detailed analysis, is a powerful combination. The addition of Doble's IDD to address bushing issues and Doble's PD range to address partial discharge provides a valuable and appropriate monitoring package for any individual application.

Profile

Dr Tony McGrail

Solutions Director, Asset Management & Monitoring Technology

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Jindal Steel and Power Ltd powers energy efficiency through its unique Coal Gasification Plant

Jindal Steel and Power Limited stresses need for India to explore alternate ways of obtaining gas to help attain energy security. At Gasification India, the 6th International summit on Gasification and its Applications, it showcased its unique, state-of-the-art Coal-to-Gas plant at Angul, Odisha.

Gasification India 2015 the two-day international summit entailed the entire field related to science, technology and policy of gasification of coal, biomass and other carbonaceous feedstock's, as well as applications to power generation, production of liquid fuels, and related topics. The scope of the summit was to estimate the global market for gasification by the end of 2020.

Naveen Jindal, Chairman, JSPL said, "We see tremendous importance of coal gasification and have invested $4 billion in coal & steel plants. We hope that the Government encourages coal gasification as this will be good for the country in the long run. Our Coal Gasifiers are performing very well, they have stabilised and can meet the gas requirement."

JSPL has entered into the Gasification Arena with the following projects-

JSPL Plant at Raigarh, Chhattisgarh

- **Fluidized bed Air Blown** Gasification of High Ash Indian Coal: Barbil, Odisha. Objective was to make Producer Gas to replace furnace oil required for Iron Ore Pelletisation Plant.
- **Fluidized bed Oxygen Blown** Gasification of High Ash Indian Coal: Angul, Odisha. Here the intent was to make synthetic gas for manufacturing Direct Reduced Iron.

Project at Barbil was undertaken to overcome price and supply uncertainties associated with furnace oil. In addition, the producer gas generated would be available at a cheaper price on per unit energy basis. The second project i.e. production of syngas for DRI production has been undertaken for the first time in the country for the similar reason, i.e. reduction of the dependence on foreign resources. Jona Pillai, ED, Coal Gasification, JSPL, "Following its philosophy of investing in technology for environment protection, JSPL has created for the first time in India a Coal Gasification plant for manufacturing direct reduced iron (DRI) plant. Coal Gasification is a highly energy efficient way to manufacture iron and has a much lower environmental impact as compared to coal based DRI."

Semiconductor
is fast changing the face of technology

Over the years, the Indian semiconductor design industry has developed significant capabilities and currently works on state-of-the-art products. Growing technical competence combined with stringent IP protection environment and trend towards localisation of contents will help this segment continue to grow.

Semiconductors are used extensively in various applications, which offer immense potential for the growth of this industry in India. Semiconductors are used majorly in Mobile Devices, Telecommunications, Information Technology & Office Automation (IT & OA), Industrial, Automotive and other industries (Aerospace & Medical industries). Indian Semiconductor Association (ISA) estimates the consumption of electronics in India to reach $363 billion by 2015 from $28 billion in 2005. Consequently, the domestic semiconductors market is to touch $36 billion in 2015 from $2.8 billion in 2005. Telecommunication (45.4%), IT Hardware and Office Automation (27.6%) and Consumer Electronics & Durables (10.6%) are major demand drivers, with Industrial Electronics (5.4%), Automotive Electronics (3.5%) and other electronics (7.5%) constituting the balance.

The semi conductor Industry has witnessed a robust growth of 17.3 per cent since 2009 and today boasts of a 5.1 percent share of the global pie. Considering the continued growth momentum, the Indian semiconductor design market is expected touch US$ 14.5 billion in 2015. India's electronics design and manufacturing industry is growing faster than the world average for the simple reason of catching up speed with the huge local demand of electronics products. Lot of MNC OEMS are going for local manufacturing to serve the local demand as well as other global markets.

Mitsubishi Electric provides semiconductors/devices including power modules and high power devices that handle the highly efficient control of power, optical devices that deliver the performance required in fiber-optic communication devices, high frequency devices that cover everything from radios and mobile phones to satellite communications, and the line of TFT-LDC modules that improve interfaces for information.

Power Modules

Mitsubishi Electric power modules are manufactured with state-of-the-art technologies that ensure the highest levels of performance and reliability while offering impressive energy savings for the products and systems they're used in. Our line-up of products is extensive, ranging from power modules developed to control high-voltage power generation, industrial manufacturing and railway systems to applications in home products, such as controlling the electricity used by air conditioners, washing machines and refrigerators. To maintain our market-leading position, the company's R&D activities aiming to realize further reductions in power consumption and size are ongoing.

- Thyristor Modules
- Diode Modules
- IGBT Modules
- HVIGBT Modules
- Intelligent Power Modules (IPMs)
- HVIPMs
- DIPIPMs
- PFC Modules
- Power MOSFET Modules.

High Power Devices

High power devices contribute to increased efficiency and energy savings by supporting the high voltage, high current and usage environment of rollers in steel works, electric power systems and the subway. From rectifier diodes to a variety of Thyristors and stacks, Mitsubishi Electric offers a broad range of new high power devices.

- Rectifier Diodes
- Thyristors
- Stacks.

IC, Sensors

Mitsubishi Electric's lineups of power semiconductors include transistor arrays, HVICs (High Voltage IC) and sensors. Using the output from a 3-volt microcomputer, our transistor arrays make possible buffer less direct drive, helping contribute to lighter weight and more compact design in a variety of equipment. An HVIC is a high-voltage IC with various built-in protection functions; it uses input signals from a microcomputer or other device to directly drive gates in power MOSFETs or IGBTs. We also provide pressure sensors for such applications as barometric pressure gauges, as well as acceleration sensors to measure vibration in LCD projectors and industrial equipment.

- Transistor Arrays
- HVICs (High Voltage IC)
- Sensors.

Frequency Devices

Mitsubishi Electric has long supported the advancement of wireless communication networks through the development of its high frequency devices. Products manufactured utilizing the latest electronics and other technologies combined with newly developed high-performance materials have kept us in a market leading position. Our range of high frequency devices are contributing to the wireless communications infrastructure, helping achieve more reliable wireless communications such as satellite communications, as well as smaller and more powerful mobile phones, and other high-performance network equipment.

- GaN High Frequency Devices
- GaAs High Frequency Devices
- Silicon RF Devices.

Optical Devices

Mitsubishi Electric is at the forefront of industry in the development and production of laser diodes and modules, including the latest optical fiber communications for broadband and telecommunications networks, and laser diodes for display and industrial applications. Renowned for energy savings, reliability and high performance, our advanced technologies and products can be found in use in major systems for the optical communications infrastructure, as well as in as applications for fiber-to-the-home (FTTH).

- Optical Fiber Communication Devices
- Laser Diodes for Industry & Display.

TFT-LCDs

Mitsubishi Electric's thin-film-transistor liquid-crystal display (TFT-LCD) modules are built for a wide variety of industrial uses, such as for measuring instruments, automatic teller machines (ATM), point of sale terminals (POS), factory automation equipment (FA) and more. Designed for high reliability, optimal visibility, and enhanced viewability, Mitsubishi Electric's leading-edge TFT-LCD modules ensure optimum performance and excellent color quality in a broad range of indoor and outdoor operating environments.

- Standard Format
- Wide Format
- Specialty Format.

The technologies behind them bring us one step closer to the realization of true images with realistic color and clear visibility in sunlight.

Profile

Hitesh Bhardwaj

Business Head, Power Semiconductor and Visual & Imaging Division, Mitsubishi Electric India

Re-Invest 2015

Reaching out to Global Audience

PM addressing at Re-Invest 2015 Meet

Narendra Modi flanked on his left by Piyush Goyal The Minister of State (Independent Charge) for Power, Coal and New and Renewable Energy &Cabinet Secretary, Ajit Seth and flanked to the right by Minister of State for Commerce & Industry (Independent Charge), Ms. Nirmala Sitharaman.

Speaking at the inauguration of RE-INVEST 2015, India`s first Renewable Energy Global Investors` Meet and Expo, in New Delhi. Prime Minister, Narendra Modi described India`s thrust towards renewable energy production as an effort to ensure universal energy access for India`s poor. He said that India has now graduated from Megawatts to Gigawatts in terms of renewable energy production, he said that even today there are lakhs of families in the country that are deprived of energy connectivity. And, the fruits of development will not reach the common man until energy connectivity reaches every last household of the country. He stated that in this age of globalization, we have no option but to make a quantum leap in energy production and connectivity.

Seven horses of energy

PM asserted that India`s stress on renewable energy is not aimed at impressing the world, but to meet our own people`s energy requirements. He also spoke of the 'seven horses of energy.' He said that so far, India has focused on thermal, gas, hydro and nuclear power. But now we need to add Solar Energy, Wind Energy and Biomass Energy. India is also working towards evolving a consortium of about 50 countries that are blessed with abundant solar radiation. This will aim to pool research and technological advancements in the field of solar energy, to improve its accessibility to the poorest of the poor, and in the remotest of locations.

Hybrid energy parks

Narendra Modi suggested the possibility of hybrid energy parks harnessing solar and wind energy together in an area to maximize benefit. He also encouraged the installation of solar panels over water bodies to harness solar energy as well as minimize surface evaporation. He further spoke about the need for harnessing rooftop solar power. In the rural areas, he stressed on the need for solar pumps to reduce input costs for farmers. He further spoke about need for micro-irrigation to conserve water and enhance crop yield for farmers. If any country has the potential to lead the world in the domain of renewable energy, it is India. He called for sustained technological research in renewable energy and a thrust on domestic equipment manufacturing for renewable energy as part of the 'Make in India' initiative. In his welcome address, the Minister of State for Power, Coal and New and Renewable Energy Piyush Goyal pointed out that India now has a historical opportunity to leverage the new paradigm in the global energy sector and define its own path of development and a national power system to achieve its energy security goal. Under Modi's leadership India has made an unprecedented thrust in the field of renewable energy. He said the first renewable energy global conference would usher in a Cleaner, Brighter and Energy secure India.

RE-INVEST is organized with a triple aim. To showcase the renewable energy potential of India to the world and attracting investments, which may go up to 200 billion dollars with the enthusiastic support received from various parts of India and from all over the world. The government would like to repose the investors' confidence once again to invest in the renewable energy sector which will certainly play an important role as we move towards energy security. We would like to establish India as the manufacturing hub for renewables and for research and innovation, which is pitched in the Make in India campaign that has become the core of the new government's initiative to create jobs in India, to make manufacturing competitiveness in India and to make India a super power in terms of its own technology and manufacturing capabilities. The government would like to signal to the world its commitment to combat climate change. It is our own commitment to the world, to our people to leave behind a better future for the future generations of India.

Make in India

Programme initiated by PM will be another thrust area in terms of wind energy where already India is a leader in the world & in terms of solar energy. Let us visualize to make India a manufacturing hub of

renewable energy products of solar power on a mission mode. And for that the government of India stands committed in supporting manufacturers with the best of their technology helping them in financing their projects & making them competitive and converting Indian solar manufacturing the world's best and the biggest. Germany as the partner country has shown the way for the renewable energy development in the world. There is need to achieve PM's vision to make India 'zero defect, zero effect' by improving manufacturing policy and ensuring environment protection.

At the function, the Prime Minister gave away the awards to 12 States for their outstanding contribution in the field of Renewable Energy. Besides, 27 companies including NTPC & SBI handed over to the Prime Minister their Green Energy Commitment Certificates.

The event included several sessions headed by senior representatives from the renewable energy industry, equipment manufacturers, global financial institutions, Public Sector Enterprises, regulatory authorities, Central and state governments, research institutions and academia. Secretaries from Government of India and Heads of International Agencies like International Energy Agency, International New & Renewable Energy Agency and also of MNCs will be participating in various sessions.

Solar and Wind Power Policies, 2015 of Andhra Pradesh

Andhra Chief Minister showcased the objectives and policies put forth by his government to smoothen process of installation of Solar and Wind Power Projects and achieve target of 10,000 MW of Renewable Energy capacities by 2018-19. He promised a "safe journey" for the investors in the state. He also launched the Online Portal for Single Window Clearance of Renewable Energy Projects in the state. During the occasion several queries of the stakeholders were answered with assurance from the Chief Minister of granting all permissions for their projects within a time frame of 21 days. 17 companies signed MoUs with the State Government. The Chief Minister assured the investors that more incentives are in the pipeline if these projects are completed within one year.

State Specific Policies on Renewable Energy

Speaking at the session tilted "Showcase of Policy Incentives by States" in the RE-INVEST 2015, Union Railway Minister called for more active participation of states in harnessing renewable energy. Pointing out that states are drivers of change, he said that states should make specific laws and policies to become self-sufficient in energy. The Minister said that states which generate more renewable energy should be given more incentives. He said that state wise action plans should be formulated and the potential of each district should be mapped. Centre has taken many proactive steps in the field of renewable energy and now it is the turn of the states to carry it forward. He also said that now clean energy should be made part for "Swachh Bharat Mission".

Addressing the session, Sardar Bikram Singh Majithia, Minister for Renewable Energy, Punjab has said "we have to move from ground to rooftop to make solar mission a movement. He said his state is lending full support to the vision of the Prime Minister for making power available round the clock for all.

Madhya Pradesh Minister for New and Renewable Energy Rajendra Shukla, said that Madhya Pradesh is second to Gujarat in providing uninterrupted power supply.

India with its renewable energy programme in the world, with a target of 15% generation by 2020 is trying to become a lucrative destination for investment in this sector. The Plenary Session at the RE-INVEST 2015 in New Delhi examined the overall renewable energy potential of the country and discussed various investment opportunities.

Michael R. Bloomberg, UN Secretary General's Special Envoy for Cities & Climate Change urged both India's private sector and foreign investors to continue developing and investing in the clean energy market which create knowledge-intensive jobs and support the nation's goals. All of these steps, he said, are helping to position India as a crucial global leader in addressing climate change, as nations work toward an international climate agreement in Paris this December. No other country, in his view, faces an energy challenge or has seized the energy opportunity on nearly the same scale and scope. "Prime Minister Modi is showing that confronting climate change goes hand-in-hand with smart economic growth," said Michael Bloomberg. "And from my experience, he is absolutely correct to make cities a central focus of his work. The more India invests in sustainable cities, the stronger its economy will grow." said Bloomberg.

Baroness Sandip Verma, Minister of Energy & Climate Change , UK said that she would encourage Indian RE firms to explore UK financing. She also said that her country will support India in three "Fs" namely Framework, Financing and Firms. Among the other participants at the Plenary session titled " India – the New Investment Destination for Renewable Energy" were Adnan Z Amin, Director General International Renewable Energy Agency, Ajay Sriram , President CII, Dr Jyotsna Suri, President FICCI, Rana Kapoor, MD & CEO Yes Bank, Tulsi Tanti, CMD Suzlon Group of companies, and Vineet Mittal Vice Chairman, Welspun Renewables. The Session, which was moderated by Dr Satish B Agnihotri Former Secretary (Coordination) Cabinet Secretariat, GoI also deliberated on key policy interventions needed to catalyse investments.

Reaching out to Global Audience through Talkathon

RE-INVEST 2015 is going to be the game changer in terms of India's growing Renewable story, setting new targets, new paradigms of growth and will demonstrate to the world India's commitment to a Clean and Green future, Piyush said, while speaking at the maiden "Talkathon with a Union Minister by PIB" on the topic REInvest 2015 organized in the sidelines of the global conference here. During 30 minute live event which was based on integration of social media platforms like Twitter, Facebook and You Tube, the Minister took about 20 questions put forward by the people across the globe. & www.india.gov.in. He said all the initiatives in renewable sector is aimed at creating new jobs through setting up of solar and wind power plants, its operation, repair and maintenance, all of these are going to be job creators. He envisaged that this conference alone could create one million jobs for India and the government has also plans for promoting 'solar entrepreneurs' in a big way.

The venue of the three day global meet, organized by Ministry of New and Renewable Energy (MNRE) was at Hotel Ashok, New Delhi and was attended by around 2800 delegates from 41 countries.

International Copper Association India in association with CEA organize 'National Workshop on Electrical Safety'

International Copper Association India (ICA India) along with Central Electricity Authority of India (CEA) came together to conduct a special and first of its kind workshop to raise awareness and rectification measures about electrical hazards and importance of electrical safety in India.

Standing from L to R: Manas Kundu, Director Energy Solutions ICA India, Amol Kalsekar Chief Manager Building Wire ICA India, Sanjeev MD, International Copper Association India, Major Singh Chairperson, Central Electricity Authority (CEA), DK Jain Chief Elect Inspector, Central Electricity Authority CEA, Mohim Jain Scientist F & Head Electrotechnical Dept. Bureau of Indian Standard BIS , Takashi Honda International Relations, FESIA, Baldev Mamtani, Sr. Advisor ICA India and Prakash Bachani, S.C. E, Director – ETD BIS

Even though there are good electrical standards present in India, the country still experiences high loss of lives and properties in the event of electrical hazard. Major Singh, Chairperson, CEA initiated the discussion on electrical safety using this platform in Delhi in presence of Sanjeev Ranjan, Managing Director ICA India along with D. K. Jain, Chief Electrical Inspector, CEA and A. K Sharma Director Delhi Fire Service. The objective of this workshop was to discuss electrical safety, share international experience and requirement for certified electricians amongst industry stakeholders.

Electricity being one of the essential commodities, if uncontrolled can also be a serious threat of injury to persons or live stocks, or damage to properties by fire. Thus, rules & regulations have been framed to ensure that all electrical installations provide adequate degree of safety from fire and shock risks, to those who operate installations and their associated apparatus, equipment's and machines. It is necessary that every individual involved in design and construction of electrical installation must be familiar with the principle set of regulations issued by governing body. This workshop helped in providing the platform to discuss the key issues related to electrical safety in the country. It also helped in provisioning for standards and regulations of electrical infrastructures in India, share experiences international counterparts and need for regular and timely inspections.

Workshop on Renewable Energy to Tamil Nadu (RE2TN) in Chennai

Achim Fabig, Consul General of the Federal Republic of Germany in Chennai inaugurated two day workshop, Renewable Energy to Tamil Nadu (RE2TN), an exclusive platform for the RE players in Tamil Nadu which showcase the issues and solutions for grid stability & energy management practiced in Germany. The workshop was inaugurated in the presence of Ms. Susanne Striegler, Senior Investment Manager, DEG - Deutsche Investitions und Entwicklungsgesellschaft mbH, a subsidiary of KFW, a German government-owned development bank, Sudeep Jain IAS, CMD, Tamilnadu Energy Development Agency (TEDA), Dr. Gomathinayagam, Executive Director, NIWE (CWET), Dr. R Velraj, Professor & Director, Institute for Energy Studies, Anna University, Chennai, Victor Thamburaj, MD, iPLON India Private Ltd.

As part of their various initiatives to Tamil Nadu, DEG join hands with iPLON GmbH, an international leader in the area of Solar PV

monitoring systems and Total Life Cycle Management established in Germany in 1996 and organising this first-of-its-kind workshop in Chennai to promote climate friendly technologies in Tamil Nadu. Major attractions at the workshop are Power Evacuation, Grid stability, knowledge transfer and know-how of the renewable energy to India, especially to Tamilnadu. iPLON is organising a live demo on smart grid and custom networking sessions which gradually makes Tamil Nadu move towards a post carbon economy.

Speaking on the occasion, Ms. Susanne Striegler, Senior Investment Manager, DEG said, "We are glad to join hands with iPLON and it is a matter of pride for us to gather some of the RE players under one roof which would be an excellent opportunity for them to exchange their vision, innovative ideas and drive Tamil Nadu from the fossil fuel society to a cleaner, greener environment through their exhibits".

She added, "I take this opportunity to thank Government of Tamil Nadu for extending whole hearted support to DEG-iPLON's initiatives in rural areas. We are confident that this joint venture with Germany and Tamil Nadu for RE2TN will set benchmarks of excellence for the other states to follow". Victor Thamburaj, CEO, iPLON GmbH & MD, iPLON India Private Ltd. said, "We are extremely happy to welcome all of you to this inaugural ceremony of RE2TN. This is very proud moment for all of us at iPLON & DEG. We are sure this workshop would be a grand success and it will be another milestone of DEG & iPLON's history".

2400kV, 240kJ Impulse Voltage Generator

2500MVA Short Circuit Generator

HVDC Generator at UHVRL, Hyderabad

1200kV Insulator String testing

Erection of Tower for Testing

Cable Testing

Tapan Misra assumes office as head ISRO's Space Applications Centre

According to ISRO space agency sources, Tapan Misra an eminent scientist has been appointed the chief of Isro's Space Applications Centre. Was an outstanding Scientist working as Deputy Director in Microwave Remote Sensing Area of ISRO's SAC, Ahmedabad. He is also heading the office of innovations management at Isro Headquarters, Bangalore.

An electronics and telecommunication engineering graduate from Jadavpur University, Kolkata, he began his career at SAC as a digital hardware engineer responsible for the development of 'Quick Look Display System of X-Band Side Looking Airborne Radar' in 1984. Later, he became the lead member of the team which designed and developed C-band Airborne Synthetic Aperture Radar (SAR). Misra mainly contributed to the system design,

Tapan Misra

simulation, integration, checkout and ground calibration for Multi-Frequency Scanning Microwave Radiometer instrument which was carried aboard India's Oceansat-1 satellite. He also led the development of scatterometer payload of Oceansat-2, launched in 2009, which provided valuable wind-related data to the global meteorological community. He was the lead designer for the development of C-band Synthetic Aperture Radar of India's Radar Imaging Satellite-1 (RISAT-1). He also led the team to develop futuristic remote sensing systems including a variety of advanced radars, millimetre wave sounders and an advanced scatterometer," Isro said in a statement. He was awarded the Hari Om Ashram Prerit Vikram Sarabhai research award and Isro merit award in 2008 for his contribution to development SAR technology. He was elected as fellow of the Indian National Academy of Engineering and also elected as corresponding member of International Academy of Astronautics.

He has 2 granted patents, 6 pending patents, 5 copyrights and many research papers to his credit, the statement added.

IEA Chief Economist Fatih Birol is named Agency's next Executive Director

Dr Fatih Birol

The Governing Board of the International Energy Agency (IEA) this week confirmed the appointment of Dr. Fatih Birol as the next Executive Director of the Agency. He will succeed Ms. Maria van der Hoeven, who will complete her four-year term on August 31, 2015.

This marks one of the rare occasions that the head of an international organisation has been selected from within its ranks. Renowned in the energy field, Dr. Birol joined the IEA in 1995 and has risen to now hold the positions of Chief Economist and Director of Global Energy Economics. In this role, he oversees the IEA's flagship World Energy Outlook publication, which is recognised as the most authoritative source of strategic analysis of global energy markets. He is also the founder and chair of the IEA Energy Business Council, which provides a forum to enhance co-operation between the energy industry and energy policy makers.

Earlier in his career, Dr. Birol served in the Secretariat of the Organization of the Petroleum Exporting Countries (OPEC) in Vienna, an experience which gives him a unique perspective on the producer-consumer relationship. He has also been a member of the UN Secretary-General's High-Level Group on Sustainable Energy for All and was named by Forbes magazine among the most influential people on the world's energy scene.

A Turkish citizen, Dr. Fatih Birol was born in Ankara in 1958. He earned a BSc degree in power engineering from the Technical University of Istanbul. He received his MSc and PhD in energy economics from the Technical University of Vienna. He is an honorary life member of Galatasaray Football Club.

Ensuring Quality, Aesthetics, Easyness and optimizing total cost of ownership

Wide span cable support systems upto 10 meters

Wide span cable trays

Wide span cable ladders

Key accessories

Wide span systems – Features and Merits

- Supports span distance upto 10 metres
- Reduced installation and accessories costs
- Strip galvanized - EN 10327
- Hot dip Galvanized - EN ISO 1461
- SS 304 Grade
- Side height – 110, 160 and 200 mm
- Widths of 200 to 600 mm
- High load capacity with parallel wide span
- Ventilation for cables and circuits
- Side rail perforation for heights of 110 mm, 160 mm
- Wide Span cable ladder with C-profile rungs for adequate cable fitting with OBO BBS clamps.

Key application areas (Heavy and medium duty)

Any PEB building,
Tunnels, steel, cement, food, textile, railways, power stations, airports, healthcare and automobiles,etc

Compliant towards CE

Existing practice - Metallic supports are installed between steel columns and cable trays are fixed in these supports.

Wide span installation - Supports distance up to 10 meters. Fixed directly in two columns without supports in between.

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THINK CONNECTED.

Socomec unveils Technological Energy Efficiency Innovation of DIRIS Digiware & BCMS 720 in India

In front of its prestigious customers and valuable partners Socomec launched Diris Digiware the solution that sparks a revolution in electrical measurement and Diris BCMS (Branch Circuit Monitoring System) 720 the new robust and compact measuring unit for monitoring up to 72 single-phase branch circuits.

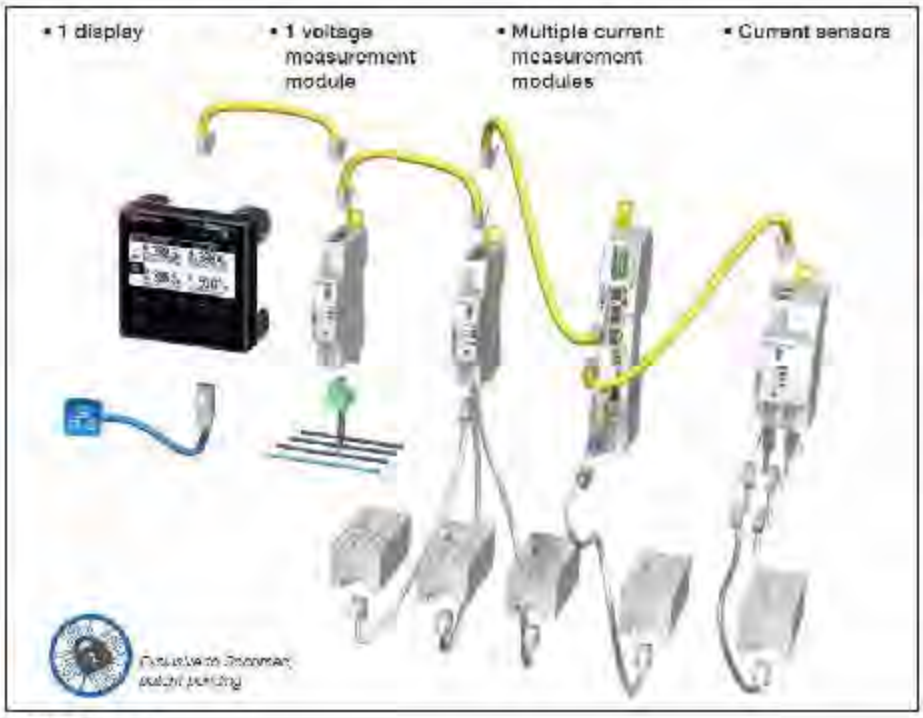
Twenty years after shaking up the electrical measurement market with the DIRIS system, the first multi-measurement solution, SOCOMEC is once again leading the way with its latest technological innovation: DIRIS Digiware, a totally modular and flexible energy measurement and monitoring system.

What is DIRIS Digiware?

A simple solution for building a modular measurement system. The system comprises as a minimum a display unit, a voltage measurement module, multiple current measurement modules and current sensors.

More precisely, the DIRIS Digiware modular system is based on:

- A centralised display and a single voltage measuring point for the entire system: DIRIS Digiware offers an effective function-sharing capability.
- Current measurement modules that are interconnected via the Digiware bus (RJ45 cables) for measuring energy consumption at the closest point to the actual loads. Each module can monitor one or more circuits via the current sensors by means of independent current inputs (3, 4 or 6 depending on the modules). With 3 inputs, a current module can monitor a three-phase circuit or 3 single-phase circuits.



DIRIS Digiware

These four elements constitute the heart of the system. For applications without local display, the DIRIS Digiware C-31 system interface centralises all of the system's data. The data from the Digiware modules and remote units is centralised on one or more DIRIS G communication gateways. Each gateway includes a WEBVIEW web server for monitoring electrical parameters in real time and for analysing energy consumption data. An optional touch-screen tablet completes the system. It can be panel-mounted and is connected by Wi-Fi (via a router) for providing information to energy management software.

For remote monitoring points, the user can also use the DIRIS B-30 measurement units with wireless or RS485 communication.

Advanced technology ... made easy

The apparent simplicity of the concept is the result of SOCOMEC's expertise in electrical measurement and communication technologies, as well a clear vision of what the measurement systems of tomorrow should be: accurate, flexible, multi-circuit, plug & play and cost-effective.

Concrete benefits

For contractors and panel builders

- DIRIS Digiware is a plug & play solution: its RJ45 and RJ12 connections means that the modules can be very quickly integrated, as well as enabling the automatic configuration of the connected current sensors.
- DIRIS Digiware is above all a very cost-effective solution: implementation in a quarter of the time normally required, the compact design of the modules frees up more space in electrical equipment cabinets, and the common voltage measurement, display and communication

functions offer up to 30% savings compared to existing metering technology.

For end-users

- The accuracy of the system over a wide range of loads means it has unequalled precision in terms of energy measurements, thereby optimizing any energy efficiency initiatives.
- DIRIS Digiware enables the identification of major loads and constantly monitors multiple electrical parameters for any anomalies. With its capacity to keep a check on the quality of electrical energy, the system can more easily anticipate network malfunctions.
- DIRIS Digiware is extremely flexible and is suited to the most space-constrained installations. The system can be easily retro-fitted in an existing facility thanks to the split-core current sensor options.

BCMS 720

To meet energy continuity requirements in critical buildings (data centers), SOCOMEC offers a new measuring unit for monitoring up to 72 single-phase branch circuits. The compact case fits in all types of power distribution units (PDU) installed in proximity to servers. It can easily be used in new or existing installations and interfaces with all supervision systems.

Special features

In addition to monitoring the current, energy and power on up to 72 single-phase branch circuits, the unit can measure an extra 2 main incomers – and all in just one single device to save even more space. The DIRIS BCMS 720 unit helps improve the energy efficiency of critical buildings by providing the following: maximising energy availability,

BCMS 720

allocating energy consumption, optimisation of the data center's power resources and reducing energy bills. With its compact design and connection options (split-core current transformers and any combination of 6 and 9 CT strips of 18mm pitch, the DIRIS BCMS 720 is easily integrated in PDUs whether in new facilities or renovation projects.

Additional functions

The DIRIS BCMS 720 system provides key functions in multi-measurement and metering, alarms management and communication. Equipped with MODBUS or SNMP, the system easily interfaces with any energy power management and monitoring software (EMS / PMS). The device measures current, power, power factor as well as metering energy consumption on all branch circuits and mains incomers. It can also measure the voltage and frequency on one or two mains incomers. Alarms can easily be configured by the user to cover events i.e. overcurrent, over/ undervoltage, 0 current, etc.

Compliance with standards

DIRIS Digiware measurement accuracy is in accordance with standard IEC 61557-12: class 0.5 for the global measurement chain from 2 to 120% of nominal current (with TE current sensors). The DIRIS BCMS 720 system complies with standard IEC 60950-1 (concerning the safety of information technology equipment).

Key points

DIRIS Digiware

- An innovative measurement system that is accurate, flexible, multi-circuit, plug & play and cost-effective
- Concrete benefits for installers, panel builders and end-users
- Drastic reduction in installation and commissioning time
- Up to 30% cost savings vs existing technology

BCMS 720

- Compact and ergonomic product
- Robust and secure case
- High level of accuracy
- Easy to install
- Advanced functions: multi-measurements, metering, alarms for electrical faults, RS485 MODBUS or Ethernet SNMP communication, 4 digital inputs.

Speaking on the launch Olivier Tremouille, Managing Director, Socomec Innovative Power Solutions said, "our customers can benefit up to 30% cost saving from the conventional technology by adapting DIRIS Digiware technology. BCMS 720 that will help to reduce the cost and improve the energy efficiency of critical applications. In continuation with our philosophy of bringing innovative solutions to the Indian market, we are proud to offer these new solutions that benefit our customers by and large".

Revolution starts in Hannover: 'Integrated Industry - Join the Network!'

The fourth industrial revolution – aka **Industie 4.0** – will bring major change to energy systems and industrial production models. In factories, there will be a shift away from mass production as customers increasingly demand customized products – albeit at the same low prices. And energy grids will need to become smarter so that they can optimally balance and deploy available power, gas and heat capacity from a wide range of sources. The answer to these challenges is Integrated Industry – the intelligent digital networking and integration of industrial systems & processes. **Integrated Industry** is about enabling machines and workpieces to communicate with one another. This, in turn, will allow entire production lines to autonomously and dynamically re-configure themselves, thereby rendering small-batch and one-off production in large-scale plants commercially viable. Industry is in the early stages of a revolution known as Industrie 4.0. It's a phenomenon. Meanwhile, there is an enormous information vacuum, and most companies still don't know what they need to do in order to be ready for Industrie 4.0. What they need to do, of course, is form close networks with all stakeholders involved in their production processes. HANNOVER MESSE 2015, with its lead theme of 'Integrated Industry - Join the Network!', will show them how." HANNOVER MESSE will also examine the social and political dimensions of Industrie 4.0. HANNOVER MESSE 2015 will play a pivotal role in fourth industrial revolution. "The revolution starts in Hannover," says Dr. Jochen Köckler, member of Deutsche Messe Managing Board.

All sectors of industry will exhibit at HANNOVER MESSE. That's everything, from industrial automation and energy to industrial supply, power transmission and control and R&D. Only at HANNOVER MESSE can visitors gain such in-depth insights into tomorrow's integrated factories and energy systems. The fair's scope ranges from individual Industie-4.0-ready components right through to complete automation solutions."

India featured as Partner Country

India is designated official Partner Country at HANNOVER MESSE 2015, putting the nation in the spotlight at world's leading industrial exhibition.

"India is an emerging economic giant which is going to open up enormous sales potential for our German and international exhibitors at HANNOVER MESSE" "Is my organization ready for the fourth industrial revolution? That's the big question that CEOs and plant managers are currently asking themselves." Dr. Jochen Köckler.

New generation of Mudblock seals

SKF will showcase a new generation of SKF Mudblock cassette seals for oil-lubricated wheel-end applications that will significantly extend seal service life compared with equivalent products in the market. The solution can reduce seal friction by up to 20%, offering off-highway customers a solution that reduces energy loss and thus increases efficiency. The seal features a multilip cassette seal design incorporating optimized lip geometry, stainless steel counter surface and a formulated nitrile compound to reduce wear and aging. The combination provides a best in class sealing solution which increases bearing life by preventing ingress of contaminants & retaining the lubricant inside bearing, thus also minimizing environmental impact due to oil leakage. The main customer need, this solution addresses is increased reliability – something all off-highway OEMs strive for, as customers may gain up to 50% longer seal operating life.

Integrated Industry - central topic at the Fair

HARTING will be presenting – live on the fair stand – a production line demonstrating solutions for Integrated Industry. Integrated Industry will feature as the HARTING Technology Group's key topic at the Hanover Fair from April 13-17, 2015. The Espelkamp family company is thereby positioning itself as a trailblazer for technological change. "Integrated Industry will change almost all industrial companies in coming years. We offer customers tailor-made solutions and accompany them along the way", as Dr. Volker Franke, Managing Director, HARTING Applied Technologies, emphasizes. The HARTING production line, as an Integrated Industry Demonstrator, presents the topic holistically and combines elements such as the flexible assembly system "FlexiMon", a research project conducted within the framework of the "it's OWL" leading-edge cluster, with system integration solutions on the basis of SAP.

Trend-setting solutions in the energy sector

Alstom presents trend-setting solutions for the power transmission and for the on- and offshore power generation and provides answers to the requirements of the dynamic market. Alstom has been the first company to present a clean alternative to SF6 suitable for high voltage applications, g3 (green gas for grid) a gas commonly used for insulation. The SF6-free solution has been developed in cooperation with 3M, a leader in environmentally sustainable solutions. g3 has 98% less impact on global warming than SF6 and herewith contributes to a cleaner planet. g3 is a suitable technology for the development of today's new generation of clean high- and ultra-high voltage equipment. At Hanover Fair, Alstom will unveil first high-voltage equipment in the world insulated with g3. In addition, Alstom Grid has developed a new hybrid switchgear specially designed for the railway energy transmission networks in Germany, Austria & Switzerland.

Robotics Award 2015: Innovative robotics solutions

For the fifth season running, HANNOVER MESSE April 13-17, 2015 will highlight outstanding robotic solutions through the prism of the ROBOTICS AWARD – the industrial prize for applied robotics solutions, with the winner receiving an extensive communications package worth 10,000 euros. Contestants for the ROBOTICS AWARD can submit their products, projects and technological innovations for adjudication by an independent jury; the competition criteria consist of the degree of technological innovation, the benefits for industry/environment/society & the economic aspects of the application.

The award will be for exceptionally innovative robot-supported solutions which exhibit a high degree of practical relevance to industrial automation, mobile robots and/or autonomous systems. Companies and institutions from any branch of industry from across the globe are eligible to compete. The awards ceremony takes place on 14 April 2015 at the Industrial Automation Forum, before an audience of industry specialists and media representatives. The award will be presented by Olaf Lies, Minister for Economics, Labor and Transportation of the German state of Lower Saxony, joined by a Managing Board member from Deutsche Messe. The relevant application materials are available for downloading at www.hannovermesse.de/en/roboticsaward.

The ROBOTICS AWARD is presented by HANNOVER MESSE in cooperation with Industrieanzeiger magazine and the Robotation Academy, the event, workshop and consulting center for robotics and automation technology located at the Hannover Exhibition Center.

HANNOVER MESSE: Get new technology 1st!

The world's leading trade fair for industrial technology is staged annually in Hannover, Germany. The upcoming event will place a strong emphasis on Industrial Automation and IT, Power Transmission and control, Energy and Environmental Technologies, Industrial Subcontracting, Production Engineering and Services and Research & Development. The event will feature India as its official Partner Country. HANNOVER MESSE 2015 will comprise ten flagship fairs: Industrial Automation Motion, Drive and Automation (MDA); Energy Wind; MobiliTec; Digital Factory; ComVac; Industrial Supply; Surface Technology; Research & Technology.

Industrial Process automation sector embraces Challenges of Industry 4.0

Industrial process automation in all its many shapes and forms will be on show this April in halls 9 and 11 at HANOVER MESSE 2015. And one of the keynote themes, alongside classic process automation topics like life cycle management and field instrumentation, will be Industry 4.0 – the 4th-industrial revolution that is set to bring fundamental change to process automation sector, as Endress+Hauser, ABB, JUMO and other big-name exhibitors will show.

Industry 4.0 describes the convergence of key trends, such as the Internet of Things, increasingly complex hardware, software and logistics systems, and advanced control technology, to create the intelligent, self-organizing factory of the future. So much for the theory. At HANNOVER MESSE 2015, Endress+Hauser will be among the exhibitors presenting solutions that turn Industry 4.0 into reality for process automation users. Their exhibits will focus on three distinct aspects of operationalizing Industry 4.0 in process automation settings: vertical integration, which puts in place key linkages all the way from the field level to business control; horizontal integration, which yields optimized value chain outputs; and end-to-end engineering, which saves valuable time and resources in all areas, from planning to process control. In this way, the products displayed and issues discussed at HANNOVER MESSE will enable visitors to discover and understand what lies at the heart of Industry 4.0.

Industry 4.0 also ties in closely with manufacturing execution systems. This was one of the insights to emerge from the discussions at last year's MES Conference, which featured over 200 participants. On 16 April this year, MES experts from around the world will again gather at HANNOVER MESSE for the MES Conference on Efficient Production, where they will present successfully implemented projects from the discrete and process manufacturing industries. Another automation-themed event that will be back at this year's HANNOVER MESSE is the PUMPplaza showcase for pumps, pump systems and components. It will be staged at Stand G43 in Hall 15. There, visitors from all industries will find a comprehensive range of solutions for handling liquids and gases.

Process automation themes will also feature strongly at the Industrial Automation Forum, thanks to presentations by ABB, Endress+Hauser, KROHNE Messtechnik and many others. The Forum will also explore production and process automation themes with respect to robotics and automation, medical technology and energy efficiency. Held at Stand L 17 in Hall 14 within the Industrial Automation part of the show, the forum is an attractive, quality meeting hub for visitors. The program for the Industrial Automation Forum will be published on the HANNOVER MESSE website at the end of January 2015.

The upcoming event will place a strong emphasis on Industrial Automation and IT, Power Transmission and control, Energy and Environmental Technologies, Industrial Subcontracting, Production Engineering and Services and Research & Development.

Budget proposes 5 Ultra Mega Power Projects

Financial budget 2015-16 appears to be a growth oriented budget with a focus on infrastructure development. Prime Minister has made a promise of increasing solar power to 1,00,000 MW by 2022. The budget proposes 5 "ultra mega" power projects for 4,000 MW each as well as second unit of Kudankulam nuclear power station to be commissioned. Herein below are the quotes from the industry stalwarts.

Tulsi Tanti,
Chairman,
Suzlon Group

'We welcome this budget as it is positive, growth oriented and puts forth realistic roadmap to attain sustainable economic growth. The government's thrust on renewable energy is clearly visible in the target of achieving 175 GW by 2022. India in the last 25 years India has done 34 GW and in the next 7 years we now have a target of 175 GW, comprising of 60 GW wind energy which is an ambitious target for the industry and we welcome the move since it is in the right direction. The budget reiterates mission & vision of the government to achieve the following:

- Affordable sustainable energy for all
- Low carbon economy
- Achieve energy security
- Long term sustainable economy & sustainable jobs

The government's commitment to green India manifests in some of the additional measures such as increasing the coal cess from Rs 100 to Rs 200 thereby providing impetus to clean energy. We appreciate the focus on providing impetus to the Make in India vision by giving clarity on taxes, definitive measures to ease of doing business in India and encouraging domestic and foreign direct investment. However, in our view to provide further stimulus for investment in captive renewable power by the manufacturing units, interest rebate should be given, which will also ensure success of Make In India. Further, innovative financing measures such as infrastructure bond, creation of mudra bank for MSME sector also augurs well for Make in India. So overall we see the budget has provided several initiatives to boost manufacturing in India. We are confident that the renewable energy in India will take off from here and witness exponential growth in the next few years and will power a greener tomorrow.'

Ratul Puri,
Chairman, Hindustan Powerprojects

"The budget is a very positive and balanced one as it addresses the requirements of multiple stakeholders and creates platform to take the economy on a high growth trajectory. The proposed national investment fund can open up massive amount of capital to help finance India's one trillion dollar infrastructure sector and could be a potential game changer for the industry. The doubling of coal cess will provide incremental 10,000 crores a year to help push renewable energy and will bring the cost of solar power to grid parity. The proposed 70,000 crores investments in the infrastructure sector along with the plug and play 4 ultra mega power projects could be the enablers to kick start finance for the sector."

Dinesh Aggarwal,
Joint MD,
Anchor Electricals Pvt Ltd

'Though there was no specific announcement on reducing Import duty on project imports or encouragement of energy saving products, we at Anchor believe that the overall direction of the budget was consistent with the government's commitment to strengthen the confidence in the Indian economy. The macro indicators are positive and there is a direction set to strengthen the governance of financial markets and move towards global standards, commitment towards investment directly by the government and through public participation in Infrastructure development. The reduction in tax on Royalty will encourage technology infusion and manufacturing of technology products in India. The phased reduction in corporate tax, reduction of customs duty in specific raw materials and inputs will support the 'Make in India' initiative further. Clearly, the Government's intention is to empower the poor & the old in recognition of the rising health care costs and aging population. Overall, the budget has set a positive direction & its for the businesses to react in support now.'

Anil Sardana,
CEO & MD,
Tata Power

'Finance Minister has rightfully focused on policy and taxation reforms to provide much needed & opportune impetus to strengthening of the economy in the Union Budget today. The budget has strongly indicated the Government's desire to move towards an annual growth of 8 to 8.5 percent this fiscal year. The budget enhanced target of 175,000 MW for Renewable energy by 2022, and also proposed 5 new Ultra Mega projects on plug & play model, with a capital outlay of Rs 100,000 Crores. This is much appreciated and this model will be good to learn the new approach to bidding & awards. The proposal to set up Regulatory process of permissions than seeking clearances, so that work can commence on investments without holding up for permissions is a welcome move. The government also launched e-Biz Portal that would help to integrate regulatory permissions at one source. This has been a long standing need of the industry. The announcement of implementation of GST from 1st April 2016 will help reduce multiple taxation and also in simplification of the tax process in India. The government is targeting Housing & 24 x 7 electricity for all, by 2022. Electrification of remaining 20,000 villages 2020 is the need of the hour. These targets need States to reform distribution sector & this aspect has far been, illusionary in most of states. We look forward for introduction of more schemes like rationalisation of Minimum Alternate Tax and introduction of innovative financing schemes for power sector.'

Sunil Mathur,
MD & CEO,
Siemens Ltd

"We welcome the growth-oriented Budget 2015. It is consistent with the stated objectives of the Government, reinforcing its commitment to realization of infrastructure projects. With the Budget, the Government seems inclined to follow its bold path of building infrastructure and improve ease of doing business. Its intention to increase public investments while decreasing Corporate Taxation over a period of time are also steps in the right direction, and we are sure these steps will further improve the confidence of investors and industry alike. We also welcome the Government's decision to defer GAAR by two years and the introduction of GST in April 2016."

Solartroniks

2C Light company Ltd, New Zealand, founded by Simon Dyer, is the world leader in the development of solar powered wearable technology as demonstrated by the innovative 2C Solar Light Cap, a product unique to the international market. The Company's research laboratory is located in Christchurch, the technical center of New Zealand. The 2C Light Company was incorporated in December 2006 to manufacture and distribute the 2C Solar Light Caps and other products. Since incorporation, global demand for the Company's product has resulted in branches being established in more than 20 countries. Their mission is to provide free light to the world by utilizing natural resources and advanced technology.

Some of the products that they have already manufactured and is available worldwide are:- 1) the 2 white LED Solar cap (2CSLC) using an amorphous solar panel, inbuilt Nickel metal Hydride batteries, microprocessor controlled, all in a waterproofing IP 66 certified sealed cap. 2) 2C TuffLiteTM - The world's first solar charged headlamp to improve worker safety and productivity with hands-free light to increase safety, productivity and zero running costs. The industrial uses for the Tufflite are in Mining, Transport, Construction, Forestry, etc. Some of the Standards adopted are CE, FCC, IP66, RoHS, and intrinsically safe (Certification pending). 3) 2C-OneTM – is the Innovating Solar Lighting Solution. The microprocessor based on 2C Boost™ technology controls the 2C One and allows you to modulate the light according to your need. Because of its unique modular design, 2C One can be used as a wide range of cap styles for many activities such as fishing, hiking, camping, etc. With 6 Hours of sunlight, 2C-One produces 12 hours of light using the dimmer, or over 2 hours on full power. The product that is next under development is the 2C SilverEye with help from New Zealand Government and University of Canterbury. The design aim is to make a commercially successful solar powered UAV to provide services such as aerial photography, atmospheric tests, GIS land use, etc. In India, 2C is represented by Solartroniks (www.solartroniks.com), a company based in Mumbai, focused on promoting innovative solutions in Solar and Engineering, like Inductive proximity sensors, photo sensors and dusk to dawn photo sensor controllers in IP66 water proof body, polycrystalline solar modules, solar candles, solar charger bags, CREE LED torches and light accessories.

For further details contact:
www.solartroniks.com

Quality Power Electrical Equipments Pvt Ltd

Quality Power is a technology based provider of power products, systems, solutions and services. Building on core strenghts of technology leadership, pioneering spirit and a sustainable approach to business.

The company was founded in 2001, operates multiple facilities in India, Turkey and United Kingdom employing over 300 skilled personnel in its activities. Quality power has been rated SE1A the highest in financial and market performance for four years in a row and are also among top 50 SME companies standard and poor in India.

With the companies design and technology and expertise they manufacture Reactors, Transformers, Line Traps, Capacitor Bank, Static VAR Compensators (SVC), Harmonic Filters, Grid Automation Components & SCADA systems in their various facilities. The project wing of the company undertakes turnkey Reactive Power Compensation Projects and Harmonic Filters. With a constant emphasis of R&D, Quality Power multiple labs in India, Turkey and England for its 11 product categories up to 765kV Systems. Also the company has multiple patents and recognitions.

Quality Power has a global presence with a satisfied customer base in over 60 countries and an International spread of 22 representative office.

For further details contact:
www.qualitypower.com

Wuhan Line Power Transmission Equipment Co Ltd

Wuhan Line Power Transmission Equipment Co., Ltd. specializes in manufacturing composite Insulator series. The products include composite post insulator, composite pin insulator, composite cross-arm insulator and composite insulator applied for railway. Since the establishment in august 2008, LINE power's persistent goal is to be top manufacturer in china on composite insulators. They have most advanced equipments both on production and testing, and also set up a high -educated and professional team of skillful engineers and technicians on designing and manufacturing, above which guarantee effectively to provide top quality products and perfect service to our customers. As a certified ISO9001: 2008 company, LINE power, with world class products and excellent service, has obtained recognition and high reputation from customers, and become one of the main suppliers to state grid corporation of china and Southern Power Grid of china.

For further details contact:
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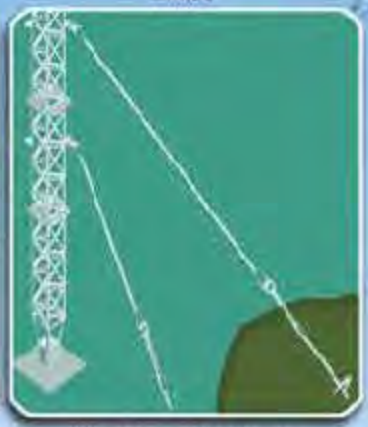
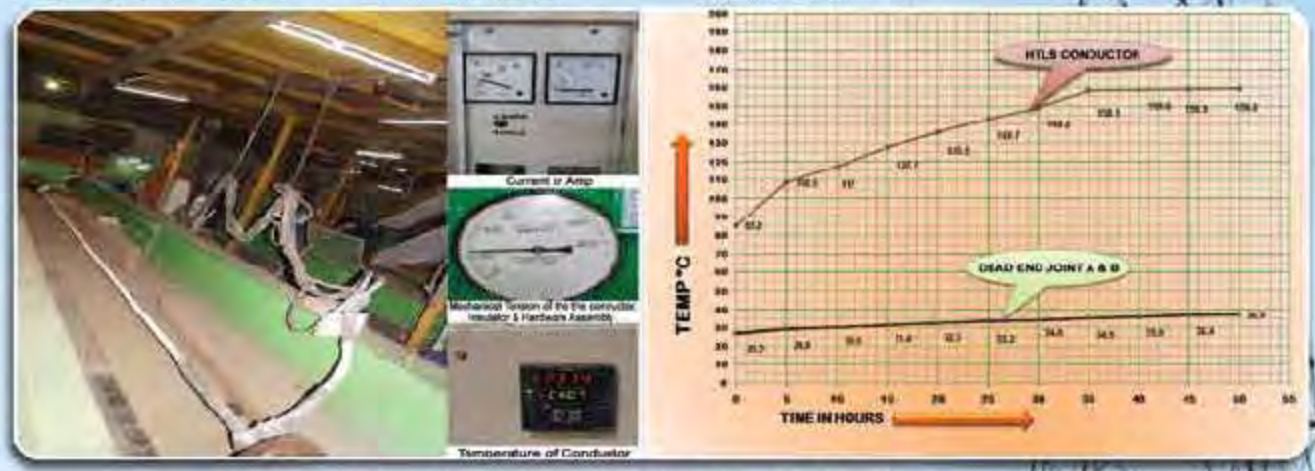


Anchoring Solutions for Emergency Restoration Tower System



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Website:

www.induselect.com

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Website:

www.asiatic-india.com

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IEC 60214-1-2014 and Indian standard IS - 8468

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An inside view of Transformer with 'L' Type OLTC

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Exposed area: 1,600 cm^2
Intensity: 1000W ~ 10,000W $/m^2$ (Adjustable)
Wavelength: 280 ~ 3,000nm (Full Spectrum)
Spectral Coincidence: Class B (Near A)
Spatial Uniformity: Class B (>95%)
Temporal Stability: Class A
Environmental Chamber Component
Chamber Dimension (Internal): 1,000W x 1,1400D x 500Hmm
Chamber Dimension (External): 2,040W x 2,500D x 3,800H mm
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** 0°C ~ + 90°C (W/ Radiation)
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Temperature Uniformity: ± 2°C
Humidity Range: N/A - Humidity Accuracy: N/A
Condensing Type: Water Cooled Type
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Control Method: PID, Programmable : 12.1 Color Touch-Screen: Built-in industrial computer
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Website:
www.solartechnology.atlas-mts.com

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Website:
www.zhoomking.com

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1. Place of Publication	: 311, Raikar Chambers, Govandi (East), Mumbai - 400 088.
2. Periodicity of Publications	: Monthly (5th of every month)
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4. Printer's Name	: Mahadevan Iyer
Nationality	: Indian
Address	: As above
5. Editor's Name	: Mahadevan Iyer
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6. Name and addresses of individuals who own the newspaper	: Mahadevan Iyer Sole Proprietor As above

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