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- Dielectric Technology in Transformer
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- Contactless Health Monitoring System for Three Phase Induction

## Design Reviews & Life Management Concepts of Transformers



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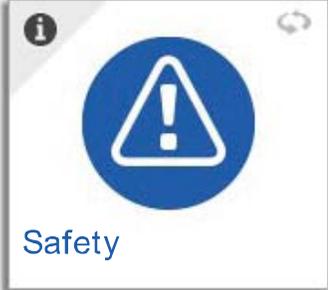
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Hello and welcome to Electrical India, the number one magazine on power industry in India. I am happy to inform you that our website [www.electricalindia.in](http://www.electricalindia.in) has been ranked as the leading website among all the power magazines in India (Source:www.alex.com). As I am writing this, our website has been ranked at 4,74,741 best site in the world among all the websites, which is an excellent figure considering the fact that it is a niche subject. In India, our site is ranked among the top 40,000 sites and definitely number one with regards to any B2B power magazine site in the country. Not one publication site on the power industry in India is anywhere close to the ranking of Electrical India's website.

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I thank you, the readers, authors and advertisers, for making this possible. I am also happy to announce that among all the websites of B2B power magazines in India, only Electrical India has got an extensive presence on the social media, with almost 35% traffic coming to our site through social media. Also visitors spend more time on Electrical India's site and view more pages than any other power magazine site in the country.

Coming to the transformer industry, electricity is a major constituent for the economic growth of the country. India being one of the leading economies in the world today and the fifth largest installed capacity in the power sector worldwide, there has been and will be a surge in power demand in the country coupled with increase in urbanization, population and capacity utilization. With the Narendra Modi government focusing more on the T&D sector, the electrical equipment industry should be looking for good times ahead. The transformers industry, which comprises of 10% of the total electrical equipment industry, is expected to reach about Rs. 18,000 crore in the next five years, especially with more investments pouring in the T&D network than ever before coupled with governments projects under the Green energy corridor. All this will help the power and distribution transformers industry, which has been in trouble for some time, to have a robust growth. However, the industry should also brace itself for some tough competition with the entry of couple of Chinese transformer manufacturers who have already set facilities in Gujarat. Well competition is always a welcome sign for better things to come. And, Electrical India will always be there at the forefront to bring to you the latest from the power industry.

Do send in your comments at [miyer@charypublications.in](mailto:miyer@charypublications.in)

*Mahadevan*

Publisher & Editor-In-Chief

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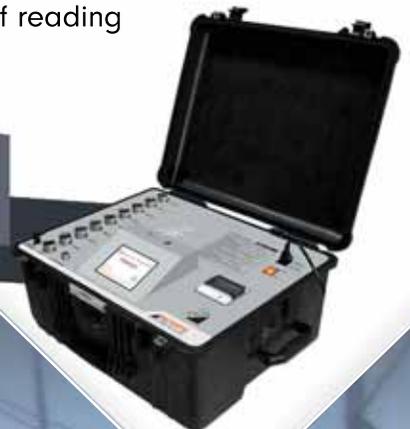
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## Powering India's largest blast furnace

As part of its Make in India vision, the Government of India, recently revealed its ambition to become the world's second largest producer of steel by 2030. This will involve trebling the capacity of crude steel production to 300 million tones (MT) and investing more in capacity building.

The industry has reported healthy growth in recent years – expanding capacity and footprint of steel mills across the country. ABB has been helping many steel producers in the country and delivering turnkey projects and advanced services covering instrumentation, controls and electricals for the country's leading iron and steel manufacturers – making high-quality steel reliably and helping shape India's infrastructure. This includes the recent 10+ million ton per annum (MTPA) integrated steel plant, which is also home to country's largest blast furnace and sinter plant

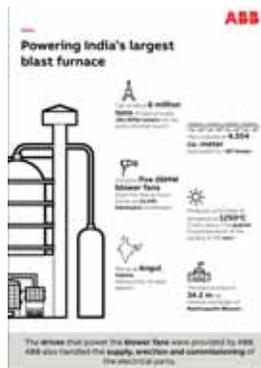


ABB - Angul infographic

of 4 MTPA capacity. ABB India provided sophisticated solutions at this modern blast furnace that keep the plant up and running smoothly.

At any plant, the quality of the steel produced depends on the chemical reactions occurring in a blast furnace that continuously operates at dynamic heat conditions with temperatures ranging from 800°C up to 1250°C as hot as molten lava. Any variations in the blast furnace or the sinter plant can lead to the disruption of the entire steel-making process and cause huge losses.

Know-how and know-why of the complexity and criticality of steel making, helped ABB India deploy a comprehensive electrification solution including switchboards, power distribution panels, HT panels and transformer to ensure reliable, efficient and uninterrupted power during this steel-making process. 

## BHEL commissions 270 MW Thermal Unit in Maharashtra

Bharat Heavy Electricals Limited (BHEL) has successfully commissioned another 270 MW thermal unit at RattanIndia Nasik Power Limited's 5x270 MW thermal power project, located at Sinnar in Nasik District of Maharashtra.

This is the fourth unit to be commissioned at this project. Significantly, the milestone has been achieved within 35 days of commissioning of the third unit.

So far, BHEL has successfully commissioned 14 sets of 270 MW rating in the country, including 9 sets for the RattanIndia group. In addition to four units at Nasik, BHEL has earlier commissioned 5 sets of 270 MW each at Amravati, for RattanIndia. The fifth unit at the Nasik project is also in advanced stages of completion.

BHEL's scope of work in the project envisaged design, engineering, manufacture, supply, erection and commissioning of Steam Turbines,



Generators, Boilers, associated Auxiliaries and Electricals, besides state-of-the-art Controls & Instrumentation (C&I) and Electrostatic Precipitators (ESPs).

The equipment for the project was supplied by various manufacturing units of the company located at Trichy, Ranipet, Hyderabad, Bengaluru, Bhopal and Haridwar while the construction work was carried out

by BHEL's Power Sector – Western Region.

Thermal sets of 270 MW rating are an in-house improvisation of 210/250 MW sets supplied earlier by BHEL, which today form the backbone of the Indian power sector and have been performing much above the national average as well as international benchmarks. The company's customers also enjoy the advantage of assured and prompt After Sales Service. 

## Renewables could power 25% of Indian Railways by 2025

Indian Railways could draw up to 25% of its electric power needs from renewables and achieve the target of 5 GW of solar by 2025, according to a study released by the Council on Energy, Environment and Water (CEEW) recently. Indian Railways would need an investment of USD 3.6 billion to meet the 5 GW target. Suresh Prabhu, Union Minister for Railways, and Piyush Goyal, Minister of State (IC) for Power, Coal, New and Renewable Energy and Mines, released the CEEW study and delivered keynote addresses.

The CEEW study 'Decarbonising the Indian Railways: Scaling Ambitions, Understanding Ground Realities', funded by UNDP, identifies key policy and regulatory challenges that developers face while supporting the Railways' renewable energy push. A potential 5 GW target, provides a unique opportunity for solar developers, with an estimated 1.1 GW coming from rooftop and 3.9 GW from utility scale projects. The Indian Railways is a guaranteed consumer and has a growing electricity demand, which should mitigate any perceived counter-party risks for project developers or investors.

Commenting on the CEEW study, Minister of State (IC) for Power, Coal, New and Renewable Energy, and Mines, Piyush Goyal, said, "Here we have an example of leadership where we have gone from populism to efficiency and from promise to implementation. Railways have come out with a commendable plan called Mission 41K where they are looking at a saving of INR 41,000 crore through the electrification of railway lines. The decision to domestically source equipment is another positive move from Railways and will largely benefit the domestic industry. I would also like to thank Railways for extending its supporting in restarting Ratnagiri plant by agreeing to purchase 500MW of generating capacity. Energy efficiency has been one of the important programmes of the Government and I am glad that Indian Railways have joined the energy efficiency programme and have tied up with EESL to have 100% LED lights. Today we are supplying power at reduced rate of 60%-70% than what it was 3 years back even at peak demand." 



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Power quality is key to improving network availability and reliability. As a world leader in power and automation technologies, ABB offers a wide range of products, systems and services that improve power quality across the power value chain in low, medium and high-voltage applications, helping shape a stronger, smarter and greener grid.

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## NTPC installs 110 KWp AC Microgrid at NETRA

An AC microgrid test bed of 110 KWp Solar PV with demand side management to cater three phase critical loads has been installed and commissioned at NTPC Energy Technology Research Alliance (NETRA), the R&D arm of NTPC Ltd, Greater Noida. System architecture and centralised control has been designed in-house to monitor and control all generating sources, storage and loads.

The system is designed to maximise the PV generation in case of grid interruptions. This type of Microgrid will be useful in places where grid is weak or absent.

Climate change, waste management, carbon capture and utilisation, new & renewable energy, efficiency improvement and cost reduction are core areas of research at NETRA. It is also providing scientific support to NTPC and other power utilities for improving availability, reliability and efficiency.



NTPC is India's largest Power Generating Company having total installed capacity of 51,527 MW with presence in Coal, Gas Hydro, Solar and Wind Power Generation, Coal Mining and EV Charging Business. 

## THDCIL inks MoU with Ministry of Power

THDC India Limited (THDCIL) signed a Memorandum of Understanding (MoU) defining the Performance Guarantee Parameters for the financial year 2017-18 with Ministry of Power (MOP) at New Delhi on 19.06.2017. On behalf of Ministry of Power, P.K. Pujari, Secretary (Power), Govt. of India and on behalf of THDCIL, D.V. Singh, CMD signed the MoU in the presence of Shalini Prasad, Addl. Secretary, MOP, Archana Agrarwal, Joint Secretary, MOP, Abhijit Phukaon, Director, MOP, U.C Kannaujia, GM(SP), THDCIL, R.N. Singh, Addl.GM(SP) & Sandeep Checker, DGM, THDCIL and other senior officials of MOP & THDCIL.

Energy generation target of 4600 MU (for excellent rating) has been set



(L2R) P.K. Pujari, Secretary, Power, Govt. of India and D.V. Singh, CMD, THDCIL at the MoU Signing Ceremony...

for the year 2017-18. THDCIL has contributed 1000 MW in the Xth Five Year Plan from Tehri HPP and contributed 400 MW from Koteswar HEP in XIth Five Year Plan in Hydro Sector.

Since the commissioning of its first project viz. Tehri Dam & Hydro Power Plant (THPP-1000 MW) a multipurpose project on the river Bhagirathi in 2006-07 and Koteswar HEP (400 MW) in 2011-12, THDCIL is a profit making

organisation and has generated 39839.96 MU energy till 31st May 2017. Tehri Dam project started with the status of a project of 'National Significance' during its planning stage and was successfully commissioned in spite of stringent opposition during its implementation. 

## SBI approves 100MW of Grid-Connected Rooftop Solar Projects

The State Bank of India (SBI) revealed that financing of solar rooftop projects worth Rs 400 crore, with private developers. This would add at least 100 MW of solar rooftop capacity to the grid, and is a significant step towards meeting the Government of India's target for 40 GW of solar rooftop installations.

SBI has availed loan of USD 625 million from the World Bank for on-lending to viable Grid-Connected Rooftop Solar PV (GRP) projects undertaken by PV developers/aggregators and end-users, for installation of rooftop solar systems on the rooftops of commercial, institutional and industrial buildings. Implementation of the program by SBI will support the installation of more than 600 MW of rooftop solar capacity. With the World Bank funded capacity development program, SBI is making efforts to expand and incentivise the market for



Karnam Sekar

rooftop solar power by way of low cost financing. Financing is being provided to those with sound technical capacity, relevant experience, and creditworthiness, meeting SBI standards.

Developers that the SBI will be financing under this Program include Azure Power, Amplus, and Cleanmax amongst others. The capacity of the projects and programs financed range from 25kWp to 16MW.

Karnam Sekar, Deputy Managing Director, SBI, said, "As the largest Bank in India, SBI is committed to finance renewable energy projects to support the Government of India in realising its renewable energy targets. With the World Bank loan, SBI aims at developing the nascent rooftop solar market. As a tropical country, India has a huge potential to be the leader in the rooftop solar space." 



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## Azure Power commissions 100 MW NTPC Solar Project in Andhra Pradesh

Azure Power, a well known independent solar power producer in India, has revealed that it has commissioned a 100-megawatt (MW) solar power plant in Andhra Pradesh.

The project was auctioned by NTPC, which has an AAA debt rating and is the Government of India's largest power utility. The solar plant has been set up at Kurnool Ultra Mega Solar Park with a total capacity of 1,000 MWs. The solar park is being developed by Solar Park Implementation Agency (SPIA) and Andhra Pradesh Solar Power Corporation Limited (APSPCL). Azure Power will supply power to NTPC for 25 years at a tariff of INR 5.12 (~USD 7.9 cents) per



Inderpreet S Wadhwa

kWh. Spread across 500 acres of land in Andhra Pradesh, the project will help in electrifying the nearby areas.

Inderpreet Wadhwa, Founder and Chief Executive Officer, Azure Power, said, "With the commissioning of this plant, we have once again demonstrated our strong project development, engineering, and execution capabilities. We are delighted to make a contribution towards realisation of our Hon'ble Prime Minister's commitment towards clean and green energy, through solar power generation. Our sincere gratitude to NTPC and the State of Andhra Pradesh for all the cooperation and support extended."

## L&T Power wins Rs 300 crore export orders from Japan

The Power Business of Larsen & Toubro (L&T) through its joint venture company L&T-MHPS Boilers Private Limited (LMB) has secured export orders worth approximately Rs. 300 crore from Mitsubishi Hitachi Power Systems Limited (MHPS), Japan.

The LMB contracts include supply of pressure parts to 2x1000 MW and



LARSEN & TOUBRO

1x650 MW power plants in Indonesia and Japan, respectively, for water wall panel, coils, piping and header. LMB is currently executing eight export orders for the supply of pulverisers and pressure parts to various MHPS projects in Japan and Indonesia.

LMB has already executed 11 export orders for supply of pressure parts, pulverisers and engineering services to the Middle East, Africa and South East Asia.

## RaysExperts commissions 5.5 MW solar project for a leading PSU

RaysExperts, India's well known innovative solar solutions provider and one of the largest solar power EPC & Development companies, revealed the commissioning of its 5.5 MW solar project for an Indian PSU. The plant is projected to generate electricity worth over INR 25 crore, which will be sold to third parties via a solar PPA agreement.

This PSU is one of the most prominent hydro power companies in India and produces enough hydroelectric power for a 1,500 megawatts (2,000,000 hp [horsepower]) underground power station from a single dam owned. With RaysExperts, the company is venturing into solar energy with its first ever solar plant, which will be situated in Charanka Solar Park, Gujarat.



Rahul Gupta

Rahul Gupta, Founder, RaysExperts, said, "We are looking forward to our association as this PSU forays into solar power with our 5.5 MW solar project. As a sustainable source of power, the plant will help the client reduce the carbon footprint in already polluted industrial regions of Gujarat by eliminating over 6700 metric tonnes Co<sub>2</sub> every year."

The 5.5 MW solar plant will give them several tax benefits, and will also add up to its revenue with the sale of electricity via PPA agreements. Apart from this project, RaysExperts has also commissioned a 5.5 MW solar installation for Delhi Metro Rail Corporation. It also has major projects under NHPC, NDMC, SECI, and CPWD in the lineup.

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## Siemens cyber security solution to protect CLP India's power plant automation system

With the growing complexity of modern energy and power infrastructure, an increasing number of power plant systems are connected through 'Internet of Things'. This creates the probability of new security vulnerabilities due to the sheer number of connected systems and the low levels of security currently available in simple devices.

Siemens has developed comprehensive cyber security solutions for critical infrastructure, power and industrial control systems. These solutions conform to the latest international standards such as NERC-CIP (North American Electric Reliability Corporation critical infrastructure protection) and VGB, the European technical association for power and heat generation.

Siemens has further strengthened its position as a leading provider of

cyber security solutions. It will be implementing a cyber security solution for power plant automation at the Paguthan (Gujarat) plant of CLP India Private Limited, the Mumbai-based wholly-owned subsidiary of CLP Holdings Limited, which is one of the largest investor-owned power businesses in Asia.

The cyber security solution being implemented by Siemens Limited will support CLP India's efforts to bolster cyber security at its power plant by detecting threats and minimising the risk of advanced cyber attacks. The solution detects, analyses and raises alarms of the threats that move laterally from Information Technology (IT) to Operational Technology (OT) networks. The solution also includes dedicated endpoint protection to prohibit execution of malicious applications. 

## Vikram Solar achieves a milestone of 1GW solar manufacturing capacity

Vikram Solar, the globally recognised and India's well known solar energy solutions provider, reached 1GW of manufacturing capacity. This feat is a major contribution towards the 100 GW target set by the Indian government by 2022. With this accomplishment, Vikram Solar cements its position as a forerunner of the Indian Solar energy segment, which is emerging to be the largest PV market in the world.

With a capacity of 1 GW, Vikram Solar is well equipped to cater not only to the Indian needs, but also contribute to the International solar industry.



Gyanesh Chaudhary

Gyanesh Chaudhary, MD & CEO, Vikram Solar, said, "For the past decade we have been toiling away, shaping the solar landscape in the country, with our high efficiency modules 'made in India'. Today we pride ourselves in being an Indian company to have fortified manufacturing capacity to 1GW. India has today come into its own as one of the largest emerging PV markets in the world and we are geared up to do our bit in the 'Make in India' initiative as well."

"In our endeavor to contribute to our make in India commitment, we aspire to expand our capacity to 2GW by FY 2020", he further added. 

## TPDDL commissions 66/11 kV grid substation at Rohini Sector 30, Delhi

Taking another step towards distribution network automation, Tata Power Delhi Distribution (TPDDL) recently commissioned a 66/11 kV grid substation at Rohini Sector 30, Delhi. The newly commissioned substation will benefit over 45,000 domestic, commercial and government & industrial (G&I) customers mainly in the DDA-constructed LIG, MIG and HIG flats in different sectors of Rohini such as 28, 29 and 30 and adjoining areas. The substation will further improve the reliability of power supply and facilitate the load growth in these areas.

The grid was jointly inaugurated by Praveer Sinha, CEO and MD, TPDDL, and Vir S Advani, MD, Blue Star.

The newly commissioned grid substation has an installed capacity of 50MVA, with 16 outgoing feeders at 11 kV level. It is an unmanned substation and will be remotely operated from TPDDL's state-of-the-art supervisory controlled and data acquisition (SCADA) centre.



(L2R): Praveer Sinha, CEO and MD, TPDDL, and Vir S Advani, MD, Blue Star, jointly inaugurate the grid substation at Rohini Sector 30, Delhi

The substation has four 66kV incoming underground cable circuits, two from 220kV Rohini Sector 2, a DTL grid at Rohini Sector 29 and two from Rohini Sector 34. TPDDL 66kV grid at Rohini Sector 34 and is equipped with two power transformers of 25MVA capacity each and nitrogen injection fire prevention and extinction system (NIFPES) power transformers along with auto-switched capacitor bank to ensure safe and quality power supply.

Praveer Sinha, CEO and MD, TPDDL, said, "The commissioning of the grid substation at Rohini Sector 30 is a part of our commitment to ensure seamless power supply in our distribution area through N-1 principle, which quickly restores supply overcoming contingencies. Our focus has always been on strengthening the power distribution network for quality and reliable power supply. We are continually making our network future ready so that it can successfully meet the growing electricity demand." 

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## Electrolab, Inc. partners with BEC Solar for product development of Apolloware Control Unit

**E**lectrolab, Inc. has entered into a new partnership with Bandera Electric Cooperative's BEC Solar division for product development and manufacturing of the new Control Unit for their Apolloware energy management software.

Apolloware is a cloud-based software platform that allows residential or commercial users to monitor and control the solar generation and energy usage from their solar panel installations in real time. Apolloware accepts data from the electric meter and solar panel inverter and transmits it to the cloud for analysis and reporting of energy usage. Electrolab worked with BEC to optimise the initial Apolloware Control Unit design and delivered the first unit for customer installation in April 2017. The two companies will continue the partnership on future development and manufacturing of the

Apolloware product line.

Bill Hetherington, CEO, BEC and BEC Solar, said, "It is my pleasure to announce BEC Solar's relationship with Electrolab. Electrolab is known for their expertise in the electronics and high technology industries, and this partnership offers strong support for our business and the future of the Apolloware product line."

Sean Drees, CEO, Electrolab, Inc., said, "Electrolab is excited to partner with a local market leader like BEC Solar to serve the members of our community. As a BEC corporate customer, we are impressed with the high quality products and services the company provides. We look forward to a long-standing partnership with BEC Solar and look forward to helping design and manufacture quality solutions for their members." 

## Siemens Gamesa to supply EnBW Albatros offshore wind power plant

**F**ollowing the 497-megawatt (MW) order for the EnBW Hohe See offshore wind power-plant, EnBW has awarded Siemens Gamesa Renewable Energy with the installation of the neighboring 112-MW-project EnBW Albatros. The scope of supply includes 16 direct-drive SWT-7.0-154 wind turbines on monopile foundations and the grid connection via a Siemens Offshore Transformer Module (OTM).

Siemens Gamesa will install both wind power plants in parallel. Installation will start in spring 2018. The projects are located 90 kilometers north of Borkum Island in the German North Sea with water depths of up to 40 meters. The combination of both projects offers synergies to EnBW in respect to planning, construction, and during operation. Due to Siemens Gamesa Renewable Energy's complete solution for Albatros -ranging from turbines to substation technology -the project benefits from full optimisation opportunities: Through the project-



Michael Hannibal

specific approach, all technology components work perfectly aligned so that the risk for all involved parties is mitigated. At the same time, a bundling of installation works and a centralised project planning create valuable synergies. After commissioning in 2019, Siemens Gamesa will initially provide service and maintenance for the turbines over a period of five years.

Michael Hannibal, CEO Offshore of Siemens Gamesa Renewable Energy, said, "EnBW Albatros allows us to demonstrate our broad competence in offshore projects, ranging from project specific engineering services and the beneficial combination of power generation and transmission technology to service and maintenance concepts. This project has a high relevance for us since we will turn the 112-megawatt wind power plant into a highly profitable investment for our customer via cutting edge technology and smart details." 

## Sungrow PV and Energy Storage Equipment powers five Maldivian Islands

**S**ungrow, a well known PV inverter system solution supplier, revealed that it has installed PV and energy storage system for five islands in the Maldives- where people heavily relied on diesel for power and were plagued by poor power quality and high power cost.

The five sunny islands, Addu, Villingili, Kurendhoo, Buruni, and Goidhoo, are now equipped with the newly established PV diesel hybrid energy storage micro-grid, which provides stable and high quality power to the island. This project can save US\$ 1.4 million in fuel costs and 4.32 million tons of carbon dioxide emissions annually, and meets above 30% of local domestic and office energy demands. The project manager of a local electricity company told the media in an interview that renewable energy projects of this kind are welcome to the Maldives- as they can reduce

the cost of diesel and help improve the environment.

The 2.7 MWp of solar and 700 kW / 333 kWh energy storage project, for which Sungrow has supplied the entire PV and energy storage system solution, including PV inverters, storage inverters, the energy management system, and Li-ion batteries by the Sungrow-Samsung SDI joint venture-- has efficiently utilised the abundant solar resources and can be fully integrated into the existing diesel network.

Professor Renxian Cao, President of Sungrow, said, "Sungrow has developed a complete system solution for load-shifting, peak-shaving, micro-grid, and frequency regulation. By the end of 2016, Sungrow has successfully completed over 400 energy storage projects globally and has an accumulated installation of over 1GWh. We'll continue to support the Maldives in their efforts to reduce power cost and protect the environment." 





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SS400CAT17-ELECTRICAL

## E.ON chooses Tieto Smart Utility for collection of meter values in Sweden

The energy company E.ON has chosen Tieto Smart Utility to support their distribution operations-- for the collection of meter values including field services for the Skåne area in Sweden with approximately 150,000 meters. E.ON can continue to offer state of the art solutions with a high degree of automation for their customers. The initial contract duration is 3 years with an option for additional years.



Olof Ferenius



Robert Tretinjak

E.ON., said, "The Swedish energy market is facing a massive change. The implementation of Tieto Smart Utility will help us to reach efficiency and standardisation in collection of meter values including operation of field services to serve our customers in the best possible way."

Olof Ferenius, Head of Energy Utilities, Tieto, said, "Tieto is already an existing provider of energy & utility services to E.ON and we see this as the next step in extending our long-term

Tieto Smart Utility optimises the energy distribution company's core business activities in collection of meter values. It also helps E.ON to be future proof in a changing market with increased automation and reduced costs.

Robert Tretinjak, Head of 2:nd Generation Smart Metering Program at

co-operation.

Our highly standardised IT solutions and services complemented by a strong technology platform create benefits and increased quality for the customer." 

## Operational start for Volvo's Electric Buses in Luxembourg

Beginning of June the first commercially manufactured all-electric Volvo buses started operating in the city of Differdange in Luxembourg. The operator is Sales-Lentz, which now has 4 electric buses, 12 electric hybrids, and 30 hybrids from Volvo in its fleet.

Differdange's focus on electrically powered buses is part of the city's ambitious sustainability drive, with public transport forming a crucial focus area. The four electric buses are used on four routes with length from 8 to 9.5 km. Each bus is driven approximately 25 minutes, then the buses' batteries are fast-charged in three to six minutes at the end stations using an open interface known as OppCharge (opportunity charging), which follows the ACEA (European Automobile Manufacturers Association) recommendations. The charging stations in Differdange were supplied by Heliox.

In addition to the all-electric Volvo 7900 Electric, the Volvo Buses range of electrified vehicles includes hybrid buses and electric hybrid buses (plug-in hybrids). All told, the company has sold more than 3300 electrified Volvo buses globally.



Håkan Agnevall, President of Volvo Buses, "The start of operations with the Volvo 7900 Electric marks yet another important step for all of us who work for a cleaner, quieter urban environment and more attractive public transport. Together with Differdange and Sales-Lentz we are in the vanguard of next-generation public transport." 

## Opening of Europe's Largest Bifacial Solar PV Plant in the Netherlands

Yingli Green Energy Holding Company Ltd., a well known solar panel manufacturers, revealed the Tempres Systems B.V., part of the Amtech Group celebrated the opening of Europe's largest bifacial PV solar plant – of close to 400 kilowatt-peak (kWp) capacity in the Netherlands, using n-type PANDA Bifacial modules manufactured by Yingli Solar. The plant is located next to the headquarter of Tempres in Vaassen, the Netherlands.

In contrast to standard monofacial modules, PANDA Bifacial modules generate electricity from both sides. As the rear side makes use of the reflected light from the surroundings and of diffuse light, the modules can yield up to 30% more energy compared to the situation when it only generates from the front side, depending on the circumstances. It is

expected that the annual energy production of the bifacial PV plant will exceed 400 MWh. The facility contains 1428 PANDA Bifacial n-type silicon modules with a nominal peak power ranging from 275Wp to 280Wp each. They contain solar cells based on the n-PERT technology jointly developed by Yingli Solar, Tempres Systems and ECN.

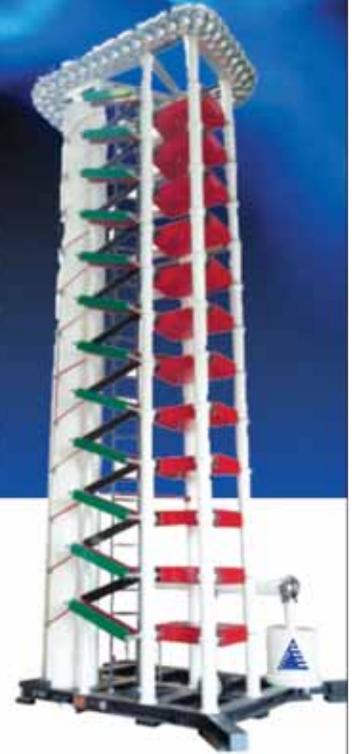
The bifacial modules have a glass front side and a glass rear side with a 30-year-linear warranty exceeding the life time of standard modules. The PANDA Bifacial modules have been independently tested for harsh environmental conditions such as exposure to salt mist, ammonia and known potential-induced degradation (PID) risk factors. The modules are equipped with n-type crystalline silicon solar cells which perform better under low light conditions than regular p-type cells. 

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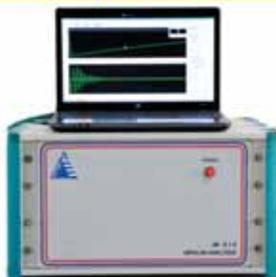
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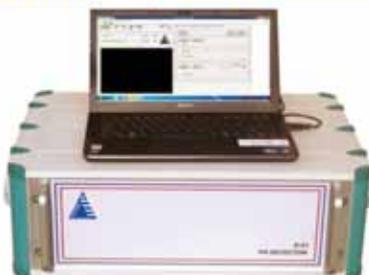
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# Power Equipment Industry Grows by 4.25% in the year 2016-17

Industry fully equipped to meet domestic demand arising from capacity addition in future...

The electrical and industrial electronics industry has witnessed a 4.25% growth in the year 2016-17 over the previous year. The industry exported INR 38,580 crore (USD 6 billion) worth of electrical equipment in 2015-16 (INR 35,276 crore April to February in 2016-17 - USD 5.25 bn). The growth in exports is helping the industry to grow especially in power transformer & high voltage switchgear products, energy meters and cables. Policy changes and various initiatives undertaken by the industry and government are eventually showing signs of revival for the sector.

The data is compiled by the Indian Electrical and Electronics Manufacturers' Association (IEEMA), the apex Indian industry association of manufacturers of electrical, industrial electronics and allied equipment. The production and sales data is collected from its member organisations, which represent 95 percent of the entire sector.

The major drivers in this growth are low voltage switchgear which has registered a healthy growth of 22% due to revival in growth of realty, infrastructure & other manufacturing industries. Distribution transformer (Especially Up to 25 KVA – REC range) & energy meters demand has declined by 12% & 10% respectively due to poor off-take from utilities due to delay in finalization of orders under Govt. schemes like DDUGVYJ and IPDS.

The growth in power transformer & high voltage switchgear can be seen due to domestic orders arising from new substation additions, especially, for above 220 KV. There is a marginal growth in LT motors, however, declining trend for HT motors due to imports & core sector industry capex not taking off. The conductors demand is declined by 5% due

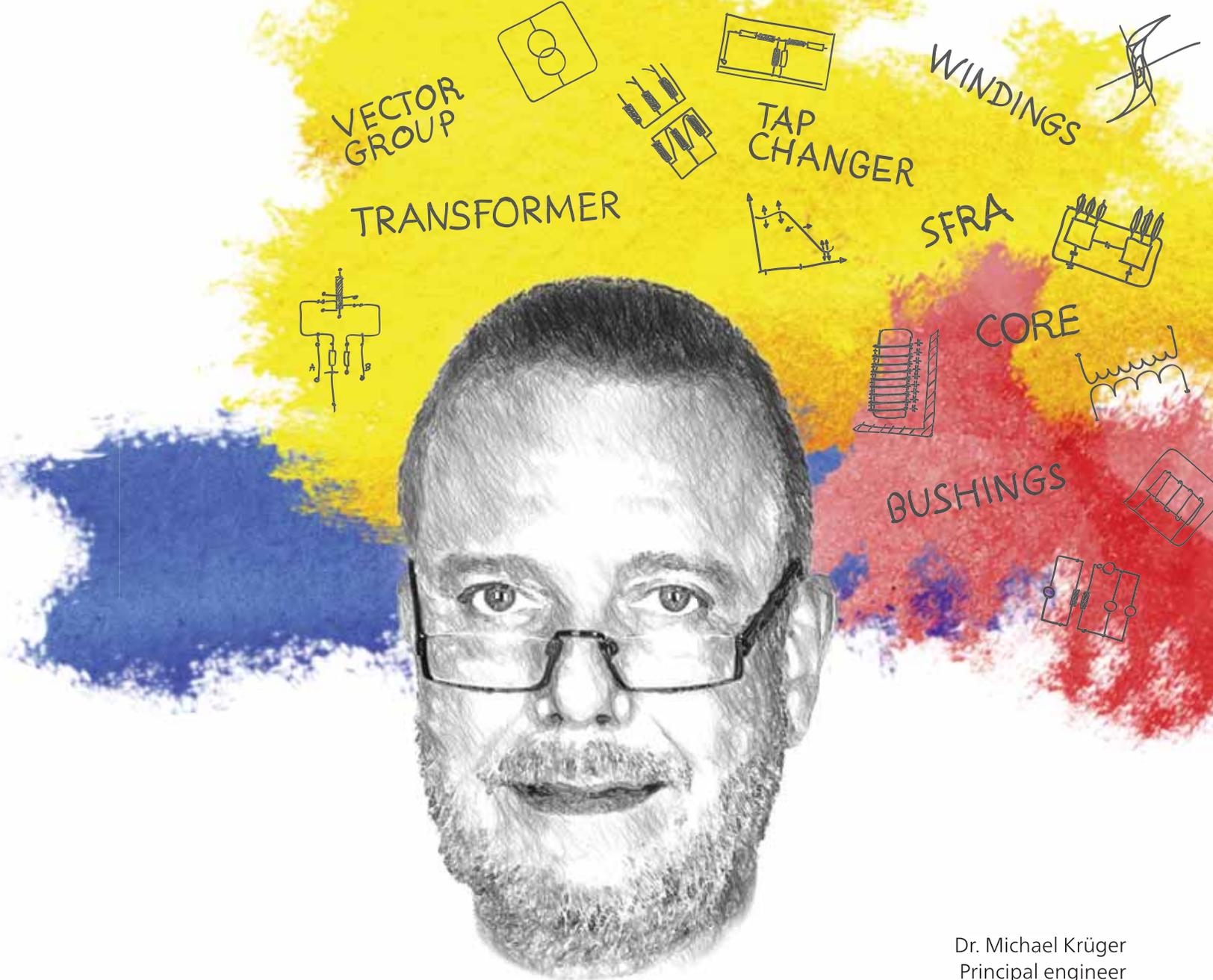
to delay in order finalizations.

Sanjeev Sardana, President, IEEMA is of the view that, "The sluggish demand and higher imports is still hampering the industry growth. There is a high imports visible in HV Switchgear (GIS), insulators, AC motors & generators. The target of 400 KV transmission & sub-station completion is over achieved in four years of 12th Plan only. In power generation, renewable energy addition is picking up fast and solar power generation addition has achieved 104% with wind power achieving over 80% of planned addition. In the 13th plan the focus will be on renewable energy, power electronics and e-mobility. These new technologies will not only pose disruptive challenges but also open vast opportunities for the industry."

Sunil Misra, Director General, IEEMA, says, "Indian Electrical equipment industry is fully equipped, not only to meet the present domestic demand, but also geared up to meet likely demand arising out from capacity addition in the future. The industry is 9.54% of the manufacturing sector in terms of value and 1.23% of India's GDP, providing a direct employment to 1.5 million and indirect employment to over 5 million people across the entire value chain. There is significant global reputation of Indian electrical equipment for sourcing of base products and components and also of Indian transmission and other EPC contractors."

He further adds, "Indian electrical equipment manufacturing industry has made huge investments in doubling and, in some cases, even tripling its production capacities. However, these built-up capacities are under-utilised across several products and the manufacturers are broadly working at 60% to 70% of their production capacities." 





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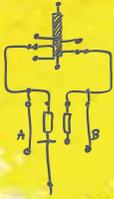
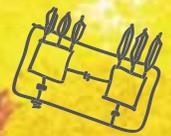


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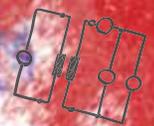
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## India Power appoints new Managing Director

India Power Corporation Limited (India Power), formerly known as DPSC Limited, incorporated in 1919, carries a 97 years long rich legacy in efficient power distribution and sustainable power generation. The company has actively forayed into a diversified portfolio with renewable and conventional modes of power generation, distribution and power trading.

Recently, the board of directors has appointed Raghav Raj Kanoria as Managing Director of India Power.

Raghav Raj Kanoria, said, "I feel privileged and excited to work with an excellent team of professionals



Raghav Raj Kanoria

in India Power. I have been working in the company for the last six years and across the distribution, finance, generation, mergers and acquisitions verticals, which has provided me with valuable insights and hands-on experience. The team at India Power has greatly contributed to my intense learning. Our objective will be to strengthen the company's leadership position in the power sector and create a 'lateral thinking' organisation, which will enable us to capitalise on the present acquisition opportunities in India and also introduce technological innovations in order to reduce power costs for the consumers." 

## Rays Power Infra appoints Rahul Mishra as the CEO of its new venture

Rays Power Infra, a well known integrated solar power company with presence across the entire solar value chain, has appointed Rahul Mishra as the CEO to lead new business initiatives under Rays Future Energy India. The new company will be focusing on distributed solar generation including rooftop solutions, Energy Storage, E- Vehicle & associated infrastructure and solar energy based products.

Mishra comes in as an equity partner and will be responsible for spearheading the overall management and the day to day business operations of the firm. He will be concentrating on facilitating the firm's business and strategically align the company through well-crafted vision.

Prior to joining Rays Future Energy India, Mishra was working with Nereus Capital, a private equity fund focused on investing in the Indian renewable energy sector. Before Nereus, Mishra was working with AES



Rahul Mishra

India where he was managing the business development efforts on originating, developing, contracting, financing and execution of wind based power projects in India. He successfully handled the implementation of a 40 MW wind power project.

Post completing his MBA from ICFAI Business School, Hyderabad, he started his career with Power Finance Corporation one of the largest lender in the Indian power sector and was part of the core group established to manage the bidding process and development of 4000 MW each, ultra mega power projects (UMPP's).

Mishra was also involved in setting up the Indian operations of GE Energy Financial Services (EFS) in India and South East Asia region and was part of the underwriting team evaluating transactions across region. During his term with EFS, he was part of the team making investment of over \$125 million across debt and equity instruments. 

## Schneider Electric appoints Venkatraman Swaminathan to lead the IT Division (India)

Schneider Electric, a well known specialist in energy management and automation, has appointed Venkatraman Swaminathan as the Vice-President, IT Division – India Zone. In his new role, he will be responsible for driving the growth of the overall IT Business in India.

With over 26 years of experience in the field of sales, service and marketing, Venkatraman brings a wealth of experience in the field, having evolved business critical solutions for spaces like data centres switch rooms, test laboratories etc. The future of data centre is going to be different in terms of managing power and energy and big data. He will be



Venkatraman Swaminathan

responsible to lead the business towards the New World of Energy, which is safer, more efficient and sustainable with the support of innovative, connected technologies.

Anil Chaudhry, Managing Director and Country President, Schneider Electric – India, said, "Venkatraman has been a vital part of our team where his sales leadership expertise, unique customer relationship, ability to collaborate with service delivery teams, and most importantly his commitment to client satisfaction has enabled the entire Schneider Electric team to consistently perform above plan, as well as secure many of the largest and most strategic deals." 



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## IIT Madras wins the 2017 IEEE Spectrum Technology in Service of Society Award

The IEEE Spectrum Technology in the Service of Society Award is presented to the company/institution voted by IEEE Spectrum editors as having developed the technology having the greatest potential to provide the most overall benefit to humankind. In 2017, the editors have chosen to give this award to the Indian Institute of Technology, Madras for the development of solar DC microgrid technology.



Dr. Pawan Goenka, Chairman, Board of Governors, IIT Madras and Managing Director, Mahindra and Mahindra Ltd., said, "I am delighted

that IIT Madras has been selected for this prestigious award by IEEE. It is an honour to be recognised globally for the pioneering work being done by the Centre for Decentralised Power Systems at IIT Madras. Besides being world-class research and teaching institutions, we look to the IITs to develop technologies that have a strong social impact. Solar-DC technology is a shining example of this, as it can quickly become part of every home in India and provide low-cost 24 x 7 power. The

government should facilitate rapid adoption of this transformative technology." E1

## Hypower named 2017 Business of the Year by South Florida Business Journal

Hypower, one of Florida's largest electrical and utility contractors, revealed that the company has been selected by the 'South Florida Business Journal' as a 2017 Business of the Year for companies with revenue of \$50 million to \$100 million.

With more than 250 people in attendance, the 2017 Business of the Year Awards at Jungle Island in Miami recognised organisations that build the South Florida economy through solid business practices, financial growth and community involvement. Now in its 20th year, this program highlights excellence across all industries in the region.

Bernard Paul-Hus, President, said, "I'm thrilled to accept this award on behalf of our entire company, and we owe this recognition to all Hypower employees for their hard work, commitment to our internal management processes and integrity. Our customers know that they can depend on the quality of our work. We are proud to



L2R (Richard Paul-Hus, Bernard Paul-Hus, Eric Paul-Hus)

provide consistency and reliability, and celebrate long-standing client relationships as a result."

Past recipients of the prestigious Business of the Year Awards have included many notable companies in the region. This award is not new to Hypower. The company was named Business of the Year in 2012. E1

## Munters wins Energy Innovation Award

Munters (MTRS) received the 'Industry Energy Innovation' award at the 2017 Europe Datacloud Awards. BroadGroup revealed the winners of this year's Datacloud Awards, showcasing innovation, inspiration and excellence in data centre and cloud.

Neil Yule, President, Data Centre Business Area, Munters, said, "We are proud to receive this recognition for our innovation and commitment to energy efficient solutions within the data centre industry. Our teams are



dedicated to working with data centre owners and operators to achieve energy goals whilst offering an innovative edge. The Oasis Indirect Evaporative Cooling technology was submitted and the star of our energy efficiency offering for this award."

The awards were presented on the evening of 6th June in the Monaco Sporting Club and the ceremony was attended by over 600 executives from the data centre and cloud industry. Entries were judged across a range of award categories. E1



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## Design Reviews & Life Management Concepts



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This paper explains importance of specifications, design reviews and life management concepts for reliable, uninterrupted and intended application of transformers throughout the life cycle. The specification forms the basis on which the manufacturer designs, manufactures and tests a transformer...

Large power transformers and shunt reactors are largest and costliest equipment in the transmission network. Transformers being a long delivery item, reliable performance of this equipment are very important to maintain the availability of power system.

The specification forms the basis on which the manufacturer designs, manufactures and tests a transformer. With the growth in size of power system and complexities of modern system, the adequacy of transformer specification plays a major role on its reliability. A good specification must properly consider the effect of application, system operating conditions, environmental considerations, site details, service conditions, termination details etc so that the transformer is designed for the conditions under which it has to operate. Thus, the adequacy of specification of transformers, particularly, that of high voltage and larger rating assumes

tremendous importance and an inadequate specification can lead to a deficient design and poor reliability.

The various parts of transformers viz magnetic circuit, insulation system, termination, cooling equipment etc are designed as per technical specification details. A technical specification has three objectives:

- I. To provide the tendered, or manufacturer, with all that technical information necessary to carry out his design and which will vary for each design, for example rating, voltage ratio, type of cooling, losses, applicable tolerances on performance parameters, applicable standards, tests requirements etc.
- II. To provide the tendered, or manufacturer, with an indication of the strategic importance of the transformer and the value to be placed on reliability, maintainability and long service life.
- III. To provide the tendered, or manufacturer

with information which will ensure that the transformer will satisfactorily interface with its associated plant and equipment and that installation and commissioning will proceed smoothly and without undue delays.

Clearly, the first two objectives will have a significant bearing on the cost of the transformer and must be met by the enquiry document to enable the manufacturer to prepare his tender. The third will include many items which will have relatively little bearing on the overall cost and which could possibly be resolved during the engineering of the contract. However, it is good discipline to identify in the technical specification all those aspects which should be known at the time of initially depicting this up, since not only does this minimize the use of engineers' time during the contract stage and ensure that there are no unnecessary delays during the contract, but it also avoids the risk that these items might be overlooked during the detail engineering of the contract.

The specification should be a crystal clear information to designer without leaving any chance of ambiguity, particularly, each parameters defined in clear terms of unit in the technical specification with or without any tolerance shown in Table 1.

## Design Review

### A. Introduction

Design reviews have since long been a formal activity accompanying critical orders, mainly because of their impact over the cost of a project and, or expected operation costs. A design review is a planned exercise to ensure that both parties understand the application and the requirements of the technical specifications and applicable standards. Hence, its purpose is to create a common understanding of purchaser's specifications and requirements, and it also gives purchasers an opportunity to check in detail the design and requisition fulfillment process of the manufacturer.

Design review is the opportunity for both purchaser and manufacturer to scrutinize the proposed design, to ensure that the supplies will be met not only technical requirements but also those relating to other aspects of the contract, like quality, testing, inspections, site installations etc. Therefore, the design review is a good opportunity to interchange experiences that can be used to propose enhancements or betterments. For these reasons, it is strongly advisable for the purchaser to have expert transformer engineer(s) with them during the meeting.

The design review cannot be taken as a second stage of the specification of the

transformer, because of the potential costs involved with the modification of design, but is an excellent opportunity to correct minor deviations, when the design does not match all desired purchaser's needs. Transformer manufacturers always benefit from interaction with purchasers, as they learn from first hand of their changing needs to improve their operation. The purchaser benefits from a closer understanding of transformer technology, as they can improve their specifications and take better operations decisions.

The process of the design review involves formally one or more sessions between the purchaser (purchaser, applications engineer and consultants) and the manufacturer (contract manager and designers) with the purpose of making sure that the product is designed according to the purchaser's needs. As power transformers are very costly equipment, and field failures are undesirable. The followings are the pre-requisites for carrying out the design review:

- i. Design review should be part of the tender inquiry and it becomes obligatory on the part of the customer and manufacturer to ensure compliances with the contract specifications.
- ii. It is to be ensured that all stakeholders are involved in the design review.

Table 1

S. No.	Test Description	Tolerances
1	Ratio	As per IS/ IEC
2	Vector group	No deviation
3	Magnetic Balance	As per CBIP.
4	Resistance	As per IS/ IEC/ Within guaranteed limit.
5	No load loss & Load Loss	As per technical specification with fixed loss/ variable loss/ penalty clause.
6	% Impedance on all three position (i.e. Normal and Extreme taps)	As per TS with applicable tolerance as per standard.
7	Noise level & Harmonics	As per IS/ IEC/ Within guaranteed limit.
8	High voltage Test	Withstanding voltage in kV for one minute with standard frequency.
9	Induced over voltage Tests	DVDF / ACSD/ ACLD as per IS / IEC
10	Impulse tests / Switching impulse	Voltage level in lightening impulse test with or without chopping one phase / three phases as per customer's specification.
11	Partial discharge	Can be measured at a time for all the 3/ 6 phases together or one by one as single phase, is a matter of time. Limits are specified in technical specification in clear term with ambient or above ambient.
12	SFRA	This test is done in the factory and verified at site to see that there is no deviation in transit.
13	Shock recorder	It is installed on the transformer to check impact of vibration due to heavy jerks during transit.

- iii. Review may include certain information which is of proprietary nature. It is, therefore, desirable to have mutual agreement between the purchaser and the manufacturer for the confidentiality of information.
- iv. It is important for the success of design review that both the purchaser and manufacturer are clear on the requirements and well prepared to have open and frank sharing of information.

## B. Objectives

The main objective of design review is to verify that the product is designed according to the purchaser's needs. Following are the main objectives of the design review:

- I. To ensure that there is a clear and mutual understanding of the transformer technical requirements according to purchaser specification & applicable industry standards.
- II. To understand the application and verify the system and project requirements and to indicate areas where special attention may be required.
- III. To verify that the design complies with the technical requirements.
- IV. To identify any prototype features and evaluate their reliability and risks.
- V. To interchange experiences that can be used to identify eventual betterments in the design and / or improvements and changes in the specification.
- VI. To strengthen the technical relationship between purchaser and manufacturer and to understand the technical capabilities of the manufacturer.

## C. CIGRE Guide for Design Review

This document is a general purpose guide for purchasers that want to review the design of their transformers. The scope of the guide is 100 MVA, 123 kV and above, but it may well be applicable to transformers of a much smaller rating. The review is understood as an activity that must be planned well ahead within the contract acknowledgement process with the purpose to confirm a common understanding of purchaser's specifications and requirements, and that gives purchasers an opportunity to check in detail the design and requisition fulfillment process of the manufacturer. The guide does not include limits for relevant design parameters,

leaving the responsibility for an appropriate selection to the manufacturer. Purchasers are advised that they should be qualified with the technical expertise necessary to understand and evaluate the design.

One particular purpose of the design review is to identify any new developments or solutions that might be applied as a prototype and assess risks and reliability. Experience shows that many purchasers would prefer to use mature solutions, replicated invariant for decades. As purchasers and consultants will have access to manufacturer's proprietary information, sometimes considered strategic and classified (e.g. new developments, competitive edge projects, design policies), good control of documents and a clear definition of responsibilities are essential matters.

## D. Conclusions

Design reviews can be very productive exercises for purchaser and manufacturer as they foster a better understanding of purchaser's needs, and have the main objective of verification that the product is designed according to the purchaser's needs. The design review cannot be construed as a second stage of the specification of the transformer, because of the potential costs involved with the modification of design, but is an excellent opportunity to correct minor deviations, when the design does not match all desired purchaser's needs.

The purchaser and his consultant must be aware of the limited access to copies of manufacturer's proprietary information, as he must protect his competitive advantages. Sometimes, the perfect match of a transformer to the purchasers needs implies solution of problems that go beyond the state-of-the-art of design technology. Those would have to be assessed regarding their impact on the contract as development projects might bring uncertainty to the process.

As long as a contract is valid, the manufacturer remains accountable for the performance of the final product. Adequacy to the initial specification is fundamental unless further commitments are agreed between both parties. Also, design review does not absolve or substitute manufacturer's ultimate responsibility for the adequacy of transformer design and construction, including design limits and margins, quality, performance on test and in service.

## Life Management Concepts

Transformer Life Management concepts help customers on secure high reliability and gain in-depth knowledge of the condition of the transformer. Life management concepts of transformer is a very vast subject, which deals with many activities like environmental conditions maintained during manufacturing, storage, installation and commissioning. Also condition assessment by on-line monitoring and diagnostic testing to assess the condition of oil and insulation material used in the transformer. On the topic, we have covered the effect of environmental factors and insulation ageing factors on the life of the transformer. Also we have presented some related case studies for better understanding of subject.

## A. Environmental Factors

First and foremost requirement of any product to sustain for a long life particularly, electrical equipment like transformers is starting from its initial processes of manufacturing to installation and commissioning at site. Care shall be taken at each step for environmental conditions i.e. dust, moisture, metal particles etc, which need to be individually dealt critically as these are the main constituents and putting direct consequences on equipment life. Effect of these factors is explained below:

- a. **Dust:** The transformer of EHV class must be manufactured in dust proof chamber so that dust cannot enter into the job and reduce its service life, the presence of dust particles in the job gives higher partial discharge and one should not negotiate / avoid / overlook such for good health of transformer. People don't allow manufacturing in such environment even for 132 KV Class of transformer and insulating for all voltage class.
- b. **Moisture:** The content of moisture even in one part of 1000 is so dangerous that it can lead the transformer to fail in few months. Hence, IS & IEC is very particular to agree certain PPM for each voltage class and in general my views not to allow any job with above 5 PPM for at least EHV class of transformer. Moisture in combination with temperature accelerates the ageing of cellulosic insulation material used in transformers, which in turn reduces the life of transformer. Impact of temperature and



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# Transformer Specifications

moisture on the lifetime of transformer is explained in detail as under:

Let us consider the critical temperature which a manufacturer should take into consideration when planning the cooling system of a transformer. In the previous century, a general estimate placed the temperature limit, below which ageing of paper insulation does not occur, at 80°C. Montsinger established in 1930 that in the temperature area between 90°C and 110°C, the ageing of normal paper insulation is doubled with each increase of 8°C. Some other researchers found that the doubling of velocity occurs when temperature increases between 5°C and 10°C. Consequently, today the generally adopted estimate states that an increase in temperature of 6°C doubles the velocity of ageing. Based on experience and findings, the family of standards IEC 60076-x and the standard IEC 60354, which was recently renamed to IEC 60076-7, give guidance to the maximum allowed temperatures of oil and windings so that in given climatic conditions and with the full load of a transformer, a transformer ought to reach a normal life-time of at least 30 years. But are such expectations firmly grounded? If we analyze the results of the latest research, the question is more than justified.

Results of laboratory analyses of the 5-year long project of paper in oil of artificial ageing brought new knowledge about the influence of temperature and other chemical factors on the velocity of ageing of transformer insulation in a wider temperature interval. It dismiss the old estimate that insulation does not age at temperatures below 80°C, which is evident from the plot of results in Fig 1.

Heat formed in a transformer because of losses, causes a thermal oxidative hydrolytic degradation of the paper-oil insulation system. The ageing of paper insulation in transformer oil is an autocatalytic (self-accelerating) process, whose velocity is largely determined by the temperature and the percentage of humidity in the insulation.

Figure 1 shows results of the laboratory analyses of artificial ageing, from which the expected life-time of a transformer (time of reduction from DP 1000 to DP 200), whose dependence on temperature and humidity of paper insulation, is evident.

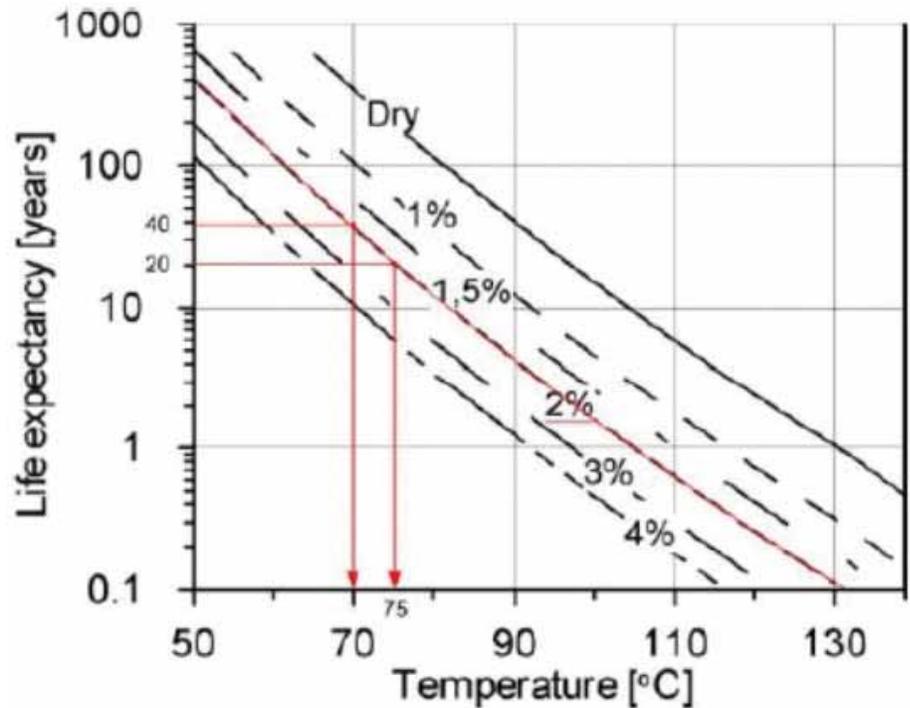


Figure 1: Dependency on temperature and humidity in the life expectancy of paper insulation in a transformer

Figure 1 shows that the presence of humidity substantially speeds up the ageing of paper insulation. Thus, with the temperature of a hot-spot at 98°C, a shortened life-time of 20 years could be expected in a transformer with completely dry paper throughout its lifetime, however, in reality no insulation is completely dry. In an operating transformer which has on average at least 2% of humidity (but even can have more), for a life-time of 20 years the temperature of the hot-spot would have to be limited to 75°C. In order to reach a 40 years life-time, however, the temperature of the hotspot would have to be limited to a maximum of 70°C. The majority of humidity in a transformer is formed as a degradation product of the ageing of paper-oil insulation (normally ca 0.1% annually). Humidity, however, can also enter a transformer from the air if a transformer which fails to be properly protected. We cannot prevent humidification of a transformer as majority of humidity is formed and retained in the paper insulation of windings due to ageing processes, which—again—are temperature conditioned (autocatalysis). Consequently temperature, or cooling, remains practically the only method which can influence the velocity of humidification

and the ageing of an operating transformer.

c. Metal Particles: Winding, insulation and active parts of the transformer should not be exposed to the forced air / gasses having metallic dust flying due to grinding or other operation like turning, milling and surfacing of conductive parts which are very dangerous and under influence of electric charges it forms a local cell and in course of time it deteriorates the insulation property and starts ageing and becomes more and more conductive in nature. Thus failure of Job occurs in short span of life. To avoid such situation to prevail, it is always suggested that the machine shop should be kept away from the manufacturing point of electrical appliances.

## B. Insulation Ageing Characteristics & Related Case Studies

When a transformer is manufactured in the factory, the paper insulated windings are subjected to drying before they are oil impregnated. At this state, the transformer has a moisture content of <0.5% by weight in paper and 6 ppm in oil. As the transformer ages, the moisture content will increase progressively at a

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# Transformer Specifications

Table 2: Acceptable limit of dew point

Temperature of insulation in °F	Maximum permission dew point in °F	Temperature of insulation in °C	Maximum permissible dew point in °C
0	-78	-17.77	-61.11
5	-74	-15.0	58.88
10	-70	-12.22	-56.66
15	-66	-9.44	-54.44
20	-62	-6.66	52.22
25	-58	-3.33	-49.99
30	-53	-1.11	-47.22
35	-48	+1.66	-44.44
40	-44	+4.44	-42.22
45	-40	+7.44	-39.39
50	-35	+9.99	-37.22
55	-31	12.77	-34.99
60	-27	15.55	-32.77
65	-22	18.33	-29.99
70	-18	23.11	-27.77
75	-14	23.88	-25.55
80	-10	26.66	-23.33
85	-6	29.44	-21.11
90	-1	32.22	-18.33
95	+3	34.99	-16.11
100	+7	37.75	-13.88
110	+16	43.33	-8.88
120	+25	48.88	-3.88
130	+33	54.44	+0.55
140	+44	59.99	+5.55

rate of ~0.1% to 0.2% / year. In severely deteriorated system, the moisture content could reach >4%.

Insulation aging is directly related to moisture content. During manufacturing process the drying out procedure is carried out as per manufacturing norms. There are possible areas of ingress of moisture in the insulation during the course of manufacturing of transformer i.e. excess hours taken when the CCA is taken out from oven or VPD for tanking, use of unprocessed insulation blocks during tanking. To avoid ingress of moisture in insulation, exposure time during tanking process to be minimized.

After tanking, testing is completed at works, the transformer (>50MVA) may be dispatched with nitrogen. In such cases dew point, relative humidity (RH) of the nitrogen / dry air and gas pressure inside the transformer shall be checked and monitored. On getting satisfactory results transformer shall be allowed for dispatch. The

acceptable limit of dew point with corresponding insulation temperature is mentioned in Table 2.

It is needless to say that after dispatch and during long storage, the transformer shall be monitored as per manufacturer's guidelines. In case of any damage noticed during transformer receipt at site, it shall be sealed immediately temporarily or permanently, as is possible and matter to be brought to the notice of the manufacturer.

## Case Studies on the Incidences of Moisture Ingress

### i. 50 MVA, 132/33kV transformer

After complete processing by end user the transformer was made ready for testing and charging. It has been informed by the customer that all other electrical test were in order except the IR values are not matching with factory test results. After thorough investigation, it has been observed that porcelain bushing was damaged during transportation and it could not be noticed

at the time of receipt of transformer at site, same is shown in photo-1 below. Since the substation work was delayed due to delay in project, priority was not given to transformer erection and commissioning, and the transformer was without nitrogen for 2 years, resulting in ingress of moisture. Rusting on core lamination below bushing was noticed, same in shown in photo-2.

From site officials, it is understood that the transformer was idle for more than two years. No nitrogen pressure was monitored. Internal inspection was not carried out before erection of the transformer and directly bushing erection, vacuuming and oil filling and filtration was done. When the transformer is tested, it has been noticed that IR value is less as compared to factory test results. Hence, it was suggested to drain out the oil completely, carry out nitrogen purging cycles and hot oil circulation. After 3-4 cycles of drying out process, the IR values found satisfactory for charging the transformer.

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# Transformer Specifications



Photo - 1 : Damaged porcelain bushing Photo - 2: Rusting on core lamination below bushing

Thereafter, transformer was taken into service and now the said transformer is working satisfactory.

## ii. 10 MVA, 66/33kV Single Phase Transformer

In this case also, the transformer was kept idle without charging for more than 1½ years and the area had huge humidity and no precaution was taken. When the transformer was taken for processing, it has been noticed that the HV-E IR value is less comparatively to other two combinations and w.r.t. factory test results. After thorough investigation of OLTC, oil view glass was found damaged which was not noticed by site officials, resulting ingress of huge moisture in OLTC chamber for longer duration. It was also noticed that though the transformer was oil filled condition, precaution was not taken for long storage as per the guidelines. Internal inspection revealed that there was huge quantity of water in the transformer oil and also some particles of water noticed on core resulting rusting of core as well as OLTC diverter chamber. Findings are shown in photo 3 & 4.

These phenomena caused the utility to return back the transformer to manufacturing works for complete reprocessing for removal of foreign particles and improvement of IR values with huge cost.

## iii. 100 MVA, 220/132 kV Transformer:

The transformer was supplied and was kept idle for more than 2 years. When it was taken into

site processing of transformer by hot oil filtration satisfactory IR values were achieved and transformer was taken into service.

site processing of transformer by hot oil filtration satisfactory IR values were achieved and transformer was taken into service.

## iv. 63 MVA, 132/33kV Transformer

In other case, we found that the IR value measured at factory was not achieved during the commissioning of 63 MVA, 132/33kV. After detailed study and investigation, it has been noted that the transformer was supplied with nitrogen filled and oil was supplied separately in tankers. The oil samples drawn from oil tanker were found in order in all respect. The filtration machine which was used for this new transformer was used earlier for failed transformer oil processing and the same machine was used without cleaning of oil chamber for removal of contaminated oil. Thereafter, new high vacuum filter machine was used for achieving satisfactory results.

In many of the cases, we have found that moisture, dusts in oil are ingresses due to the improper care taken at the time of commissioning. Oil drums are kept vertical instead of horizontal, as captured in photo-6. Filter Machine, Suction & Delivery pipes and storage tanks are not used for a long period resulting in heavy deposition of sedimentation and impurities which are not checked for its internal condition and cleaned before oil filling and filtration resulting ingress of moisture.

## Recommendations

In view above it is recommended to check the following things to avoid ingress of moisture during the commissioning stage:

- Monitor the gas pressure inside the transformer during storage at site. Storage in gas filled condition shall be limited to six months duration.
- For storage more than 6 months, transformer



Photo - 3 & 4: Rusting of core as well as OLTC diverter chamber



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# Transformer Specifications



Photo - 5: Oil turned dark brown in new transformer



Photo - 6: Oil drums are kept vertical instead of horizontal

- shall be stored in oil filled condition.
- iii. Store oil drums in horizontal position with bangs at 45 degree.
- iv. Check the oil parameters supplied in tanker / drums before filling in transformer.
- v. Do the internal inspections of transformer

- and check thoroughly for presence of any foreign particles inside the transformer; if observed clean it thoroughly.
- vi. Check the filtration machine chamber is cleaned before it is used for new transformer.
- vii. Check the oil storage tank used for filtration

- machine is having oil resistance paint on inside surfaces and is in good condition. Use the storage tank after proper cleaning.
- viii. Breathers of transformers shall be maintained in healthy condition by periodical reconditioning. 

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Each Metropolis train delivered to Kochi Metro Rail Limited (KMRL) will be able to carry up to 975 passengers and provide 136 seats, with wide gangways and longitudinal seating arrangements—allowing passengers to walk from one end of the train to the other, optimising transport capacity and facilitating easy boarding. As the first Communication-Based Train Control (CBTC)-based metro in India, Alstom's Urbalis 400 will control the movement of trains precisely, allowing more trains to run on the line at higher speeds in total safety. Alstom has also provided the telecom solution, with a third rail-based 750VDC power supply solution along with the associated SCADA system.

Alstom focused on enhancing the customer experience to all possible aspects of the train. In an interesting design feature, the train conjures up an image of a 'nettippattam' on an elephant tusk with eyes that light up when in drives through dark tunnels. The trains are fitted with air conditioning and real time passenger information systems for a high level of passenger comfort. They are also equipped with CCTV, fire &



smoke detection system for passenger safety and multiple USB charging points for mobiles – the latter is another first for metros in India.

Bharat Salhotra, Managing Director, Alstom in India and South Asia, said, "The Kochi Metro re-affirms our strong commitment and endorsement of the Government's 'Make in India' vision. It reinforces our goal to being the preferred partner of cities, countries and operators to answer their mobility needs as a

turnkey solution provider. This is an exciting day for us and we are proud to be associated with this project."

Elias George, Managing Director and Additional Chief Secretary of Transport of Kochi Metro Rail Limited, said, "Our goal was to deliver an innovative and effective mobility solution for the people of Kochi. Alstom's smart solutions have helped us meet that aim. Their end-to-end services and close attention to our needs ensured there the lead time was extremely competent and no gaps were caused by multiple-party involvement." 

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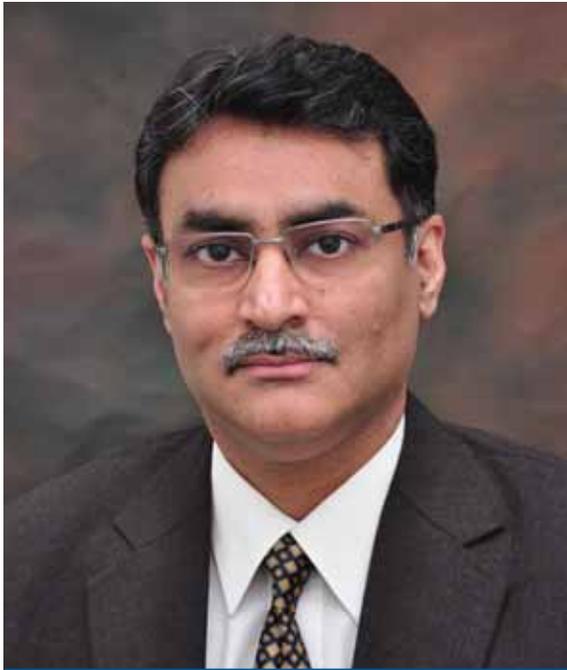


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Cost is always a challenge in the Indian market. Having GLOCAL approach, we continuously work on automation in processes, new technologies and alternate designs to address market requirements.

### **What is the size of Indian Energy Meter industry? At what rate industry will grow in the medium term?**

India is currently witnessing a revolution in the field of energy metering, where advanced products are fast replacing the conventional ones. The current size of the dynamic energy meter market, estimated to be in excess of Rs 3,000 crore, is trying to keep pace with the rapidly evolving requirements of end users in India and technological advancements abroad. It is expected to grow at a CAGR of 8-10 per

cent over the next 4-5 years. Extensive power capacity augmentation and improvement of electrical grid networks are supporting the growth of this industry. According to recent industry reports, distribution utilities globally are expected to spend \$378 billion in smart grid technologies by 2030, where India is estimated to install 130 million smart meters by 2021. No doubt, intelligent smart meters are going to be the trend in the future.

**What kind of potential do you envisage for the sector with the government's particular focus on upgrading overall infrastructure like roll out of 100 smart cities, commitment to provide 24\*7 electricity to all? So, what have been the recent technological innovations in the Indian energy meter industry?**

India as a developing country is full of potential. Generation, transmission and distribution need to become more efficient and to be monitored in real-time to compensate for any losses and breakdowns.

In the Indian Meter Industry, smart meters are being implemented. Smart meters facilitate real-time pricing, automated recording of the electricity consumption and a complete eradication of errors due to manual readings and reduce labor cost. They also enable instant fault detection. Smart meters not only enhance the ease with which electricity bills are generated and transmitted, they also provide better control on one's electricity consumption by providing real time consumption data. The consumer can monitor their electricity usage and in turn optimize their consumption. A smart meter offers insights into the expenditure on electricity which proves to be a great incentive for consumers to save electricity and in turn reduce the pressure on the constantly depleting non-renewable sources of energy. A network of all the smart meters connected to a smart grid will positively influence the methods and modes of electricity generation, transmission and distribution.

**What are the bottlenecks that the Indian Energy meters industry is facing? What kind of support would you expect from the government?**

The meters are to be at affordable prices as the state electricity board's financial condition is not strong enough.

Good quality manufacturers are facing competition from cheap quality manufacturers.

Moreover, Smart intelligent meters are the way forward for India. The Government needs to push for regulations and 'Smart Meter Approach' along with some incentive schemes in order to promote this change.

The Government can make it mandatory for every utility to

deploy smart meters so that energy auditing, accounting and billing becomes much more easy and reliable.

Product awareness should be created among the end users and even among consultants or decision makers.

**Import of Chinese equipment is still a matter of concern for the industry. What is the scenario for Indian energy meters?**

Be it any industry ranging from metering to computers to automobiles, China dominates the global market in terms of production and export. The reason being the availability of quality engineers, R&D Centers, Govt's support and the required raw material at lower costs. However, not much China dominance is seen in the Indian metering market yet.

**India is close to implementing smart meters. What will its implications on general consumers? How will this move benefit the Indian power sector?**

Customers will be benefited as they would be receiving accurate and timely bills as the energy consumption details will be available with utilities on real time basis. Reduced costs/tariff and increased convenience for prepay will also be an added advantage. There will be less environmental pollution due to reduced carbon emission.

Indian power sector utilities on the other hand will have advantages like:

- Reduced peak load demand
- Improved power reliability and quality
- Enhanced capacity and efficiency of existing electric power networks
- Reduction in AT&C losses resulting in improved outage management
- Monitoring of energy consumed by end users billing them accordingly and remote connect/disconnect facility
- Grid becoming more reliable and fault-tolerant
- Integrate renewable energy projects into the grid

**The Government has up-scaled the target of renewable energy capacity to 175 GW by the year 2022 which includes 100 GW from solar, 60 GW from wind, 10 GW from bio-power and 5 GW from small hydro-power. Going ahead, what potential will it generate for the energy meters segment?**

The country is shifting its focus from coal based power plants to renewable energy generation plants like solar power, hydro power project, wind power project and all other renewable energy generation scheme. This step is highly appreciated as this will help to

reduce the carbon emission significantly and will also help in attaining sustainable development.

Because of the recent steps taken by the government to boost power infrastructure, the market for energy meter looks good. Also, with the government giving subsidy to rooftop solar plants, the net meter will soon gain its ground in complex energy sector of India.

### What will be the impact of GST on Indian energy meters sector?

Currently, tax concessions and exemptions, both at the Central and state level are available on specified goods and services which are used in the energy sector. However, with the GST regime generally set to trim such exemptions and concessions, the effect on the energy sector may be significant.

### What is your outlook for the sector?

Presently, India is gearing up to develop its infrastructure in order to become a global economic leader. In its quest to develop its

infrastructure, the major push is being given to the power sector which has been languishing for so long. Recent schemes like UDAY, R-ADRP and many more are providing financial and technical support to the Discoms. The Government of India is also trying to convert their traditional grid into the smart grid, and the smart meters are an indispensable part of smart grid.

Growing of renewable energy in power sector will increase the complexity of the grid management. Increasing the capacity of renewable energy also requires increasing the capacity of the transmission lines. Hence, it's good news for meter manufacturing industries, because requirement of the meter will increase.

All this will be achieved by implementing smart grid in India, and smart meter is the major part of the smart grid. The only question is the rate of growth, which can vary from state to state largely depending on the government's policies and willingness of utilities to take the risk in terms of finances, technology and implementing smart metering. 

## Reducing Potential Utility Equipment Damage through Fluke Ti450 SF6 Gas Leak Detector

Combination infrared camera and SF6 gas leak detector precisely pinpoints leaks as part of regular maintenance without taking equipment offline

Identifying leaks of sulfur hexafluoride (SF6), used as an electrical insulator in extremely high-voltage utilities applications, generally, requires the purchase or rental of an expensive gas detector or hiring an outside consultant. The alternatives are shutting down equipment and using a sniffer, which after some time, can determine only the approximate area of the leak, or coating the entire equipment in soapy water and inspect, which is extremely time consuming and requires the equipment to be powered down.

The new Fluke® Ti450 SF6 Gas Leak Detector combines a high-quality infrared camera with an SF6 leak detector that visually pinpoints the location of SF6 leaks without shutting equipment down. The Ti450 SF6 allows utility crews to include it as a normal part of their maintenance routine, allowing them to conduct both infrared and gas inspections whenever and wherever necessary. It eliminates the need to wait for special annual or bi-annual leak inspections — and the corresponding expensive equipment rentals or contractors — so maintenance work can be done as required, reducing potential equipment damage.

"Leak detection in utility equipment has always been a disruptive operation that requires expensive equipment and equipment downtime," said Brian Knight, Fluke Thermography Business Unit Manager. "The Fluke Ti450 SF6 makes it incredibly convenient to make leak detection part of regular maintenance identifying the problems so leak corrections can be performed during a scheduled maintenance period."

The pistol-grip Ti450 SF6 makes diagnoses of issues point-and-shoot convenient, even in hard to reach or high overhead locations. With the Ti450 SF6, technicians can monitor leaks more frequently allowing maintenance scheduled at a convenient time without unplanned downtime. The leak detector can also be used to quickly verify that the repair was fixed.

The infrared camera includes the award-winning LaserSharp® Auto Focus that delivers instant focus on a single target using a built-in laser distance meter to calculate and display the distance to the designated target with pinpoint accuracy. LaserSharp Auto Focus enables technicians to precisely target up to 100 feet away for infrared readings and SF6 gas detection no matter how awkward the position of the target. This makes it safe to measure around high voltage areas and potentially dangerous areas. It also features Fluke IR-Fusion® technology, which combines both digital and infrared images in one for better clarity. By adjusting the blending of the image, technicians can easily detect then pinpoint the exact location of the SF6 gas leak.

The Ti450 SF6 comes complete with 2x telephoto smart lens, tripod holder for mounting to any industry standard tripod, eyepiece, cable, viewer, batteries and chargers, all in a hard shell carrying case. SF6 gas detection training tools, including a systematic instructional video, are also available on the Fluke website.

For more information, visit: [www.fluke.com/fluke-ti450](http://www.fluke.com/fluke-ti450)



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# Dielectric Technology in Transformer



Utilities and transformer manufacturers focus on the design and manufacture of environmentally-friendly transformers that are non-hazardous while offering improved life cycle costs with minimal maintenance.

These transformers offer reduced carbon footprint, reduced levels of pollution (water, soil, noise), enhanced lifecycle costs, enhanced product lifetime, and enhanced fire safety...

In all power distribution networks, transformer is an important part of system. Utilities and transformer manufacturers focus on the design and manufacturing of environment-friendly transformers that are non-hazardous while offering improved lifecycle costs with minimal maintenance. These transformers offer reduced carbon footprint, reduced levels of pollution (water, soil, noise), enhanced lifecycle costs, enhanced product lifetime, and enhanced fire safety.

As according to research analysts, the top three emerging trends driving the global liquid-immersed power transformers market are:

- Evolution of eco-efficient transformers
- Environmentally friendly and fire-resistant insulating liquids
- Transformer going intelligent.

The various transformer manufacturers focus on their R&D for the development of transformers that operate insulating liquids which are different from crude base. The research for alternatives fluid led to interesting classes of insulation fluids such as, silicone liquid, synthetic ester and Natural Ester fluids.

As mineral oil is the most commonly used

type of transformer insulating medium for more than a century, it facilitates good dielectric transfer property. However, there are some concerns related to the use of mineral oil in transformers. It has a very high carbon footprint and a very low fire point, lying in the range of 150°C to 160 °C which makes it more fire prone. We have enough examples of transformer fire accelerated due to mineral oil globally.

Now-a-days, Natural Ester fluid technology getting popular due to its inherent advantages like its higher thermal capability improves capability of insulation paper & life of transformer. These are in conformity with standards like, IEC 60056, IEEE C57, IEEE 637, ASTM D6781 and IEC 60296.

Natural Ester Fluids: In the early 1990s, natural ester made an appearance. It is made of plant seed oils (e.g. soybean). These can be broken down into saturated, single, double and triple unsaturated fatty acids. The main advantages are significantly higher fire points (360°C) and the best biodegradability. One of the best examples of Natural Ester is Envirottemp FR3 dielectric fluid.

Utilization of Natural Ester fluid is on the rise

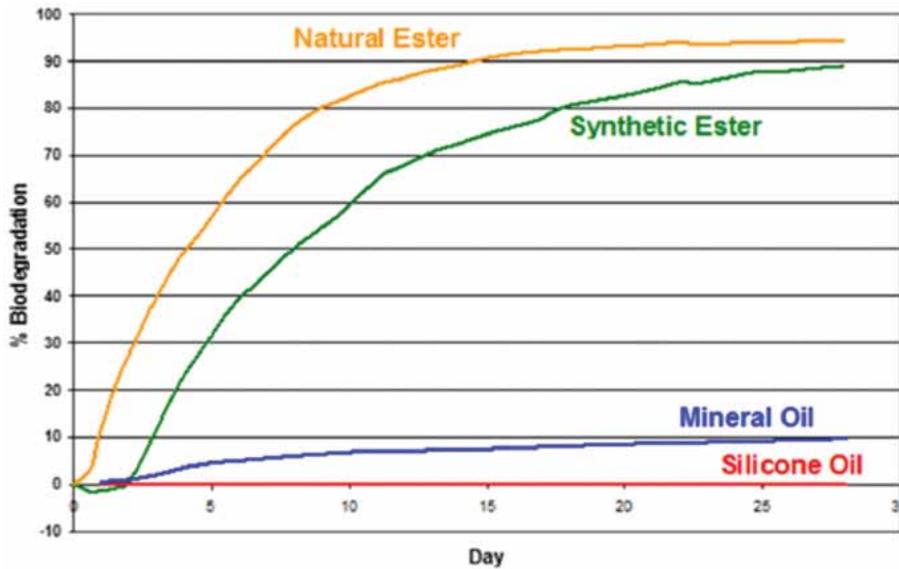


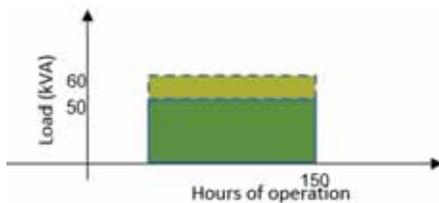
Figure 1: shows the good biodegradability of ester based insulating fluids (CIGRE SC A2 reports)

owing to the increased safety against fire hazards and eco-efficient solution. Natural Ester fluid is incombustible and it possesses non-toxic attributes, which has boosted its increasing popularity and use in transformers. The advantages offered by Natural Ester over mineral oil are as follows:

- Offer higher flash/fire points
- Biodegradation of Esters is much better as compared to mineral oil or silicone liquid shown in (figure 1).

**Key optimization options for advantage with Natural Esters that leverage the insulation life extension and thermal capabilities of FR3 fluid.**

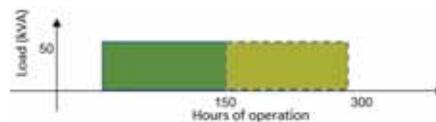
**1. Increase load capacity:**



A second option is to use the same life but gain more load capacity. This is useful in situations where cannot put in a larger transformer either due to space constraints or cost. You can get more power out of the same asset. Also, this is a great option for retro fills. This does not require any changes to your standard transformers. It can be used the same

transformers and know there is approximately up to 20% more load capacity.

**2. Life extension:**

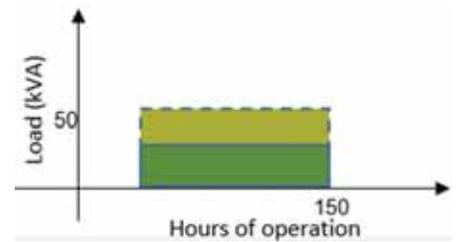


By protecting the insulation life of the paper, you could then likely extend the life of the asset (depending on the transformer loading profile). This allows to use the same kVA, but can get more useful life out of the existing asset. Thus, it

helps in lowering your total cost of ownership. This does not require any design changes to your existing specifications.

**3. Smaller Transformer**

This third option enables a transformer to be built with a smaller footprint, yet have to maintain the original capacity needed. Often times, this allows an initial cost savings as well given you likely will use less raw materials (copper, paper, steel, fluid, etc.). This would require design changes.



The earliest Natural Ester fluid-filled transformers were new designs built and installed in early 1990 followed by Retro-filling. These early units led the way for many new and retro-filled transformers that presently number over million. The Natural Ester-filled power transformers include power substation units in the range of 6 kV to 420 kV. Few Examples:

**Transnet BW:** A transmission network operator in the German state of Baden-Württemberg – commissioned a 420kV power transformer in one of its substations in southwest Germany that is cooled and insulated with

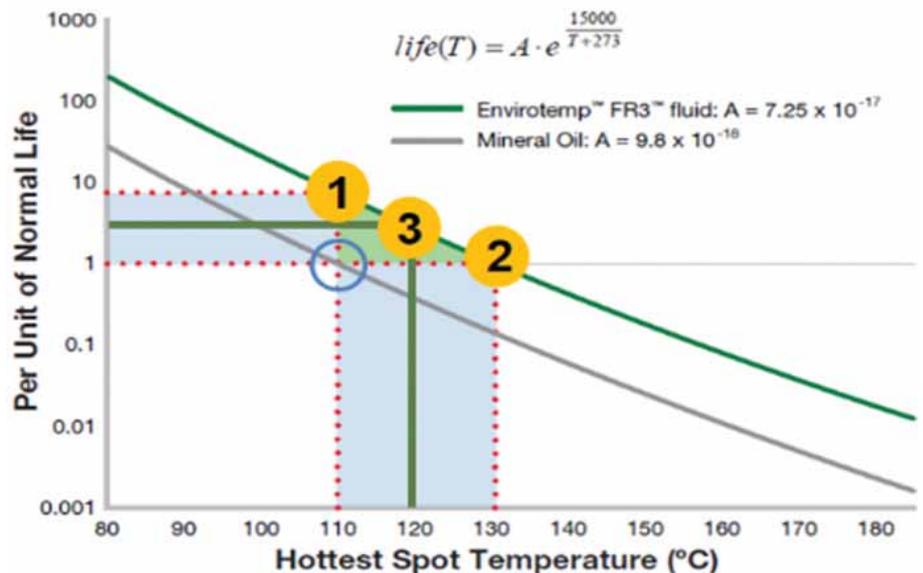


Figure 2: High temperature curve based on Thermally Upgraded Kraft (TUK) paper.

Natural Ester FR3. The substation, which has a power rating of 400 MVA is the first in this high-voltage category has been working satisfactory since 2013 (OEM Siemens).

1. **Electronorte Brazil:** 22.14 MVA, 242KV, 3ph. reactor KNAN cooling class, new transformers manufactured in June 2007 by Areva Brazil and commissioned in March 2009.



2. **Petrobras refinery chooses FR3 fluid for improved fire safety:** Petrobras Northeast Refinery Project "Abreu e Lima". 14 Transformers using Envirotemp FR3 dielectric fluid. A.75/100MVA, 242/72.5 KV -2 transformers.



B.70MVA, 72.5/15/15 KV - 4 transformers  
C.45/60MVA, 72.5/15KV 8 transformers.



3. **Tata Power:** One of the green milestones in the company's centenary year celebrations, two of India's first 25 MVA natural ester filled

transformers were installed in Mumbai. With this initiative, Tata Power has once again showcased its priority in driving sustainability by implementing path breaking green technology. Sustainability remains a core business philosophy of Tata Power, and green transformer is one of the company's many green initiatives under its 'Be Green' campaign. Tata Power's 25 MVA transformer filled with Natural Ester Enivrotemp FR3 Dielectric fluid. (OEM Schneider India)

4. **GETCO (Gujarat Electric Transmission Company):** Installed transformers with natural ester fluid FR3 & after satisfactory on site performance has decided to go in big way with almost 200 plus 66KV, 20MVA units (OEM T&R and Atlanta). Transformers will be tested for its higher thermal class as per IEC 60076 part 14, Table C.2.



5. **Torrent Power:** Two numbers of 20 MVA, 33/11 KV having KNAN/KNAF cooling class Manufactured by T&R India in December 2016.



## Conclusion

Transformer manufacturers are designing Natural Ester fluid-filled transformers that operate within the temperature limitations outlined in IEEE/IEC and other international standards while providing access to the thermal capabilities. Utilities are improving performance by adopting Natural Ester fluid and changing their usage profiles.

Now that the Indian Standard IS-16659 On Unused Natural Esters is published, the progression of the use of natural ester insulating liquids is now starting the "acceleration". After providing excellent performance in power transformers (up to 440kV) for many years, currently, there are a number of 550 kV projects and higher under study. The transformer made by Siemens Germany for Transnet BW with Envirotemp FR3 Natural Ester has opened further market & voltage class. 

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# Typical Phenomena in Transformers & Protections



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An analysis of the current during an over excitation condition shows a predominant 5th harmonic component while analysis of inrush current shows a predominant 2nd Harmonic component. These characteristics help to differentiate an over excitation condition from inrush current condition.



The transformer plays a vital role in reliable transmission and distribution of power. It is a critical link in industrial and domestic power system network. It is a simple, static and robust machine utilized for the multi-dimensional development of infrastructure from urban to rural. Although it is a simple induction machine, some critical issues and typical phenomena are associated with it.

## Typical Phenomena in Transformers

Some typical phenomena in transformers are elaborated below:

- Over-excitation or over fluxing and generation of harmonics
- Magnetization Inrush and Harmonic Current

### Over-excitation or over fluxing and generation of harmonics

Normally, a transformer gets over-excitation due to over voltage or under frequency. In this

scenario, excitation current increases sharply and the transformer will tend to become overheated due to increased excitation current, hysteresis losses, and eddy currents. The transformer may get damaged if this condition is sustained.

As shown in figure-1, for an overvoltage of 20%, the excitation current can increase about 10 times of normal excitation current. For a higher overvoltage, the excitation current can increase above the pickup level of a differential relay unrestrained for excitation current.

The increased excitation current produces operating current in the differential relay, but an operation of this relay is not desirable since the immediate response is not necessary. The power system should be allowed time to correct itself.

The operation of a differential relay indicates a transformer failure. Therefore, after operation of a differential relay investigation of a transformer always shall be done. If the relay has operated during an over-excitation condition,

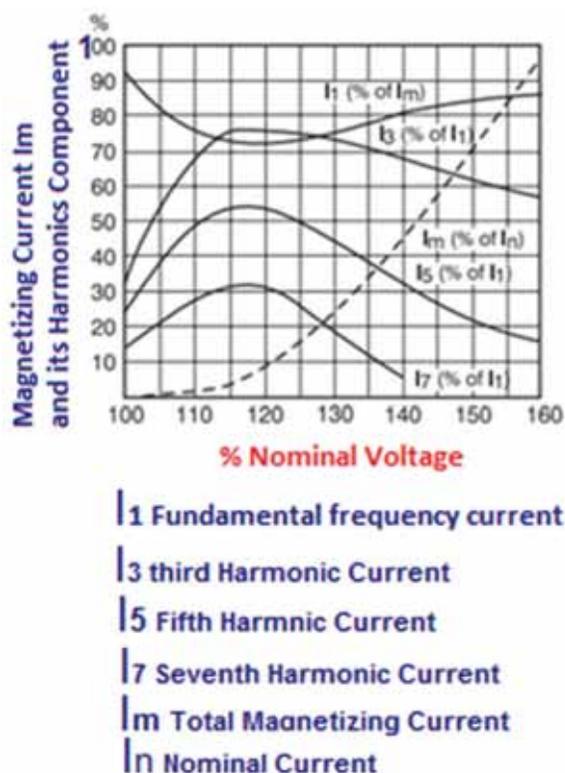


Figure 1: Transformer Excitation Current Vs Excitation Voltage

additional valuable time for investigation of the transformer would then be lost.

An analysis of the current during an over-excitation condition shows a predominant 5th harmonic component. A typical example for a modern transformer is provided in fig. 1. This can be utilized to identify an over magnetizing condition. The differential relay is, therefore, provided with a 5th harmonic restraint to prevent the relay from operation during an over-excitation condition of a transformer due to over-voltage. Transformer likely to be exposed to over-voltage or under-frequency conditions should be provided with a V/Hz relay,

### Magnetization Inrush and Harmonic Current

#### A Phenomenon-Magnetization current

A transformer inrush event is actually magnetizing inrush current. Since in the transformers windings are magnetically coupled by the flux, therefore, on increasing the excitation voltage, flux increases. In this situation to maintain this additional flux, transformer draws more current from the source. This additional

current would be inrush current, required for a magnetizing branch of the transformer as shown in the figure 2.

Inrush current is more predominant in one winding, results in differential current lead to operation of differential protection.

During transformer charging event, an inrush current flows only in one winding, but magnetizing current may appear in both winding. In the above figure, the current I1 is the inrush current.

#### Characteristics of Magnetic Inrush Current

The inrush current has the following features:

- It can appear in all three phases and a grounded neutral.
- Its magnitude is always different in all three phases as well as in the neutral.

- Transformer with oriented core steel lamination, if energized from high voltage side, the magnitude of inrush current would be 5-10 times of rated current while from low voltage side it could be 10 to 20 time of its rated current.
- The shape of the inrush current for a delta connected transformer will not be the same as for a Y-connected transformer.
- The inrush current has a significant DC component and is also rich in harmonics.

- Second harmonic is predominant harmonic in the inrush current.

### Events Generate Inrush current

The inrush current can be produced during the following events:

#### Transformer Energization

In concern of magnetizing inrush currents, transformer charging is a crucial event.

#### Magnetizing inrush current during fault clearing

During any external fault system voltages reduces significantly. Therefore, transformer excitation voltage reduces. This excitation voltage will be recovered when this fault is cleared. Recovery of the voltage will force a DC offset on the flux linkages, resulting in magnetizing inrush current. In this case, residual flux is not available in the core. Therefore, magnetizing inrush current will be less than that of energization. The current measured by the differential relay will be fairly linear due to the presence of load current and may result in low level of second harmonic current.

#### Sympathetic inrush

As shown in the figure 3, when an un-energized transformer TR-2, connected parallel to an energized transformer TR-1, is charged from the source, sympathetic magnetizing inrush currents flows in an energized transformer TR-1.

On energizing the second transformer TR-2, a voltage drop appears across the impedance of power supply line of the transformers. As a consequence of voltage drop, the core of transformer TR-1 will be saturated in the negative direction. This saturation causes magnetizing

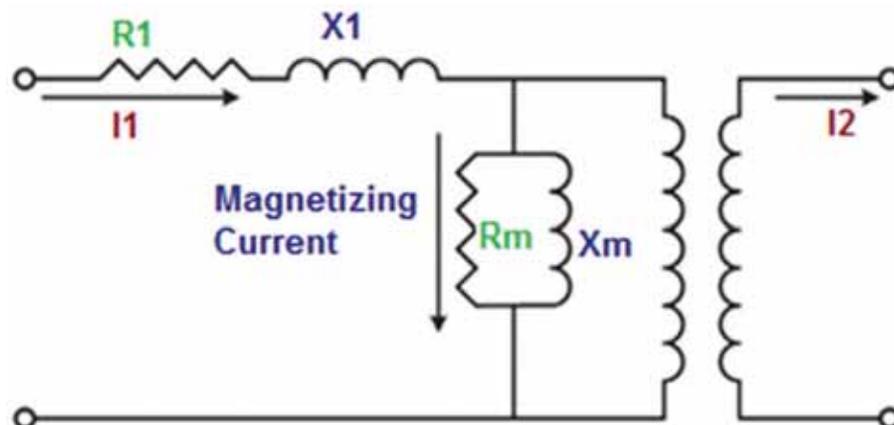


Figure 2: Equivalent Circuit of Transformer

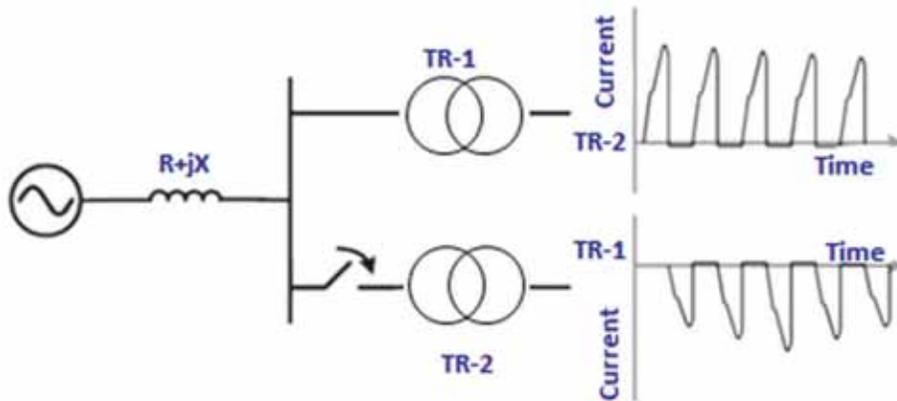


Figure 3: Sympathetic Inrush circuit & Waveform

inrush current will flow to supply the flux.

The inrush current in the parallel transformer will have a phase shift of 180 degrees. The magnitude of the magnetizing inrush current is generally not as severe as the other cases.

## Factors Affecting Inrush Current

The shape, magnitude, and duration of the inrush current depend on the following characteristic factors:

- Source impedance
- Size of the power transformer
- Moments of transformer switch-in
- Residual flux in the core
- Magnetically efficient transformer core material
- Content of inrush current

## Source Impedance

The location and physical installation of the transformer also play an important role to influence the magnetizing inrush current. The excitation voltage at the transformer terminals is the system source voltage minus the voltage drop across the system impedance. Therefore, as the source impedance decreases, transformer excitation voltage increases which is a characteristic of stronger sources. As a consequence of this, the magnitude of the inrush current increases.

## Size of Power Transformer

The impedance of the power transformer is also an important factor to control the decay of the inrush current over time. The time constant of the circuit (L/R) is not constant because L is variable due to change in permeability of the core material. If system resistance is high, the

value of the time constant (L/R) will be low. Thus, inrush current will decay more rapidly. The time constant of the inrush current is 0.2 to 1 minutes depending upon whether the transformer is small or large.

## Moments of Transformer Switch-in

At the moment of transformer switching, the magnitude of the inrush current depends on the scenario of applied voltage, the available residual flux in the core and phase angle difference between them.

The magnetizing inrush current will be maximum, if the moment of switching occurs at the zero crossing of the voltage, with zero phase difference between residual flux and flux due to inrush current. Thus, both fluxes will be added due to the same direction. As a consequence, the core would be saturated, and inrush current would be increased under the constraint of the

source and residual impedance of the transformer.

If both fluxes get the opposite direction, there will be no saturation of the core, and the magnetizing inrush current will be minimum or tends to zero.

## Residual Flux in Core

When excitation voltage of the transformer is removed, some level of flux remains in the transformer core, this flux level is called of Remnant flux or Residual flux. It can be found from the magnetic hysteresis loop of the transformer core. Its value can be 30% to 80% of the maximum flux in the core with a positive or negative sign. When the transformer is energized, residual flux is added to the flux generated by the excitation voltage. Therefore, the flux equation becomes,

$$\varphi(t) = \varphi_{\max} \sin(\omega t - \theta) + \varphi_{\max} \sin(\theta) + \varphi_{\text{Residual}}$$

Where,  $\varphi_{\text{Residual}}$  is the residual flux in the core

Transformer core saturation depends on the sign of the residual flux. Once the core is fully saturated, the residual flux will not be effective.

## Magnetically Efficient

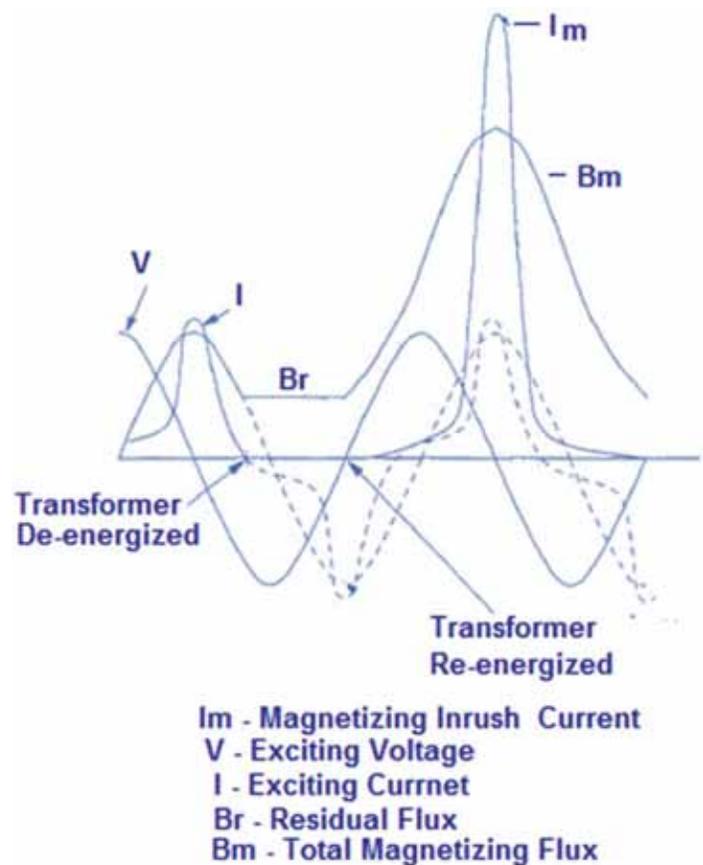


Figure 4: Moment of Transformer switching



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AV Onload Changeover Switch



AV Load Break Switch



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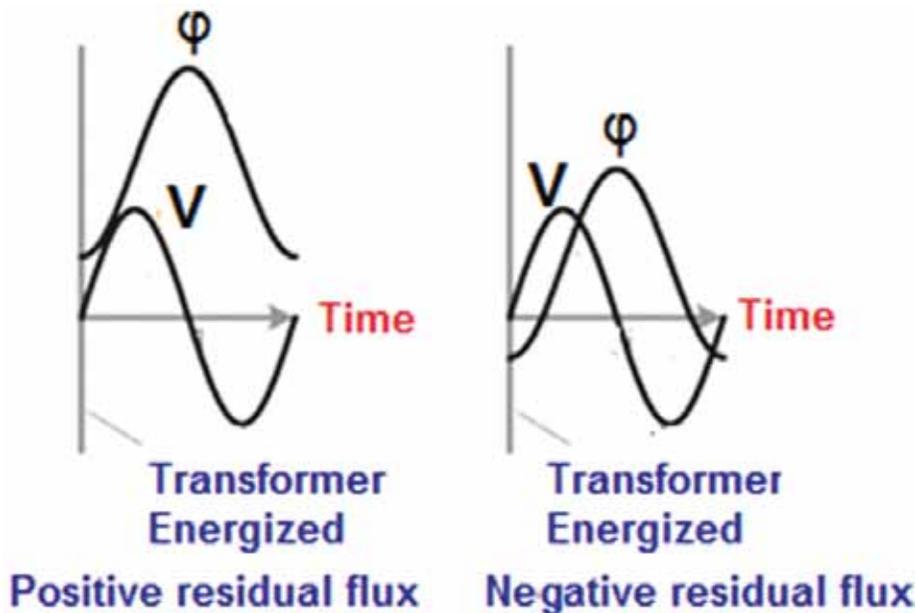


Figure 5: Excitation Voltage and Flux at 90° voltage angle with residual flux

## Transformer Core

To reduce the losses in the core, some significant changes are being incorporated in transformer core designing.

Use of high permeability electrical steel (High-B)

High permeability steel is magnetically very efficient, results in lower excitation currents and therefore lower inrush current.

Reduction of reluctance in the core

The air gap increases the reluctance of the core, thereby, reducing the magnetic efficiency of the core. Laminations are now constructed such that they overlap each other to provide a continuous path for the flux. This construction reduces the reluctance in the core, and therefore, increases the flux density and reduces the excitation current.

Use of larger cross-sectional area core

To limit losses, transformers are designed with lower flux densities. The flux density is limited by using a core with a larger cross-sectional area. As a consequence of larger cross-sectional area, level of excitation current as well as magnetizing inrush current reduces.

## Content of Inrush Current

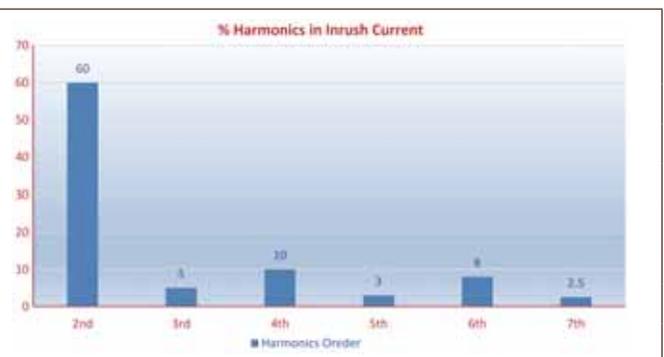
The initial inrush of magnetic current has a high component of even and odd harmonic, as shown in the table 1 obtained by an event recorder.

It can be observed from the above recorded event, in inrush current, 2<sup>nd</sup> order harmonic is the predominant component. This property of inrush magnetizing current is used for restraining the relay operation during initial inrush of magnetizing current.

## Effects of Magnetization Inrush current

Table 1: Content of Inrush Current

Harmonic component in the magnetizing current	Amplitude as a % of fundamental
Harmonics orders	%
2nd	60
3rd	5
4th	10
5th	3
6th	8
7th	2.5



In the operation of an electric power system, charging of large power transformers is considered as a critical event. When a transformer is charged by the grid or utility, it draws very high magnitude of the current, known as inrush current, the typical value of this current could be ten to twelve times.

This high magnitude inrush current produces many problems like mechanical stress on transformer & harmonics injection towards generator or grid, malfunctioning of system protection, etc. The main reason behind this criticality is a generation of the unpredictable system transients during charging of transformers.

## Effect of Inrush Current on Differential Protection

Differential protection is the standard protection used to protect transformers. It compares entering and leaving currents the transformer to create a differential current.

In an ideal case, when normal current is flowing through the transformer the differential current is zero. In an internal fault condition, a differential current is always greater than zero or restraining current therefore differential relay operates. Apart from ideal situation, there are two common situations when differential protection incorrectly gets differential current and operates the protection relay.

- For faults outside the protection zone, if fault current is very high, CT gets saturated. Thus, the error in the measured signal of the saturated CT results in a significant error in the differential current leads to undesired operation of the differential element.
- The other scenario depends on the switching operation and corresponding inrush event of

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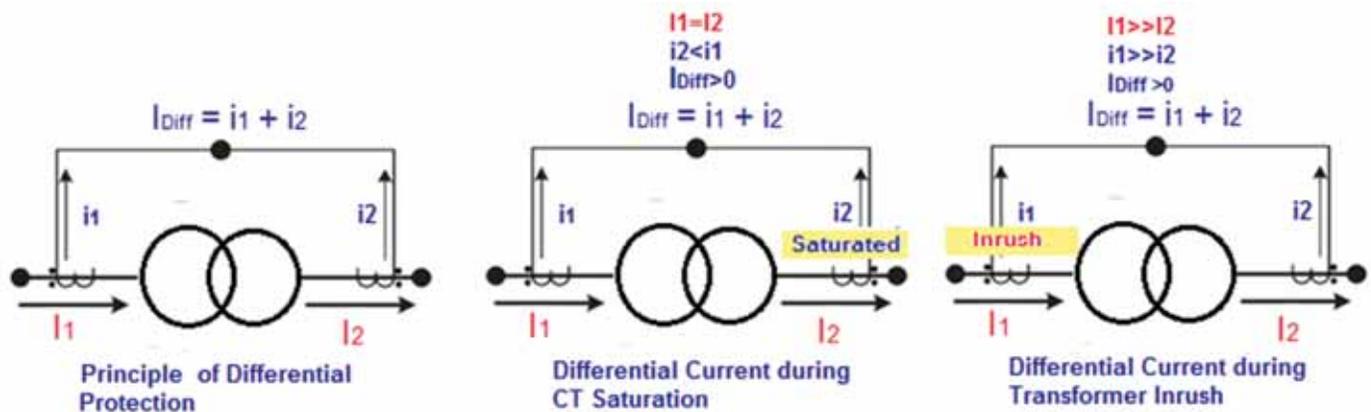


Figure 6: Effect on Differential Protection

the transformer. This inrush of current occurs only in one winding of the transformer. Therefore, it may produce a differential current that results in the operation of the differential protection.

## Harmonic Blocking and Harmonic Restraint in Transformer Differential Protection

The main purpose of transformer inrush restraint function is to block the differential element from operation during an inrush event. It will permit the differential element to operate only during the event of an internal fault.

Since both events supply large differential current to the differential element, differentiation between inrush current and fault current is the great challenge. Here, traditional and latest generation methods adopted for their differentiation are briefed below:

### Traditional Method - Harmonic Blocking & Restraint

This method works on the following assumptions:

- The magnetizing inrush current contains high levels of second harmonic current.
- Transformer's internal fault current typically has very low levels of second harmonic current.
- The method compares the magnitude of the second harmonic current (100Hz) to fundamental frequency current (50Hz) in the differential current.
- When the ratio of the second harmonic component to the fundamentals component is more than a second harmonic set point, thus the system would understand it as inrush phenomenon, and it will block to the differential operation.
- When the ratio of the second harmonic component to the fundamentals component is

less than a second harmonic set point, thus, the system would understand it as transformer internal fault phenomenon, and it will allow operating the differential operation.

### Latest Generation Method - Harmonic Blocking & Restraint

In latest generation, harmonic restraint is a modified version of traditional harmonic restraint that considers the magnitude and phase of the second harmonic and fundamental frequency component in the differential current. Some inrush events initially produce low levels of the second harmonic in the differential current.

However, this method successfully restrains tripping when faced with low levels of second harmonic current during an inrush event. If some second harmonic is present in the internal fault current, this method may give slow tripping by a few cycles. B

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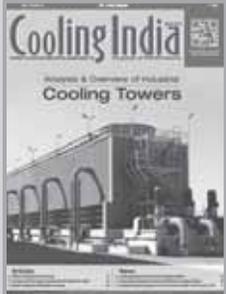
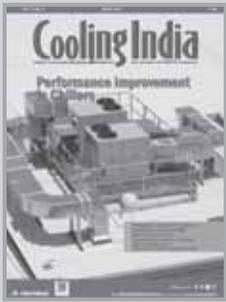
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## “Smart Cities project will generate opportunities for Dry Type Distribution Transformers”

The area of concern is the falling tariffs within the renewable energy sector which is affecting the cost of transformers, states **Manjit Singh Sethi, Local Business Unit Manager - Transformers, ABB India & Chairman, IEEMA Transformer Division** in an interaction with **Supriya Oundhakar...**

### **What are the key market trends in the Indian Transformer sector? What are the growth drivers for this sector?**

The transformer market is mainly divided into two categories - power transformers and distribution transformers. The major market driver for power transformers is the government's push to add 175GW of renewable energy to the grid by 2022. In addition, the government's mandate to provide 24x7 reliable power to all, and thrust on infrastructure such as railway electrification, metro rail projects also imply growth for the transformer sector. Other influences include the increase in investment due to the 100% FDI in the power and renewable energy segment, investment in high power transmission corridors, and the green energy corridors of the integrated power development scheme, which will provide a boost to the sector.

In the transmission and distribution sector, we are seeing the need for grid reliability backed by power quality, energy efficiency,

digitalization and smart metering. Power quality is critical and new technologies such as Flexible Alternating Current Transmission Systems (FACTS) and Wide Area Monitoring System (WAMS) are critical in this area.

**What kind of opportunities do you see for the Indian transformer sector with the government's particular focus on giving a new facelift to the country's infrastructure like roll out of 100 smart cities, commitment to provide 24\*7 electricity to all, announcement of railway electrification projects, new metro projects, dedicated freight and cargo corridors project etc? So, what have been the recent technological innovations in the Indian energy meter industry?**

The government's initiatives provide a positive outlook for the sub-transmission and the distribution sector. The Smart Cities initiative will generate opportunities for Dry Type Distribution

Transformers. The 24X7 electricity to all program which will mainly be implemented in the suburban and rural areas will boost the requirement of oil-filled distribution transformers. The electrification of railways as well as new metro projects are already generating a demand for trackside and traction transformers (both locomotive and electric multiple units). The dedicated freight and cargo corridors project, in addition to the normal distribution transformers, is creating demand for special transformers – used for special applications such as furnace transformers.

In the energy meter industry, we are witnessing a digital transformation with both consumers and utilities shifting from conventional metering to smart metering systems. This shift is being driven by the creation of smart cities and by utilities opting for smart grids. To give you an idea of the rapid change taking place, a report by Berg Insight states that smart grid penetration is expected to increase from 25% to 75% in Asia-Pacific by 2030.

### **What are the hurdles that the Indian transformer industry is facing? What kind of support would you expect from the government?**

The major challenges have been the slow pace of projects and the weak financials of DISCOMs. Another area of concern are the falling tariffs within the renewable energy sector which is affecting the cost of transformers. Further, with the introduction of GST there will be uncertainties with regard to tax.

### **What are the threats that the Indian transformers sector face due to cheap import of Chinese equipment? According to you, what precautions does the sector need to take in order to curb import of these equipment?**

The import of electrical equipment has increased the number of players in the Indian market, resulting in a more dynamic and competitive environment. However, to ensure grid reliability it is paramount that sub-stations use equipment that meets the highest standards of quality and safety, which has long-term benefits for utilities.

### **India is close to implementing smart meters. What will be its implications on general consumers? How will this move benefit the Indian power sector?**

For utilities, using smart meters will improve efficiency by limiting transmission and distribution losses. Real time as well as historical consumption data can be analyzed and relevant solutions implemented. Such data will also help restrict the theft of electricity.

Consumers will be able to control their consumption with time of day metering, they could also analyze their consumption patterns use that data to plan their power expenditure.

### **The government has up-scaled the target of renewable energy capacity to 175 GW by the year 2022 which includes 100 GW from solar, 60 GW from wind, 10 GW from bio-power and 5 GW from small hydro-power. Going ahead, what potential will it generate for the segment?**

To meet the goal of 100GW of solar power generation and other renewable targets, there is extensive investment in these projects, which are being implemented. Currently, there are approximately 10-12 GW of solar projects being tendered every year, and in addition another sector is that is picking up is Wind Energy. The increase in these projects leads to increased demand for power and generator transformers.

The electrification of railways as well as new metro projects are already generating a demand for trackside and traction transformers (both locomotive and electric multiple units). The dedicated freight and cargo corridors project, in addition to the normal distribution transformers, is creating demand for special transformers – used for special applications such as furnace transformers.

### **What will be the impact of implementation of GST on the Indian transformer sector?**

Under the new tax regime, as with any new system being rolled out, there will be short term hiccups and this will take a few quarters for the industry to stabilize. However, the extent of business efficiency is estimated to be higher once GST is in place. There might be some delays in case of engineering procurement and construction (EPC) projects, where the EPCs do not have a statutory variation clause with the end user.

### **What is your outlook for the sector?**

For the power generation sector, the focus on renewables, drive towards urbanization and thrust on development of transport systems are positive indicators for growth in the transformer sector. For the transmission sector the shift towards digitization and power quality is what will drive growth. The successful implementation the UDAY scheme and smart metering will be key factors in driving the transmission and distribution sector.



# Smart Plastics Intelligence for Greater Plant Availability

Monitoring the operating state of all e-chains with just one module...



The new isense EC.RC uses different sensors to carry out measurements and check that the energy chain is functioning correctly. A single communication module can monitor many e-chains and cables simultaneously. (Source: igus GmbH)

**P**redictive maintenance is part of Industry 4.0 and the factory of tomorrow. For this future, igus has developed a family of products under the heading of 'isense', where different sensors and monitoring modules make the plastic solutions intelligent. At the Hannover Messe 2017, igus showed new and improved products. These included, for example, isense EC.RC, a new system for monitoring e-chains, the optimised CF.Q module for the intelligent chainflex cables that customers are already using today and the intelligent iglidur PRT slewing ring bearings.

Making production processes easier and more reliable – in order to enable its customers to do this, igus the motion plastics specialist, develops intelligent solutions that warn of potential failure in good time before unplanned and very costly downtimes occur. One year ago, igus presented its first products at Hannover Messe – due to the considerable customer demand, visitors coming to the stand a year later could now experience the new generation of 'smart plastics'.

### Continuous Monitoring for Safe Operation

It monitors the operating status of the e-chains, especially, in guide troughs used on long travel applications. Sensors measure and check the

position of the energy chain. In this way, the machine is prevented from continuing to operate when mechanical faults occur, meaning that total loss of the chain or an electrical shutdown (for example, due to cable damage) is a thing of the past. In this way, the isense EC.RC, like all isense products from igus, guards against any unscheduled machine shutdowns.

### Further Intelligent Motion Plastics for Diverse Applications

Another new product from the smart plastics family is the EC.M module, which is mounted on the moving end of the chain and automatically records its status, i.e. acceleration, speed, temperature and completed cycles. The distance travelled and the remaining service life of the system can be derived from this. igus has also improved the CF.Q module with which the data of the intelligent chainflex cables are gathered. Due to continuous measurement of the electrical properties, ambient temperature and the number of cycles, a possible failure of the cable is predicted in good time. "Continuous testing in our test laboratory and in customer applications help us to make analysis of the measured values increasingly more precise", explains Michael Blaß, Head of Sales and Marketing e-chain systems at igus. "Real applications in which we are already using our intelligent products and our chainflex cables include, for example, robot gantries for transportation in automobile factories, where even short unscheduled standstill times result in very large production losses."

### One Module for Many Energy Chains & Cables

Whereas igus presented different isense measuring systems for its linear guides, energy chains and cables last year, the icom communication module, which gathers, and transfers all the values of these systems, was improved at the same time and now communicates mostly without cables. It is even easier to integrate into existing production, one of the reasons being that only a single icom module is needed for several systems. In addition, customers can now connect other manufacturers' data-generating units which monitor status to the icom module. Igus showed live on the stand, how the operating states of all moving e-chains are measured by only a single icom module. In addition, igus showcased the intelligent iglidur PRT slewing ring bearing, a new member of the smart plastics family. Thanks to an integrated wear sensor, which is mounted in a cut-out niche under the slide elements, the so-called PRT.W sensor ('W' for wear) also measures the abrasion so that replacement of the bearing in good time without an unscheduled machine shutdown can be ensured, thus, contributing towards increased security in production. 



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# Mitigation of Power Problems through Nanotechnology



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Nanotechnology is one of the frontier material techniques of today. In fact, it is an advanced material engineering. Nanotechnology could affect us all, beyond nanoparticles, critical length scales and nanotools. The word 'nano' is a Greek word which means 'dwarf' and mathematically, nano means size of order  $10^{-9}$  meter. Nanotechnology has been emerged from the branch of science termed as "Nanoscience" which is defined as the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a bulk scale. Bulk materials (the 'big' pieces of materials we see around us) possess continuous (macroscopic) physical properties for e.g. the material (gold) at the nano scale can have properties (e.g. optical, mechanical and electrical) which are very different from (and even opposite to!) the properties the material has at the macro scale (bulk) as can be seen in figure 1.

Internationally, nanotechnology is defined as the design, characterization, production and

application of structures, devices and systems by controlling shape and size at the nanometer scale (The nanometer scale is conventionally defined as 1 to 100 nm). Therefore, nanoscience and nanotechnologies deal with clusters of atoms of 1 nm in at least one dimension. Further, the principles of classical physics are no longer applied for the nano scale materials, in fact, it has to adapt quantum mechanics. Nanostructured materials solids or semi-solids (e.g. hydrogels, liquid crystals) characterized by a nano-sized inner structure. They are defined as nano structured materials; the spatial order is at the nanoscale, which lies between the microscopic and the atomic scale. The size of the nanostructures and the scale order within them in the solid impacts the properties of a material. Examples of nanostructured materials are nanoporous, nanocrystalline, nanocomposite and hybrid materials.

Methods for fabricating nanomaterials can be generally subdivided into two groups: top-down methods and bottom-up methods as

In order to tap into the nanotechnology solution to electricity generation, transmission, storage and distribution, basic requirement is to have the complete knowledge of power system, and according to the papers regarding nanotechnology appropriate solutions can be found to the problems facing in power system...

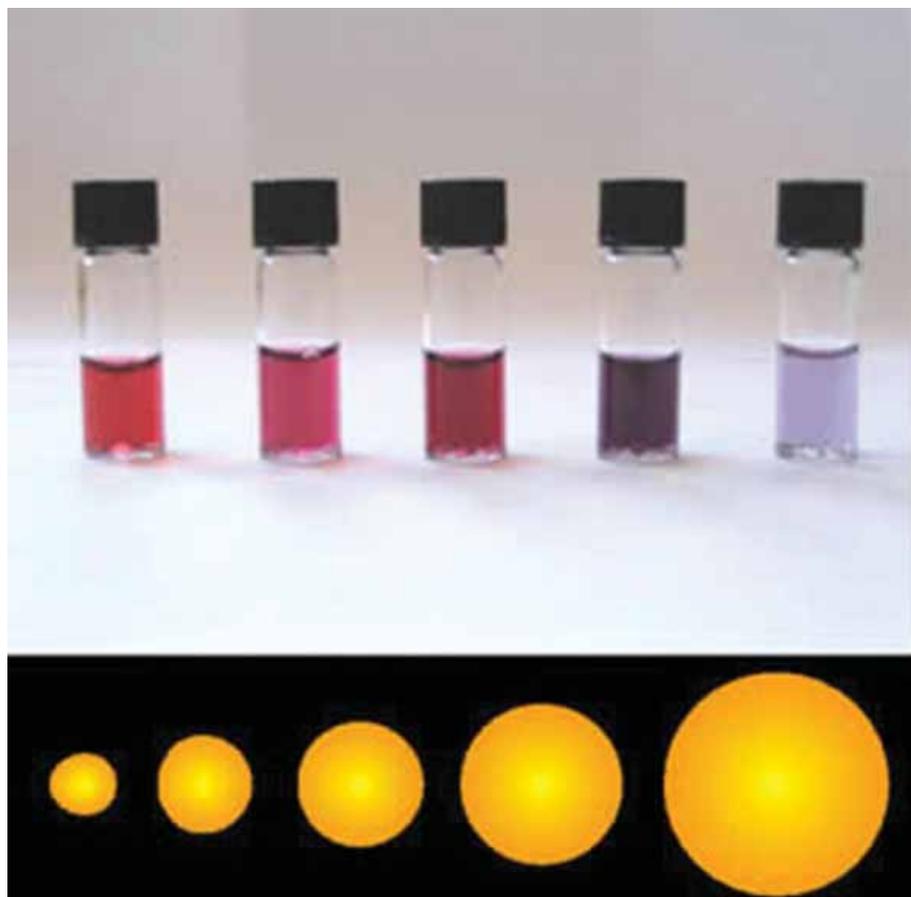


Figure 1: Color of gold particles for different sizes

shown in figure 2. In the first case, nanomaterials are derived from a bulk substrate and obtained by the progressive removal of material, until the desired nanomaterial is obtained. A simple way to illustrate a top-down method is to think of carving a statue out of a large block of marble. Bottom-up methods work in the opposite direction, the nanomaterial, such as a nanocoating, is obtained starting from the atomic or molecular precursors and gradually assembling it until the desired structure is formed.

### Problems faced by power system

As power system is broadly categorized in three pillars namely generation, transmission and distribution. Each plays a vital role in the socio-economic and technological development of every nation. The shortage of power has been a great barrier for commercial and domestic usage in many countries. Many countries are facing with acute electricity problems, which are hindering its development notwithstanding the

availability of vast natural resources. Industries and household have tremendously engaged in using generating set, so as to cover for this short coming in power supply. Incomplete combustion of the fuel in generating set leads to production of carbon monoxide, which is emitted to the atmosphere; these increase the amount of greenhouse gases, which are linked to climate change and global warming.

#### (i) Generation

Electricity generation faces the following challenges: Inadequate generation availability, inadequate and delayed maintenance of facilities, insufficient funding of power stations, obsolete equipment, tools, safety facilities and operational vehicles, inadequate and obsolete communication equipment, lack of exploration to tap all sources of energy from the available resources and low staff morale. As per the generation is concerned, fossil fuels are getting limited, emphasis have been shifted to renewable sources like solar, wind, geothermal, hydro, etc. That to solar energy is in great demand due to the abundant sun

energy that can be converted to electricity for generation. One such technology used with the help of solar cells which are called photovoltaic cells. These cells are made out of semiconducting material, usually silicon. When light hits the cells, they absorb energy through photons. This absorbed energy knocks out electrons in the silicon, allowing them to flow. By adding different impurities to the silicon such as phosphorus or boron, an electric field can be established. This electric field acts as a diode, because it only allows electrons to flow in one direction. Consequently, the end result is a current of electrons, better known to us as electricity.

Conventional solar cells have two main drawbacks: they can only achieve efficiencies around ten percent and they are expensive to manufacture. The first drawback / inefficiency, is almost unavoidable with silicon cells. This is because the incoming photons, or light, must have the right energy, called the band gap energy, to knock out an electron. If the photon has less energy than the band gap energy then it will pass through. But if it has more energy than the band gap, then that extra energy will be wasted as heat. Second drawback is they are expensive to manufacture.

#### (ii) Transmission & Distribution

Copper / aluminum conductors used in transmission and distribution are having less electrical conductivity, less flexibility, less elasticity and weak tensile strength. These factors are mainly responsible for the poor performing of current overhead power lines. These wires have the heating losses which degrade the efficiency of power carrying capability to the load centers.

Power transformers have service lives that exceed 25-50 years, but when they fail prematurely, the result is often a dangerous explosion. Monitoring the condition of these transformers is critical to maintain the nation's energy infrastructure. Further, the use of transformer oil for high voltage insulation and power apparatus cooling is also a problem with both its dielectric and thermal characteristics. Presence of particulate matter in the transformer oil leads to decrease in the breakdown strength.

High voltage ceramic insulators which are integral part of the power system suffer from the problem of environment contamination and

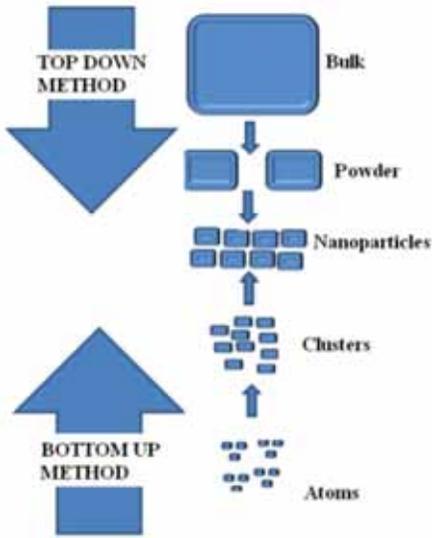


Figure 2: Synthesis methods of nanotechnology

thus, prematurely fail due to surface flashover phenomenon.

### (iii) Energy Storage

Substation batteries are important for load-leveling peak shaving, providing uninterrupted supplies of electricity to power substation switchgear and for starting backup power systems. Smaller and more efficient batteries will reduce the footprints of substations and possibly the number of substations within a ROW.

The ability to store energy locally can reduce the amount of electricity that needs to be transmitted over power lines to meet peak demands. Energy storage allow downsizing of base load capacity and is a prerequisite for increasing the penetration of renewable and distributed generation technologies such as wind turbines at reasonable economic and environmental costs. Suitable energy storage is critical to the increased use of renewable energies, particularly, solar and wind. However, the storage capacity of battery is limited and takes more time for charging thereby, reducing the overall efficiency.

## Remedial measures through nanotechnology

### (i) Nanotech Solar cell for electricity generation

Nanotech solar cell is unique both for its energy efficiency and cost effectiveness. It is used in a printing process to deposit a thin-film,

copper indium gallium diselenide CIGS-based PV semiconductor to create an efficient, durable solar cell. This semiconductor was 100 times thinner than a silicon wafer and the printing process is 10 times faster than the conventional thin-film process of high-vacuum deposition. The uses of copper indium gallium diselenide-based PV thin-films had reached sunlight-to-electricity conversion efficiencies of about 19.9 percent in laboratory tests. This is far superior to other thin-film technologies and even better than most crystalline silicon technologies, using monocrystalline silicon, is able to convert the most sunlight into electricity, about 20 percent per panel, but the cost of the silicon was much greater than that of thin-film cells.

Less costly quantum dot (nano crystal) technologies are also making important contributions to improving the efficiency of solar energy systems. Examples of some of these potential nanotechnology-enabled improvements are highlighted below:

- High-performance semiconductor nano crystals (nano dots) that are active over the entire visible spectrum and into the near-infrared have been combined with conductive polymers to create ultrahigh-performance solar cells. The solar cells have improved efficiencies because the nano crystals harvest a greater portion of the energy spectrum. Solar roofing tiles using quantum dots that

are based on metal nanoparticles are expected to be commercialized within the next several years.

- Highly ordered nano tube arrays have demonstrated remarkable properties when used in solar cells. Researchers explain that the nano tube arrays provide excellent pathways for electron percolation, acting as “electron highways” for directing the photo-generated electrons to locations where they can do useful work. Research results suggest that highly efficient solar cells could be made simply by increasing the length of the nano tube arrays.

### (ii) Nanotech Transmission

Nanotechnology will help to improve the efficiency of electricity transmission wires. There are numerous nano-materials and other nano-related applications relevant to electricity transmission. Aluminium conductor steel reinforced (ACSR) wire is the standard overhead conductor against which alternatives are compared. Carbon nanotubes are one such nanomaterial which has potential to impact the energy transmission system. A carbon nanotube (CNT) is a type of fullerene (carbon-only) molecule (Fig. 3) that is formed when atoms of carbon link together into tubular shapes. A special type of single walled CNT named as armchair Carbon Nano Tubes (CNTs) exhibits extremely high electrical conductivity (more

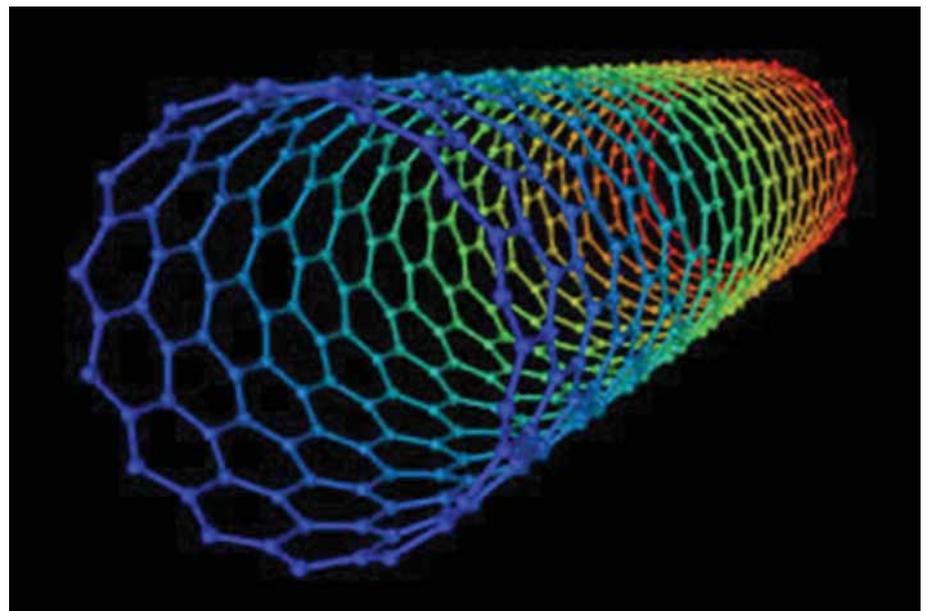


Figure 3: Carbon Nanotubes

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than 10 times greater than copper) and also possessing flexibility, elasticity, and tremendous tensile strength, have the potential, when woven into wires and cables, to provide electricity transmission lines with substantially improved performance over current power lines.

Also, the current wires can be replaced with nano-scale transmission wires, called quantum wires (QWs) or armchair QWs, which can revolutionize the electrical grid. The electrical conductivity of QW is higher than that of copper at one-sixth the weight and QW is twice as strong as steel. A grid made up of such transmission wires would have no line losses or resistance, because the electrons would be forced lengthwise through the tube and could not escape out at other angles. Grid properties would be resistant to temperature changes and would have minimal or no sag. Reduced sag would allow towers to be placed farther apart, reducing footprint and attendant construction and maintenance impacts.

### (iii) Other Electrical Transmission & Distribution Infrastructure

Nanotechnology applications will help to improve other components of the electric transmission infrastructure, thereby potentially reducing environmental impacts. The examples below pertain to transformers, substations and sensors.

- a. **Transformers:** The widespread use of transformer oil for high voltage insulation and power apparatus cooling has led to extensive research work aimed at enhancing both its dielectric and thermal characteristics. A particularly innovative example of such work is the development of dielectric nanofluids (NFs). These materials are manufactured by adding nanoparticles suspensions to transformer oil, with the aim of enhancing some of the oil's insulating and thermal characteristics. Fluids containing nano-materials could provide more efficient coolants in transformers, possibly reducing the footprints or even the number of transformers. Nano-particles increase heat transfer and solid nano-particles conduct heat better than liquid. Nano-particles stay suspended in liquids longer than larger



Figure 4: CNT batteries

particles and they have a much greater surface area, where heat transfer takes place easily. Using nano-particles in the development of High Temperature Superconductors (HTS), transformers could result in compact units with no flammable liquids, which could help increase its flexibility.

Researchers have investigated transformer oil-based NFs using magnetite nanoparticles from ferrofluids. The research showed that a transformer oil-based magnetic NF could be used to enhance the cooling of a power transformer's core. Electrical breakdown testing of magnetite NF found that for positive streamers the breakdown voltage of the NFs was almost twice that of the base oils during lightning impulse tests. The lightning impulse of increased transformer oil breakdown strength with the addition of conducting nanoparticles for two common transformer oils (i.e., Univolt 60 and Nytro 10X).

Power transformers have service lives that exceed 25-50 years, but when they fail prematurely, the result is often a dangerous explosion. Monitoring the condition of these transformers is critical to maintaining the nation's energy infrastructure. One of the most reliable ways to predict premature failure within a transformer is to monitor the levels of hydrogen gas in the insulating oil. As the oil deteriorates, hydrogen gas levels increase. Applied Nanotech Inc has created a palladium alloy nanoparticles sensor that is as small as a square millimeter. This sensor can offer continual monitoring of hydrogen in the oil at levels as small as 4 parts per million. The sensors can monitor increases in hydrogen levels as well, allowing utilities to monitor the pace of oil deterioration. The devices work by the expansion and contraction of the palladium allows within a dielectric substrate. The palladium allows act like switches, turning on as they expand when in contact with hydrogen. Because

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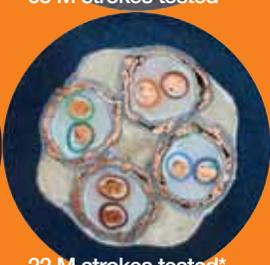
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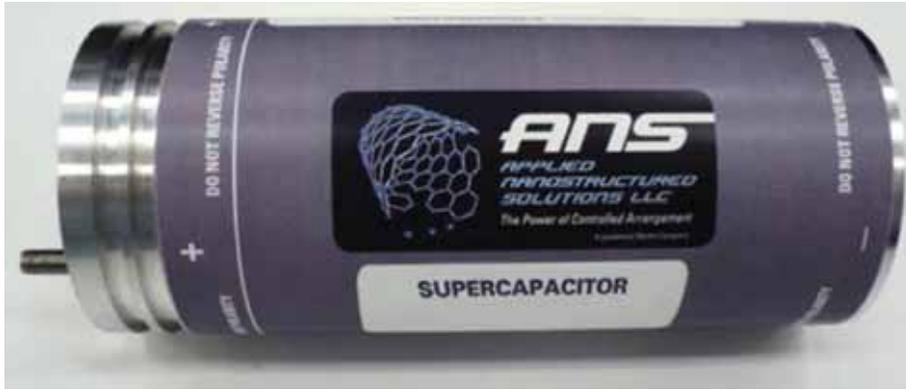


Figure 5: Supercapacitor

they only turn on when expanding, they consume no power under normal operation. Prior to the advent of these devices, oil deterioration and hydrogen levels had to be monitored with expensive and time-consuming gas chromatography. Current research has expanded upon these properties to create thin film-hydrogen sensors. These new sensors could be vital to future transportation infrastructure once hydrogen is scalable as a store of energy.

- b. **Sensors:** Nano-electronics have the potential to revolutionize sensors and power-control devices. Nanotechnology-enabled sensors would be self-calibrating and self-diagnosing. They could place trouble calls to technicians whenever problems were predicted or encountered. Such sensors could also allow for the remote monitoring of infrastructure on a real-time basis. Miniature sensors deployed throughout an entire transmission network could provide access to data and information previously unavailable. The real-time energized status of distribution feeders will speed outage restoration; phase balancing and line loss would be easier to manage. Also help to improve the overall operation of the distribution feeder network.
- c. **Insulators:** Nanostructured hydrophobic coating can mitigate the problem of surface flashover phenomenon of high voltage insulators. It will not only increase the reliability but also increases the durability of the whole power system network.

#### (iv) Energy Storage

Nanotechnology plays a role in distributed generation and substation through the

development of cost-effective energy storage batteries and capacitors.

- a. **Batteries:** Carbon Nano Tubes (CNTs) have extraordinarily high surface areas, good electrical conductivity and has a linear geometry that makes their surface areas highly accessible to a battery's electrolyte. These properties enable CNT-based electrodes in batteries to generate an increased electricity output as compared to traditional electrodes. This ability to increase the energy output from a given amount of material means not only that batteries could become more powerful, but also that smaller and lighter batteries could be developed for a wider range of applications.

The battery technology utilizes 25-nm nanostructured lithium titan ate spinet (a hard, glassy mineral) as the electrode material in the anode of a rechargeable lithium-ion battery, replacing the graphite electrode typically used in such batteries and contributing to performance and safety issues. The new battery offers vastly faster discharge and charge rates, meaning that the time to recharge the battery can be measured in minutes rather than in hours. The nano-structured materials also increase the useful lifetime of the battery by 10 to 20 times over current lithium batteries and provide battery performance over a broader range of temperatures than currently achievable, over 75% of normal power would be available at temperatures between  $-40^{\circ}\text{C}$  and  $+67^{\circ}\text{C}$ .

- b. **Supercapacitors:** Characterized by fast charge and discharge capabilities over

hundreds of thousands of cycles, supercapacitors serve in a wide range of commercial power storage applications, including light-rail regenerative braking systems, load leveling in electric and hybrid electric vehicles, as well as in utility-scale power grids.

Applied Nanostructured Solutions (ANS) is set to enable supercapacitors with significant improvements in performance characteristics:

- Up to 200 percent improvement in specific capacitance
- Three-fold boost in high-rate capability
- At least a 15 percent improvement in low-rate capability
- Three- to four-fold enhancement of through-plane conductivity

ANS's new technology can infuse substrates in a continuous, high-volume manner with highly crosslinked matrices of carbon nanostructures (CNS). The resulting paper-like CNS supercapacitor material works in both organic and aqueous solutions. ANS is now exploring commercial development with major power.

#### Conclusion

Nanotechnology holds a lot of promises in terms of potential applications and products for power system. Whatever the exact definition, key features in this field are:

- Combining different sciences and technologies
- Enhanced or new properties new applications all at very small dimensions.

Based on the information discussed in this paper, it is worthy of note that in order to tap into the nanotechnology solution to electricity generation, transmission, storage and distribution, basic requirement is to have the complete knowledge of power system, and according to the papers regarding nanotechnology appropriate solutions can be found to the problems facing in power system. The people should also be informed about the technology and possible adaptation to electricity generation. Further, we have sophisticated tools to build, characterize and utilize structures at the nanoscale, across a breadth of disciplines. Also, the researchers should work more on this new profitable technology that is useful in many facet of the economy.



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## Contactless Health Monitoring System for Three Phase Induction



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In this research work health monitoring of an induction motor by using infrared (IR) thermograph technology has been developed for both real time and off line application...

**F**ault detected at the earlier stage at any part of the three phase induction motor may protect the machine from catastrophic failure. Due to that reason early stage detection of fault plays an important role in nondestructive preventive maintenance of three phase induction motor. So, early detection of fault could save the machine and as well as protect the system from the total shutdown. This health monitoring could be done by using various sensors also, but that system needs various sensors connected directly to the machine. So, the different sensors connected to the machine create the system complicated and sometime make the system inefficient to detect the fault at the earlier stage. Therefore, the researchers have taken their interest in the field of health monitoring for the preventive maintenance of the machine which are widely used in the industry by using contactless method. Particularly, in three phase induction motor, different type of bearing faults occur because of the mass unbalance on motor shaft. In such cases, a mechanical load distributed asymmetrically over the shaft, causing displacement of the center of mass of the elements coupled to the motor from the rotation center of the machine. This asymmetric distribution generates vibrations and strokes. This unexpected friction produces some of the power loss and that loss is coming out in the form of heat. Similarly, in all the faults in the induction motor produce some of the heat in the particular parts of the machine. Different types of faults in induction motors that could be electrical faults or mechanical faults. Electrical faults include different winding faults and rotor faults. Whereas the mechanical faults could be bearing faults and eccentricity faults. In all the above said faults the machine directly or indirectly will gradually produce the heat in the

concerned part of the machine. So, thermal imaging is one of the pioneer methods to detect the fault at the earlier stage without having any contact with machine. Now a day, the infrared (IR) thermograph technology has been recognized and accepted as health monitoring method by researchers. Moreover, this method is one of the most popular gained more recognized and accepted due to its non-contact and non-destructive features of inspection. It is very quick and trustable monitoring system which can monitor the induction motor without any interference to the whole system. In IR thermograph based technique, health monitoring is performed by making the analysis of the thermal images captured by infrared camera. It is very well known fact that durability of any electrical equipment is notably reduced as temperature rises. Infrared (IR) thermograph technology offers many advantages over any conventional methods such as prompt response times, ample temperature ranges, highly reliable, harmless, high spatial resolution, and very lucrative approach for the health monitoring of electrical power systems machinery.

In this research work health monitoring of an induction motor by using infrared (IR) thermograph technology has been developed for both real time and off line application. Continuous monitoring of induction motor gives the real time information, which is useful for health monitoring of running induction motor. On the other side off line monitoring gives the information of standstill contacts which is useful for the health monitoring of other apparatus like fuse cabinet, inductive heating, corrosion, electrical panel and all those which is stand by connected to motor.

### Similar Works

Due to the consequence of liberalization, the new investment in the electrical machinery has

come down over past two decades. A lot of electrical machines specially three phase induction motors have been working well beyond their anticipated life and moreover, they are operating under rising stress. As these machines are often exposed to hostile environments during operation, this leads to deterioration and hence work beyond the specification. This leads the situation to work under unhealthy condition. As a corollary, new technologies must be exposed to allow electrical machine to better fit under such circumstances and also be economically acceptable and reliable. A good amount of attention is paid against the health monitoring of induction motor for the quality and uninterrupted drive system. The equipment on which whole drive system depends is induction motor and the monitoring of induction motor in efficient way is still a big task. In most of the existing health monitoring systems, monitoring of induction motor is done through the current

signature analysis. But this technique is tedious and costly procedure to detect faults. Few mathematical models and fuzzy rule based techniques are also now a day's popular to detect the health of the motor, but, these techniques also require some measured data to interpret and predict. So, the non invasive temperature monitoring of three phase induction motor and its components with less complexity and high reliability is a prime necessity with existing system to overcome the maintenance cost and revenue loss during the fault of the system. The infrared (IR) imaging technique makes non invasive type health monitoring systems for the induction motor which is more reliable for prediction of the health of electrical machine. This IR technique is also useful to monitor the health of any household electrical appliances, real time thermal monitoring of power system devices like transformer, measurement of excitation winding temperature in synchronous

generator, and real time high temperature measurement in control industry. The design of visual inspection system (VIS) based on charge-coupled device (CCD) and complementary metal oxide semiconductor (CMOS) cameras are already into existence for the monitoring of different processes, objects, sorting, and quality check but designing VIS based on IR cameras for health monitoring system are very rare.

In most of the papers discussed above, only invasive or pointed temperature is considered and no non-invasive monitoring and controlling systems were proposed in any research. But, in our case, RGB color model is used to detect the faulty condition of the motor. By using the R-mean G-mean and B-mean we find the abnormal temperature rise in a particular part or area of the machine. Graphical analysis of the thermal image also is done for better understanding of the abnormal temperature rise of any part of the machine. Two IR imaging based visual monitoring

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and controlling systems are proposed: Non Invasive off Line Visual Inspection System (NIOLVIS) and Non Invasive Real Time Visual Monitoring System (NIRTVMS), for off line and real time applications respectively. The proposed systems have the ability to identify the area of the hotspots in the induction motor and make decisions accordingly to keep other part of the machine healthy. The proposed methods are simulated for a large number of thermogram images of induction motor and performance are analyzed using statistical and geometrical features. This method is executed by using MATLAB.

## Basic Theory

### A. Thermal Image

Infrared camera will not have the ability to measure the body temperature directly of the machine. The camera detectors are very much sensitive to the luminance which is emitted from the object whose photo is to be taken. This luminance is directly proportional to the temperature of that particular object. That kind of image captured by the infrared thermography camera is called thermal image. This camera is able to capture electromagnetic spectrum within infrared bands, 0.78–1000  $\mu\text{m}$ . A thermal image is a function of radiated energy on an inspected object. This thermal image can be converted into digital form and can be represented in matrix form for computational processing as follows:

$$f(x, y) = \begin{pmatrix} f(0, 0) & f(0, 1) & \dots & f(0, N-1) \\ f(1, 0) & f(1, 1) & \dots & f(1, N-1) \\ \vdots & \vdots & \ddots & \vdots \\ f(M-1, 0) & f(M-1, 1) & \dots & f(M-1, N-1) \end{pmatrix}$$

### B. Image Thresholding

Image thresholding is commonly used for the process of image segmentation. Thresholding is also very useful method for the detection of fault of any substance by IRT image. Thresholding is a process to separate objects from its background in a digital image. Histogram is the main tool in this separation process. Say that the grey level corresponds to an image  $f(x, y)$  that is composed of lights objects on a dark background, in such a way that object and background pixels have grey levels grouped into two dominant modes. Extracting the object from the background is performed by selecting a threshold  $T$  that separates these modes. A threshold image

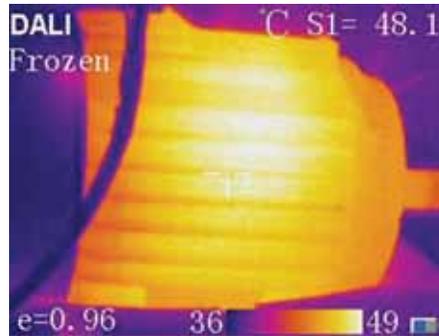


Figure 1: Thermal image of a running Induction motor

$g(x, y)$  is defined as

$$g(x, y) = \begin{cases} 1 & \text{if } f_{x, y} > T \\ 0 & \text{if } f_{x, y} \leq T \end{cases}$$

### C. RGB colour model

The RGB (red green and blue) is colour model based on the three basic colours red green and blue. These three colours are mixed together in different amount to produce a broad array of colours. The name of the model comes from the initials of the three additive primary colours red, green, and blue. For the representation and display of images in electronic systems, such as televisions and computers and also in digital cameras RGB colour model is used. In infrared thermal camera also this RGB model is used to display the thermal image. The first experiments with RGB in early colour photography were made in 1861 by Maxwell himself, and involved the process of combining three colour-filtered separate takes. In modern technological era we can analyse the digital image by various methods. A broad area for the researchers is now a digital image processing. We can very easily analyse the image taken by any infrared thermal imaging camera or any simple digital camera by using the MATLAB. We can plot the whole image in a numerical matrix form and easily can identify the each pixel. Each pixel contains three colours red, green and blue as the theory of RGB code. We can identify the intensity of colour of each pixel by the value of individual red green and blue (RGB). MATLAB can be used to calculate the average value of each individual red, green and blue (RGB). We can make any comparison between images. In Infrared thermal imaging camera the temperature is identified based on its colour. The image will be brighter for the higher temperature in the thermal imaging camera. By calculating

the average value of red, green and blue (RGB) in a pixel in the thermal image we can detect the hotter place or the hottest place in the image. Even we can identify the hottest pin point and the location of that pixel where the hottest point situated. Here one thermal image of a running induction motor is shown in Figure 1 by using Thermal imaging Camera.

## Experimental Setup

### A. Test Bench



Figure 2: Experimental setup

The experimentation is done in Electrical Engineering lab at Dayalbagh Educational Institute (Deemed University) Agra, India. The experiment setup is consisting of one induction motor having a healthy cooling system with the arrangement through which fault in the cooling system can be created. The specification of the motor are three phase Squirrel cage induction motor 230V, 50Hz, 3HP, inbuilt fan type cooling. A voltage –current-frequency (VIF) meter, one infrared thermal imaging camera with a proper fixed camera stand and one computer with MATLAB software installed. The real time image is acquired with the help of infrared thermal imaging camera for both healthy and faulty condition of the cooling system at different load conditions. For both the condition data are sent to computer. MATLAB imports these signals and graphs are drawn for all the parameters at faulty and healthy condition. Graphical analysis is also done for the final declaration of the health condition of the induction motor. Fig.2 shows the experimental setup of health monitoring system of induction motor using infrared thermal imaging camera.

### B. Infrared Thermal Camera Specification

Used camera specification for the thermal imaging for experimental purpose of induction

motor is shown as follow.

**Image characteristics:**

- Focus: Manual
- Field of view / min focus distance: 18° x 13° / 0.3m Thermal sensitivity: ≤ 0.1°C@30°C
- spatial resolution (IFOV): 1.9 mrad
- Frame rate: 50/60 Hz
- Spectral range: 8 - 14µm
- Electronic zoom: 2X

**Detector characteristics:**

- Array size / format: 160 X 120
- Detector type: Uncoiled FPA microbolometer.

**Image display:**

- Temperature ranges : -20°C ~ + 350°C, optional up to +600°C or 1000°C
- LCD: Built-in-high resolution Color 2.50 LCD
- Measurement:
- Setup functions: Date / time, temperature unit, language
- Emissivity correction: Variable from 0.01 to 1.0
- Ambient temperature correction: Automatic correction according to user input
- Atmospheric transmission correction:

Automatic correction according to user input object distance, relative humidity, ambient temperature.

- Accuracy: ± 2°C or ± 2 % of reading, whichever is greater.

**Laser pointer:**

Laser pointer: Class 2, 1mw / 635nm (red)

**Image storage**

Storage mode: Automatic / manual single image saving

File format - thermal: JPEG, 14 bit thermal image with measurement data

**Experimentation**

For the proposed method, we have a system i.e. one induction motor with the arrangement that we can create the fault in the cooling system of that motor easily. One digital camera is fixed on the stand to capture the infrared digital images. First we acquired the infrared thermal images of the motor from the healthy motor at different load conditions. Then we create the fault in the cooling system of motor manually.

Then we acquired the infrared thermal images the faulty motor at different load conditions. All the images are taken from a fixed location from the camera stand. Then we plot the images in the matrix form by Matlab and also crop all the images to a fixed size to consider the exact motor portion. We find the hottest part of the machine by finding the RGB average and maximum of the image pixels. RGB plots are plotted to visualize the results better. After making the comparison between the healthy and faulty part of the motor we can conclude the fault. For all the analysis only thermal images are used in MATLAB.

**Result and Analysis**

A. RGB average of Healthy motor image at different load

	Red mean	Green mean	Blue mean
No load	188.5523	32.3792	125.9808
Quarter load	215.5657	103.8495	46.1426

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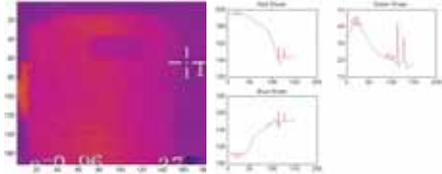
# 97, Magadi Road, Metro Pillar # 219, Bangalore - 560023. India.

Ph : +91 80 4160 8100 E-mail: lvswitchgear@sevaspl.com www.sevaspl.com

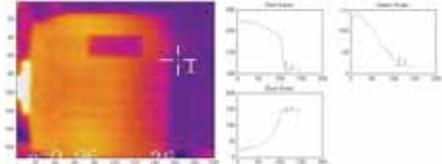
	Red mean	Green mean	Blue mean
Half load	220.1767	118.0164	37.2316

If the load is increased then the heat is increased with the load. Trends show that red mean and green mean both are also increased with the increase in heat, but the blue mean is decreased with the increase in heat.

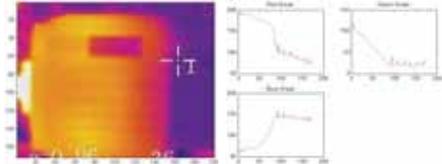
## B. At healthy condition



(a) No-load image and its RGB Analysis

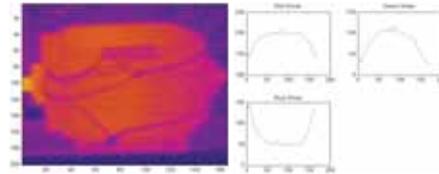


(b) Quarter Load image and its RGB Analysis

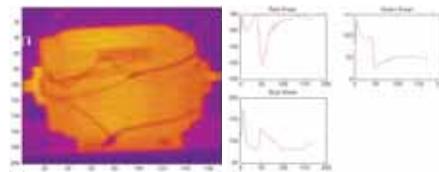


(c) Half Load image and its RGB Analysis

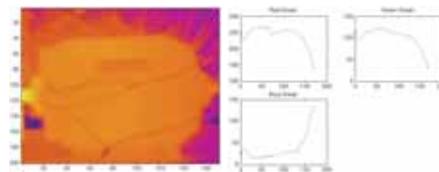
## C. At faulty condition (Cooling system failed)



(a) At no load (cropped) image and its RGB Analysis



(b) Quarter Load image and its RGB Analysis



(c) At half load (cropped) image and its RGB Analysis

## Conclusion

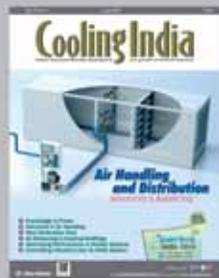
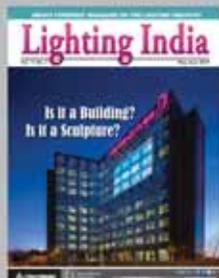
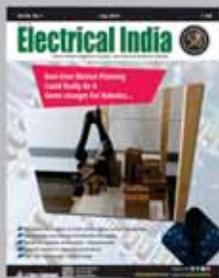
The purpose of this paper is to diagnose the health condition of the induction motor by using an innovative technique where the whole motor will be monitored without having any physical contacts.

Here no sensor is used to get any physical parameters. So, the system is very simple and chances of failure are almost nil. It is very much important for an engineer to monitor the induction motor while it is working in a system, because any fault generated in induction motor can be the reason of excessive heating.

Excessive heat produced in the machine can burn the windings of the motor and the situation will be very harassing. In this method all the sensor which is normally used in conventional condition monitoring is replaced by an infrared digital camera alone. The system is almost maintenance free and analysis is very particular to the every part as if the whole motor condition is vivid in front of eyes.

The analysis results showed that the proposed method is able to monitor the health condition of the induction motor. The method described provides a promising way to establish potential metrics for the description of the health of an induction motor. Therefore, it is desirable to develop an on line health monitoring system for the induction motor based on the above method and realize on-line health evaluation of each part of induction motor. With such a function, the critical failure of induction motor systems can be avoided, and the reliability and efficiency of motor can be increased. B

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## CLP's Smart Energy Programme for Hong Kong

To combat climate change and support the government's vision to develop Hong Kong into a smart city, CLP Power Hong Kong Limited (CLP Power) announced the launch of a one-year Smart Energy Programme, for which smart meters have been installed for 26,000 selected residential customers. With the Advanced Metering Infrastructure (AMI) system, customers are given timely access to data on their electricity consumption, and are encouraged to lower their energy use at peak times and save on electricity bills through a change in their consumption habits. The programme provides CLP Power with a better understanding of customers' feedback towards a variety of demand response measures, enabling the company to explore how to effectively implement AMI in the future, and offer a service that can better cater to customers' future needs.

The programme covers residential customers who live in private and public housing, Home Ownership Scheme flats, and village houses in 14 districts of Kowloon and the New Territories, which cover customers of varying characteristics and ensure a representative result. Traditional mechanical meters can only record electricity consumption data, while residential customers receive their consumption information through electricity bills on a bi-monthly basis. With the AMI system, customers can get timely access to detailed information about their home energy use through a web portal and a mobile app, making it easier for them to monitor and manage their electricity consumption behaviour.

The AMI system also enables the power company to timely monitor the performance of the power grid, and automatically notifies the control centre about any abnormalities. This helps speed up power restoration and further enhances supply reliability. CLP Power Deputy Director - Smart Grid Dr Anthony Lo said: "Smart city development is a global trend, and the government is formulating a smart city blueprint that uses innovation and technology to improve our quality of life. The AMI system not only helps customers manage their electricity consumption but also further enhances supply reliability, safety, and operational efficiency. The system is a critical element of infrastructure to facilitate the development of a smart grid and support the government's vision of creating a smart city." Dr Lo said CLP Power had introduced specific tariff schemes for the Smart Energy Programme, namely a Time-of-Use (ToU) Tariff and a Summer Saver Rebate (SSR), drawing on best practices from the global trends towards AMI development and application, and the experience of demand side management implementation in different countries and regions. The ToU Tariff applies different rates for electricity at different times of the day, divided into a peak period, a shoulder period, and an off-peak period. Customers are encouraged to reduce their peak period consumption and transfer their energy use to off-peak periods at a lower tariff. The SSR encourages customers to reduce their consumption on the hottest days of summer. A special rebate will be credited to customers if they reduce their consumption on specific days during the peak period in summer. As a further incentive for customers to save energy, people who meet weekly energy-saving targets will have the chance to earn eco points through the Eco Rewards Scheme, which can be used to claim fabulous gifts from CLP Power's online platform Eco Power 360. To help customers achieve energy saving targets effectively, customers will be offered a pre-set personal consumption alert service including projected consumption and tariff alerts. Energy saving tips will also be provided to raise customers' conservation awareness and allow them to make informed choices about energy use. Alerts will be sent to customers if abnormal consumption is recorded. Dr Lo said he believed that the Smart Energy Programme would be an effective way to encourage customers to save energy, reduce power demand at peak times.



CLP Power Deputy Director - Smart Grid Dr Anthony Lo says the Smart Energy Programme aims to encourage customers to lower their energy use at peak times by changing their consumption habits, and to better understand customers' feedback to various demand response measures.



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# FLIR Thermal Camera & Clamp Meter Pass Electrician's Test



When self-employed electrician Gary Fisher was given the opportunity to 'road test' a FLIR C2 thermal imaging camera and CM174 clamp meter, he saw it as a chance to see exactly how much value these advanced devices could add to his work.

In electrical installations, successful diagnosis of problems before they become a genuine danger is a real advantage. Among the devices best able to help facilitate this is a thermal imaging camera. Its speed and ease-of-use make it a must-have gadget for the electrical trade. At least that's the theory, but what about in practice? Gary Fisher carries out a wide range of electrical work, typically involving distribution boards, covering an area between his base in Milton Keynes, down the M1 corridor as far south as Harrow in northwest London. His father, now retired, started the business originally, which Gary joined after finishing school.

### Identify heat spots in circuits

"There's no doubt that thermal imaging is coming more and more into what we do," he says. "Even before I tried the camera I knew it would be able to identify heat spots that would show up circuits using a lot more energy than elsewhere in the system. I couldn't wait to put the FLIR C2 through its paces."

The first thing that Mr Fisher noted was the size of the C2 (125 × 80 × 24mm), which he says “could easily be mistaken for a mobile phone”. Compact and light (130g), the device fits comfortably within an electrician’s top pocket.

“Its ease-of-use was also striking,” he says. “I have never used a thermal camera before but it really is point and shoot. The image can be viewed through the 3” touchscreen, which displays amazing picture quality.”

### Report with razor-sharp images

The C2 features FLIR’s patented MSX® real-time image enhancement technology to help identify problem locations easier. Furthermore, the C2’s 4800-pixel resolution detector is able to capture and display subtle thermal patterns, while a built-in work light and flash helps illuminate poorly lit areas encountered by many electricians.

“It’s easy to see objects and heat areas extremely clearly and with plenty of detail, which helps quickly identify the areas that need attention,” says Mr Fisher. “It’s the sort of device that can benefit electricians of all levels from serious professionals who maintain high voltage installations in the industrial and heavy commercial sectors through to domestic tradesmen. From my point of view the opportunity to present the customer with a binder complete with thermal images that record and report findings is a mark of quality, and would definitely give me a competitive edge.”

The C2 can store radiometric JPEGs at the push of a button. Furthermore, the images can be downloaded later using the free FLIR Tools software, which allows the user to adjust thermal image levels, isolate and add temperature measurements, change colour palettes and create persuasive reports.

### Prevent Danger, Save Lives

However, aside from the C2’s innovative features, it is the device’s pure ability to avoid dangerous situations and, potentially, save lives that proves

the main attraction. One of principal reasons that consumer units are made from metal is because of the fires that can occur due to loose connections building up heat points.

“The FLIR C2 is just the thing to prevent this,” states Fisher. “When performing an estimate you can simply point it at the client’s consumer unit and provide clear proof



Gary Fisher: “If there is any humming noise or any uncertainty surrounding a circuit, I can get the CM174 on the job and see immediately what’s going on.”



The thermal images provided by the FLIR C2 thermal camera and the FLIR CM174 imaging clamp meter visually guide electricians to the precise location of a potential problem.

that there is a possible danger that needs to be addressed.”

### Visualize Electrical Issues

Sufficiently impressed with the FLIR C2, Fisher also had the opportunity to test the FLIR CM174 600AC/DC clamp meter.

“When I’m undertaking a job I find it’s important to know what current is being consumed as it helps with my decision making,” he says. “If there is any humming noise or any uncertainty surrounding a circuit, I can get the CM174 on the job and see immediately what’s going on.”

With the FLIR CM174 clamp meter, which features IGM (Infrared Guided Measurement), users can identify dangerous and unknown problem areas quickly and safely. In short, electrical issues can be visually identified without requiring direct contact with panels, cabinets or cluttered wires and cables that may present safety hazards.

“In essence the CM174 is a clamp meter combined with a thermal imager, which makes it a really neat device,” says Fisher. “If I owned this I know I would use it regularly.”

Further features of the FLIR CM174 admired by Mr Fisher include the narrow clamp jaws, which help getting in between all the cables inside consumer units. He also says that it is of sufficiently robust design to keep inside his toolbox with the rest of his kit. “What more could an electrician want?”

For more details: [www.flir.eu/c2](http://www.flir.eu/c2)

### Method for Timing Tests on GIS with Grounding on Both Sides

OMICRON's circuit breaker test system CIBANO 500 now offers the new Current Sensor Measurement (CSM) method. This allows the operating times of the circuit breaker to be determined accurately despite the fact that the GIS is grounded on both sides.

During a close or open operation of the circuit breaker, the current sensor measures the current change through the ground connection or the circuit breaker and sends its signals to CIBANO 500 which determines the switch response times.

Since the new current sensor has a flexible design and can be easily installed on a multitude of different grounding switches, it is ideal for on-site applications in GIS installations.

As part of the test results, a GIS operator receives a condition assessment of the circuit breakers' interrupter units and operating mechanisms and can avoid circuit breaker damage and outage of the GIS.

The new CSM method offers an increased level of safety for the tester, as it can be performed with both sides of the circuit breaker grounded.

CIBANO 500 combines a precise micro-ohmmeter, a multi-channel timing analyzer, and a powerful coil and motor supply in a single device. It can perform all common electrical tests, such as static and dynamic contact

resistance tests, timing tests or analysis of coil and motor current, minimum pick-up tests or undervoltage tests using the same wiring. All tests can be performed either with power supplied by the station battery or the test device.



CIBANO 500 – circuit breaker test system

The lightweight test system (20 kg / 44.1 lbs) supports all types of circuit breakers: medium- and high-voltage circuit breakers with live- and dead-tank design and in GIS installations.

OMICRON is an international company serving the electrical power industry with innovative testing and diagnostic solutions. The application of OMICRON products allows users to assess the condition of the primary and secondary equipment on their systems with complete confidence. Services offered in the area of consulting, commissioning, testing, diagnosis and training make the product range complete.

Customers in more than 150 countries rely on the company's ability to supply leading edge technology of excellent quality. Service centers on all continents provide a broad base of knowledge and extraordinary customer support. All of this together with our strong network of sales partners is what has made our company a market leader in the electrical power industry.

### Adani Group's 50 MW Solar Plant in UP

Adani Group, a global integrated infrastructure conglomerate, announced commissioning of 50 MW solar PV plant in Mahoba, Uttar Pradesh, under the National Solar Mission Scheme, with an investment of Rs 315 cr.

The technology used for setting up this plant includes String Inverter Technology which is 1st of its kind in UP with crystalline silicon modules that allows miniature level control of solar power generation. The transmission line runs up to a stretch of 21.5 km. The power generated by this plant will be evacuated by 132 kv transmission line to UPTCL, Mahoba Substation under agreement signed with NTPC. Indirect and direct employment opportunities were created for a total of around 250 personnel, who worked diligently to achieve this feat, and employment opportunities will be provided through the generation period as well.

"We are delighted to have achieved the setting up of this plant, helping us prove our dedicated efforts towards nation building as well as showing our commitment to the government's green energy mission. We are moving

closer to our aim of revolutionizing the renewable energy sector in India. We would like to extend our heartiest gratitude to the UP government officials for their support and playing a huge role in helping us achieve the smooth commissioning of this plant," said Jayant Parimal, CEO, Renewable Energy Business, Adani Group.

Apart from the 100 MW Solar Power Plant in Bhatinda, the company also has a 40 MW solar plant at Bitta, Gujarat and has also recently unveiled a 648 MW solar power plant at Ramanathapuram district in Tamil Nadu which is the world's largest solar power plant at a single location. With this plant the company has added another 50 MW to the existing portfolio. Adani Group capacity in solar energy goes up to 838 MW, spreading across Gujarat, Tamilnadu, Uttar Pradesh and Punjab. Thus, by the end of this year Adani Group will be above 2 GW of solar installed capacity making the company the largest player in India's renewable energy sector in various states. Till now, we have generated 1472 GWH of solar energy from above plants which have reduced CO<sub>2</sub> emission by 650590 MT.



## New Coal Allocation Policy to benefit private IPPs: ICRA

The Cabinet Committee on Economic Affairs (CCEA), Government of India recently approved a new coal allocation policy to power sector to enable signing of fuel supply agreements (FSAs) with existing holders of Letter of Assurance (LoA) from Coal India Limited (CIL) and to introduce a transparent bidding-based mechanism to allocate fresh coal linkages. According to rating agency, ICRA, the implementation of the new coal allocation policy namely "SHAKTI" or the scheme for harnessing and allocating koyal (coal) transparently in India, is a positive development for the domestic thermal power generators, with a combined capacity of around 28 GW in the private IPP segment. Hitherto these were adversely affected by lack of FSAs. This includes both units with power purchase agreements (PPAs) and those without.

Commenting on the development, Sabyasachi Majumdar, Senior Vice President and Group Head, ICRA Ratings, says, "The ability of the IPPs with existing PPAs and without LoAs to secure coal linkage in bidding process will be dependent upon the quantum of quoted tariff in existing PPA and the distance of coal-linked mine from the project. In this context, any aggressive bidding to secure coal linkage may lead to a risk of under-recovery in variable cost. Even IPP capacity without FSAs and without PPAs estimated at 16.9 GW, would benefit from this policy."

The signing of FSAs with existing holders of LoA from CIL will be subject to meeting all milestones including commissioning. It is noteworthy that operational coal-based IPPs with an aggregate generation capacity of 8.3

GW, having long-term PPAs with state distribution utilities, are affected by lack of long-term fuel supply arrangements from CIL. For IPPs with existing PPAs and without LoAs, the award of coal linkage shall be through an auction process, based on discount to quoted tariff in PPA.

For IPPs without PPAs, linkages shall be made available under the auction route with bid parameter being premium over the CIL notified price. However, the supply of coal under this linkage shall be subject to availability of valid long-term PPAs or medium-term PPAs with distribution utilities. "The overall slow progress in signing of long-term and medium-term PPAs by state distribution utilities will remain a key area of concern, given that the coal drawl is only subject to a PPA tie-up. Risks for such IPPs will remain high", Majumdar added.

The policy has also included a provision to allocate domestic coal to projects based on imported coal through the auction route. This is expected to benefit such projects as the availability of domestic coal may enable such projects to lower their fuel cost under-recovery, given that some of these projects have competitively bid PPAs with fuel cost risk.

From the perspective of distribution utilities, the new coal allocation policy is a positive development as it is likely to improve coal supply from domestic sources to the coal-based power generation companies. This in turn would lower the cost of procurement and provide a relief in cost of supply to the distribution utilities. B



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## RS Components: Providing Value Added Solutions

### Electrocomponents is the global distributor for engineers

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- Trading brands: RS Components and Allied Electronics
- Revenue: £1.29bn (financial year ended 31 March 2016)
- Listing: London Stock Exchange, FTSE 250
- Employees: 6,000

### Global scale and reach

- Countries with operations: 32
- Global network of distribution centres
- Customers: 1 million+ in more than 80 countries



### Leading product range and service

- Products: 500,000+
- Suppliers: 2,500+
- Parcels shipped per day: 44,000+

RS Components and Allied Electronics are the trading brands of Electrocomponents plc, the global distributor for engineers. With operations in 32 countries, we offer more than 500,000 products through the internet, catalogues and at trade counters to over one million customers, shipping more than 44,000 parcels a day. Our products, sourced from 2,500 leading suppliers, include electronic components, electrical, automation and control, and test and measurement equipment, and engineering tools and consumables.

Electrocomponents is listed on the London Stock Exchange and in

the last financial year ended 31 March 2016 had revenues of £1.29bn.

The key to the company's strategy is that it is a high-service level distributor. No order is too small, as we believe in supporting every aspect of the business from design to production through to maintenance."RS Components as distributor has been serving the needs of the Indian ESDM community for over 20 years. The Indian subsidiary of the global giant caters to the needs of over 10,000 diverse businesses. With massive investments in electronics, RS is further positioning itself as a major electronics player in addition to having market leadership in maintenance, repair and operations (MRO).

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- Rapid bills of material support
- Multichannel sales and marketing

We offer the broadest range of semis, passives, interconnect and electromechanical components, test & measurement equipment and essential tools to support every design engineer's job. We are committed to providing value-add solutions to electronic design engineers at every stage of the design life cycle from concept to pre-production.

**For further information:** [in.rsdelivers.com](http://in.rsdelivers.com)

## Energy Management for Industries

In this age of rapidly dwindling natural resources, the prudent use of available resources cannot be overemphasized. One such critical expensive resource is energy. Energy Management is, therefore, key to maximizing productivity at the least possible cost.

### Right Energy Management involves the following cyclic steps:

- Get - Get the right data on actual energy consumption
  - Set - Set targets for optimum use of energy
  - Save - Execute energy saving plans
  - Review - Monitor progress towards the goal and refine action plans
- A good Energy Management System or Solution (EMS) must provide continuous, reliable and actionable information to effectively implement energy saving plans.

### It should have the following components:

- Data collection - Information is everything!
- Fully automated, accurate meters for measuring real time data from all critical consumption points, 24x7.

Data transmission - Data lost is opportunity lost!

Smart Gateways with in-built memory can ensure zero data loss even in case of communication failure. Smart Gateways also capture and transmit alarms via SMS.

Data Analysis - Reports & Alerts for Action

Converting the collected raw data into actionable reports to generate energy saving plans and achieve cost savings with user-friendly software.

### The EMS should generate reports in the following broad categories:

- Electrical energy accounting & power system management:
- IPlant energy & power flow monitoring
- IDemand & PF monitoring to avoid penalties
- IEnergy reports as per ISO 50001
- ICost center reports (Shift wise, daily, weekly, monthly etc)
- ISpecific energy consumption (SEC / EPI) - Plant / department wise
- IPareto analysis to identify areas for action

Utilities Management

IDiesel Generators, Air Compressors, Steam Generation (Boilers)

IWater Management

Load Management

IMachine wise SEC analysis, Bench-marking & Loss Accounting

IMachine Utilization analysis

Additional Features

IEnergy Saving & Rol Calculator

IMaintenance Modules

An EMS implemented with the right meters, right network, right software and most importantly the right partner will surely pave the way for a energy efficient enterprise.

### Happy Savings!

**Credit:** Mr. Sudhir Kumta, Vice president, AtandraKrykard, Atandra Energy Pvt Ltd.

## XetaWave reveals XetaPAK, an Advanced Smart Battery

XetaWave, a Colorado-based wireless technology provider, recently announced the release of XetaPAK, an advanced, long lasting smart battery that represents an entirely new approach for batteries used in remote telemetry sites.

As a drop-in replacement for 12 AH, 24 AH, and 100 AH lead acid batteries, the XetaPAK is lighter weight, longer lasting, higher capacity and offers monitoring capabilities not available with traditional lead acid batteries. Further, instead of being just a battery, the XetaPAK adds a Maximum Power Point Tracking (MPPT) solar panel controller, load current limiter, low voltage shutdown, battery temperature management and data logging through Modbus all in one insulated package. Further, the XetaPAK offers unsurpassed reliability, is invulnerable to abuse, and has a very long life. By contrast, today's



typical lead acid battery offers no ability for monitoring and needs to be replaced on a regular basis, sometimes as frequent as annually, requiring the costly deployment of field resources and the cost of repeated purchases.

The XetaPAK is available in three versions – XetaPAK15 offers 15 amp hours (AH), XetaPAK30 35 AH, and the XetaPAK135 135 AHs. The XetaPAK135 offers 35% more capacity than 100 AH lead acid batteries.

Jonathan Sawyer, XetaWave CEO/CTO, said, "There has long been a need for a replacement to lead acid batteries.

The XetaPAK is the industry's most advanced battery management system. It is the only product that combines solar charging, thermal management and fault protection with Modbus data logging."

**For further information:** [www.xetawave.com](http://www.xetawave.com)

## Perle launches RS232 Serial Interface Isolator

Perle Systems, a well known global provider of serial device networking hardware, recently announced the launch of RS232 Serial Interface Isolators.

Known for its very low signal power, the RS-232 interface is an asymmetric voltage interface with common signal ground, connected to the grounded chassis housing, for all signals. This results in very little immunity to interference and a maximum range of 15 meters. Using the PSM-ME-RS232/RS232-P Serial Isolator, considerably higher immunity to interference can be achieved.



The PSM-ME-RS232 Serial Isolator effectively protects RS232 devices and data transmissions by isolating the TX/RX data channels and the RTS/CTS control lines. Their high-grade 3-way isolation also protects expensive termination devices against damage.

John Feeney, COO at Perle Systems said, "RS232 communication is very susceptible to EMI, RFI, transient surges, ground loops and noise interference. This can cause real issues when transmitting critical data in a laboratory, factory, retail or industrial system."

**For further information:** [www.perle.com](http://www.perle.com)



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[www.sevitsil.com](http://www.sevitsil.com)

## UHF PD Detector – A non-invasive tool for online PD measurements in MV and HV substations

The UHF PD Detector is the ideal tool for non-invasive quick surveys in MV and HV substations and should be part of the toolbox for all maintenance and service teams. The UHF method allows, as of the high measurement bandwidth, for accurate local online partial discharge (PD) measurements on HV assets such as cable end-terminations, surge arrestors, voltage transformers, isolators etc. For MV switchgear surveying the UHF PD Detector is equipped with an RF channel allowing too connect TEV and HFCT sensors. As of the dual channel functionality it is possible to compare two



phases or two types of UHF sensors with each other, this further increases the scope of use of the UHF Detector and making it the most unique and cost effective unit of its kind. Furthermore, in the time domain mode, phase resolved PD (PRPD) patterns can be generated which is an utmost for segregating noise from PD. The handheld unit can either be operated via a foil keypad or via the large 6" colour touch-screen and has a battery life of over 8 hours.

**For further information:** <http://en.megger.com>

## Ultrasonic Thickness Gauge

Model Km-8041, is a new Device introduced by "Kusam-Meco" an ISO 9001-2008 Certified Company. This Ultrasonic Device is used to measure the Thickness of various Materials like Metals, Glass/ Plastics Pottery & many more. It has an Adjustable Ultrasonic Velocity Adjustment. It is used to Measure Velocity Function. The Thickness Unit is in mm/inch which is Convertible. It has a Coupling Indication. It is build in a Metal Piece for Calibration. It has a Low Battery Voltage Indication with Auto Power Off. This Ultrasonic Thickness Gauge is designed



according to European Unions CE Safety Norms. It has an Ultrasonic Frequency of 5MHz. It has a Digital Display of 4 Digits. Its measuring Range is between 1.2mm to 225mm & its Pipe has a minimum diameter of 20\*3mm. Its Velocity Range is between 1000 to 9999m/s. It has a Resolution of 0.1mm & Accuracy of +-1%H + 0.1mm. Its Response Time is 0.5S. It can be operated to an Operating Temperature of 0 to 40°C & Operating Humidity of 10 to 90%RH.

**For further information:** [www.kusam-meco.co.in](http://www.kusam-meco.co.in)

## eMotorWerks adds Webasto to expand its JuiceNet Smart Grid Electric Vehicle Charging Platform

Further expanding its reach into the electric vehicle (EV) market, eMotorWerks is teaming up with Webasto, one of the top 100 automotive suppliers worldwide, to launch new EV charging solutions tailored specifically for automotive manufacturers and their dealer networks. The line of intelligent and cloud connected EV charging solutions aims to empower drivers to charge their electric vehicles on the cleanest energy possible, while also enabling electric utilities to aggregate and control EV charging load on the grid to improve reliability and resiliency.



smart grid charging products to both drivers and utilities with a seamless approach. Webasto's goal is to offer a 'one-stop-shop' charging solution, supporting vehicle OEMs in the field of charging by providing hardware that meets automotive standards and superior installation and training for end customers.

The Webasto partnership marks the first occasion a traditional Tier 1 supplier has teamed with an EV platform company to deliver these solutions directly to automotive OEMs. It is the latest in a series of partnerships

for eMotorWerks to enable the expansion, scale, and reach of its JuiceNet platform, including the most recent announcement with Aerovironment and with other partners such as Nayax.

**For further information:** [www.emotorwerks.com](http://www.emotorwerks.com)



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## Solar Power Capacity Requirement (FY12-FY22)

As per the National Tariff Policy, it is envisaged that the targets for Solar RPO (Renewable Purchase Obligation) shall be 0.25% by 2012-13 extending to 3% by 2022. The Jawaharlal Nehru National Solar Mission has been the first step towards achieving these targets.

The following table illustrates the Solar RPO requirement by 2022 on the basis of expected demand in India.

### Solar Power Capacity Requirement by 2022

Year	Energy Demand (MU)* (A)	Solar RPO (%) (B)	Solar Energy Requirement (MU) for RPO compliance (A)X(B)	Solar Capacity Requirement for RPO compliance (MW)
2011-12	953,919	0.25%	2,385	1,433
2012-13	1,022,287	0.25%	2,556	1,536
2013-14	1,095,555	0.50%	5,478	3,291
2014-15	1,174,074	0.75%	8,806	5,291
2015-16	1,258,221	1.00%	12,582	7,560
2016-17	1,348,399	1.25%	16,855	10,127
2017-18	1,443,326	1.75%	25,258	15,176
2018-19	1,544,936	2.25%	34,761	20,885
2019-20	1,653,700	2.50%	41,343	24,839
2020-21	1,770,120	2.75%	48,678	29,247
2021-22	1,894,736	3.00%	56,842	34,152

Note: \*Based on the National Electricity Plan for Generation January 2012

(Source: www.mnre.gov.in)

**Assumptions:** Average CUF for Solar Power Technologies to be 19%

**Key Inference:** • To achieve 3% RPO compliance by 2022, we would need ~34,000MW of solar capacity

- To be able to achieve such capacity additions, states have come up with Renewable Purchase Obligations, with yearly targets, based on Model regulation by FOR.

### State-wise Solar RPO Targets

States	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Andhra Pradesh	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%					
Arunachal Pradesh	Not regulation issued for RPO by the Power Department										
Assam	0.10%	0.15%	0.20%	0.25%							
Bihar	0.25%	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	1.75%	2.00%	2.50%	3.00%
Chhattisgarh	0.25%	0.50%									
Delhi	0.10%	0.15%	0.20%	0.25%	0.30%	0.35%					
JERC (Goa & UT)	0.30%	0.40%									
Gujarat	0.50%	1.00%									
Haryana	0.00%	0.05%	0.75%								
Himachal Pradesh	0.01%	0.25%	0.25%	0.25%	0.25%	0.25%	0.50%	0.75%	1.00%	2.00%	3.00%
Jammu and Kashmir	0.10%	0.25%									
Jharkhand	0.50%	1.00%									
Karnataka	0.25%										
Kerala	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%	0.25%
Madhya Pradesh	0.40%	0.60%	0.80%	1.00%							
Maharashtra	0.25%	0.25%	0.50%	0.50%	0.50%						
Manipur	0.25%	0.25%									
Mizoram	0.25%	0.25%									
Meghalaya	0.30%	0.40%									
Nagaland	0.25%	0.25%									
Orissa	0.10%	0.15%	0.20%	0.25%	0.30%						
Punjab	0.03%	0.07%	0.13%	0.19%							
Rajasthan	0.50%	0.75%	1.00%								
Sikkim	Not regulation issued for RPO by the Power Department										
Tamil Nadu	0.05%										
Tripura	0.10%	0.10%									
Uttarakhand	0.03%	0.05%									
Uttar Pradesh	0.50%	1.00%									
West Bengal			0.25%	0.30%	0.40%	0.50%	0.60%				

(Source: SERCs Order on RPO Regulations)

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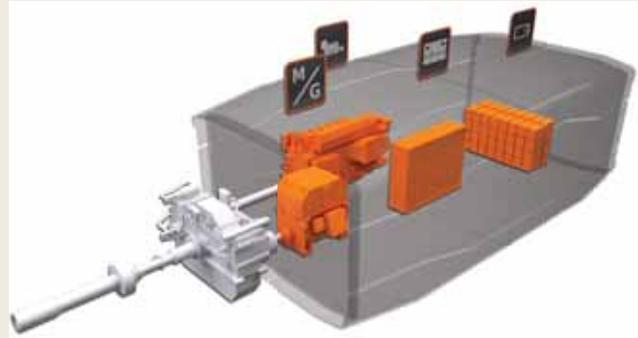
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## Wärtsilä HY hybrid power module is first of its kind for the marine industry

The technology group Wärtsilä has announced the introduction of a unique hybrid product, the Wärtsilä HY, representing an unprecedented innovation in marine propulsion systems. By leveraging its technical strengths in both engine design and electrical & automation (E&A) systems, Wärtsilä is launching a fully integrated hybrid power module combining engines, an energy storage system, and power electronics optimised to work together through a newly developed energy management system (EMS). It is the marine sector's first hybrid power module of this type produced, thereby establishing a new industry benchmark in marine hybrid propulsion.



The Wärtsilä HY will provide a wide range of customer benefits through increased operational efficiency and flexibility, resulting in lower fuel consumption, reduced emissions, and improved vessel performance. When operating in 'Green Mode' zero emissions can be achieved. Smokeless operation is also achievable at all load points and in all operating modes, thanks to a new patent pending automation procedure.

**For further information:** [www.wartsila.com](http://www.wartsila.com)

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# Forthcoming Events At A Glance

## National

### Automation 2017

**Venue:** Bombay Convention & Exhibition Centre, Mumbai  
**Date:** 09-12 August, 2017  
**Website:** [www.automationindiaexpo.com](http://www.automationindiaexpo.com)

### electronica India

**Venue:** Pragati Maidan, New Delhi  
**Date:** 14-16 September, 2017  
**Website:** [electronica-india.com](http://electronica-india.com)

### Renewable Energy India Expo 2017

**Venue:** India Expo Centre, Greater Noida  
**Date:** 20-22 September, 2017  
**Website:** [www.renewableenergyindiaexpo.com](http://www.renewableenergyindiaexpo.com)

### Intersolar India 2017

**Venue:** Bombay Exhibition Centre, Mumbai  
**Date:** 05-07 December, 2017  
**Website:** [www.intersolar.in](http://www.intersolar.in)

## International

### 18<sup>th</sup> POWER Sri Lanka 2017

**Venue:** Sri Lanka Exhibition & Convention Centre (SLECC)  
**Date:** 14-16 July 2017  
**Website:** <http://cems-powerseries.com/powersri/>

### Vietnam ETE 2017

**Venue:** SECC, Ho Chi Minh City  
**Date:** 19-22 July, 2017  
**Website:** [www.vietnam-ete.com](http://www.vietnam-ete.com)

### ENERGETAB

**Venue:** Bielsko-Biala, Poland  
**Date:** 12-14 September, 2017  
**Website:** [www.energetab.pl](http://www.energetab.pl)

### 12th International Wire & Cable Trade Fair for Southeast Asia

**Venue:** BITEC Bangkok, Thailand  
**Date:** 19-21 September 2017  
**Website:** <http://www.wire-southeastasia.com/>



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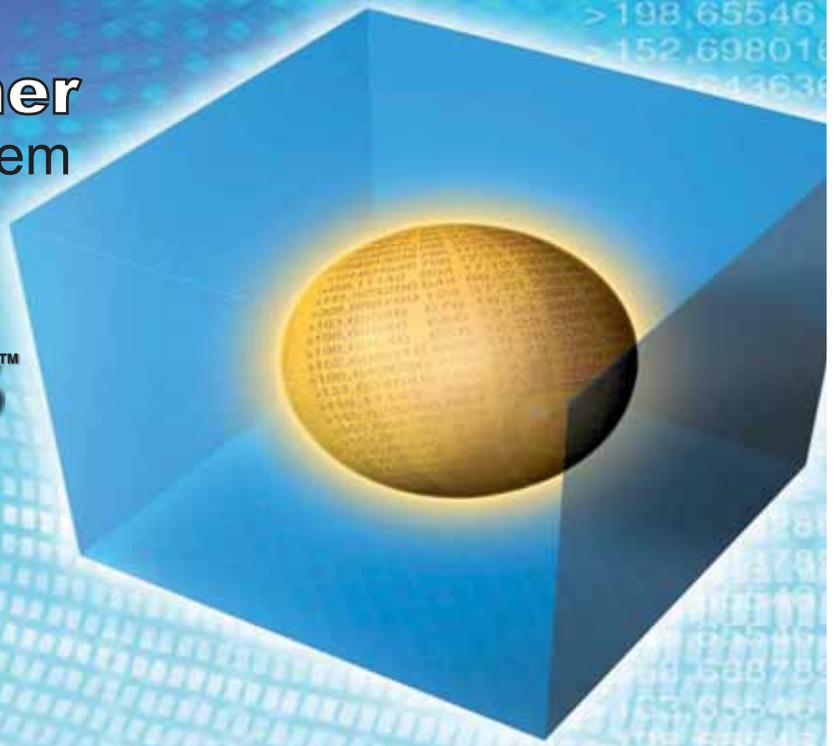
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