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Electrical India

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Power Sector in 2019 & Beyond

INSIDE

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Publisher's letter

After coal, gas, hydroelectricity and wind power, nuclear power is the fifth-largest source of electricity in India. The country's installed nuclear power capacity is expected to rise from the current 6,780 MW to 22,480 MW by 2031. Of late, India's nuclear power programme has attained a rare feat involving home-grown reactors.

On 10 December 2018, Unit 1 of Karnataka's Kaiga nuclear power plant, the indigenously designed pressurised heavy water reactor (PHWR), broke the previous world record for continuous operation by clocking 941 days of non-stop run establishing India as the frontrunner among all types of nuclear power reactors. Further, at around 11 pm on 31 December 2018, when Kaiga 1 was taken offline for scheduled inspections and maintenance, the unit accomplished its continuous operation of 962 days generating about 5 billion units of electricity. Moreover, the non-stop 962-day run at a plant load factor of about 99.3 per cent demonstrates the pre-eminence of NPCIL in the design, construction and operation of PHWRs with unprecedented levels of efficiency and safety.

In the time to come, it is expected that India will be able to create a vibrant domestic nuclear power eco-system that can help us achieve self-reliance.

Do send me your comments at miyer@charypublications.in

Mahadevan

Publisher & Editor-In-Chief

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EDITOR'S LETTER

2018: Year of mixed fortunes

The year 2018 was a mixed one for the Indian power sector. On the one hand, some major policies and programmes were announced to expand electricity access and to improve the health of distribution companies. On the other hand, shortage of fuel—especially coal for thermal power plants—was a major concern.

Power sector reforms remained a top priority for the government in power and '100 per cent electrification' claims to be one of the biggest achievements in this direction. "28th April 2018 will be remembered as a historic day in the development journey of India. Yesterday, we fulfilled a commitment due to which the lives of several Indians will be transformed forever! I am delighted that every single village of India now has access to electricity," Prime Minister Narendra Modi announced. However, reports suggest, around 178 million people in India still live off the grid with no access to electricity. In 2019, this is expected to provide an impetus for the growth in terms of providing last mile connectivity and meeting increased electricity demand.

Though India has made giant strides in the area of reducing power outages, it still suffers from high transmission and distribution losses. At 22 per cent, it is among the highest in the world. Advanced technologies like smart grids and smart meters can play a crucial role in mitigating T&D losses. Of late, the government announced its plans to make all electricity meters smart prepaid in three years commencing 1st April, 2019. This move will bring revolution in power sector by way of reduction in aggregate technical & commercial (AT&C) losses.

So, in 2019, the power sector is expected to witness a lot of transformation which will unfold new opportunities to explore.

Subhajit Roy
Group Editor

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Rahul Prithiani,
Director, CRISIL Research

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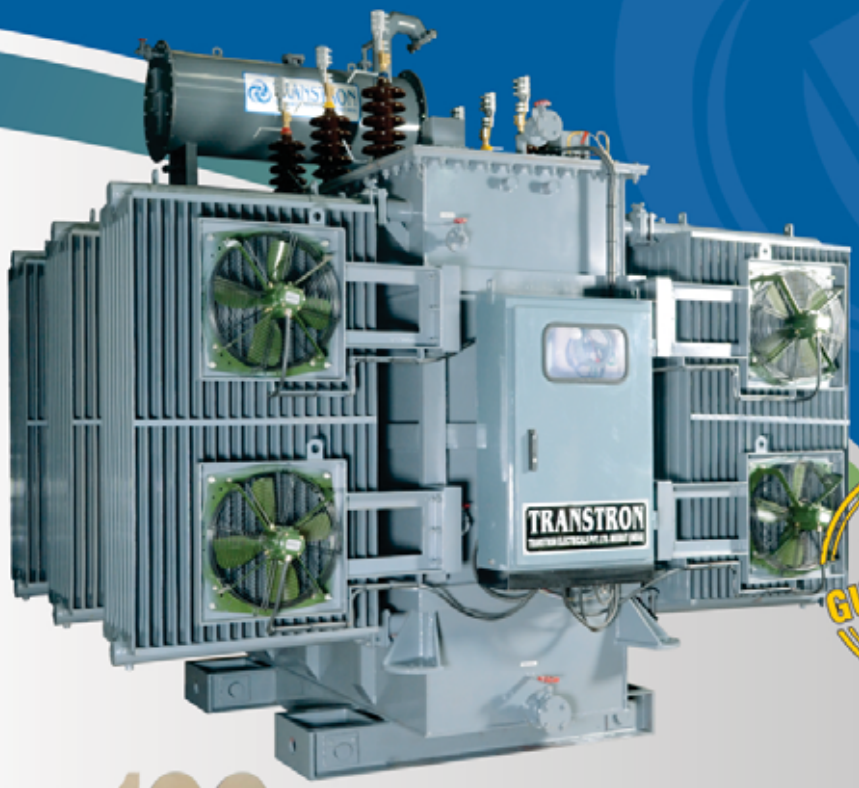

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Govt Plans to Make All Meters Smart Prepaid in 3 Years

The Ministry of Power has decided to make all meters smart prepaid in three years from April 1, 2019. This step is likely to bring revolution in power sector by way of reduction in AT&C losses, better health of DISCOMs, incentivisation of energy conservation, ease of bill payments and doing away with the paper bills. Move towards smart meters is a pro-poor step as consumers need not pay the whole month's bill in one go, instead they can pay as per their requirements. Manufacturing of smart prepaid meters will also generate skilled employment for the youth.

Earlier the State Governments had signed the Power for All document and had agreed to supply 24 hours power supply to their consumers. Thus, the distribution licensee shall provide 24 hours power to their consumers by 1st April, 2019 or earlier.

Rawatbhata Atomic Power Project to install BHEL's Nuclear Steam Generator

Bharat Heavy Electricals Limited (BHEL) has achieved a major milestone with the despatch of its 40th nuclear steam generator to the Nuclear Power Corporation of India Ltd (NPCIL). The steam generator, to be installed in NPCIL's Rajasthan Atomic Power Project (RAPP), was flagged off recently from BHEL's Trichy plant in the presence of senior officials of BHEL and NPCIL. BHEL has been catering to the nation's Nuclear Programme since 1976 by way of design, manufacture, testing and supply of critical nuclear components like reactor headers, steam generators, other heat exchangers and pressure vessels.

The first stage of the indigenous nuclear power program of the country has attained maturity with 18 operating Pressurised Heavy Water Reactors (PHWRs). Twelve PHWRs accounting for 74 per cent of the nuclear power capacity are equipped with BHEL-supplied steam turbine generator sets (10 units of 220 MW each and two units of 540 MW). Notably, BHEL is the only Indian company associated with all the three stages of the Indian Nuclear Power Programme-the first stage PHWR, the second stage Fast Breeder Reactor (FBR) and the third stage Advanced Heavy Water Reactor (AHWR) and has been a partner for over four decades in the development of the indigenous Nuclear Power Programme since its inception.

NTPC Group Crosses 5 Trillion Units Generation Mark

NTPC Group has generated 5 trillion units of electricity on 30th November 2018 from its power stations spread across the country since inception. NTPC with an installed capacity of 52,946 MW has 20 coal based, 7 gas based, 11 solar PV, 1 hydro, 1 small hydro, 1 wind and 9 subsidiaries or joint venture power stations. The company has projects of over 20,000 MW under construction at multiple locations in the country. NTPC has been ranked No.1 Independent Power Producer and Trader globally in the Platts global company rankings 2018.

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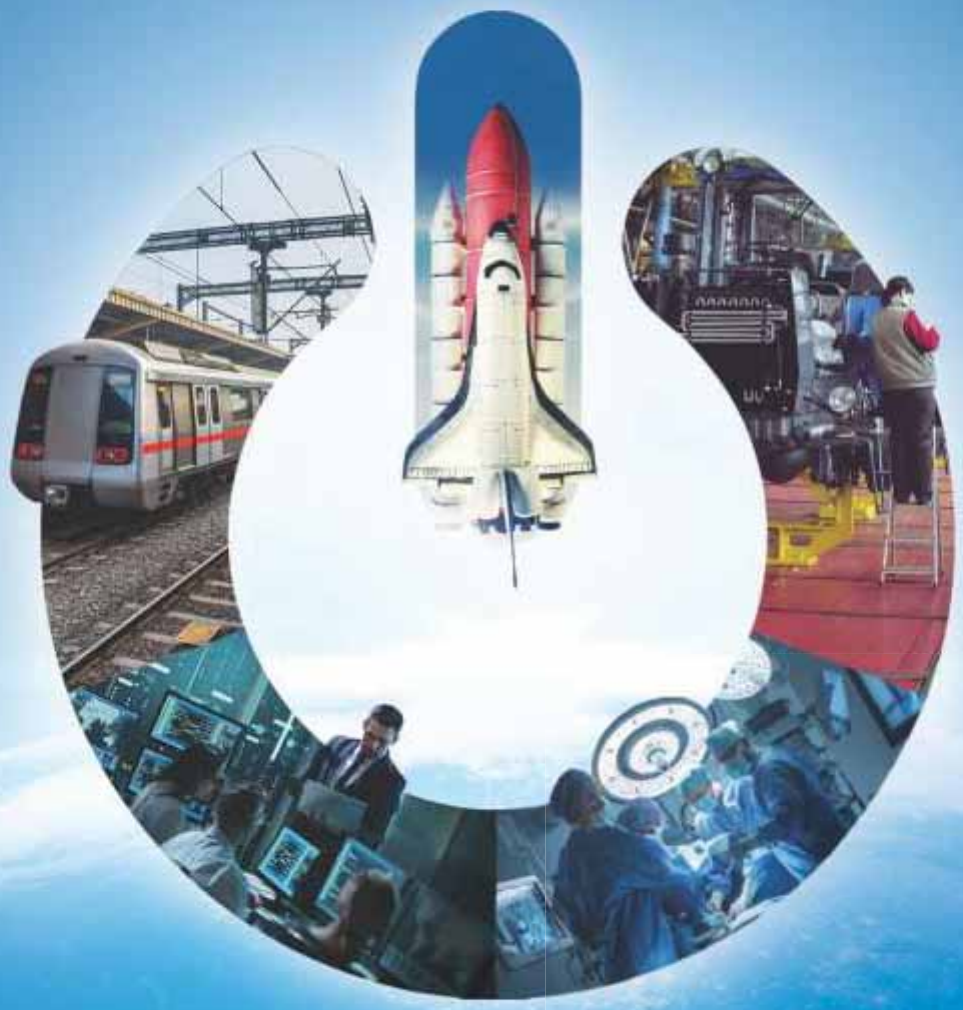

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Azure Power Commissions 95 MW Project in Gujarat Ahead of Schedule

Azure Power announced the early commissioning of a 95 MW solar power plant in Gujarat which was completed in record time for a ground mount project built by the company and has been commissioned approximately five months ahead of the scheduled PPA operation date. This section is the first phase of a 260 MW allocation by Gujarat Urja Vikas Nigam Ltd (GUVNL) to Azure Power and was developed outside a solar park. Azure Power will provide power for 25 years at a tariff of Rs 2.67 (~US 3.9 cents) per kWh to GUVNL which has a strong offtake credit and has been rated AA- by ICRA, a Moody's company.

Azure Power developed and is operating India's first MW-scale distributed solar rooftop project in Gandhinagar. Inderpreet Wadhwa, Founder, Chairman and Chief Executive Officer, Azure Power said, "With the early commissioning of this plant we have set a new record for the company on delivering projects ahead of schedule, once again demonstrating our strong project development, engineering, and execution capabilities. "

Eco Niwas Samhita 2018 to Save 125 bn Units of Power By 2030

Giving a further fillip to India's energy conservation efforts, the Ministry of Power has launched the ECO Niwas Samhita 2018,an Energy Conservation Building Code for Residential Buildings (ECBC-R).The Code was launched on the occasion of National Energy Conservation Day 2018 in the presence of Chief Guest Sumitra Mahajan, Speaker, Lok Sabha and R K Singh, Minister of Power and New and Renewable Energy recently. Implementation of this Code will have potential for energy savings to the tune of 125 billion units of electricity per year by 2030, which is equivalent to about 100 million ton of CO_2 emission.

While launching this ECBC-R, R K Singh stated that building sector will have highest growth in energy demand in coming 10-15 years. Government is encouraging all building professionals including architects, builders to generate awareness towards energy conservation while constructing new residential homes.

The implementation of this Code will give a fillip to energy efficiency in residential sector. It aims to benefit the occupants and the environment by promoting energy efficiency in design and construction of homes, apartments and townships. This Code has been prepared after extensive consultations with all stakeholders, consisting of architects and experts including building material suppliers and developers.

GAIL Gas MoU with EESL to fast-track co-generation & tri-generation projects

GAIL Gas Limited, a subsidiary of GAIL (India) Limited, has signed a Memorandum of Understanding (MoU) with Energy Efficiency Services Limited (EESL) for fast-tracking the implementation of co-generation and tri-generation projects and use of natural gas in industrial and commercial segments. The MoU was signed by A K Jana, Chief Executive Officer, GAIL Gas and Saurabh Kumar, Managing Director, EESL in the presence of Gajendra Singh, Director (Marketing), GAIL (India) Limited and Director, GAIL Gas and Rajeev Mathur, Director GAIL Gas at INSPIRE 2018 conference. The MoU is set to benefit

advantages of combined heat and power technology.

It will help increase the consumption of natural gas through City Gas Distribution networks in co-generation and tri-generation projects, being a natural choice for operating the gas engines. Under the MoU, EESL will manage equipment at the customer's location and GAIL Gas will supply natural gas to the feasible projects with in the authorised geographical areas.

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Sterlite Power Wins Transmission Project in Brazil

In the recently concluded auction for transmission projects in Brazil, Sterlite Power emerged as the winner for the project of development of six substations. The project will require an investment of USD 0.6 billion over the period of next three to five years in the state of Rio Grande do Sul, south region of the country. This addition increases the portfolio of Sterlite Power to ten projects.

Talking about Brazil and the company's investment in the region, the Group CEO of Sterlite Power Pratik Agarwal said, "We feel proud and honoured to be part of the Brazilian growth story. Our motivation to work on the toughest transmission projects that empower humanity has been the cornerstone of our journey in Brazil. We feel committed to the region and look forward to delivering the new project ahead of schedule."

Sterlite Power CEO in Brazil Rui Chammas said, "We are happy to have won this project in the current auction. I must congratulate ANEEL for providing a visible pipeline of projects and for the transparent way of conducting these auctions."

EPCOS India rechristened as TDK India

TDK Corporation announced that it has changed the name of its subsidiary EPCOS India Private Limited (EPCOS India) to TDK India Private Limited (TDK India) with effect from December 13, 2018. The name change took place within the scope of renaming of all EPCOS entities worldwide after EPCOS AG, the parent company of the EPCOS Group, was renamed to TDK Electronics AG on October 1, 2018.

This change will further strengthen the uniform market presence of the TDK Group in India.

The new company name will have no effect on the EPCOS product portfolio, the organizational and business structure of the company, or the scope of its services.

TDK Corporation has been present in India since 2008 when it acquired EPCOS AG, and with it EPCOS India. TDK India has a network of design and manufacturing locations for film capacitors and ferrites and sales offices all over the country. In fiscal 2018 (ending in March) the company employed more than 2200 people and posted sales of more than Rs 800 crore.

Schneider Electric Rolls Out Pilot Project for Electricians in UP

Schneider Electric rolled out its pilot project in Lucknow to spread awareness about the Government of India's flagship healthcare programme 'Ayushman Bharat PM-JAY' among the region's electricians. Schneider Electric will be conducting the project in association with National Health Agency team, which is the apex body for the implementation of PM-JAY.

Talking about the association with Schneider Electric, Dr Indu Bhushan, CEO, Ayushman Bharat-Pradhan Mantri Jan Arogya Yojana, said, "We are happy about this unique association. One of the objectives of the scheme is to change healthcare seeking behaviour among the poor who have not been able to access quality healthcare and often fall below poverty line due to catastrophic health expenditure arising out of serious illness. This partnership with Schneider Electric will help reach out to some of the principal stakeholders and help spread the word around Ayushman Bharat PM-JAY". Srinivas Shanbhouge, Vice President-Retail, Schneider Electric-India, said, "Schneider Electric firmly believes that all sections of the society should have access to energy as well as quality healthcare facilities. Aligned with this belief, the company has partnered with the Government of India's flagship healthcare initiative to spread awareness among electricians about the comprehensive health insurance scheme that has started to deliver high quality healthcare to the needy."

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Suzlon Secures 50.4 MW order from Atria Power

Suzlon Group has secured its maiden order for development of 50.4 MW wind power project from Atria Power. Suzlon will install 12 units of S111-140m and 12 units of S120-140m wind turbine generators (WTGs) with a Hybrid Lattice Tubular (HLT) tower with rated capacity of 2.1 MW each. The project is located in Tuticorin, Tamil Nadu and is in advanced stages. It will be commissioned in two phases by H1, FY20. This order formed a part of our Letter of Intent (LoI) orders of 484 MW. Suzlon will execute the project on turnkey basis and will also provide comprehensive operation and maintenance services.

Sunder Raju, Director, Atria Brindavan Power said, "The project will further our footprint in Tamil Nadu's commercial and industrial (C&I) energy space. We are simultaneously working on converting this plant into a Wind-Solar PV hybrid plant to provide a more reliable energy supply to our customers. We are pleased to partner with Suzlon, given their technologically advanced products, EPC capabilities, operations and maintenance services."

SmartE to Introduce Mahindra Electric's 10000 e-three wheelers

Mahindra Electric Mobility and SmartE signed a Memorandum of Understanding (MoU) to drive electric mobility forward in India. Under the MoU, SmartE will introduce the first 1,000 Mahindra Treo and Treo Yaari electric three-wheelers in Delhi-NCR by March 2019. The company also plans to deploy a total of 10,000 Mahindra electric three-wheelers across the country by 2020. The MoU was signed by Mahesh Babu, CEO, Mahindra Electric and. Goldie Srivastava, Co-founder and CEO, SmartE, in New Delhi.

The two companies in the electric mobility market will offer convenient, affordable and zero-emission last-mile connectivity, not just for the NCR region but also for major cities across the country.

Mahesh Babu, CEO, Mahindra Electric, said, "India is witnessing rapid urbanisation and metros are driving the multi-modal mobility needs of the large working population in urban cities. Our Treo range of three wheelers will address the demand for first and last mile connectivity and transform the way urban India travels. Associations with partners such as SmartE will make it easier to adopt electric mobility."

Vikram Solar Commissions 100 kW Rooftop Solar project for Parijat Industries

Vikram Solar installed a 100 kW grid tied rooftop solar PV system for Parijat Industries in Ambala, Haryana. The project covers a space of 1100 square metres, and 292 monocrystalline 345 Wp modules were used to power two factory sheds of Parijat Industries.

The system will produce an approximate 1.5 lakh units of electricity annually and reduce carbon emissions by nearly 123 metric tonnes in a year.

Neha Agrawal, Head of Corporate Strategy and Rooftop Business, Vikram Solar, shared on the occasion, "It was a privilege for us to aid Parijat Industries in their decision towards adopting green energy. Like every project, we brought forward quality, performance and customer centricity in delivering state-of-the-art solutions for the company. We are hopeful that Parijat Industry's first step towards solar revolution will begin a long-lasting association with Vikram Solar for all future expansions."

Rahul Shriram Surwade, Manager, Parijat Industries, shared, "We at Parijat are deeply committed to being a responsible and environmentally conscious company. Contribution to green energy shift is another step towards upholding India's values mission and vision, and we appreciate Vikram Solar's solution in this matter."

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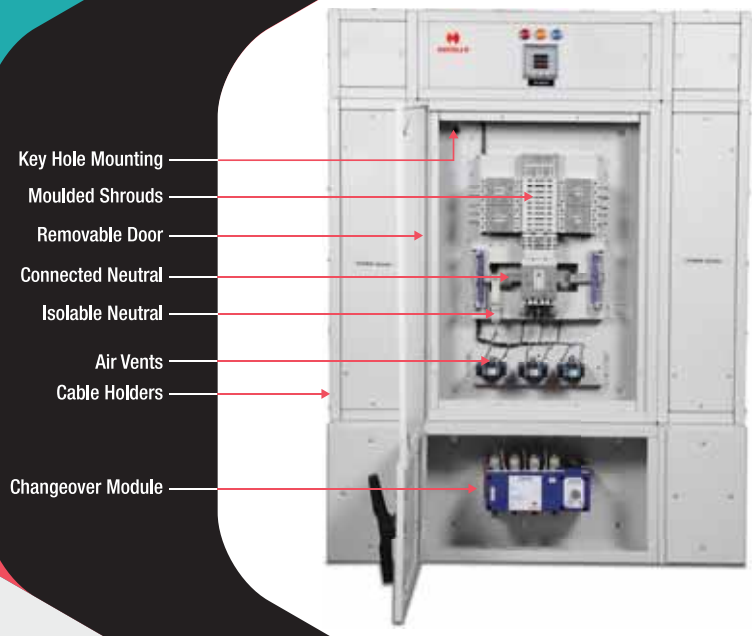

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KEC International Wins New Orders of Rs 1,491 Cr

KEC International has secured new orders of Rs 1,491 crore across its businesses. Transmission and Distribution Business has secured turnkey orders of Rs 1,257 crore across India, SAARC, East Asia Pacific, Middle East, and the Americas. The project order book consists of order from PGCIL for diversion works of various transmission lines, 220 kV cables - supply and laying order from WBSETCL, 400 kV transmission line project in Bangladesh, 220 kV transmission line project in Nepal, 500 kV transmission line project in Thailand, and 132 kV GIS substation project in Dubai.

SAE Towers has received an EPC order of 500 kV transmission line in Brazil and other orders in the Americas The Cables Business has secured orders of Rs 120 crore for various types of cables. The Railway Business has secured an order of Rs 114 crore for overhead electrification works and associated civil works in Eastern India. Vimal Kejriwal, MD & CEO, KEC International commented, "We are delighted with the new order wins especially in the international markets in our core T&D business. The substation order in Dubai along with the earlier transmission line order will help in strengthening our position in the Middle East market. The order wins in SAARC and Brazil reaffirm our faith, in these regions being major growth drivers for us."

Hitachi to Buy ABB's Power Grids Unit Valued at $11 Bn

Hitachi Ltd. announced that it has decided to acquire the power grids business from ABB Ltd and has signed an agreement with ABB. Hitachi plans to initially acquire an 80.1 per cent stake in the power grids business and expects to close the acquisition in the first half of 2020. Hitachi has entered into a purchase option to acquire the remaining 19.9 per cent stake in power grids.

"Hitachi and ABB agreed to the enterprise value of the company operating power grids business separated from ABB as US$11 billion. The purchase price of 80.1 per cent stake is expected to be approx. US$6.4 billion after deducting debt like item from the enterprise value," a statement issued by Hitachi said.

Toshiaki Higashihara, President and CEO of Hitachi said, "Today's agreement between ABB and Hitachi is a significant turning point in the global energy markets at a time when digital technology is changing our society and the pattern of energy demand and supply is diversifying. Hitachi will combine ABB's strengths in the power grids business with our digital technology to build an energy platform that contributes to innovating the energy business. This creates further innovation for business fields such as life and industry."

Fortum to Build a 250 MW Solar Power Plant in India

Fortum won the right from Gujarat Urja Vikas Nigam to build a 250 MW solar power plant in Raghanesda solar park in Banaskhata district of Gujarat. The plant will be commissioned in the fourth quarter of 2020. The capital expenditure is estimated to be approximately EUR 135 million and the solar park will be entitled to a fixed tariff of 2.89 INR/kWh for 25 years. Based on its strategy, Fortum will continue to build on its long-standing expertise to grow in CO2-free power generation. In solar and wind, the ambition is to increase the solar and wind portfolio to a multi-gigawatt scale in home markets. Fortum's business model in renewables consists of development, construction and asset management of solar and wind assets. Fortum utilises partnerships and other forms of co-operation to maintain a more asset-light structure.

The company owns 85 MW solar capacity in India and 35 MW in Russia. In June, Fortum won the right to build 250 MW of solar in India which is currently under construction and expected to be commissioned in 2019. In Russia, Fortum has 110 MW of solar capacity under development.

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Sterlite Power Announces Financial Closure of Arcoverde project

Sterlite Power, a global power transmission company announced the financial closure of their Arcoverde project in Brazil. This closure was successfully achieved in the month of November, 2018. Arcoverde project was won by Sterlite Power during the auction conducted by ANEEL in April, 2017 and the concession was signed in August 2017.

This project includes building 139 km transmission line, constructing one greenfield and two brownfield substations. With the project clearances in place and land acquisition completed, the project is in advanced stages of completion.

Anuraag Srivatava, Group CFO, Sterlite Power, said, "It is a matter of immense pride that we have managed to achieve financial closure for this project in a short period of time. This will allow us to focus on completing the project ahead of schedule, in accordance with our track record. The partnership with bankers has been extremely smooth and we thank them for extending a warm welcome to us."

GE Renewable Energy to Provide Turbines for 300 MW Wind Farm

GE Renewable Energy has been selected by ReNew Power to provide 120 GE 2.5-132 turbines for the Gadhsisa Wind Farm in Gujarat. The wind farm will have a total installed capacity of 300 MW, making it the largest full turnkey EPC (engineering, procurement and construction) project by GE Renewable Energy in India. The project will power the equivalent of 11 lakh homes in India with clean and reliable electricity. ReNew Power successfully bid for this project in the third round of auctions conducted by the Solar Energy Corporation of India (SECI) in February 2018.

The 2.5-132 turbines have been designed primarily at GE's Technology Centre in Bangalore and built on learnings from more than 22,000 GE wind turbines around the world. This turbine is a significant improvement over previous version with improved rotor diameter, wind capture and 30 per cent more Annual Energy Production (AEP) than GE's 2.3-116 turbine.

Mahesh Palashikar, Region Leader for GE Renewable Energy's Onshore Wind business in Asia, said, "We are delighted to have the opportunity to work with ReNew Power on this project. This is an important milestone for GE in India and this relationship with ReNew will help us expand our turnkey Balram Mehta, President - Wind, ReNew Power said, "GE Energy, with its customised maintenance support and suite of modern turbines driven by cutting edge technology was a natural choice as our partner for this critical project. By leveraging our combined strengths and synergies, we hope to make a significant contribution towards augmenting renewables capacity in India."

Cabinet Approves MoU between France & India on EV

The Union Cabinet chaired by Prime Minister Narendra Modi was apprised of a Memorandum of Understanding (MoU) which has been signed between the Solar Energy Corporation of India Limited (SECI), India and Commissariat a l energieatomique et aux energies alternatives (CEA), French state-owned research entity and BlueStorage SAS, a French company. The MoU was signed on 3rd October, 2018 in New Delhi. The objective of the MoU is to define the modalities of discussions concerning, in particular, the future collaboration regarding in a pilot project to provide SECI an e-vehicle charging station with embedded batteries, powered by solar panels and optimised connection to the grid in order to support the Indian government's ambitious plan for the deployment of electrical vehicles by maximising solar mobility and minimising its grid impact. The MoU will help in strengthening bilateral cooperation between India and France.

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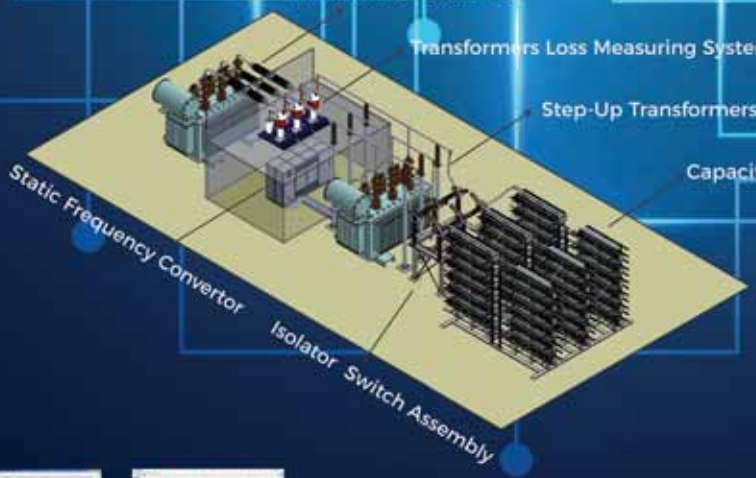

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Gener Miao Appointed as Vice President Global Sales and Marketing of JinkoSolar


Gener Miao

JinkoSolar Holding announced the appointment of Gener Miao as its Vice President Global Sales and Marketing. Miao previously served as Chief of Staff for JinkoSolar's Chairman since 2010. Prior to 2010, Miao worked at Fosun Group's Tebon Securities and Ingersoll Rand China Investment. Miao received his MBA from the China Europe International Business School, his master's degree in finance and economics from the University of Southampton, and his bachelor's degree in mathematics and applied mathematics from Tongji University.

"Miao has served JinkoSolar diligently since 2010 and made substantial contributions to the company's development. I am pleased to announce his appointment as the Company's VP Global Sales and Marketing," commented Xiande Li, Chairman of JinkoSolar. "His experience, expertise and knowledge of JinkoSolar's operations and global sales and marketing will allow him to hit the ground running and achieve success in his new role."

ERDA appoints Hitesh Karandikar as Director


Hitesh Karandikar

Electrical Research and Development Association (ERDA) has announced appointment of Hitesh R. Karandikar as the new Director.

Karandikar is a Graduate Electrical Engineer from Gujarat University. He has completed his MBA on Finance and Marketing from Sikkim Manipal University and has obtained a PG Diploma in Human Resources from M.S. University, Vadodara. He brings with him 27 years of industry experience from GEB, DNV, KLG Systel, Bureau Veritas and GETRI. In his last assignment, Karandikar was working as Director GETRI (under GUVNL).

"ERDA is on a continuous growth trajectory over the last few years and is diversifying into various new domains in the field of testing & evaluation, field services, R&D and expert services. With the sustained growth of the organisation, it has been decided to strengthen the management team of the organisation," ERDA said in a statement.

Manoj Kumar Varma Appointed as Director (Power) BHEL


Manoj Kumar Varma

Manoj Kumar Varma, has assumed charge as Director (Power) on the board of Bharat Heavy Electricals Limited (BHEL). Prior to this, he was heading the company's power sector - Southern Region (PSSR), Chennai as Executive Director. Significantly, PSSR is executing major power projects in the southern region, contributing substantially to BHEL's power sector business segment. He is a mechanical engineering graduate from SGSITS, Indore and an MBA in Marketing from Bhopal University.

He has 35 years of experience in the field of energy, industrial systems and infrastructure industries, covering major value chain functions viz. production, commercial management, marketing and business development, contract management, planning and development, information technology and strategic management.

Varma joined the company as an engineer trainee at BHEL's Transformer Plant, Jhansi and subsequently moved to its heavy electrical plant, Bhopal where he worked in various capacities. Subsequently, he was transferred to the company's industry sector business segment headquarters, New Delhi as General Manager. During his career in BHEL, he has also headed the Ceramic Business Unit of BHEL, Bengaluru with the Electroporcelains Division (EPD, Bengaluru) and Insulator Plant (IP, Jagdishpur) under its ambit.

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Transformer Thermal Image

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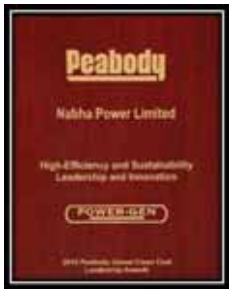
L&T's Nabha Power Wins Global Clean Coal Technologies Award

Nabha Power Limited (NPL), a wholly owned subsidiary of Larsen & Toubro, received global recognition for high-efficiency, sustainability, leadership and innovation during the fifth Annual Peabody Global Clean Coal Leadership Awards. The awards were recently presented at POWER-GEN International in Orlando, Florida, USA.



The award was in recognition of NPL's 1,400 MW coal-based supercritical thermal power plant at Rajpura, Punjab achieving the best heat rate and auxiliary power consumption amongst India's 660-megawatt class for FY 2017–2018, along with 100 per cent dry fly ash utilisation and zero liquid discharge. Commenting on this recognition, Shailendra Roy, Whole-Time Director, Larsen & Toubro said, "We are delighted to have received this global recognition highlighting our unwavering commitment towards environment, innovation and clean fuel technologies."

Roy added, "Nabha Power has demonstrated exemplary leadership in innovating and benchmarking best O&M practices in the power sector to achieve high availability, PLF and efficiency during the year 2018. The award also validates L&T's capability to deliver large size supercritical power plants on complete EPC basis that are technologically proven and are best in class performers on a sustained basis."

Akhila Reddy Gets CII IWN Telangana Leadership Award

Confederation of Indian Industry with IWN Telangana Leadership Conclave awarded Akhila Reddy, Managing Director of Sturdy Volt Pvt Ltd for achieving excellence in her field of work i.e. compact and light weight On-Load Tap-Changer (OLTC).

OLTC manufactured at Sturdy Volt is an entire new design and a new approach to the transformer industry. Its compact size, reduced weight, easier assembly, long lasting, easy maintenance makes OLTC a very unique one. Coming up with lot of advanced technologies this OLTC will make a value in the market. 25 OLTCs can be manufactured in a single day, and hence delivery being at its fastest rate.

Sturdy Volt is a company based in Hyderabad focusing on providing the best quality components to transformer manufacturers. The company is equipped with a world class manufacturing facility with in-house 3D design competence. It manufactures components such as Cast Resin Coils up-to 36kV class, Marshaling boxes, and Remote Tape Changer Control Cubical (RTCC).

CRI Pumps Wins National Energy Conservation (NEC) Award 2018

CRI Pumps has won the National Energy Conservation Award 2018 in Pumps Category for manufacturing energy efficient pumps for the fourth time. G Selvaraj, Joint Managing Director, CRI Group said, "We pursue excellence and the awards are a natural result of our mission to conserve energy. It is a matter of honour to receive this prestigious award for the fourth time. All through the years CRI has endeavoured to offer energy efficient pumps through innovative design and technology. This in turn greatly benefits the customer, environment, society and the world at large. C.R.I. would tirelessly continue on its mission to conserve energy, a very scarce natural resource. "

CRI offers a range of BEE 5-Star rated pumps for various applications. CRI's energy efficient products are well recognised by various Government Institutions, as trustworthy products for various projects across the globe to save energy. CRI is the contributor in the country for the projects of EESL (Energy Efficiency Services Limited) to replace the old inefficient pumps with 5-Star rated smart pumps with IoT. Until now, CRI has installed over 10 lakhs Star-Rated Pumps across the country resulting in a cumulative saving of more than 9,000 MUs of power for the nation.

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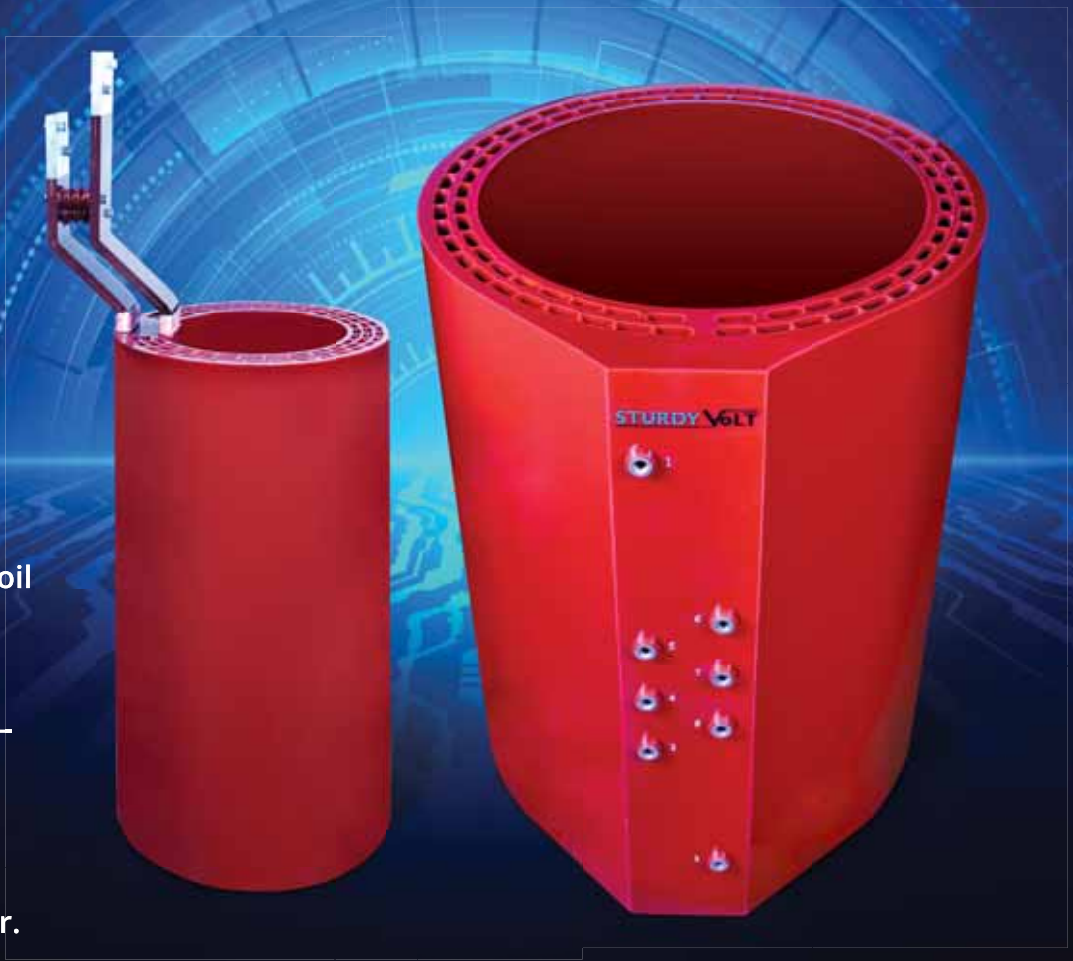

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Global Energy Storage Market to attract USD 620 bn by 2040

The tumbling cost of batteries is set to drive a boom in the installation of energy storage systems around the world in the years from now to 2040, according to the latest annual forecast from research company Bloomberg New Energy Finance (BNEF).

The global energy storage market will grow to a cumulative 942GW/2,857GWh by 2040, attracting USD 620 billion in investment over the next 22 years. Cheap batteries mean that wind and solar will increasingly be able to run when the wind isn't blowing and the sun isn't shining.

BNEF's latest Long-Term Energy Storage Outlook sees the capital cost of a utility-scale lithium-ion battery storage system sliding another 52 per cent between 2018 and 2030, on top of the steep declines seen earlier this decade. This will transform the economic case for batteries in both the vehicle and the electricity sector.

Yayoi Sekine, energy storage analyst for BloombergNEF and co-author of the report, said, "We have become much more bullish about storage deployments since our last forecast a year ago. This is partly due to faster-than-expected falls in storage system costs, and partly to a greater focus on two emerging applications for the technology – electric vehicle charging, and energy access in remote regions."

Logan Goldie-Scot, Head of Energy Storage at BNEF, added, "We see energy storage growing to a point where it is equivalent to 7 per cent of the total installed power capacity globally in 2040. The majority of storage capacity will be utility-scale until the mid-2030s, when behind the meter applications overtake."

Behind-the-meter, or BTM, installations will be sited at business and industrial premises, and at millions of residential properties. For their owners, they will perform a variety of tasks, including shifting grid demand in order to reduce electricity costs, storing excess rooftop solar output, improving power quality and reliability, and earning fees for helping to smooth voltage on the grid.

China, the US, India, Japan, Germany, France, Australia, South Korea and the UK will be the leading countries. These nine markets will represent two thirds of the installed capacity by 2040. In the near-term, South Korea will dominate the market, the US will take over in the early 2020s, but will be overtaken by China in the 2020s. China will then lead throughout to 2040.

Especially, developing countries in Africa will also see rapid growth in battery storage. Utilities are likely to recognise increasingly that isolated assets combining solar, diesel and batteries are cheaper in far flung sites than either an extension of the main grid or a fossil-only generator," the report says.

BNEF analysis estimates energy storage build across multiple applications to meet variable supply and demand and to operate the grid more efficiently, while taking into account customer-sited economics for using storage as well as system-level needs. Aggregating BTM energy storage could be a viable alternative to utility-scale for many applications but it will take years before regulatory frameworks in some countries fully allow this. There is significant opportunity for energy storage to provide flexibility – to help balance variable supply and demand – and systems will undoubtedly be used in complex ways. Energy storage will become a practical alternative to new-build generation or network reinforcement. Behind-the-meter storage will also increasingly be used.

Despite the rapid growth from today's levels, demand for batteries for stationary storage will make up only 7 per cent of total battery demand in 2040. It will be dwarfed by the electrical vehicle market, which will more materially impact the supply-demand balance and prices for metals such as lithium and cobalt. EI

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Power Sector in 2019 & Beyond

Indian power sector is poised to attract investments worth Rs 11,55,652 crore between 2017 and 2022. Let's see what's in store for power sector in 2019 and beyond.

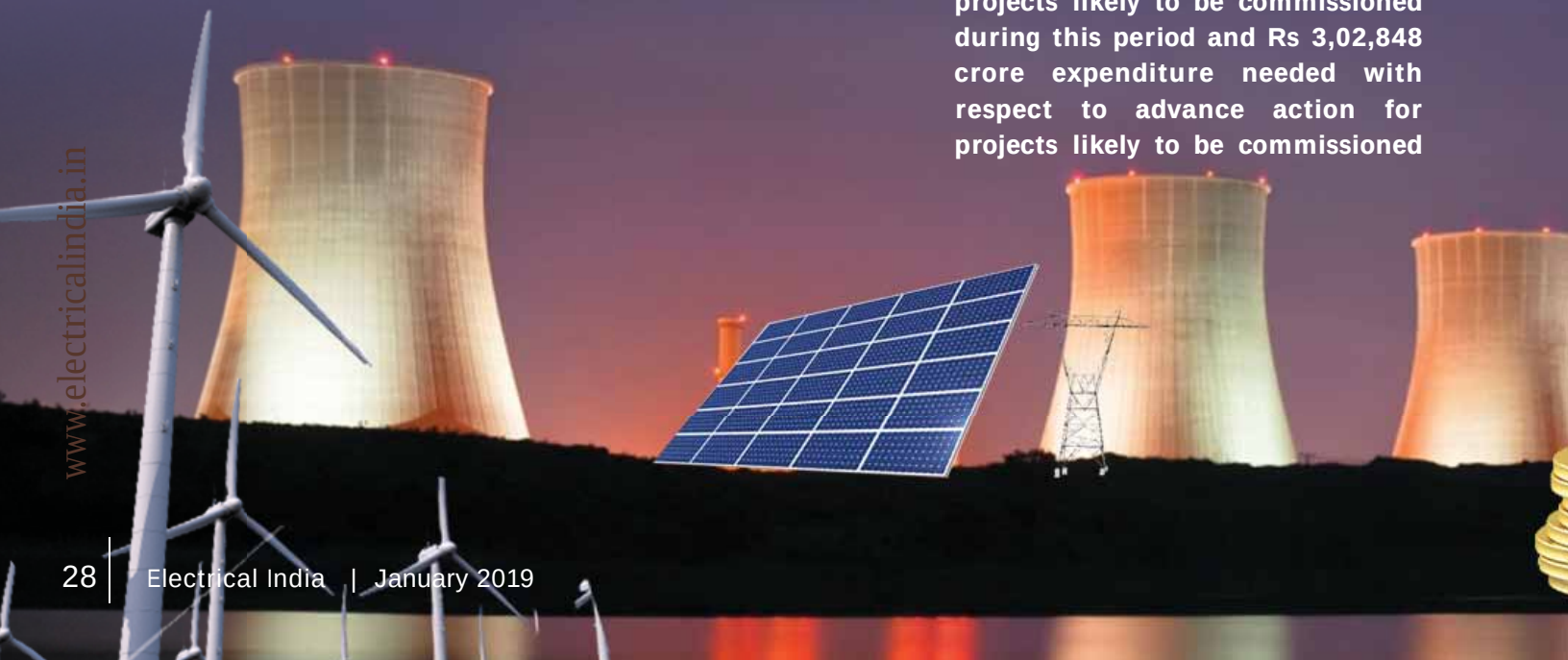
By Subhajit Roy, Group Editor

The power sector in India is witnessing exponential growth like never growth. With a total installed power generating capacity of 3,46,048 MW as of October 2018, India emerges as the world's third-largest electricity producer.

Further, a total capacity addition of 58,384 MW from conventional sources has been envisaged for the period 2017-2022, consisting of 47,855 MW of coal-based power stations, 406 MW of gas-based power stations, 6,823 MW of hydro power stations and 3,300 MW of nuclear stations. In addition, there has been a big thrust by the government for setting up renewable power generation capacity of 175 GW by the year 2022.

According to the National Electricity Plan (NEP) report published by the power ministry's planning wing, Central Electricity Authority, such huge project execution will attract an investment of Rs 11,55,652 crore in power generation sector in the five-year period between 2017 and 2022.

The total fund requirement of Rs 11,55,652 crore for 2017-22 includes Rs 8,52,804 crore investment in projects likely to be commissioned during this period and Rs 3,02,848 crore expenditure needed with respect to advance action for projects likely to be commissioned



Sector	MW	% of Total
State	83,922	24.3%
Central	103,030	29.8%
Private	159,096	45.0%
Total	**3,46,048**	

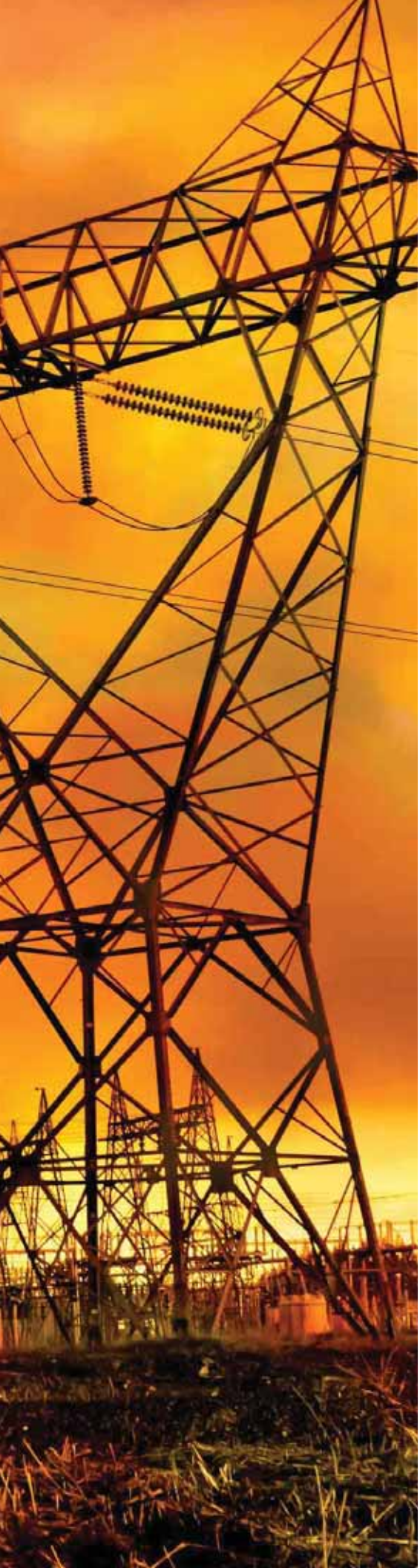
Table 1: Total Installed Capacity (as on 31.10.2018) Source: Central Electricity Authority (CEA)

in the next five-year period (2022-27).

Out of the fund requirement of Rs. 8,52,804 crore for the projects likely to be commissioned during 2017-22, Rs 1,42,566 crore would be required for central sector projects, Rs 92,889 crore would be required for state sector projects and Rs 6,17,349 crore for private sector projects. In this estimation, it is assumed that all the renewable projects will be implemented by private developers, the CEA's NEP report said.

Thermal PLFs set to improve, with sustained energy demand growth

Rating agency ICRA has estimated a healthy 6 per cent demand growth



for the power sector during FY2019 and has maintained a stable outlook for the segment. This coupled with the slowdown in addition of new capacity and slow progress in resolution of stressed thermal assets would enable a steady improvement in the utilisation of the existing capacity. If the demand growth of 6 per cent sustains over the next three years, the utilisation of the thermal capacity would improve to about 63 per cent in FY2020 and further inch upwards to about 67 per cent by FY2022.

"During the first seven months of FY2019, national power demand growth has remained at a steady 6.5 per cent which is higher than the 5.5 per cent reported in the first seven months of FY2018 and the full year growth of 6.2 per cent reported in FY2018. The rising demand is being met from higher generation by both thermal and renewable energy plants. This is reflected in the improvement in thermal power PLF to 61.1 per cent in the first seven months of FY2019 against 59 per cent in the first seven months of FY2018, and also 29.5 per cent higher generation from renewable energy sources (y-o-y basis)," ICRA reports.

Domestic coal availability and efficiency improvement by discoms remain critical

Sabyasachi Majumdar, Group Head & Senior Vice President, ICRA, says "The increased demand for electricity coupled with the shortfall in coal supply from domestic sources, has led to higher dependence on costlier coal imports in FY2018 and FY2019. The higher dependence on coal imports is augmented by the rising international coal prices and depreciation of rupee against dollar. The Indonesian coal price index has increased by about 16 per cent in the first 11 months of calendar year 2018 on a y-o-y basis. This has resulted in an upward pressure on cost of power purchase for the distribution utilities. Given this, augmentation of domestic coal supplies through both higher mining activity and improved rail infrastructure, remains crucial for the sector from a cost control perspective."

The relatively higher energy demand growth amid the state and central government elections over the next 6-month period, coupled with the domestic coal shortages

Continued on page 32

Power Sector in 2018 – Key Highlights

- 9 States achieved 100 per cent household electrification under SAUBHAGYA; total 16 states have 100 per cent household electrification now.
- More than 2 crore electricity connections released under SAUBHAGYA and 100 per cent village electrification achieved under DDUGJY.
- Energy deficit reduced to almost zero and India emerges as net exporter of electricity to Nepal, Bangladesh and Myanmar.
- 31.68 crore LED bulbs distributed under UJALA scheme and 74.79 lakh LED street lights have been installed.
- India's rank improved to 24 in 2018 from 137 in 2014 on World Bank's Ease of doing business - "Getting Electricity" Ranking.

(Source: Year End Review 2018 – Ministry of Power)

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Continued from page 30

(₹Crores)

	2017-18	2018-19	2019-20	2020-21	2021-22	Total
For projects likely to be commissioned during 2017-22	2,19,509	2,22,030	1,92,582	1,71,208	47,475	8,52,804
Advance action for projects likely to be commissioned during 2022-27	2,304	18,757	35,303	67,198	1,79,286	3,02,848
Total	2,21,813	2,40,787	2,27,885	2,38,406	2,26,761	11,55,652

Table 2: Total fund requirement for generation projects during 2017-2022 Source: CEA

have led to a sharp rise in spot power tariff in recent months. ICRA however notes that the high spot energy prices are unlikely to sustain in the medium term, given the significantly unutilised thermal power capacity available and rising generation from renewable sources.

On the distribution front, the implementation of the UDAY scheme has enabled a reduction in losses for the discoms at all India level, by about 43 per cent for FY2018, mainly from reduction in interest costs. Estimates of the Ministry of Power suggest that the aggregate losses of all discoms have fallen below Rs. 20,000 crore for FY 2018. However, the improvement in the operational profile of the discoms remains slow, given that the reduction in AT&C losses is much lower than expected across majority of the states.

Further, the tariff revision approved by the state regulators have remained lower than the revisions agreed in the UDAY MoUs. Going forward, the progress in improvement in the operating efficiencies as well as securing timely and adequate tariff hikes along with the subsidy support from the respective state governments remain important for improving the discom finances.

India strides towards clean energy leadership

Renewable energy is fast becoming a major source of power in India. As per Climatescope report by energy researcher BloombergNEF, India ranks second after Chile in the year 2018 with increased investments and clean energy installations, as well as the world's largest renewables auction market.

"India's ambitious clean energy policies and extremely competitive renewable energy market pushed the country to second position. The Indian market is home to the largest and most competitive auctions in the world, which contracted over 10.5 GW from wind and solar in 2017 alone. The country's solar market almost doubled in size in 2017, making it a record year with annual PV installations touching 8 GW," the report said.

Country	Climatescope 2018 score
Chile	2.63
India	2.57
Jordan	2.54
Brazil	2.52
Rwanda	2.31
Philippines	2.29
China	2.28
Mexico	2.25
Peru	2.24
Thailand	2.24

Source: BloombergNEF

India has also one of the world's most ambitious renewable energy targets. It aims to reach 175 GW of clean energy capacity by March 2022, with 100 GW coming from solar, 60 GW from wind, and 15 GW from other sources. The share of renewable energy in overall installed power generation capacity has increased from 9 per cent in March 2009 to around 20 per cent (which translates to capacity of around 71 GW) as on June 2018.

Rating agency ICRA anticipates the share of renewables in the total generation mix to increase by 5 per cent in next four years – from 7.7 per cent in FY18 to 12-13 per cent by FY22.

Amongst the Indian States, Karnataka is leading the race with

(₹Crores)

Year	Thermal	Hydro	Nuclear	Renewables	Total
2017-18	76,781	15,622	9,479	1,19,931	2,21,813
2018-19	73,376	19,465	9,728	1,38,218	2,40,787
2019-20	52,915	23,461	8,088	1,43,422	2,27,885
2020-21	55,846	26,431	11,912	1,44,218	2,38,406
2021-22	63,991	29,546	16,127	1,17,096	2,26,761
TOTAL	3,22,908	1,14,524	55,334	6,62,885	11,55,652

Table 3: Fund requirement for generation projects (mode-wise) during 2017-2022 (Rs crore)

Source: CEA

27 per cent of its power generation coming from renewable energy in 2018 whereas Maharashtra has extended its lead in the rooftop solar with 1,095 MW capacity.

Future is digitalisation

There is a lot of talk at the moment about how digital technologies will impact on a variety of aspects of our lives – power sector is not an exception. In an interview with Electrical India, Dr. Harald Griem, Executive Vice President and Head - Energy Management Division, Siemens Ltd. earlier said, "Digital and power electronics supported technologies will prove to be a game changer for the energy management and power sector in India. It will help consumer take center stage. The smarter, more decentralised, and yet more connected power system will help in achieving objectives like security, environmental sustainability, better asset utilisation and open new frontiers for businesses."

Opportunity for electrical equipment industry

According to the Central Electricity Authority's draft National Electricity Plan (Transmission), 2016, a line length addition of over 100,000 circuit kilometre and a substation capacity addition of about 290,000 MVA is envisaged during 2017-22. This is expected to enhance demand in the electrical equipment market. With the current focus on various schemes on the transmission and distribution sector, significant changes in the technology are expected in the products which will be deployed to improve supply reliability, quality and reduce losses. This will certainly have more focus on the research and development in product design, manufacturing and testing facilities.

Dr. Katsutoshi Toda, Executive Chairman, Toshiba Transmission and Distribution Systems (India) Pvt. Ltd. anticipates: Electrical industry will continue to grow in the coming years backed with proper industrial and sector-specific policy which will not only bring in investments in this sector but also transform it with latest technology and products.

Experts from the switchgear industry also believe government schemes like the Ujwal Discom Assurance Yojana (UDAY), the Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) and the Integrated Power Development Scheme (IPDS) will continue to create demand for the switchgears beyond 2019.

Conclusion

Of late, India has made significant strides in expanding access to electricity, as more than 130 million people joined the power grid since 2013. However, 178 million people in India still lacked access to grid electricity in 2017. The 2018 Global Competitiveness Report ranked India 80th among 137 economies in the reliability of electricity supply.

According to a new World Bank report titled, In the Dark: How Much Do Power Sector Distortions Cost South Asia, "Connecting all of India's population to the grid and expanding the power supply to 24 hours a day would increase the income of rural households by $9.4 billion a year, while eliminating power shortages would prevent an estimated $22.7 billion a year in business losses."

Ashok Khurana, Director General of Association of Power Producers (APP) earlier suggested: "To ensure that the households connected under SAUBHAGYA get adequate power, it is imperative that the states lagging in meeting their operational and financial milestones under UDAY are monitored very closely and brought on the path of commercial sustainability."

Finally, 2019 is going to be the mega election year for India. Whichever political party comes in to power, the next government must set its priorities straight in terms of providing reliable access to electricity for all!

Curbing Harmonics using Apparent Energy Metering

The article explains how an electrical revolution can be effectively triggered - where market sees rapid sales of efficient electrical appliances.

Traditionally, 'power quality' is considered to be a compatibility problem: is the equipment compatible with the power delivered by the grid including its events, and vice versa? Hence, ac power quality involves voltage, its frequency and waveform. If the supply voltage is steady, its frequency close to the rated and the voltage waveform a smooth sinusoid, the power quality is said to be good. In power quality, thus defined, the quality of electric current is simply ignored! Hence, wouldn't it be a more appropriate definition for 'voltage quality'? The above misinterpretation of 'power quality' has had major consequences. While utilities have been making sincere attempts to control and improve the voltage quality, it has simply ignored the current! Unlike voltage, current demanded by the load is in the hands of the consumers, who, under the active energy tariff regime, are largely uncontrollable. Consumers have been observed, lately, to be connecting non-linear loads that are polluting the electrical system by injecting harmonics.

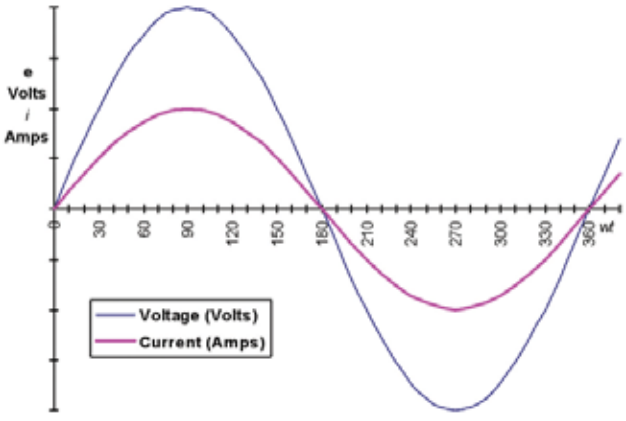

Figure 1: Ideal AC voltage and current waveforms

What are Harmonics?

Just as still water when disturbed

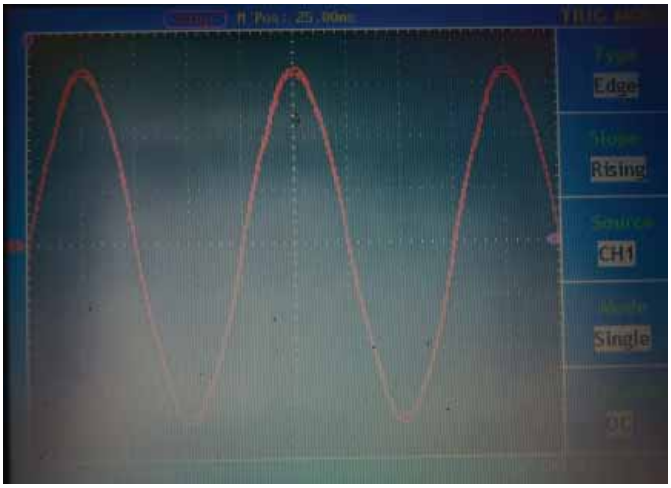

Figure 2: A 230V ac voltage waveform at consumer end

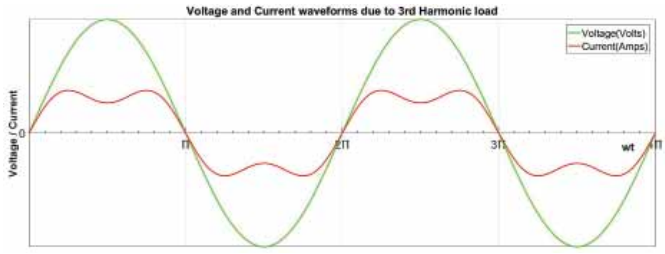

Figure 3: Voltage and Current waveforms of load injecting 3rd harmonic current

form ripples, a standard sinusoidal supply when disturbed by connecting non-linear loads cause harmonic currents to be injected into the system affecting also the neighbouring consumers connected to the same bus.

The proliferation of solid state devices in lighting ballasts, computers, electronic and communication equipment, variable frequency drives for motors, DC-powered loads, to name a few are non-linear loads that are all pervasive. These loads distort the current waves from following the sinusoidal voltage waveform. This distorted periodic current waveform can be represented using a Fourier transform to discern the contribution of each frequency component which is but a multiple of the fundamental frequency (50 Hz). These higher frequency components, such as 3rd Harmonic (150 Hz), 5th Harmonic (250 Hz), etc., are in general referred to as harmonic currents.

Why Stress on Harmonic Currents and not Harmonic Voltages?

The voltage waveform of the power generated is fairly sinusoidal. Each utility company ensures operation free from faults and vibrations, and with high efficiency. All this helped keep the voltage a smooth sinusoid (Figure 2).

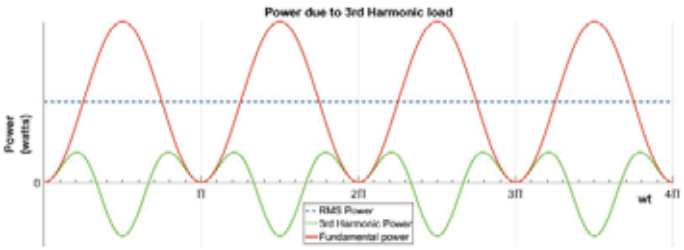

Figure 4: Active Power due to load injecting 3rd harmonic current

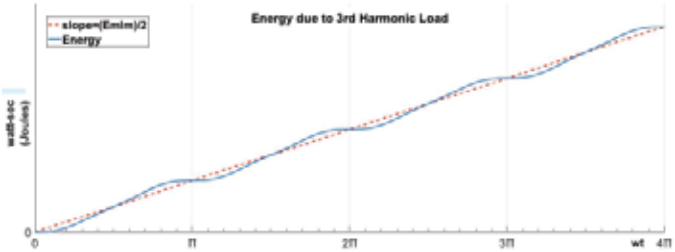

Figure 5: Active energy due to load injecting 3rd harmonic current

However, the same cannot be said about the current waveform. Current is in the hands of the consumers. The number of consumers is high - in lakhs, if not crores, per utility. Choice of purchase of non-linear loads, their installation and operation are all in the hands of the consumers who distort the current waveform. It is extremely difficult to control them. In ideal condition assuming harmonic voltage to be zero with only 3rd harmonic current flowing, the average active power consumed by the load due to the 3rd harmonic current is zero (see Figure 4). Hence, the average slope of the steadily increasing active energy characteristic curve remains constant regardless of the presence of the 3rd harmonic current (see Figure 5).

LED Lamps - A Case Study on Harmonics

In figures 6 and 7, two types of LED lamps are displayed from the market. The current waveforms of the 60W and 200W lamps have been captured in figure 8 and figure 9 respectively. None of them resemble the ideal sinusoidal current waveform (shown in Figure 1) due to the high levels of harmonic current injected by the respective lamps.

The LED lamps have been dismantled. It was found that the manufacturers of these low-cost lamps had eliminated the driver circuit. Their design team was least bothered about harmonics. Their focus was simply to light up the

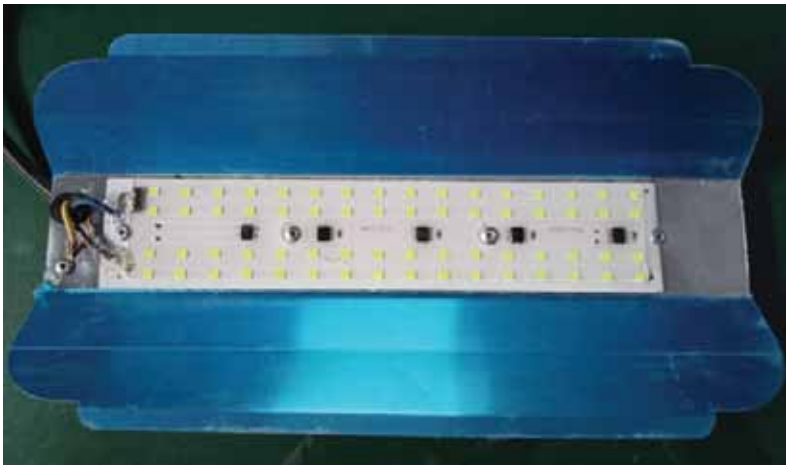

Figure 6: A 60W LED Street Lamp

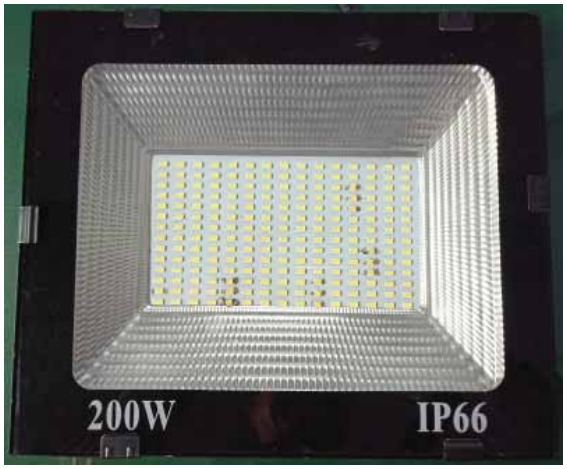

Figure 7: A 200W LED Flood Light

Figure 8: Current Waveform of 60W LED Street Lamp

Figure 9: Current Waveform of 200W Flood Light

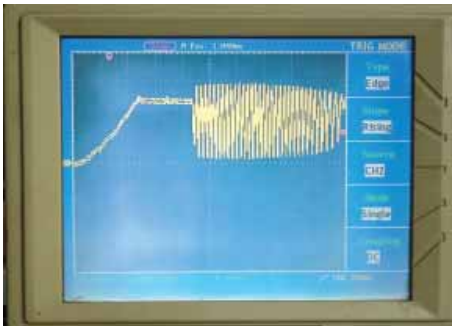

Figure 10: Stretched Current Wave of 200W Flood Light

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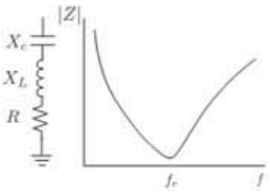

Figure 11: Circuit Schematics and Impedance Characteristics of Single-Tuned Filter

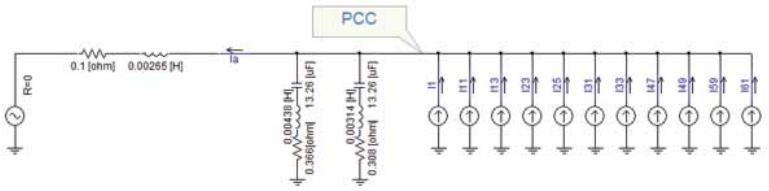

Figure 12: System Configuration with 11th and 13th Harmonic Series Filter

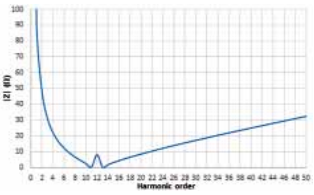

Figure 13: Impedance Characteristic for a Combination of 11th and 13th Harmonic Series Filters

LEDs at a minimum cost. Giving due consideration to the unidirectional, non-linear characteristics of LEDs, the minimal circuit comprises of a bridge rectifier and a current limiter. While the bridge ensures unidirectional flow of current through the LED strings, the current limiter ensures fail safe operation beyond the knee point of the LED characteristic curve.

Both lamps have approximately 70 numbers of 1W LEDs per string. Considering an LED drop of 3 volts (knee point in LED characteristics), the current will be essentially zero during the time period when the instantaneous voltage is below the knee point i.e (3 x 70) = 210 Volts. From figures 8 and 9, one can identify the sections where the current is essentially zero. What differentiates the two lamps are the current limiting circuits, resulting in unique distortions(harmonics).

Harmonic Menace Solutions

Nowadays, a popular solution to suppress harmonic currents is to insert filters in the system. There are two types of filters, namely active and passive. An active filter can be designed using a three-level IGBT bridge topology that offers a good approximation to a sine wave with low switching losses. A passive filter has a combination of capacitors and inductors that are tuned to resonate at a single frequency, or through a band of frequencies.

It is possible to have series and shunt configurations of the filters. A filter connected in series is designed to present a high impedance to the harmonic frequency that needs to be blocked.

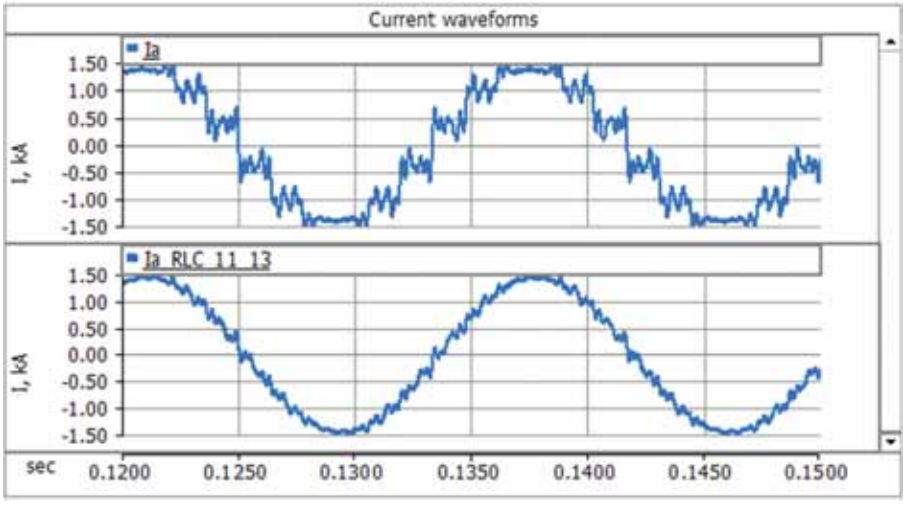

Figure 14: Improvement in Current Waveform after inserting 11th and 13th Harmonic Series Filters

A current (harmonic) source should be ideally short circuited. Hence, a shunt configuration is more common where filters are connected in parallel to divert harmonic currents to ground, and simultaneously provide reactive power to correct the power factor (as they are designed to be capacitive at the fundamental frequency). In the example below (Figure 11), a commonly used passive, single-tuned (single frequency) or notch or series filter in a shunt configuration has been chosen.

One such example on PSCAD X4 to illustrate the use of the series filter is simulated. The circuit in figure 12 represents a system that has *X/R* = 10 (*Q*) and a load that injects typical harmonic currents generated by a twelve-pulse converter. This type of converter injects high levels of 11th and 13th harmonic currents into the AC side.

The results obtained thus show a reduction of 96 per cent in the magnitude of the 11th and 13th harmonic currents (see Figure 14).

Though the solution is effective, it involves cost. Unless there is a lucrative incentive to install active or passive filters, consumers would resist. In an illiterate society, the onus is rightfully pushed over to the electrical appliance manufacturers to ensure that they produce goods that exhibit an ideal resistive load, void of harmonics.

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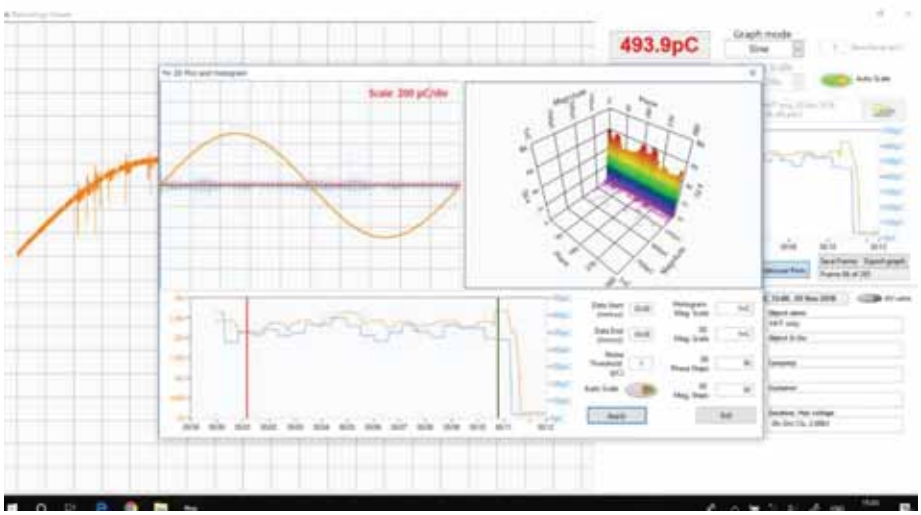
Partial Discharge Measuring System



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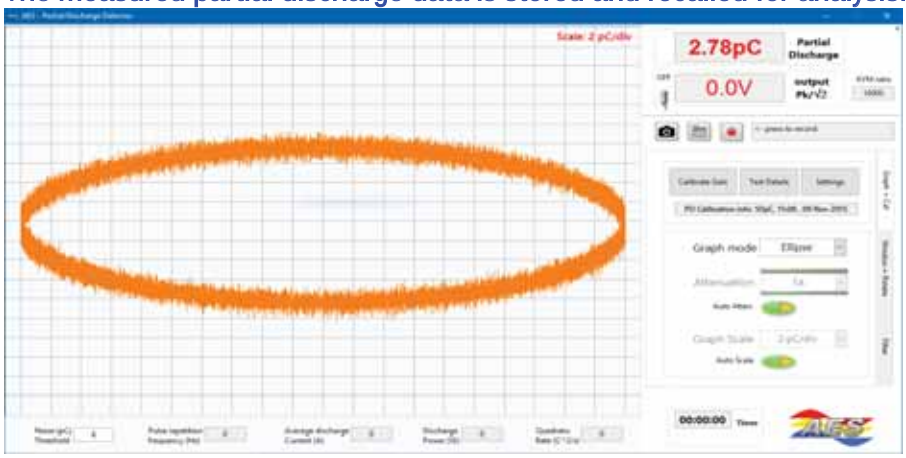

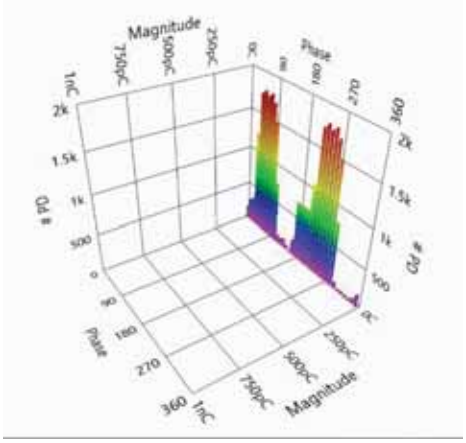

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Figure 15. Single Phase Apparent Energy Meter

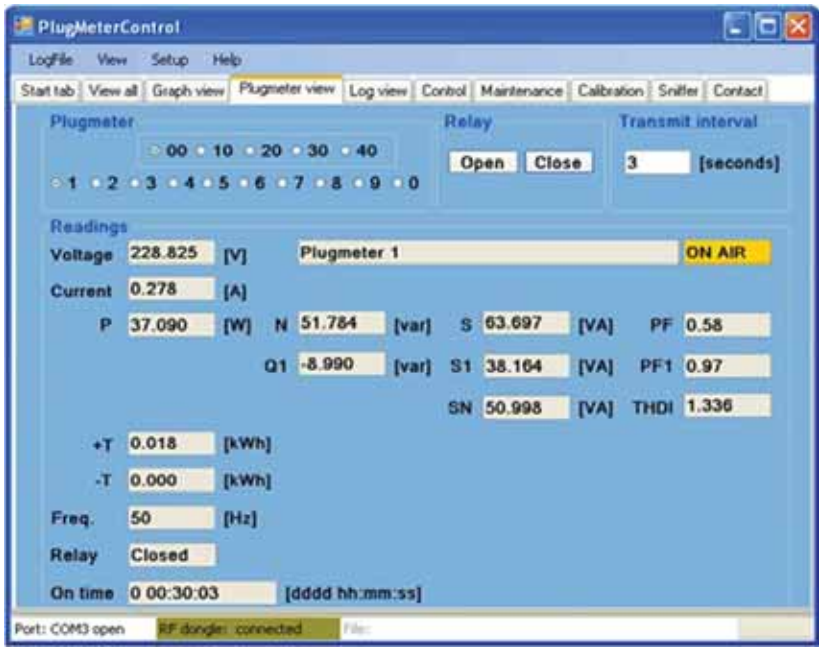

Figure 16: Interface to the Smart Apparent Energy Meter

Apparent Energy Metering and Tariff

Effective Value of Current

The RMS value of a complex current wave is equal to the square root of the sum of the squares of the RMS values of its individual components [1, p. 315]. Using standard notations, the RMS value of the complex current, I, can be given as follows.

$$I = \sqrt{I_1'^2 + I_3'^2 + I_5'^2 + \dots} \quad (1)$$

Similarly, the RMS value of a complex voltage wave, E, can be given as follows.

$$E = \sqrt{E_1'^2 + E_3'^2 + E_5'^2 + \dots} \quad (2)$$

Apparent Power

The apparent power S in Volt-Ampere (VA), is measured as the product of the RMS voltage (E) and RMS current (I): S = E I or

$$S = \sqrt{E^2}\sqrt{I^2} = \sqrt{E^2 I^2} = \sqrt{(E_1'^2 + E_3'^2 + E_5'^2 + \dots)(I_1'^2 + I_3'^2 + I_5'^2 + \dots)} \quad (3)$$

The unit of apparent power is volt-amperes (VA) or kilovolt-amperes (kVA). This power is then integrated to get apparent energy (kVAh). For a constant line power loss, and a constant load RMS voltage E, the apparent power is the maximum active power that can be transmitted through the line. In other words, maximising the amount of power transmitted while keeping the thermal stress of the line constant.

Apparent power is a measure of the maximum heat generation potential in the load, and its value does not drop when the load becomes inefficient. This enables to effectively use apparent power as a basis and reference for obtaining a measure of efficiency of the load either in generating useful heat, useful torque, or useful light in the load for a certain effective or RMS value of current.

Outdated Definition of Power Factor and Apparent Power

Multiple definitions of apparent power have been causing confusion. By comparing the definitions (as per IEEE Std 1459-2010) with those used by the meter manufacturers, one can conclude that mostly all meters manufactured so far measure fundamental reactive power Q_1 and use it to compute apparent power S_1. Hence, the quantities those meters recording are actually of fundamental frequency, and not inclusive of harmonics. Hence, the harmonic currents go undetected in those meters!

Correct Definition of Power Factor and Apparent Power

Here, the IEEE 1459-2010 standards is quoted to justify the choice of parameters - namely true power factor (*PF*) and apparent power (*S*) respectively for the design and development of the apparent energy meters. That is inclusive of all harmonics.

Total Harmonic Distortion - Current: THD_I

The harmonic currents can be quantified by the parameter - Total Harmonic Distortion - Current (THD_I) which is given as the summation of all the harmonic components of the current waveform compared against the fundamental component of the waveform.

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Table 1: Consumption of Common Electrical Appliances

Description	Active Power	Apparent Power	Fundamental Apparent Power	Power Factor	Fundamental Power Factor	THD of Current
	P (W)	S (VA)	S1 (VA)	PF	PF1	THDI (%)
Compact Fluorescent Lamp	35.24	61.09	36.57	0.58	0.96	133
Laptop Adaptor	22.61	46.91	22.99	0.48	0.98	178
LCD Monitor	15.48	32.42	17.01	0.48	0.91	162

$$THD_I = \frac{\sqrt{(I_2^2 + I_3^2 + I_4^2 + \ldots + I_n^2)}}{I_1} \times 100\ \% \quad (4)$$

However, the above equation requires separation of the fundamental component from the higher harmonics. An easier technique to measure the dimensionless parameter, THD_I, is by using the approximation formula below, which is accurate within 1 per cent for voltages with THD_V < 0.05 and for currents with THD_I > 0.4. For values outside this range, it is an indicative approximation.

$$THD_I = \frac{S_N}{S_1} \quad (5)$$

The non-fundamental apparent power S_N in Volt-Ampere (VA) is measured according to $S_N = \sqrt{S^2 - S_1^2}$. For the same condition, namely THD_V < 5 per cent and THD_I > 40 per cent the following expression holds.

$$PF = \left(\frac{1}{\sqrt{1 + THD_I^2}}\right) PF_1 \quad (6)$$

What is noteworthy is the sequence in which the parameters are computed. The most fundamental parameters, such as apparent power, *S*, are computed in the beginning, offering higher accuracies, while the most complex derived parameters, say of THD_I, are computed at the end. The apparent energy meter offers accuracies of 1 per cent for *S* and 5 per cent for THD_I respectively. This means that computation of *S* is simple, straightforward and hence, viable for large scale production and proliferation of apparent energy meters.

Smart Apparent Energy Meters

In 2011, the apparent energy meters (originally developed in 1997) have been we redesigned using the energy metering chip, EM773 from NXP semiconductors, that has an inbuilt metrology engine to compute S, as per the new IEEE 1459 (see Figure 15). Further, to offer a smart solution, the EM773 chip was connected to a two-way RF transceiver – OL2381 (also from NXP), that gave it a wireless M-Bus communication capability.

Figure 16 shows the user interface offered by such a smart apparent energy meter. The differences between *S* and S_1 or *PF* and PF_1 for a typical household appliance that injects harmonics (THD_I = 133.6 per cent) can be observed from the readings displayed. In Table 1 similar differences observed when different appliances were chosen at random are shown. This strengthens the belief that nowadays, mostly all appliances are injecting high levels of harmonics (THD_I > 120 per cent).

Apparent Energy Tariff

Earlier, apparent energy (*S*) based tariff (unit *kVAh*) is introduced that is to be the only single parameter-based tariff that is fair, incorporates an embedded power factor-based discount mechanism and meets the above objectives. It can play a vital

Table 2: Savings in Line Losses

Action	Apparent Power Consumption	Apparent Power Savings	Line Loss	Line Loss Saving	Line Loss Savings/ month[1]
	(VA)	(%)	(W)	(%)	(`)
Initial Condition	99		9		
Improvement of PF from 0.5 to 1.0	49	50	2.25	75	8.91
Reduction in active power consumption from 49 W to 27W	27	23	0.66	17.7	2.10
Total		73		92.7	11.01

[1]Assuming tariff rate of Rs 4/kWh

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Table 3: Street Lighting Tariff offered by GERC

Tariff as per ERC directive	Active Energy Tariff	Apparent Energy Tariff	
	(Rs/*kWh*)	(Rs/*kVAh*)	Scope and Status
GERC Tariff Directive, in 2010	3.35	2.50	Pilot; Optional
GERC Tariff Directive, in 2011	3.60	2.70	All four Gujarat State Utilities; Optional
GERC Tariff Directive in 2015	4.05	3.05	All four Gujarat State Utilities; Optional

role particularly in the developing countries that are facing a crisis of high losses and low degree of utilisation (high degree of blocking) of transmission and distribution equipment due to highly inductive loads, loads injecting harmonics, and switching loads. It is a win-win solution where consumers can avail tariff discounts by becoming more efficient while electric utilities can increase its revenue both through line loss reduction and through the collection of penal charges from defaulting consumers.

Street Lighting Pilot

Empowered with recommendations from the Ministry of Power, and two separate directives from the Gujarat Electricity Regulatory Commission (GERC), in the year 2011, Centre for Apparent Energy Research's R&D centre successfully demonstrated technical loss reduction to the tune of an amazing 92.7 per cent in a pilot project involving three street lighting feeders of Anand Municipality, Gujarat. Smart dimmable fluorescent lamps were used. If we consider a typical street light feeder with 80 lamps, this represents a savings of Rs 880 per month in terms of line losses.

More importantly, this pilot has given a basis for our estimate of national level savings potential of `15 million per hour. Through the implementation of an apparent energy tariff with 25% discount, we were able to demonstrate its effectiveness in reducing, both the harmonic current and reactive current levels. Table 3 shows the street lighting (SL) tariff rates as offered by GERC. It is observed that the apparent energy tariff carries a 25 per cent discount over the active energy tariff rates. See how the incentive mechanism works.

If a consumer decides to operate non-linear loads that inject significant amount of harmonics and makes no effort to curb the same, then due to low power factor load (PF < 0.75), he would get billed more under the apparent energy (*S*, kVAh) tariff in comparison to the active energy (*P*, kWh) tariff. The lower the PF, the greater the difference or higher the bill under the kVAh tariff!

If the consumer puts in limited effort to only obtain a partial improvement in his PF such that it rises and stays at the threshold point of PF = 0.75, then in this situation, the bills would be identical under both the tariffs.

On the other hand, if the consumer puts in the complete effort, as intended under the new apparent energy tariff mechanism to shift to linear loads (PF ≅1), then he will avail the complete discount of 25 per cent and his bills will be lower

Figure 17: The Apparent Energy Metering Project at Nandesari

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by 25 per cent under the kVAh tariff.

Unlike the kWh tariff, the new kVAh tariff has an inbuilt discount or penalty mechanism to lure the consumers, to exercise their choice, to opt for efficient (linear) loads and save. If a consumer cannot discard his non-linear load, he has the option of inserting filters in parallel to sink the harmonics instead of injecting them into the distribution system, and still avail the discount in the bills. In this manner, his load would appear as a linear load to the utility feeding him, thereby minimising the utility's line and transformer losses.

Shift from Pilots to Large Scale Implementation

A project is considered to be truly successful when it is bankable and repeatable on a larger scale. Nandesari Industrial Estate, in Vadodara District of Gujarat state is selected for this purpose in 2015. A total of over 800 number of lamps were systematically replaced by smart and efficient dimmable LED street lamps. Metering and tariffs were based on apparent energy. As a result, Nandesari Industries Association has been reaping a 25 per cent discount in their electricity bills.

Challenges posed by Harmonics

Is it possible to identify the location of the harmonic current source by simply measuring the electrical parameters at the PCC (point of common coupling) or metering point? The answer is no. There could be multiple 3rd harmonic current sources located at different consumer installations in the vicinity (a realistic scenario today), and no clear technique to identify each of their locations from the PCC (though there are a number of published papers claiming to do so!).

A simpler and more elegant mechanism would be to shift to apparent energy metering and tariffs. As it is observed earlier, apparent energy simply deals with scalar quantities, and thus, effectively breaks down the need to have a vector relationship. This does not only eliminate the overhead of locating the source of harmonic currents, but automatically incorporates a community or co-operative feature that would help curb harmonics. This is how the mechanism works:

Here a current harmonic source is treated like just like any other polluting source in another medium, say air or water. Currents are shared in a distribution system like air or water with others. Just as an entity polluting the air or water would irk others in the neighbourhood, so also would injection of harmonic currents into the distribution system.

The usage of apparent energy tariff system compounds the problem. The neighbour does not only get irked by the damage these harmonic currents do to his appliances, but also due to the higher bills that he would be paying if he draws those harmonic currents. Such a condition will invigorate 'Community behaviour' which means that everyone would aspire to belong to a good neighbourhood, where one gets the benefits of a better quality of power supply, and lower bills!

Conclusion

Today, when energy resources are becoming scarce, it is a crime to spoil or waste energy and to charge only for the active energy consumption is no longer considered acceptable. Even the component of energy not contributing towards any useful work should be accounted for. In other words, wasted energy should be treated as energy consumed. Apparent energy is a measure of the 'Energy Delivering Potential', and, therefore, is considered most appropriate parameter for measurement of energy and tariffs. Armed with the correct definition of apparent energy and low cost apparent energy meters based on simple digital signal processing technology, It is shown how an electrical revolution can be effectively triggered - where market sees rapid sales of efficient electrical appliances. Once the revolution sets it, It is expected a disruptive but pleasant change where even appliance labels would display ratings in terms of VA instead of W. EI

P. Chaitanyasreerama

UG Student, BVM Engineering College V V Nagar

Dr. Vithal N. Kamat

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A Long Way to Go for Smart Meters

Smart metering is still in its infancy, as there is no large-scale execution of smart metering system. It is required to start progressing of customers, wherein an end user can get the return on investment (RoI) of smart meter.

– Supriya A Oundhakar, Associate Editor

The Indian power sector has been witnessing rapid changes with the government's roll out of various policies for achievement of affordable and accessible 24x7 power for all. According to Energy Efficiency Services Limited (EESL), a joint venture of PSUs under Ministry of Power, India's power demand is expected to surge by 79 per cent in the next decade. So, the country's energy sector has been treading the path of new energy mix like renewable energy. Being the third largest producer of conventional energy, India is ramping up its solar energy with the development of the world's largest solar parks to achieve the goal of 175 GW of renewable energy by 2022. Currently, India has a total installed capacity of 3,46,048 MW with ability to meet about 190

GW peak demand, to which 5-10 GW is likely to get added through plants under construction.

According to the ICICI Securities report, the country reported peak power demand of 177 GW in September, an increase of 13 GW over FY18 peak demand — the highest year-on-year growth since 1993-94. The report also pointed out that with improvement in financials after debt transfer or re-pricing under UDAY (Ujwal Discom Assurance Yojana) and the Central Government's push for '24x7 Power for All', there had been 32 per cent reduction in declared load shedding in 2017-18 over FY17 to 7.7 hours per month from 11.3 hours per month.

The government's initiatives such as the UDAY, the Integrated Power Development Scheme, the Deendayal Upadhyaya Gram Jyoti Yojana and the Saubhagya scheme aim to achieve the objective of 100 per cent metering. The Indian Energy Metering sector has been witnessing transition from manual meter reading to automated meter reading.

According to Saurabh Kumar, Managing Director, Energy Efficiency Services Limited, the Indian electricity meters market is dynamic and has been benefitted by technological landscape due to the government initiatives like smart grid mission, Integrated Power Development Scheme and Smart City Mission. The Government initiatives to achieve hundred percent metering and reduce Aggregate Technical and Commercial (AT&C) losses, coupled with energy efficiency measures facilitated by Bureau of Energy Efficiency (BEE) has opened up opportunities in private commercial and industrial segment.

> "The public-private partnership is the way forward to accelerate adoption of grid edge technologies. All stakeholders will have to deploy enabling infrastructure that is flexible, open and interoperable.
>
> **Saurabh Kumar,** Managing Director, Energy Efficiency Services Limited

It is also necessary to reduce AT&C losses to below 12 per cent by 2022, and below 10 per cent by 2027. UDAY endeavours to provide some reprieve to India's DISCOMs and distribution sector through financial restructuring. With their capability to cut transmission and distribution losses, and ensure 24X7 power, smart meters have also been made a part of this scheme, which can unlock a cascade of benefits for DISCOMs and consumers. The Government's Smart Meter National Programme is working to implement one of the world's fastest ramp-ups of smart meter installation, targeting the retrofitting of 25 crore meters. A wide product and packaged solution portfolio, competitive pricing, and extensive market reach are likely to be the key success factors of the Indian electricity meters market

India is estimated to invest USD 44.90 bn in smart metering, distribution automation, battery storage and other smart grid market segments. This investment will help India reduce the 22.7 per cent transmission and distribution loss, informs Sunil Misra, Director General, IEEMA.

Being the second largest consumer market in the world, India's energy market is USD 340.82 million and is expected to grow at a CAGR of 8-10 per cent over the next four to five years. India is expected to install 35 million smart meters by 2019.

Rapid urbanisation, industrialisation, and the most important, the pressing need for energy efficiency is substantially driving the growth of smart meters. Favourable regulatory conditions and increasing smart grid initiatives are supporting the smart meters market growth in the coming years. In addition to enabling a smart energy system, smart meters can reduce energy suppliers' costs and encourage consumers to pay more attention to the energy they use, which will reduce energy consumption. EESL business model to roll out smart meters is revamping the current manual system of revenue collection which leads to low billing and poor collection efficiencies. This roll-out is proposed under the build, own, operate, transfer (BOOT) model on cost plus approach, which means all capex or opex is performed by EESL and the states or utilities are not required to invest upfront, according to EESL's Saurabh Kumar.

As of now, EESL has signed MoU

> One of the most critical issues is the procurement of meters across utilities which differ for each segment of the metering ecosystem.
>
> **Sunil Misra,** Director General, IEEMA

for smart meters in the states like Andhra Pradesh Eastern Power Distribution Company Limited (APEPDCL) and Andhra Pradesh Southern Power Distribution Company Limited (APSPDCL), Andhra Pradesh for 18 lakh smart meters; Uttar Pradesh Power Corporation Limited (UPPCL) for 40 lakh smart meters and for one crore prepaid meters; Uttar Haryana Bijli Vitran Nigam and Dakshin Haryana Bijli Vitran Nigam in Haryana for 10 lakh smart meters; North Delhi Municipal Corporation (NDMC), Delhi for 50,000 smart meters; North Bihar Power Distribution Company Limited and South Bihar Power Distribution Company Limited in Bihar for 18 lakh smart meters and Tripura State Electricity Corporation for 2.8 lakh prepaid meters.

Additionally, the work on smart metering project is under progress in Varanasi, Lucknow, Kanpur and Meerut in the state of Uttar Pradesh, Gurugram and Karnal in the state of Haryana and NDMC area in New Delhi. Till date, over 90,000 smart meters have been installed in the state of Uttar Pradesh and NDMC area, New Delhi

It must be pointed out that the advantages of smart meters go beyond billing. This vision needs to have a very broad view of operational and business efficiency.

The vision of Government of India to bring financial turnaround of utilities with smart prepaid metering in the next three years will be a game changer and bring acceleration in metering Industry, states Sandeep Jain, Solution Architect, Landis+Gyr Ltd., India.

Challenges

Over the years, smart meters have emerged as an effective device which transforms energy consumption and management by offering significant value to both consumers and utilities. However, it has also its own challenges.

One of the most critical issues is the procurement of meters across utilities which differ for each segment of the metering ecosystem. To make things more complicated, each segment has multiple specifications leading to unfocussed approach in product development and utilising the available resources. One of the key objectives of the smart grid pilots in India is to arrive at single specification for a metering segment, resting on the Advanced Metering Infrastructure's (AMI) specification issued by Central Electricity Authority. It remains a challenge to date, informs Sunil Misra from IEEMA.

Evaluation of the bids based solely on the most competitive quoted price has impact on the quality of the product and service delivered. The Government needs to enforce a uniform policy of bid evaluation which will be a balance between quality and financial price mechanism, he further informs.

While the power sector has witnessed an unprecedented turn-around in generation, its weakest link is distribution. Poor equipment maintenance and high-power theft are responsible for (AT&C) losses of approximately 25 per cent, amongst the world's highest. Currently, India curtails renewable generation to prevent grid overloading, causing renewable developers losses, and affecting equipment efficiency, informs Saurabh Kumar from EESL.

Sandeep Jain from Landis+Gyr

Continued on page 52

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> The blockchain is promising and emerging in the electrical distribution area and has a long way to go.

Sandeep Jain,
Solution Architect, Landis+Gyr Ltd., India.

Ltd., India lists the following challenges:

Variation in the metering specification: India has a unique meter requirement owing to its vast geographical spread. Each utility has a unique requirement and manufacturer needs to have a meter variant to support it. Therefore, the design and sustaining such a spread of inventory has an impact on the manufacturing capacity. Unified specification remains a dream in the metering industry.

Scope of Project: Most of the AMI solution needs legacy system integration, which does not have any visibility on the interfaces supported and are often decades old technology. Most of the unknowns are included in the scope of work and therefore risk in project completion criteria. This safeguards utility from any changes required in future but leaves a large room for risk for bidders.

Evaluation Criteria: All the public utilities have a final lowest bidder bid gate. After clearance of technical bid gate, eligible bidders are evaluated on a single scale cost. There is no impact of quality, maturity and capability of the solution in influencing the selection of the bidder.

Cyber Security: Like any other IT-driven system, AMI is also prone to malicious attacks. The requirement needs to be similar to financial systems (meters are cash register to utility) if not military grade. We have to ensure detection and prevention of any intrusion to the system, which could affect the reliability, and efficiency of the system in delivering electricity to the last mile.

Communication Technologies: Communication technology has seen rapid growth and advancement in the past few decades. On the flip side, each and every technology has its specific application. Its applicability and adaptability in AMI may or may not work. The utility or industry is looking forward to adoption of newer technologies bringing efficient, cost-effective and stable communication technology for the solution.

IT Infrastructure: One of the most important ingredients in the AMI solution is the IT infrastructure and off the shelf, applications required, which have a different design life, warranty than the rest of the components.

Blockchain Technology

Over the years, smart meters have emerged as an effective device which transforms energy consumption and management by offering significant value to both consumers and utilities. The arrival of the Internet of Things (IoT) affirms more potential and provides utilities extraordinary opportunities to make smart meters even smarter, in this manner totally revolutionise energy management. As the demand for new sources of energy rises, there is a need of more efficient utilisation of existing energy sources.

Smart meters represent a major development for the electricity grid leading to fundamental transformation of modern power grids and sustainable energy mix protocols. However, cybersecurity problems pose the biggest hurdle in deployment of these smart meters. In this regard, blockchain has the potential to enable IoT-based deployments to be more secure.

With the development of technology, the blockchain technology is all set to change buying and selling scenario of power. The blockchain is a promising area in the metering market. With the advent of Prosumers in the value chain of electrical distribution network distributed vividly, it will definitely carve a path in how the energy is traded and settlement executed. Blockchain requires fast and accurate meter data acquisition for seamless trading and settlement. Smart meters will play a major role in meter data dissemination required in implementing. As we progress on mini or micro-grids and its integration with mainstream distribution can be an ideal choice. The blockchain is promising and emerging in the electrical distribution area and has a long way to go, avers Sandeep Jain from Landis+Gyr Ltd., India.

The underlying technology has

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identification security through private-public encryption with key access. If the key access codes are kept secure and safe, blockchain has the potential to take care of the rest. However, the impact of initiatives is likely to be profound in the smart electric meter market, informs Saurabh Kumar from EESL.

Outlook

The metering industry is undergoing massive transformation due to adoption of technology and innovation. With the advent of the Internet of Things (IoT) and a surge of power-consuming connected devices, grid edge technologies are paving the way towards a new energy system that will deliver major economic and societal benefits. The speed of adoption and the success in shaping the transformation will depend on a broad range of factors, ranging from regulation, infrastructure, business models and customer engagement. The public-private partnership is the way forward to accelerate adoption of grid edge technologies. All stakeholders will have to deploy enabling infrastructure that is flexible, open and interoperable. Emerging markets that may be less encumbered by existing infrastructure, investments, or system structure may have the opportunity to leapfrog some of these challenges and head straight to mass adoption of these new technologies, states Saurabh Kumar.

India has the third major electricity transmission and distribution network in the world. However, India also faces a lot of challenges such as supply shortfalls, inadequate access to electricity, huge network losses, reliability, poor quality and theft. Smart metering will address these key issues and make over the existing issues into a more proficient and consistent way. In return, it will help in provisioning of electricity access to all. Smart meter is the main element for the end user or consumer (residential or industrial), conventional energy meter, manual reading of energy meter, manually bill payment, micro-controller, and database management smart grid, so, it is expected to provide social, economic, and environmental benefits for several stakeholders. One of the major factors which will decide the success of smart meters is its data analytics. It deals with data acquisition, processing, and interpretation, which ultimately convey profits to all stakeholders.

Smart metering is still in its infancy, as there is no large-scale execution of smart metering system. It is required to start progressing of customers, wherein an end user can get the return on investment (RoI) of smart meter. The progress of smart meters will take time as the demand is yet to arise, informs Sunil Misra.

Despite the challenges in its implementation, smart meter industry has a bright future ahead. Sandeep Jain states, "The metering industry had an impressive market roadmap on the AMI system coupled moving towards an integrated approach in the supply chain of electricity. Most of the metering beyond 2019 will be AMI solutions as foundation and metering will play an important role in the turnaround of ailing utilities duly supported by the regulatory and its enforcement framework."

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"We expect bid tariffs to go up by 35-40 paise per unit"

CRISIL Research expects that safeguard duty implementation would create 20-25 GW market for domestic module makers over FY'20-FY'23, based on current domestic module makers following through on expansion plans already announced and foreign module players expanding in the Indian market, informs Rahul Prithiani – Director, CRISIL Research in an interaction with Electrical India.

India imposed 25 per cent safeguard duty on solar cells imports. What kind of potential will it generate for domestic solar cells manufacturing segment?

Typically, domestic modules are 8-10 per cent higher in terms of cost (pre-duty). However, the implementation of the duty at 25 per cent is aimed at not only eliminating this cost gap but making domestic modules more cost-competitive. Having said that, module prices continue to fall in light of lower capacity additions in the world's largest solar market, China, which would have a bearing on this gap going forward.

In the current scenario, CRISIL Research expects that safeguard duty implementation would create 20-25 GW market for domestic module makers over FY'20-FY'23, based on current domestic module makers following through on expansion plans

already announced and foreign module players expanding in the Indian market and setting up manufacturing units here, which would add to the domestic production.

What kind of challenges will it create for the solar sector? According to you, what are the solutions to overcome these hurdles?

Modules form 55-60 per cent of the capital cost of a solar project. India has imported 80-85 per cent of modules from China and Malaysia till date. The safeguard duty would raise capital costs by 15-20 per cent leading to an impact on bid tariffs. CRISIL Research expects bid tariffs to go up by 35-40 paise per unit from the current range of Rs. 2.5-2.8 per unit to Rs 2.9-3.2 per unit, based on the current module prices.

How will this move of the government impact the country's solar sector?

For already bid-out projects, there is current uncertainty regarding the pass-through mechanism of the change in law clause incorporated into the bidding guidelines or tender documents. The developers have to approach the respective electricity regulatory commissions either state or central for approving a pass-through of the increased costs i.e. they have to get the consequent higher tariffs due to a cost increase approved by the relevant authorities. The procedure and timeframe for the same is yet to be clarified.

For subsequent projects, developers would factor in the risk of increasing capital costs due to the duty in bid tariffs causing a rise in the same. As a consequence, cost competitiveness of solar power may decrease viz not only conventional sources but also other renewable energy sources such as wind.

In both cases, ability of distribution utilities to absorb higher tariffs is key as they have seen record lows for solar in the past.

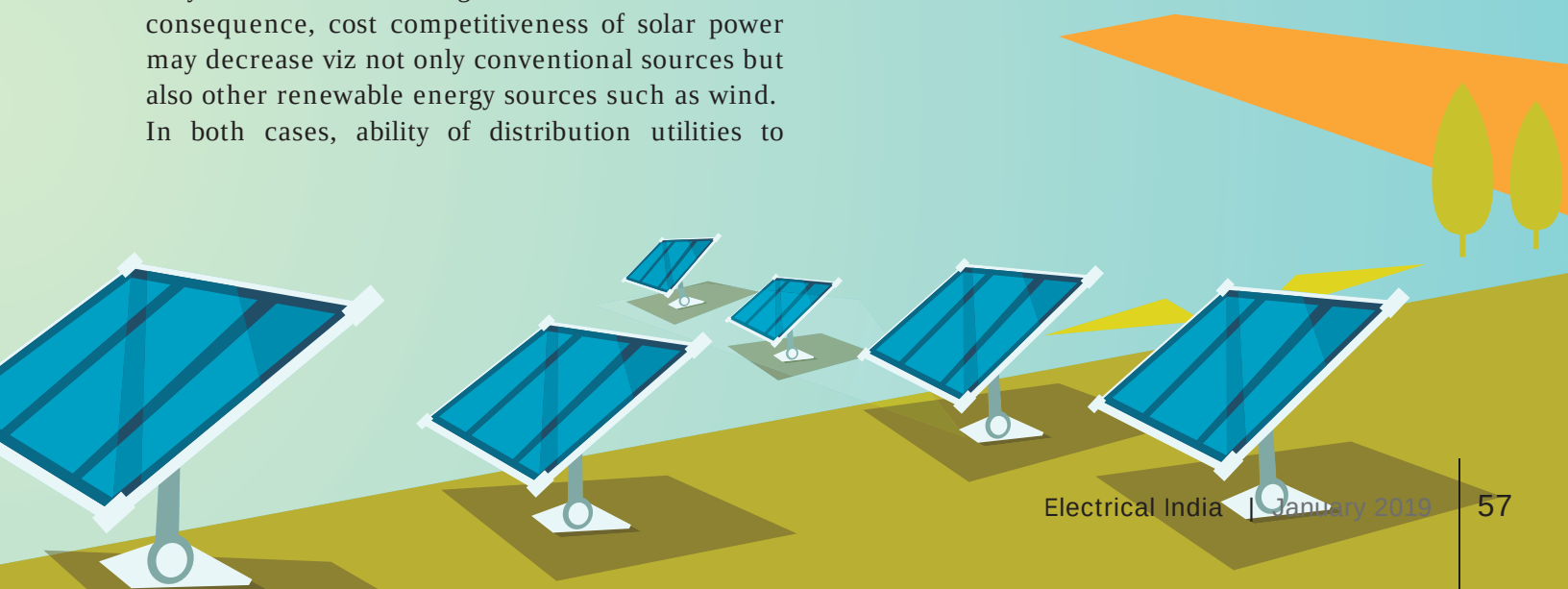
The government has ambitious plans of generation of 100 GW of installed solar energy by 2022. Will the country achieve this target with the imposition of safeguard duty on solar cells? Please elaborate.

We believe capacity additions would be impacted in the near-term as the sector copes with procedural challenges as well as module supply issues. However, over the long-term, with positive regulatory focus, increase in domestic supply of modules, active private sector participation and the gradual phasing out of the duty, additions should continue apace.

CRISIL Research expects that the 100 GW solar target is slightly ambitious based on the current challenges being faced by the sector such as grid challenges, land availability, availability of funds etc. which may constrain capacity additions.

What are the solutions to remove the ambiguity created due to this imposition of duty?

The government should clear the procedure for implementation of the change-in law clause at the earliest to mitigate the impact on already allocated projects and not impact the existing pipeline. In addition, tendering authorities both state and central should understand the impact of a rise in capital costs on end-tariffs and not cancel or compare future bid results to a pre-duty scenario. EI



IoT: Empowering Energy Management

The main motive behind the merger of IoT and energy management systems is to allow the linked entities to communicate with each other via a common information model.

With the evolution of Internet of Things (IoT), energy management has become smart and efficient. IoT has emerged as a promising platform for energy management. With ultra-reliable operation and a wide range of applications, IoT can be considered as a pioneering approach in the field of energy management.

IoT refers to a network of physical devices, appliances, automotive and many other items embedded with sensors, actuators, electronics, software and connectivity to communicate and exchange information for smart monitoring, positioning, recognition, tracing and various other activities. The physical objects are linked to each other through wired and wireless networks which often use

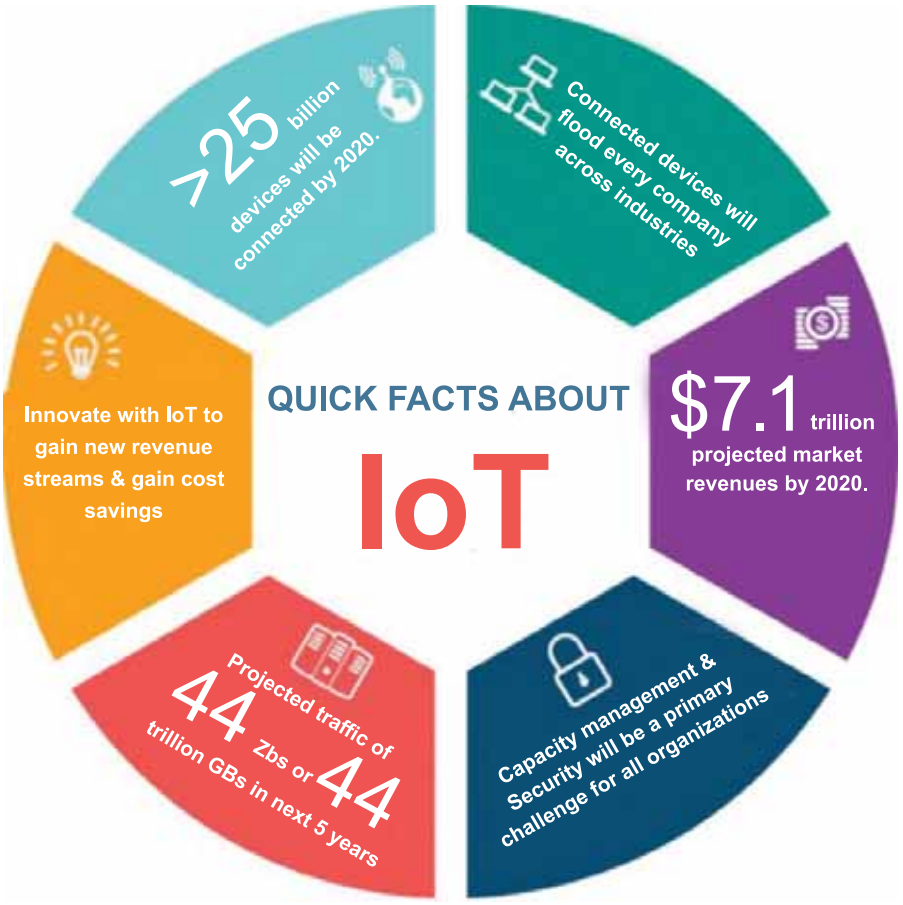


Figure 1: Some quick facts about IoT

same Internet Protocol (IP) that connects the Internet. The term IoT was coined by Kevin Ashton in a presentation to Proctor & Gamble, initially to promote Radio Frequency Identification (RFID) technology in 1999. Nowadays, market is flooded with IoT applications such as:

- Smart energy meters
- Home automation
- Industrial asset monitoring
- Wearable devices/fitness trackers
- Supervisory Control & Data Acquisition System (SCADA)
- Smart solar tracking
- Power quality and monitoring.

IoT market is estimated to grow from $157B in 2016 to $457B by 2020, achieving a compound annual growth rate (CAGR) of 28.5per cent. The IoT market share worldwide is expected to be ruled by three sub-sectors; Smart Cities (26%), Industrial IoT (24%) and Connected Health (20%). The ranking is followed by Smart Homes (14%), Connected Cars (7%), Smart Utilities (4%) and Wearables (3%).

By the year 2020, IoT based devices are expected to reach 31 billion worldwide. The existing usage along with predicted data is given in figure 3.

The fundamental characteristics of IoT are as follows:

- **Intelligence:** The concept of IoT works with various algorithms, software and hardware that make the product smart. IoT enhances working of any device in an intelligent way which makes it desirable in tough situations. In the world of smart technologies, IoT acts as the best way to interact with devices by using graphical user interface and standard input methods.
- **Connectivity:** Internet connectivity can be provided by an access point or within the device itself. The access point acts as collector of all the data and information from various sensors

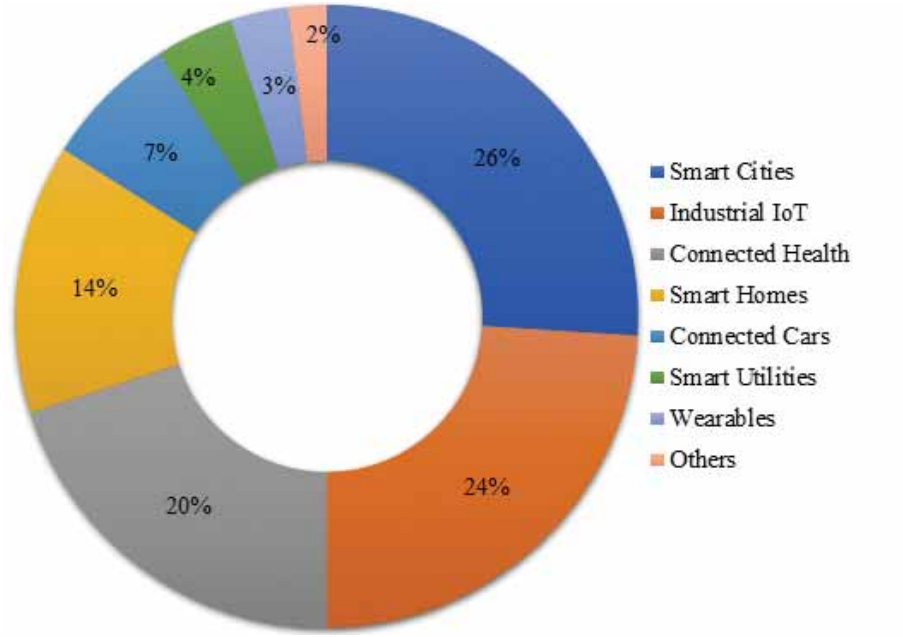


Figure 2: Global IoT market share by sub-sectors

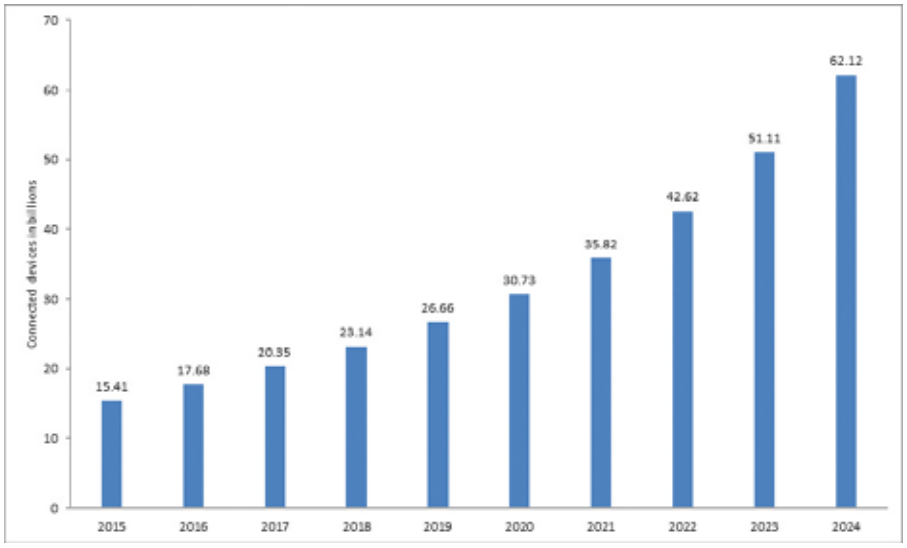


Figure 3: Number of IoT connected devices worldwide from 2015 to 2020.

for a specific device which then communicates with the cloud to pass this information. It activates network accessibility, intelligent analysis and compatibility.

- **Sensing:** The sensors monitor, track and measure the activity and then pass the information to the cloud storage. Sensors that can monitor physical fitness and health of a person or sensors that can monitor usage statistics of household appliances are some of the examples of useful sensors. The sensed data is just an analog input from the physical world which can be interpreted for further use.
- **Expressing:** This characteristic enables interaction of devices with physical world. Whether it is smart agriculture technology or smart home technology, expressing enables interaction of device with the real world. It allows the device to directly communicate with people and the environment.
- **Energy:** Energy is essential component for functioning of any system. IoT devices operate in unforgiving environment and harsh surroundings like deep mines and outer space. Since, the surrounding conditions can be tough for the device, it is important to make them energy efficient, reliable and quality product.
- **Safety and security:** Since, safety is the number-one priority in the field of technology. Modern high-end technologies are more prone to safety and security threats. Thus, it is necessary to provide a safe and secure way of transmission of data among the devices. Apart from data security, safety of physical well-being is also a major concern. However, various features such as secure booting, access control, device authentication and firewalling and IPS (Intrusion prevention system) have been introduced in this field.

Energy Management Practices

One of the major issues in front of researchers, scientists and key-people in factories is to develop an energy efficient system which is non-polluting and more reliable as compared to traditional systems. The growing demand of energy-led several companies such as Siemens, Schneider, General Electric, Mitsubishi, ReMake Electric, Socomec, Energy Metering Technology Ltd and Wi-Lem to bring innovation in the field of IoT. Figure 5 depicts a general system architecture using the concept of IoT in energy monitoring.

The bottom layer of the architecture consists of sensors and smart meters. These devices may be connected through wireless or wired network. Energy meters provide a high level of features such as smart monitoring and analysis energy consumption depending on several parameters such as power factor, power consumption, max/min peak voltage, and power consumption.

Figure 4: Characteristics of IoT

Continued on page 62

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Meters can be used with various monitoring targets including single components, single machines or even whole production line.

The middle layer is responsible for transmission of acquired data to the gateway and then to a local computer or to the Internet by means of standard communication protocols such as Wireless Hart or ZigBee wireless technology. Sensors can be placed in a much flexible way at nearby spots or even at remote locations.

As shown in Figure 5, data is transferred into EEM (Enterprise Energy Management) software for detailed analysis or in other enterprise systems including Manufacturing Execution Systems (MES), Building Management Systems (BMS) or Advanced Production and Scheduling systems (APS). The data acquired from smart energy meters can be integrated with SCADA.

There are numerous applications of IoT in the field of energy management. Some of them are discussed below:

Smart Grid: IoT provides the system act on energy and power-related data in a pre-defined way with the aim to improve overall efficiency of the system. Improvised monitoring and management of energy consumption leads to sustainability of the production and efficient distribution of electricity. High-end techniques such as data mining can be taken into account to analyse acquired energy data to get the detailed information about energy wastage.

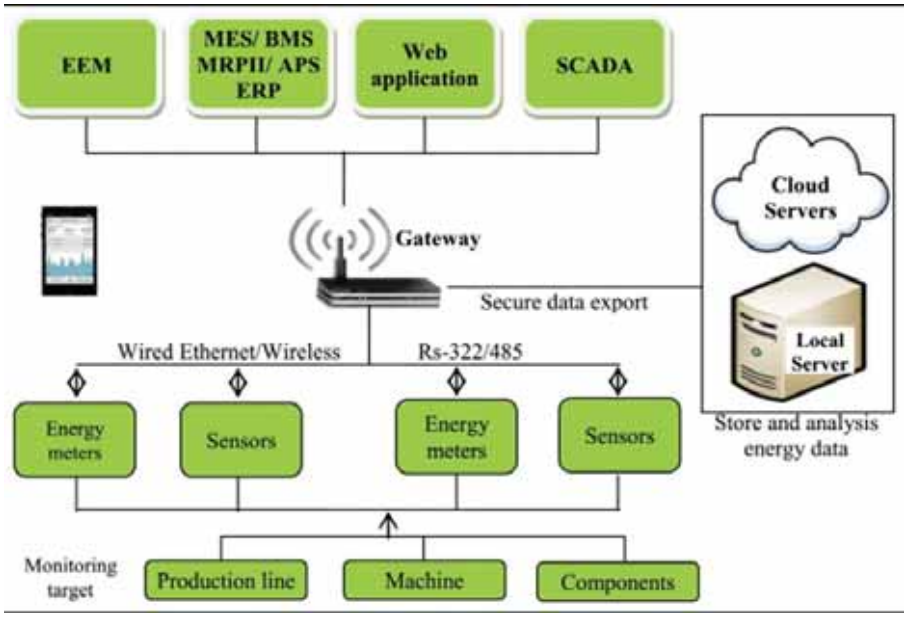

Figure 5: General IoT system architecture for energy monitoring

Wind Turbine/Power House: Energy flow from wind turbines and power house can be monitored and analysed in an efficient and reliable way by using concept of IoT. Energy consumption pattern of consumer can be analysed by smart energy meters.

Power Supply Controller: AC-DC power supplies can be regulated by controller which in turn improves efficiency by reducing energy wastage for power supplies associated to telecommunication, computers and consumer electronics applications.

Photovoltaic Installations: Performance of solar photovoltaic plants can be monitored and optimised using IoT. Majority of the solar photovoltaic plants are installed at remote locations. This creates a need of monitoring of these set-ups at dedicated desired locations using web-based interface.

The concept of IoT has been merged with Smart Grid (SG) as it enables systems to act on the energy and information which is related to power in an innovative way with the aim to improve the overall efficiency, economics, reliability and sustainability of the production and distribution of the electricity. Electric utilities can not only manage distribution automation devices such as transformers and reclosers but also, collect data from end-user connections using advanced metering infrastructure (AMI) devices linked to the Internet.

The emerging technologies IoT is an essential aspect for various types of industries. Efficient management

of energy and intelligent consumption by appliances is the main motive behind implementation of this technology. However, some factors lead to inefficient operation such as illicit consumption, transmission and distribution losses, faulty wiring, harmonic problems and untargeted supply. More than 35 per cent of the power produced is wasted because of these undesired factors. In modern era power sector, rising electricity prices, increasing environmental concerns, and changing choices of consumers are the key reasons for advancement in technology in energy sector. The Internet of Things technology is emerging as a promising platform for the improvement in energy sector. The credit goes to smart sensors and smart energy meters at industrial level.

Conclusion

The combined approach by sensing and actuation system, linked via Internet is expected to optimise the overall energy consumption. The main motive behind the merger of IoT and energy management systems is to allow the linked entities to communicate with each other via a common information model. IoT devices are expected to fuse with various devices such as bulbs, switches, television, power outlets, etc. which consume energy. This will enable utility supply company to generate power more efficiently and balance their energy usage. The users would be able to remotely control to the devices, centrally manage various devices via a cloud-based interface, and advanced functioning such as scheduling the device.

S Prabhakar Karthikeyan
Associate Professor, Vellore Institute of Technology, Vellore, Tamil Nadu

Kshitij Sharma
Student, School of Electrical Engineering, Vellore Institute of Technology, Vellore, Tamil Nadu

Parallel Operation of Transformers

Loading considerations for paralleling transformers are simple unless kVA, percent impedances, or ratios are different.

For supplying a load in excess of the rating of an existing transformer, two or more transformers may be connected in parallel with the existing transformer. The transformers are connected in parallel when load on one of the transformers is more than its capacity. The reliability is increased with parallel operation than to have single larger unit. The cost associated with maintaining the spares is less when two transformers are connected in parallel.

It is usually economical to install another transformer in parallel instead of replacing the existing transformer by a single larger unit. The cost of a spare unit in the case of two parallel transformers (of equal rating) is also lower than that of a single large transformer. In addition, it is preferable to have a parallel transformer for the reason of reliability. With this at least half the load can be supplied with one transformer out of service.

Condition for Parallel Operation of Transformer

For parallel connection of transformers, primary windings of

the transformers are connected to source bus-bars and secondary windings are connected to the load bus-bars. Various conditions that must be fulfilled for the successful parallel operation of transformers are

- Same voltage ratio and turns ratio (both primary and secondary voltage rating is same)
  - Same percentage impedance and X/R ratio.
- Identical position of tap changer
- Same KVA ratings
- Same phase angle shift (vector group are same)
- Same frequency rating
- Same polarity
- Same phase sequence.

Some of these conditions are convenient and some are mandatory. The convenient are same voltage ratio and turns ratio, same percentage impedance, same kva rating, and same position of tap changer. The mandatory conditions are same phase angle shift, same polarity, same phase sequence and same frequency. When the convenient conditions are not met, paralleled operation is possible but not optimal.

Same voltage Ratio & Turns Ratio (on each tap)

If the transformers connected in parallel have slightly different voltage ratios, then due to the inequality of induced emfs in the secondary windings, a circulating current will flow in the loop formed by the secondary windings under the no-load condition, which may be much greater than the normal no-load current. The current will be quite high as the leakage impedance is low. When the secondary windings are loaded, this circulating current will tend to produce unequal loading on the two transformers, and it may not be possible to take the full load from this group of two parallel transformers (one of the transformers may get overloaded).

If two transformers of different voltage ratio are connected in parallel with same primary supply voltage, there will be a difference in secondary voltages. Now, when the secondary of these transformers are connected to same bus, there will be a circulating current between secondary's and therefore, between primaries also. As the internal impedance of transformer is small, a small voltage difference may cause sufficiently high circulating current causing unnecessary extra I2R loss. The ratings of both primaries and secondaries should be identical. In other words, the transformers should have the same turn ratio i.e. transformation ratio.

Same percentage impedance and X/R ratio

If two transformers connected in parallel with similar per unit impedances, they will mostly share the load in the ration of their KVA ratings. Here, load is mostly equal, because it is possible to have two transformers with equal per unit impedances but different X/R ratios. In this case, the line current will be less than the sum of the transformer currents and the combined capacity will be reduced accordingly. A difference in the ratio of the reactance value to resistance value of the per unit impedance results in a different phase angle of the currents carried by the two paralleled transformers; one transformer will be working with a higher power factor and the other with a lower power factor than that of the combined output. Hence, the real power will not be proportionally shared by the transformers.

The current shared by two transformers running in parallel should be proportional to their MVA ratings. The current carried by these transformers are inversely proportional to their internal impedance.

From the above two statements it can be said that impedance of transformers running in parallel are inversely proportional to their MVA ratings. In other words, percentage impedance or per unit values of impedance should be identical for all the transformers run in parallel.

When connecting single-phase transformers in three-phase banks, proper impedance matching becomes even more critical. In addition to following the three rules for parallel operation, it is also a good practice to try to match the X/R ratios of the three series impedances to keep the three-phase output voltages balanced.

When single-phase transformers with the same KVA ratings are connected in a Y bank, impedance mismatches can cause a significant load unbalance among the transformers.

Let's examine following different type of case among impedance, ratio and KVA.

If single-phase transformers are connected in a Y-Y bank with an isolated neutral, then the magnetising impedance should also be equal on an ohmic basis. Otherwise, the transformer having the largest magnetising impedance will have a highest percentage of exciting voltage, increasing the core losses of that transformer and possibly driving its core into saturation.

Case 1: Equal Impedance, Ratios and Same kVA

The standard method of connecting transformers in parallel is to have the same turn ratios, percent impedances, and kVA ratings. Connecting transformers in parallel with the same parameters results in equal load sharing and no circulating currents in the transformer windings.

Example: Connecting two 2000 kVA, 5.75 per cent impedance transformers in parallel, each with the same turn ratios to a 4000 kVA load.

Loading on the transformers-1 =KVA1=[(KVA1 / %Z) / ((KVA1 / %Z1)+ (KVA2 / %Z2))]X KVAl

kVA1 = 348 / (348 + 348) x 4000 kVA = 2000 kVA.

Loading on the transformers-2 =KVA1=[(KVA2 / %Z) / ((KVA1 / %Z1)+ (KVA2 / %Z2))]X KVAl

kVA2 = 348 / (348 + 348) x 4000 kVA = 2000 kVA

Hence KVA1=KVA2=2000KVA

Case 2: Equal Impedances, Ratios and Different kVA

This parameter is not in common practice for new installations, sometimes two transformers with different kVAs and the same percent impedances are connected to one common bus. In this situation, the current division causes each transformer to carry its rated load. There will be no circulating currents because the voltages (turn ratios) are the same.

Example: Connecting 3000 kVA and 1000 kVA transformers in parallel, each with 5.75% impedance, each with the same turn ratios, connected to a common 4000 kVA load.

Loading on Transformer-1=kVA1 = 522 / (522 + 174) x 4000 = 3000 kVA

Loading on Transformer-1=kVA2 = 174 / (522 + 174) x 4000 = 1000 kVA

From above calculation, it is seen that different kVA ratings on transformers connected to one common load, that current division causes each transformer to only be loaded to its kVA rating. The key here is that the percent impedance is the same.

Case 3: Unequal Impedance but Same Ratios & kVA

Mostly this parameter is used to enhance plant power capacity by connecting existing transformers in parallel that have the same kVA rating, but with different percent impedances. This is common when budget constraints limit the purchase of a new transformer with the same parameters. It is important

to understand that the current divides in inverse proportions to the impedances and larger current flows through the smaller impedance. Thus, the lower percent impedance transformer can be overloaded when subjected to heavy loading while the other higher percent impedance transformer will be lightly loaded.

Example: Two 2000 kVA transformers in parallel, one with 5.75 per cent impedance and the other with 4 per cent impedance, each with the same turn ratios, connected to a common 3500 kVA load.

Loading on Transformer-1=kVA1 = 348 / (348 + 500) x 3500 = 1436 kVA

Loading on Transformer-2=kVA2 = 500 / (348 + 500) x 3500 = 2064 kVA

It can be seen that because transformer percent impedances do not match, they cannot be loaded to their combined kVA rating. Load division between the transformers is not equal. At below combined rated kVA loading, the 4% impedance transformer is overloaded by 3.2%, while the 5.75% impedance transformer is loaded by 72%.

Case 4: Unequal Impedance & KVA Same Ratios

This particular of transformers used rarely in industrial and commercial facilities connected to one common bus with different kVA and unequal percent impedances. However, there may be that one situation where two single-ended substations may be tied together via bussing or cables to provide better voltage support when starting large load.

If the percent impedance and kVA ratings are different, care should be taken when loading these transformers.

Example: Two transformers in parallel with one 3000 kVA (kVA1) with 5.75 per cent impedance, and the other a 1000 kVA (kVA2) with 4 per cent impedance, each with the same turn ratios, connected to a common 3500 kVA load.

Loading on Transformer-1=kVA1 = 522 / (522 + 250) x 3500 = 2366 kVA

Loading on Transformer-2=kVA2 = 250 / (522 + 250) x 3500 = 1134 kVA

Because the percent impedance is less in the 1000 kVA transformer,

it is overloaded with a less than combined rated load.

Case 5: Equal Impedance & KVA Unequal Ratios

Small differences in voltage cause a large amount of current to circulate. It is important to point out that paralleled transformers should always be on the same tap connection. Circulating current is completely independent of the load and load division. If transformers are fully loaded, there will be a considerable amount of overheating due to circulating currents. The point which should be remembered that circulating currents do not flow on the line, they cannot be measured if monitoring equipment is upstream or downstream of the common connection points.

Example: Two 2000 kVA transformers connected in parallel, each with 5.75 per cent impedance, same X/R ratio (8), transformer 1 with tap adjusted 2.5 per cent from nominal and transformer 2 tapped at nominal. What is the percent circulating current (%IC)?

%Z1 = 5.75, So %R' = %Z1 / √[(X/R)2 + 1)] = 5.75 / √((8)2 + 1)=0.713

%R1 = %R2 = 0.713

%X1 = %R x (X/R)=%X1= %X2= 0.713 x 8 = 5.7

Let %e = difference in voltage ratio expressed in percentage of normal and k = kVA1/ kVA2

Circulating current %IC = %eX100 / √ (%R1+k%R2)2 + (%Z1+k%Z2)2.

%IC = 2.5X100 / √ (0.713 + (2000/2000)X0.713)2 + (5.7 + (2000/2000)X5.7)2

%IC = 250 / 11.7 = 21.7

The circulating current is 21.7 per cent of the full load current.

Case 6: Unequal Impedance, KVA & Different Ratios:

This type of parameter would be unlikely in practice. If both the ratios and the impedance are different, the circulating current (because of the unequal ratio) should be combined with each transformer's share of the load current to obtain the actual total current in each unit.

For unity power factor, 10 per cent circulating current (due to unequal turn ratios) results in only half per cent to the total current.

At lower power factors, the circulating current will change dramatically.

Example: Two transformers connected in parallel, 2000 kVA1 with 5.75 per cent impedance, X/R ratio of 8, 1000 kVA2 with 4 per cent impedance, X/R ratio of 5, 2000 kVA1 with tap adjusted 2.5 per cent from nominal and 1000 kVA2 tapped at nominal.

%Z1 = 5.75, So %R' = %Z1 / √[(X/R)2 + 1)] = 5.75 / √((8)2 + 1)=0.713

%X1= %R x (X/R)=0.713 x 8 = 5.7

%Z2= 4, So %R2 = %Z2 /√ [(X/R)2 + 1)]= 4 / √((5)2 + 1) =0.784

%X2 = %R x (X/R)=0.784 x 5 = 3.92

Let %e = difference in voltage ratio expressed in percentage of normal and k = kVA1/ kVA2

Circulating current %IC = %eX100 / √ (%R1+k%R2)2 + (%Z1+k%Z2)2.

%IC = 2.5X100 / √ (0.713 + (2000/2000)X0.713)2 + (5.7 + (2000/2000)X5.7)2

%IC = 250 / 13.73 = 18.21.

The circulating current is 18.21 per cent of the full load current.

Same Polarity

Polarity of transformer means the instantaneous direction of induced emf in secondary. If the instantaneous directions of induced secondary emf in two transformers are opposite to each other when same input power is fed to the both of the transformers, the transformers are said to be in opposite polarity.

The transformers should be properly connected with regard to their polarity. If they are connected with incorrect polarities then the two emfs, induced in the secondary windings which are in parallel, will act together in the local secondary circuit and produce a short circuit. Polarity of all transformers run in parallel should be same otherwise huge circulating current flows in the transformer but no load will be fed from these transformers. If the instantaneous directions of induced secondary emf in two transformers are same when same input power is fed to the both of the transformers, the transformers are said to be in same polarity.

Same Phase Sequence

The phase sequence of line voltages of both the transformers must be identical for parallel operation of three-phase transformers. If the phase sequence is an incorrect, in every cycle each pair of phases will get short-circuited. This condition must be strictly followed for parallel operation of transformers.

Same Phase Angle Shift: (zero relative phase displacement between the secondary line voltages)

The transformer windings can be connected in a variety of ways which

produce different magnitudes and phase displacements of the secondary voltage. All the transformer connections can be classified into distinct vector groups.

Group 1: Zero phase displacement (Yy0, Dd0, Dz0)
Group 2:180° phase displacement (Yy6, Dd6, Dz6)
Group 3: -30° phase displacement (Yd1, Dy1, Yz1)
Group 4: +30° phase displacement (Yd11, Dy11, Yz11)

In order to have zero relative phase displacement of secondary side line voltages, the transformers belonging to the same group can be paralleled. For example, two transformers with Yd1 and Dy1 connections can be paralleled.

The transformers of groups 1 and 2 can only be paralleled with transformers of their own group. However, the transformers of groups 3 and 4 can be paralleled by reversing the phase sequence of one of them. For example, a transformer with Yd1 1 connection (group 4) can be paralleled with that having Dy1 connection (group 3) by reversing the phase sequence of both primary and secondary terminals of the Dy1 transformer.

One can only parallel Dy1 and Dy11 by crossing two incoming phases and the same two outgoing phases on one of the transformers, so if one has a DY11 transformer, he can cross B&C phases on the primary and secondary to change the +30-degree phase shift into a -30-degree shift which will parallel with the Dy1, assuming all the other points above are satisfied.

Same KVA Ratings

If two or more transformers are connected in parallel, then load sharing per centage between them is according to their rating. If all are of same rating, they will share equal loads.

Transformers of unequal kVA ratings will share a load practically (but not exactly) in proportion to their ratings, providing that the voltage ratios are identical and the percentage impedances (at their own kVA rating) are identical, or very nearly so in these cases a total of than 90 per cent of the sum of the two ratings is normally available. It is recommended that transformers, the kVA ratings of which differ by more than 2:1, should not be operated permanently in parallel.

Transformers having different kVA ratings may operate in parallel, with load division such that each transformer carries its proportionate share of the total load To achieve accurate load division, it is necessary that the transformers be wound with the same turns ratio,

and that the percent impedance of all transformers be equal, when each percentage is expressed on the kVA base of its respective transformer. It is also necessary that the ratio of resistance to reactance in all transformers be equal. For satisfactory operation, the circulating current for any combinations of ratios and impedances probably should not exceed ten percent of the full-load rated current of the smaller unit.

Advantages of Transformer Parallel Operation

Maximise electrical system efficiency

- Generally, electrical power transformer gives the maximum efficiency at full load. If one runs numbers of transformers in parallel, one can switch on only those transformers which will give the total demand by running nearer to its full load rating for that time.
- When load increases, one can switch no one by one other transformer connected in parallel to fulfil the total demand. In this way one can run the system with maximum efficiency.

Maximise electrical system availability

- If numbers of transformers run in parallel, one can take shutdown any one of them for maintenance purpose. Other parallel transformers in system will serve the load without total interruption of power.

Maximise power system reliability

- If nay one of the transformers run in parallel is tripped due to fault, other parallel transformers in the system will share the load hence power supply may not be interrupted if the shared loads do not make other transformers over loaded.

Maximise electrical system flexibility

- There is a chance of increasing or decreasing future demand of power system. If it is predicted that power demand will be increased in future, there must be a provision of connecting transformers in system in parallel to fulfil the extra demand, because it is not economical from business point of view to install a bigger rated single transformer by forecasting the increased future demand as it is unnecessary investment of money.
- Again, in future demand is decreased, transformers running in parallel can be removed from system to balance the capital investment and its return.

Disadvantages of Transformer Parallel Operation

- Increasing short-circuit currents that increase necessary breaker capacity.
- The risk of circulating currents running from one transformer to another transformer. Circulating currents that diminish load capability and increased losses.
- The bus ratings could be too high.
- Paralleling transformers reduce the transformer impedance significantly, i.e. the parallel transformers may have very low impedance, which creates the high short circuit currents. Therefore, some current limiters are needed, e.g. reactors, fuses, high impedance buses, etc
- The control and protection of three units in parallel is more complex.
- It is not a common practice in this industry.

Conclusion

Loading considerations for paralleling transformers are simple unless kVA, percent impedances, or ratios are different. When paralleled transformer turn ratios and percent impedances are the same, equal load division will exist on each transformer. When paralleled transformer kVA ratings are the same, but the percent impedances are different, then unequal load division will occur. The same is true for unequal percent impedances and unequal kVA. Circulating currents only exist if the turn ratios do not match on each transformer. The magnitude of the circulating currents will also depend on the X/R ratios of the transformers. Delta-delta to delta-wye transformer paralleling should not be attempted.

Jignesh Parmar

Deputy Manager, (Electrical), Adani Township & Real Estate Co

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Compact Split Core Current Transformers

To avoid financial and production hampering in a plant during turnaround, compact split core current transformer (CT) is the best solution.

Plant turnarounds or shutdowns, are one of the critical times in the operation of a plant. Shutdowns have an intense impact on the plant's financial future either in positive or negative ways. To avoid financial and production hampering in a plant during turnaround, compact split core current transformer (CT) is the best solution. These CTs provide openable cores which are easy to install with different bus bar mountings and cable tie provision.

Figure 1: RISH Compact Split Core CT

CTs are important tools to aid in the measurement of Alternating Currents. They scale down a large primary current (input) to a reduced magnitude of current at secondary (output), for measurement and instrumentation.

A CT utilises magnetic field strength around the conductor inducing current in its secondary winding. This indirect method provides a high-level of isolation between the primary circuit and secondary measurement circuits and allow for easy installations.

CTs are available in various sizes, designs and input-output ranges. This technical article attempts to address one such innovative type of CT.

Compact Split Core CT

CTs are generally located in the main breaker panels or in branch distribution panels where space is always a challenge.

Since CTs are to be installed 90-degree to the conductor. CT cores are solid core type or may have a split core. The construction of core, whether solid or split defines how the CT can be installed. Solid core CTs feature a closed loop, in which the primary conductor must be passed through.

Whereas, a split core CT can be temporarily made open for retrofit installations. During which the primary conductor need not be disconnected while the CT is being installed.

RISH Compact Split Core CT

CTs are indispensable in areas of application like substation monitoring and control, process industries, automation industries and for systems where SCADA has been implemented.

To cater the needs of such industries an innovative approach by Rishabh Instruments put forth a compact split core CT, reducing the system complexities regarding space, hard-wiring and installation.

The RISH Compact Split Core CT offers significant advantages to professionals during the power analysis, meter implementation and installation phase in electrical panels, mitigating the aforementioned complications.

General Specifications and Features:

- Applicable to International standard IEC 61869-1 & -2: 2012
- Current ratios ranging from 60/1 to 500/5A
- Complies to accuracy Class 1 and 3
- Hinged split core with swing open for ease of installation
- Cable tie provision for faster installation
- Safety plug-in shorting link.

In designing a split core CT instead of solid core CT, certain design complications arise. The first and most crucial difficulty is the reduction in

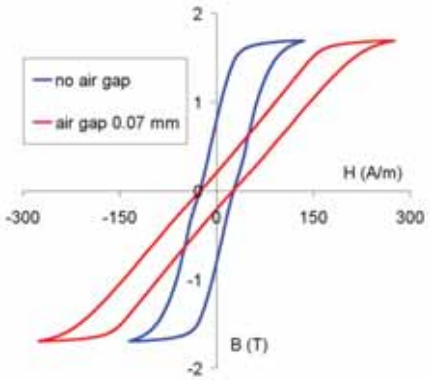

Figure 2: Comparing B-H loop of solid and split core CT

Figure 3: Safety plug-in shorting link

accuracy due to split core (air-gap core).

The figure 2 shows the B-H loop measured on a toroidal core made from grain-oriented electrical steel grade M4 and split core of the same material.

The blue curve shows B-H loop for solid core having a larger slope whereas, the split core B-H curve in red has a comparatively lesser slope, changing the loop shape but having almost no effects on the power loss (W/kg). Air-gap due to split core leads to increase in magnetizing current inducing errors and thus degrading CT accuracy. As well as the ampere turns affect the accuracy, increasing error at low ampere turns.

Error (e) increases by the relation:

$$e = k * \frac{1}{(AN)^2}$$

Where,

k = constant

AN = ampere turns

And also, the core length increases the error by:

$$e = k * L_j$$

In order to redefine the accuracy as per IEC standards

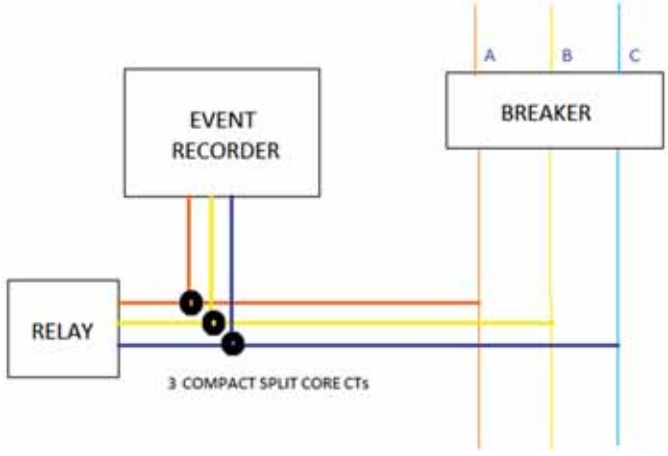

Figure 4: Power System Analysis

a better core material like ZDKH is used. This core material offers hysteresis loop with smaller hysteresis area.

The ratio between accuracy class and burden is approximately constant.

Where burden is the resistance of the load which one can put on the secondary of the CT.

This constant may be called the "accuracy quality factor" K of the winding.

$$K = \frac{100 * A}{P}$$

Where,

A = accuracy class

P = rated burden in VA

Hence, maintaining a higher accuracy quality factor we provide CTs which have a small burden of 0.2VA.

Another challenge which we generally come across in handling CTs is its secondary winding voltage during open circuit.

Due to the relatively large (5A) current requirement, CTs require a larger, heavier core and a larger cross section wire. This translates to a larger, heavier final

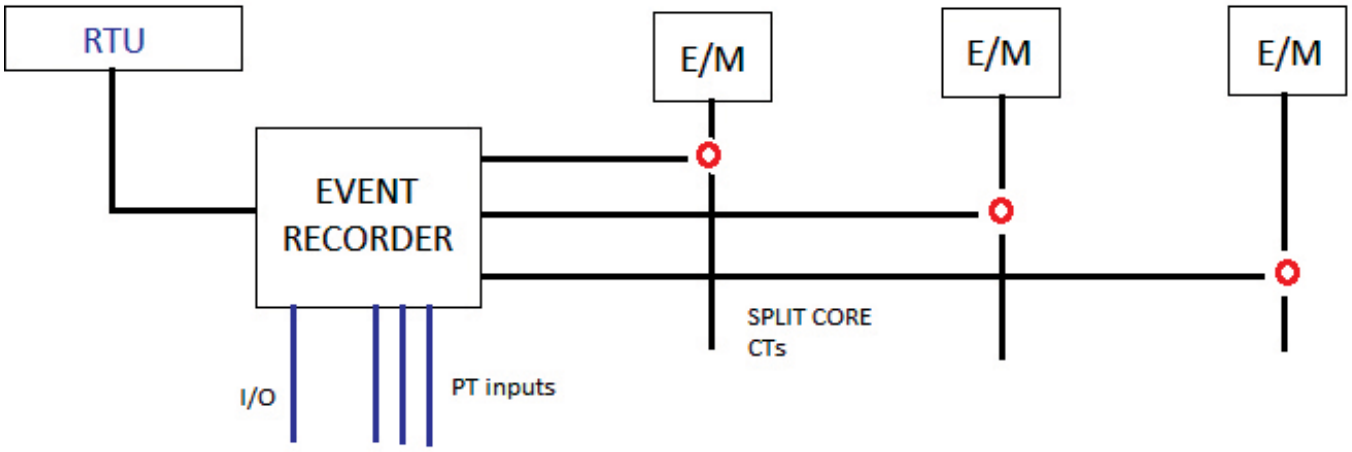

Figure 5: Automating E/M Relays

product and high costs. Moreover, these CTs can be extremely dangerous because of voltages induced when CT secondaries are not shorted. Leads to occurrence of high voltage across secondary terminal.

To mitigate this, Rishabh Instruments engineered safety plug-in shorting links to ensure that the CT remain shorted, even if disconnected from the meter as shown in figure 3.

Areas of application

The safe, low VA burden and click fit split core CT makes it very convenient to use in retrofit applications without disconnecting any cable. This saves down-time period and revenue loss which would occur due to shut down of plant during installation of CT.

In modular panels, distribution boards, automation systems this type of CTs are ideally suited.

Power System Analysis

Power system analysis is an analytical method in which the electrical power system is studied in order to find the values of current on which depends the design of protection system.

It generally consists of Load flow analysis, stability studies and short circuit studies. These are generally achieved through software. After the implementation of the derived parameters for protection, the system parameter check can be done using event recorders which would measure current of relays and breakers via compact split core CTs.

This helps in verifying relay and breaker performance To mention, this CT is a metering CT and can be used only for measuring & monitoring and not for protection purpose.

Automating electro-mechanical relays

A low-cost upgradation automation solution in substations for an electro-mechanical relay is using SCADA.

Measuring and reporting SCADA data to RTUs, includes measurement of parameters like RMS voltage, current, power factor, calculating peak fault currents and report to SCADA. For such applications split core CTs are compatible eliminating outages and maintains high measurement accuracy.

Thus, RISH Compact Split Core CT has all the features required in a metering CT. Plus its compact size and openable core makes installation easier and haste-free, suitable for almost every application.

Ms. Neha Mistri
Application Engineer
Rishabh Instruments

H.D. Wires Celebrating its 25 Years of Glorious Journey

On 16th of March 2019, H.D Wires will celebrate its 25th Anniversary in Indore. It is one of the leading manufacturers of G.I wires, cable armour wire, stay wires, earth wire and cable tape in India. It is an ISO 9001:2015 company and is being acknowledged as eminent name in India as manufacturer and exporter of end to end GI wires and other wire products.

H.D. WIRES PVT. LTD.

H.D. Wires stands by its claims: *"We just don't draw wires, we draw customer satisfaction"* and committed to quality and timely delivery. Today they are the major manufacturer and supplier of various products that are also complied with IS, BS, ASTM and other international standards as per the requirements of the customers. The company has also received the approval from Power Grid for supply of GI wires and ACSR wires. H.D. Wires is supplying cable armour to some of the top cable wire manufacturers in India like Polycab, Havells, Ravin Cables, UCL, Finolex, KEI, and Apar Industries.

Key highlights of the company

- Biggest single location manufacturer for GI armour wire, high carbon wires and other wire products in Central India with annual delivery production capacity of 45,000 M.T.A (2017-18)
- Power Grid Corporation of India, one of the toughest empanelment, has approved H.D Wires for supply of HTGS wires and cable armor wires that are being used to help build the power infrastructure in India.
- Despite stiff competition from Chinese products and adverse tax mechanism in India, H.D Wires is able to start exporting 'Make in India' products to various counties.
- Customer delight by delivering products meeting the stringent quality standards as per IS (Indian Standards) as well as BS (International British Standards).

Awards and recognition

Award Title	Awarded by	Period
National Award for Outstanding Entrepreneur	Council of State Industrial Development and Investment Corporations of India (Governing body of all State Financial Corporations)	2016
Award of Excellence (Innovation in Manufacturing of GI & MS Wires)	FITS (Federation of Industry Trade & Services), sponsored by SMC Global Securities	2015
India SME 100 Awards	India SME Forum, sponsored by Axis Bank	2014-15
India SME 100 Awards	India SME Forum, sponsored by Bank of India	2013-14

For more details, visit: www.hdwires.com

Why not use the synergies?

"OMICRONs CMC test sets are not only a solution for testing protective relays and distribution automation schemes, they enable the user to benefit from a broad range of synergies."

Figure 1: The CMC 256plus provides high precise signals that can be used (in combination with an optional scanning head) for meter testing on-site and in laboratory.

The measurement of electrical quantities in a power system is one of the central tasks of every plant operator. For this purpose, current and voltage transformers supply the primary current and voltage values to measuring transducers, electricity meters and other measuring equipment. These measuring devices then forward the measured values by equivalent DC signals or via communication protocols to the data acquisition system. The measurement results provide the basis for system operation, for measuring the energy consumption for accounting purposes, and also for more extensive analyses.

The requirements regarding the accuracy of the measured data depend on the specific purpose. Regular functional testing and calibration of the measuring devices are either prescribed by mandatory standards and regulations or form part of an established quality assurance concept. All types of measuring equipment, such as power quality measurement devices, electricity meters or transducers, can only be considered to provide valid measured values after prior calibration. This requires a comparison of the device against a precise and reliable signal source for current and voltage.

Functional and accuracy tests of measurement devices are not only necessary at the place of operation in an electrical utility or industrial plant. Precision tests are also carried out on measurement equipment at the manufacturer's premises, ranging from product development through type testing, certification and production testing to commissioning and handover to the end-user on site. In the development and production process, specific requirements are often applied to the test equipment, which can include the interaction with other test devices or their integration into an automated test environment. In acceptance testing, decisive factors in the

Figure 2: The CMC 430 as well provides high precise signals for testing meters or power quality meters as well as for calibrating measurement equipment.

choice of this equipment include: reliability, efficiency, test automation, data transmission and documentation. It is therefore advantageous to be able to exploit the synergies offered by a test device that is already available for other applications, such as protection testing.

Meter testing on-site and in a laboratory

Depending on the specific purpose of the meter, the accuracy requirements are different; CMC 430 and CMC 256plus accuracy allow testing class 0.2 meters as they are approximately 4 times more accurate than the equipment under calibration. If accuracy requirements are less, or for a plausibility check, all CMC test sets can be used.

These regular functional tests and the calibration of energy meters may take place in the laboratory or on site. Using one of the test sets mentioned above, tests can be performed without reference meters because the voltage and current sources of the test set are so precise that the test device itself is used as the working reference. For on-site testing in particular, this solution is much more convenient due to the substantial simplification of this test setup. Also, for laboratory calibration, the CMC is quite convenient because it can be used on its own or in conjunction with a reference meter. Especially for sporadic testing of meters it is a big benefit that the CMC test sets can also be used for protection testing. Both test sets, the CMC 256plus (Figure 1) and CMC 430 (Figure 2), provide test signals via high-precision voltage and current outputs (Figure 3). Furthermore, their inputs for the meter pulses allow closed-loop testing. To this end, special scanning heads for virtually any type of meter capture the pulses emitted by the meters.

For manual testing at site the CMControl P is the easiest and quickest way to control the test set. CMControl P is available as an App for Windows PC or Android tablets or as a dedicated front panel control device for a CMC test set. CMControl P provides an intuitive and guided user interface, so setting up a test is very convenient and feasible without special training. The new edition of the CMControl P App also offers testing without scanning heads. In this case, the meter readings before and after the energy injection are entered, the software then calculates the meter error which comprises the error of the measurement elements and the meter display (Figure 4).

The Meter module of the Test Universe software in combination with one of the CMC test sets allows for manual or automated testing of single and multifunction energy meters.

- **Load test:** Accuracy of measurement unit (time power method)
- **Mechanism test:** Accuracy of entire meter including display
- **Gated Mechanism test:** Testing internal meter registers
- **Injection test:** Quick check (wiring, sense of rotation)
- **No-load test:** No start-up at zero load
- **Creep test:** Start-up at low loads

The results of an automatic test are clearly summed up in a tabular test report (one line per test point).

For planning of all meter calibration activities, documentation of results and certificates, the ADMO maintenance management software can be used. It also takes care of supervision of the calibration status of the used test equipment and matches perfectly with the CMC test sets and the Test Universe Software.

Calibrating measurement equipment

Function and accuracy tests of measurement devices in electrical power systems are either prescribed by

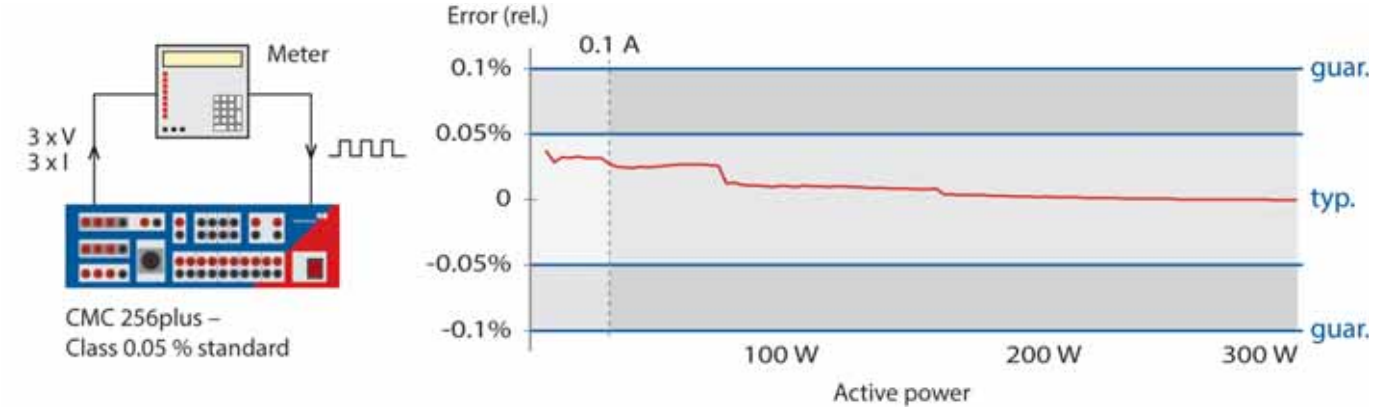

Figure 3: Setting up a meter test is very simple using the CMC test sets that provide high-precision current and voltage output.

mandatory standards and regulations or form part of an established quality assurance concept.

Periodic calibration of in-house measurement equipment such as multimeters, transducers, current clamps, etc., is also a standard procedure in many enterprises. If measurement equipment is calibrated in an external laboratory according to the organisation's quality assurance specifications (usually based on ISO 9000), in addition to a considerable financial overhead, the equipment is often unavailable for long periods of times. Because of their high accuracy, the CMC test sets are a versatile and portable solution for these applications. Their functionality makes calibrating measurement equipment a quick and safe in-house job to establish an internal calibration service that is very cost-efficient and can be performed when no routine tests are taking place.

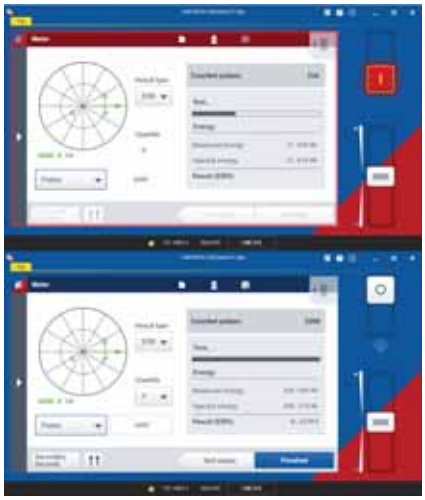

Figure 4: The CMControl P App for Android Tablets and Windows PCs is the easiest way to perform a quick manual meter test.

Testing of Power Quality Meters

Many important production plants and other consumers require a certain level of power quality. On the other hand, non-conventional energy supplies, modern power converters in the network and non-conventional consumers lead to increasing distortion of the voltage and current waveforms in the network. Therefore, monitoring of the power quality becomes more and more important, especially in case of contractual obligations with important consumers.

Accordingly, more and more PQ-meters are applied, e.g. at connection points for decentralised power producers or feeders connecting industrial plants. To ensure correct monitoring of the power quality test and calibration of power quality meters is essential.

The PQ Signal Generator (part of the TU software) turns a CMC test set – ideally a CMC 256plus or CMC 430 with its high-precision voltage and current outputs – into a calibration tool that generates relevant power quality phenomena according to IEC 62586 and IEC 61000-4-30:

- Power frequency
- Power supply voltage
- Flicker
- Dips & Swells
- Voltage interruption
- Transient voltages
- Voltage unbalance
- Harmonics
- Interharmonics
- Rapid voltage changes.

Depending on the type of CMC test set used, it is possible to generate voltage and current signals with superimposed harmonics (up to the 60th harmonic at 50 Hz or 50th harmonic at 60 Hz) and interharmonics up to 3 kHz or to enter harmonic magnitudes either in absolute values or in percentages of the fundamental value. For advanced applications, even fluctuating harmonics can be generated. The PQ Signal Generator allows the creation of comprehensive test sequences, to group test steps and to run repeatedly in a user-definable number of loops. If the test object provides a binary output, it can be used for automatic assessment of the test results. If no alarm contact is available, it is possible to perform a manual assessment.

Sample test plans typically used for type testing of PQ meters are available. A subset of these tests can be used for testing at site or for an acceptance test to select the best suitable PQ-meters for a given application.

Again, using the same test set and the same software platform makes this task very quick, easy and inexpensive.

Summary

OMICRON's CMC test sets are not only a solution for testing protective relays and distribution automation schemes, they enable the user to benefit from a broad range of synergies. They can also be used for testing energy meters, power quality measurement devices, measuring transducers, Phasor Measurement Units and even to calibrate measurement equipment. These additional application scenarios make OMICRON CMC test sets much more efficient from a business point of view.

Cord Mempel
Product Manager in secondary technology
OMICRON Electronics
Klaus Jotz
Marketing Communications Engineer
OMICRON Electronics

igus reduces assembly time of machining centres

Thanks to ready-to-install readychain systems from igus, process costs can be lowered and errors reduced

Robotic machining systems, energy chains from igus ensure a safe and reliable energy supply. (Source: igus GmbH)

In its robotic machining centres, many companies uses fully harnessed energy chain systems from igus. This cuts out many process steps for the manufacturer, reducing assembly time from several weeks to just half a day. Another benefit receives is from a single source and delivered onsite fully-tested for reliability and safety.

In very few industries where throughput times is as important as in the machine tool industry. Cutting out individual work steps means achieving considerable savings in process costs. In developing CNC equipment industry, precision and reliability are critical factors. Therefore, it was important to have a reliable means of energy supply from the switch cabinet to the moving parts, which include spindles and motors. At the same time, all the information regarding axis position and dynamics must be passed back to the control system without any interruption. All this happens at accelerations of up to 0.5 g and a maximum travel speed of up to 60 m/min.

Reliable complete solution from a single source

Many engineering company's engineers turned to igus, the motion plastics specialist as igus is the only provider to develop energy chains that are configurable and predictable online, as well as specially designed, highly flexible chainflex cables tested for two billion cycles per year in a 2,750-square-metre test laboratory. As a complete system from one source, these so-called 'readychains' are harnessed to customers' requirements and then delivered as ready-to-install products. The advantage in using igus energy chains is the amount of installation space needed can be reduced considerably. One reason for this is that all chainflex cables on the machine have an oil-resistant PUR outer jacket. As additional protective hoses are superfluous because of this feature, the amount of space needed for the cables, and therefore the size of the chains, are reduced. The absence of these protective hoses reduces cost and helps ease maintenance too. 3D drawing of the readychain with assembly frame can be created in order to simulate the assembly procedure. The benefit could be seen straight away: The first energy chain fitted with all electrical cables was installed on the machine in an hour. The second chain with hydraulic hoses was installed even faster, taking just 40 minutes.

Work steps cut out for significantly greater productivity

Normally, machine tool manufacturers try to avoid too many different work steps being carried out on a system at the same time. A lot of manual work done by different employees does not necessarily enhance efficiency; on the contrary, it increases the probability that errors can occur. By using igus readychains, all four e-chains from igus can be fully installed in half a day. Readychain is able to cut out some work steps, reduce process cost and, at the same time, greatly improve productivity.

For more details, visit: www.igus.in

igus energy chains, including cables and mounting frame, are delivered as fully-assembled readychains. The energy supply systems are then fitted within half a day instead of several weeks. (Source: igus GmbH)

SIAF Guangzhou to feature sensor technologies & machine vision

SPS – Industrial Automation Fair Guangzhou (SIAF) will return to the China Import and Export Fair Complex Guangzhou on 10 – 12 March 2019. Backed by steadfast support of the industry professionals, SIAF will continue to showcase state-of-the-art industrial automation solutions revolving around six themes. These include sensor technologies in hall 5.1, which would increase in exhibition area size by 60 per cent compared to the same period last year. Autonics, Balluff, Contrinex, Controlway, ifm, Pepperl+Fuchs and SICK have been exhibiting at the fair for more than three years, and right after the 2018 edition of SIAF, each exhibitor confirmed that they would return for the 2019 fair. Other brands who will showcase their strengths at the fair include Banner Engineering, Baumer, Captron, EMA, Hanyoung Nux, Keyence and M.D. These important indices underscore the importance of SIAF as an extremely valuable platform to promote smart manufacturing in South China, while at the same time unveiling the future growth prospects of the sensor market in the region.

Incorporates machine vision exhibitors to present total solutions for industrial automation

As technologies relentlessly evolve, market users are eager to look for comprehensive solutions which could overcome multiple hiccups in smart manufacturing. In order to streamline visitors' sourcing experiences, part of the machine vision brands will be featured in hall 5.1 coupled with sensor technologies and integrated solutions. Visitors can expect to find a diverse array of total solutions to stay ahead of the latest advancements.

SPS – Industrial Automation Fair Guangzhou
China Import and Export Fair Complex Guangzhou, China
10 – 12 March 2019

For more information about the 2019 show, visit www.spsinchina.com

54th SKOCH Summit takes stock of power sector reforms in India

With elections around the corner, SKOCH Group, the independent think-tank for socio-economic issues with a focus on inclusive growth, recently organised 54th SKOCH Summit on the state of power, oil and gas to take stock of the power sector and discuss the reforms carried out in the last four years of the current government.

The country's power sector has been going through a massive transformation. 54th SKOCH Summit on State of Power Sector addressed some of the key areas of the sector such as *State of the Power Sector: Emerging Policies, Regulations & Reforms in Indian Utilities; Challenges faced by the Indian utilities: People, Processes & Technology Adoption and Innovation, New Technologies and Cyber Security*.

In his opening remarks, Sameer Kochhar, Chairman of SKOCH Group and an eminent reforms historian said, "Did Modi government deliver? As author of ModiNomics, this is the question I am often asked these days. With four and a half years of current government

in power, it is critical for all of us to think that how the report card looks like. I promise to all of you that much before elections, my book "Did ModiNomics deliver?" will answer this big question."

Receiving the SKOCH Award, Anand Kumar, Secretary, Ministry of New & Renewable Energy said, "Today India is leading the growth in renewable energy on the world map. We have already installed 73.35 GW, projects worth 21.5 GW are under various stages of implementation and projects amounting to another 25 GW are under various stages of bidding."

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w: www.alliedpowersolutions.co
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Kolkata: +91 83348 95599

Enhanced Submersible Cables for Uninterrupted Power Flow

Addressing the issue of constant hindrances to uninterrupted Power transmissions, Anchor by Panasonic has emerged with an inimitable line of 3CF submersible cables, to add to their growing portfolio of wires and cables. This new range of submersible cables has been designed to be abrasion-resilient and dependable in physically demanding environments with little to nil drop in its performance. Health and environmental concerns are added other factors that are influencing the electrical market with intensified demand for improved options.

Keeping in mind that this cable is used deep underground the earth's surface, submerged in damp situations, cables have been ingrained to be weather and moisture resistance. Additionally, focussing on dealing with health & environmental hazards, electrolytic grade copper conductors having 99.97 per cent purity are insulated with REACH and RoHS compliant FR grade PVC and PVC sheathing, ensuring it to be absolutely safe for usage in populated areas and challenging landscapes.

Taking cognizance of the increasing demands for water, Anchor by Panasonic has introduced this three-core flat shaped cable to make it suitable shape wise for the flat slot provided in submersible pumps with 101 per cent conductivity.

Each of the features have been designed keeping in mind the enhanced need of uninterrupted power flow with reliable attributes that will ensure continual fetching of water for irrigation and drinking purpose.

Priced at an economical rate, the product is available at all existing Anchor by Panasonic dealer network and trade outlets.

Specifications

- **Copper:** Bright annealed electrolytic grade copper having 99.97 per cent - 99.99 per cent purity
- **Conductivity:** 101 per cent
- **Insulation:** REACH and RoHS complaint FR PVC (1st in industry)
- **Sheathing:** REACH and RoHS complaint PVC (1st in industry)
- **Core colours:** Red, yellow and blue
- Weather and moisture resistant
- **Sheath colour:** Black

HPL unveils solar inverter range

In its endeavour to provide affordable and renewable energy products, HPL has introduced the solar inverter range. The solar inverter comes equipped with an upgraded design and advanced technology ensuring higher performance thus, helping to maximise the total solar system power production. The inverter runs on solar power and is highly cost effective being a battery less inverter, that distinct it from other off-grid inverters.

It comes infused with remote monitoring features that enable the user to use the product at any location and also ensures higher security.

The inverter also has a twin MPPT charge controller that helps to optimise sun light utilisation at all times with IP 65 being embedded in its design makes it suitable for outdoor applications. This transformer less solar inverter projects upto 97 per cent efficiency thus making it cost effective and durable in the long run.

For more information, visit www.hplindia.com

New software component for easy access to temperature control

With mapp Temperature, B&R offers temperature control that combines maximum usability and powerful control algorithms. Integrated simulation capabilities allow virtual commissioning in minutes. mapp Temperature also provides heating current monitoring.

B&R's temperature control component covers every requirement with maximum flexibility and scalability.

With mapp Temperature, it is possible to define zones and groups for temperature control. A zone is a unit consisting of an actuator, a temperature process and a sensor for measuring the temperature. Multiple zones can be combined into a physical group and controlled and optimised together. This gives the user maximum flexibility and scalability to meet any temperature control requirement.

Autotuning and integrated simulation

If applications cover a wide temperature range, simple tuning is often not sufficient to optimally adjust the parameters. mapp Temperature therefore includes a multi-stage autotuning process. The user can define several operating points and optimise them individually. The integrated simulation capability enables simple virtual commissioning without any hardware. This option makes it possible to test the application's logic, error handling and HMI system in advance to significantly accelerate on-site commissioning.

Heating current monitoring

B&R's temperature control system also offers heating current monitoring to enable early detection of faults through predictive maintenance. By monitoring the current of the heating elements, it is possible to react to a fault at an early stage without stopping the entire process. This ensures a high level of operational reliability and helps prevent extended downtime.

For more information, visit www.br-automation.com

Orient launches 'lifestyle portable fans'

Orient Electric Limited, part of CK Birla Group, recently launched a new range of lifestyle portable fans featuring distinctive designs. With changing climatic conditions, increasing dust and air pollution, shrinking spaces and need for more personalised cooling solutions, there arises a need for solutions beyond the traditional ceiling and table fans.

With the launch of this premium series, Orient Electric aims to reinstate its thought leadership in the category while meeting aspirational needs of the consumers. The company targets to not only grow this category exponentially but also build a dominant share in the next one year. Speaking on the occasion, Atul Jain, Senior VP & Business Head, Fans, Orient Electric said, "There is a need for better air circulation in air-conditioned rooms and safer portable fans for kids along with far more personal need for air in confined spaces. Each of our lifestyle range of fans addresses unique consumer insights and requirements. Designed to bring alive exclusivity, these fans exude sheer elegance."

He further added, "With rising incomes and aspirations, along with increased exposure to digital & global lifestyle and technologies, individualisation trend is catching up fast in consumer durables space. Consumers today want to have individualised solutions that make life simpler and experiences better. Our luxurious breed of mobile lifestyle fans is sure to interest the modern aspirational consumers and add glam quotient to their home and office interiors."

IR320 Waterproof Dual Laser IR Thermometer with Alarm

Rugged design with waterproof (IP65) and 9.8-ft (3-m) drop-proof protection, Extech IR320 provides fast temperature measurements from (-) 4-degree F to 1202-degree F or (-) 20-degree C to 650-degree C with high basic accuracy and adjustable emissivity. Its dual guided laser shows the target area between two points (~1-inch/25mm diameter of measured area) at a 12:1 distance to target ratio. It also features programmable high and low alarms with red (HI) and blue (LOW) visual LED alert. Lock function for continuous measurement without pressing the trigger.

Ideal applications include:

- HVAC/R Diagnostics: Diagnose ventilation systems outdoors in rain or shine conditions.

- Insulation Inspection: Blue LED flashes when temperature is below low alarm set point.
- Automotive troubleshooting: Red LED flashes when temperature is above high alarm set point.

For more details, visit: www.extech.com

Kyoritsu DC Milliamp Clamp Meter

Kyoritsu, Japan has a frontline global presence in electrical test and measurement equipment since 1940, with specialised expertise in low voltage test and measurement.

In India, the company has been present for many decades already, offering world-class products optimised for Indian needs at 'just right prices'. Many of these products have for long been the choice equipment of Indian electrical installation professionals.

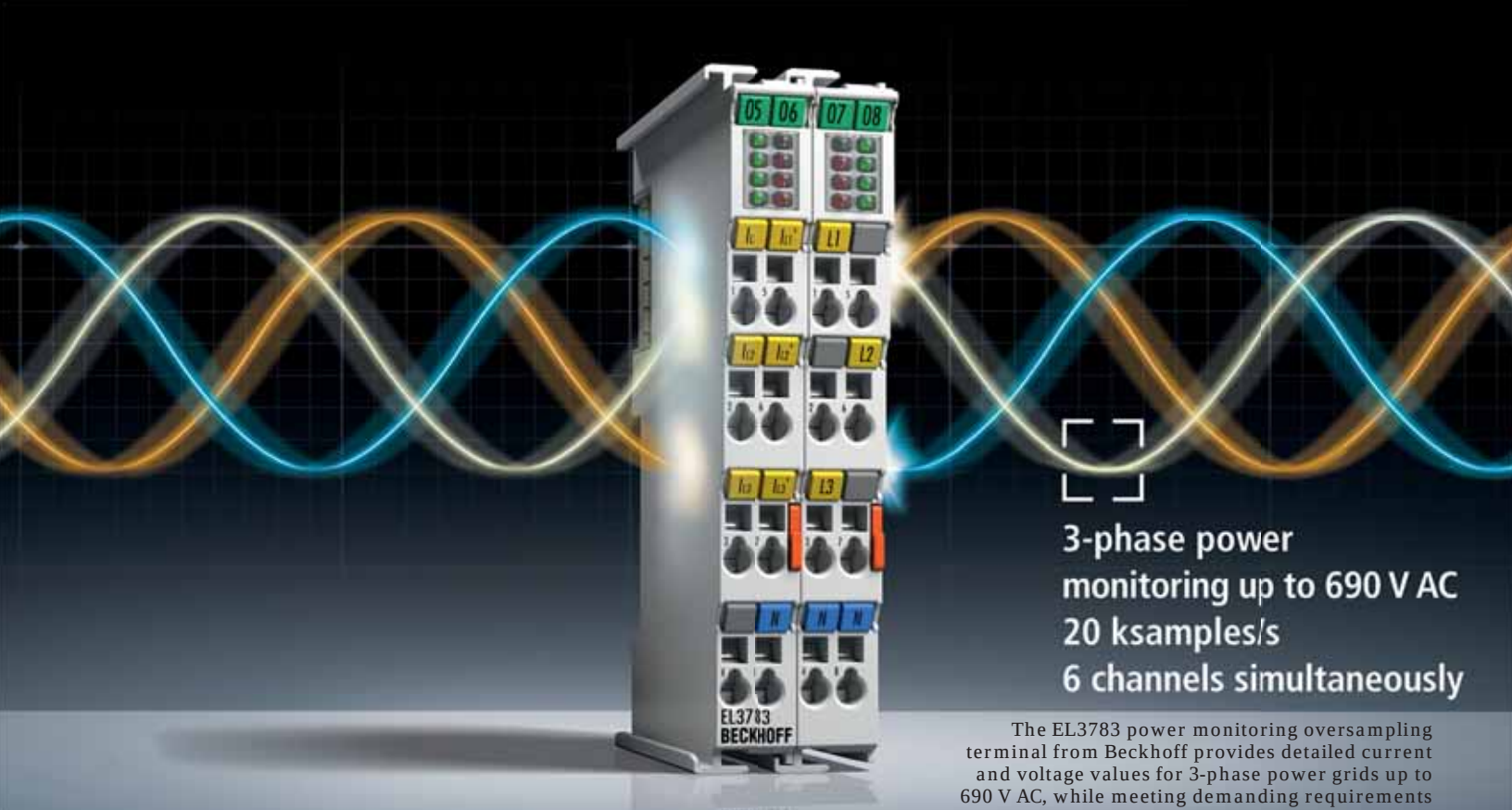
Kyoritsu DC Milliamp Clamp Meter measures DC current with the help of small jaw clamp without breaking the electrical circuit.

Kew 2500's key features are:

- 0.01mA resolution for DC current
- Top class measurement 0.2 per cent accuracy
- Ø6mm clamp jaw easy to use in tight places
- Measurement from 0.01mA to 120.0mA
- Dual display with backlight shows both mA measurement and percent of 4-20 mA span
- Spotlight for illuminating measurement point
- Analog output terminal for recorder connection
- Auto power off function
- Data hold function
- Zero adjust button
- Battery level indicator.

Kyoritsu products are readily available in India and have complete service- and calibration- support set-up too.

For more details, contact: info.ei@kew-india.co.in



The EL3783 power monitoring oversampling terminal from Beckhoff provides detailed current and voltage values for 3-phase power grids up to 690 V AC, while meeting demanding requirements in wind turbine applications.

High-precision grid analysis within the EtherCAT Terminal system

New Beckhoff EL3783 power monitoring oversampling terminal for high-resolution diagnostics of alternating voltages up to 690 V AC

Conventional automation and power measurement technology are increasingly converging. With the integration of the new Beckhoff EL3783 oversampling terminal for power monitoring into standard control systems, high-precision grid analysis becomes available for power-generating systems. Most importantly, 3-phase AC voltage systems up to 690 V can be analysed simultaneously on six channels and with 20 kSamples/s directly in the PLC.

For each of the three phases, the EL3783 EtherCAT Terminal from Beckhoff samples voltages up to 400/690 Vrms and currents up to 1 or 5 Arms as instantaneous values with 16-bit resolution. The six terminal channels are evaluated simultaneously based on the EtherCAT oversampling principle, with a temporal resolution of 50 μs, i.e. significantly faster than the cycle time of the controller. Using the EtherCAT distributed clocks functionality, it is also possible to measure synchronously ($<<$ 1 μs) with other EtherCAT devices in systems of virtually any size and precisely detect propagating grid faults, for example.

Extensive data with relevant details are available in the control system if true RMS and performance calculations or complex user-specific algorithms are used to analyse the voltage and current curves, for instance. In addition, the EL3783 EtherCAT Terminal achieves 650 per cent of the nominal 1-ampere measuring range through automatic current range switching, offering high accuracy with a maximum measurement error of only 0.2 per cent (of the full-scale value).

In conjunction with TF3650, the TwinCAT 3 Power Monitoring library, the EL3783 Terminal represents a highly dynamic measurement system for detailed network analysis that is seamlessly integrated into standard PC-based control technology. In this way, requirements for network supporting measures in the event of voltage drops (LVRT, Low Voltage Ride Through) can be identified, for example, or harmonics analysis can be used to implement condition monitoring without additional costs for acceleration sensors. EI

For more details, visit: www.beckhoff.co.in

Amazon invests $10 million to boost recycling rates

The investment will divert 1 million tonnes of recyclable material from landfill into the recycling stream eliminating the equivalent of 2 million metric tonnes of CO2 by 2028

Amazon announced that it will invest $10 million in Closed Loop Fund to support recycling infrastructure in the United States. The investment is expected to increase the availability of curbside recycling for 3 million homes in communities across the country, making it easier for customers to recycle and further develop end markets for recycled commodities. The investment will divert 1 million tonnes of recyclable material from landfill into the recycling stream and eliminate the equivalent of 2 million metric tonnes of CO2 by 2028—equivalent to shutting down a coal-fired power plant for six months.

Roughly half of Americans today lack access to convenient, sufficient curbside recycling at their homes. Closed Loop Fund finances the building of advanced recycling infrastructure and services, bringing this invaluable service to the community while saving taxpayers and municipalities money.

"This investment will help build the local capabilities needed to make it easier for our customers and their communities to recycle and to increase the amount of material recycled across the country," said Dave Clark, Amazon's Senior Vice President of Worldwide Operations. "We are investing in Closed Loop Fund's work because we think everyone should have access to easy, convenient curbside recycling. The more we are all able to recycle, the more we can reduce our collective energy, carbon, and water footprint."

Closed Loop Fund invests in sustainable consumer goods, advanced recycling technologies, and the development of the circular economy. It aims over the next 10 years to eliminate more than 16 million tonnes of greenhouse gas, divert more than 8 million cumulative tonnes of waste from landfills, improve recycling for more than 18 million households, and save nearly $60 million for American cities.

CEO of Closed Loop Fund Ron Gonen added, "Amazon's investment in Closed Loop Fund is another example of how recycling is good business in America. Companies are seeing that they can meet consumer demand and reduce costs while supporting a more sustainable future and growing good jobs across the country. We applaud Amazon's commitment to cut waste, and we hope their leadership drives other brands and retailers to follow suit."

Solving customers' needs for recycling can create economic benefits in the cities and towns where they live. Increasing the amount of recycled materials available can also lead to a lower cost of goods sold, and lessen the impacts of transportation, as there is no need to ship waste to landfills. Cities also directly benefit through increased cash flow and jobs, as most recycling is done locally.

Amazon's investment in Closed Loop Fund furthers Amazon's longstanding commitment to reducing packaging waste through its Frustration-Free Packaging programs, which are designed to produce less waste than traditional packaging. Amazon works directly with thousands of manufacturers to help them redesign their packaging, eliminate waste throughout the supply chain, and ensure products arrive undamaged on customers' doorsteps. Amazon introduced Frustration-Free Packaging 10 years ago, and it has eliminated more than 244,000 tonnes of packaging materials to date, avoiding 500 million shipping boxes. EI

Forthcoming Events At A Glance

National

IMTEX 2019

Venue: Bengaluru International Exhibition Centre, Bengaluru
Date: 24-30 January 2019
Website: www.imtex.in

DistribuELEC 2019

Venue: Mumbai Exhibition Centre, Mumbai
Date: 4-6 February 2019
Website: www.distribuelec.ieema.org

Renewable Energy Expo

Venue: Chennai Trade Centre, Chennai
Date: 21-23 February 2019
Website: www.renewableenergyexpo.biz

International

DistribuTECH Conference & Exhibition

Venue: Ernest N. Morial Convention Center
Date: 5-7 February 2019
Website: www.distributech.com

Power-Energy Summit 2019

Venue: Dubai, UAE
Date: 18-20 February 2019
Website: www.powerenergyconferences.org

Energy, Utility & Environment Conference

Venue: San Diego, California
Date: 25-27 February 2019
Website: www.euec.com

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ETL PRÜFTECHNIK

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Electrical Test & Measuring Solutions

Digital Micro Ohm Meter

Contact Resistance Meter 200A

Turns Ratio Meter

Winding Resistance Meter

Current Transformer Tester

Standard CT

Automatic Transformer Test System

Cast Resin Standard PT

Battery Analyzer

75 KV AC High Voltage Test Set

Automatic Portable HV Tester

Our Product Range

- Winding Resistance Meter
- Turns Ratio Meter
- Digital Micro OHM Meter
- Contact Resistance Meter
- Current Transformer Tester
- Standard Current Transformer
- Standard Voltage Transformer
- Transformer Loss Measuring System
- Automatic Transformer Test System
- Online DGA
- Static Frequency Convertor (EPS)
- Mobile EPS
- High Voltage PD Filters
- Coupling Cpacitor / HV Dividers
- Online PD Test System
- Oil BDV Test Set
- AC HV Test Set
- AC / DC HV Test Set
- Battery Analyzer

Corporate Office : 35-B, Ashiana Duplex, Tandalja Vaodara - 390012, Gujarat

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Transportation

Cable Pulling

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Brugg Cables India Pvt Ltd
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