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Electrical India

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India's oldest magazine on power and electrical products industry

58th Year of Service to the Industry

ANNUAL 2018

Thermal Sector: Performance & Constraints in 2018

Distribution Network for Smart Cities

Transformer Trends

Wires & Cables Industry: Betting Big on Infra

Lighting Market Shines Bright

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Publisher's letter

It is remarkable to be celebrating the 58th year of publication of Electrical India. On this landmark occasion, I take this opportunity in thanking you for your continued support and patronage.

We bring you this annual issue with detailed insights on almost every aspect of Indian power and electrical industry.

In this issue, Ashok Khurana from Association of Power Producers answers the question: "How to revive the thermal power sector?" Former Coal Secretary Anil Swarup acknowledges that UDAY hasn't travelled the distance it should have travelled in the states.

For 58 years, technology has turned the world upside down and inside out. Now the industry stalwarts tell us how technology will change the future. IEEMA's Harish Agarwal predicts that the SMEs are going to be the game changer for tomorrow whereas Dr. Harald Griem of Siemens explains how digitisation is transforming energy management and power sector.

Renewable energy is quickly becoming the dominant locus of new electricity generation investment. Here, we present you some thought-provoking insights into the past and the future of renewable energy in India.

We thank all contributors who have helped us celebrate this 58th Annual issue by putting their thoughts to print. We hope you will celebrate with us.

Do send me your comments at miyer@charypublications.in

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Editor's letter

Revival on the Horizon

Energy is the lifeline of economic development. In his book *'The Audacity of Hope: Thoughts on Reclaiming the American Dream'*, former US President Barack Obama states: "A nation that can't control its energy sources can't control its future." Couldn't have said it better!

In India, with growing population and expanding economy, there is the clear shift in focus from agriculture to the manufacturing and services sectors. This has led to an increase in energy intensity which has resulted in an unprecedented demand for energy sources. Further, according to Prime Minister Narendra Modi, India's energy consumption will grow 4.5 per cent every year for the next 25 years. So, India needs to ensure energy security to maintain its growth momentum and emerge as an economic superpower.

However, fuel scarcity is the major roadblock in the path of achieving energy security. As coal remains the largest energy source for India, the production of coal will need to be ramped up substantially. The Scheme for Harnessing and Allocating Koyala (coal) Transparently in India (SHAKTI) is introduced to ensure coal linkage to power producers based on an auction and tariff-based bidding.

With the aim of improving gas supply, the government also seeks to revisit the E-RLNG scheme. The scheme envisages supply of imported RLNG to the stranded gas-based plants as well as the plants receiving domestic gas, upto the target PLF, selected through a reverse e-bidding process.

The government also plans to warehouse stressed power projects totalling 25,000 MW under the proposed Power Asset Revival through Warehousing and Rehabilitation (PARIWARTAN) scheme. Further, the Electricity (Amendment) Bill, which is slated to be tabled in the Parliament during Winter Session, is expected to bring in reforms in an order to increase reliability and reduce risk in the power sector.

The telecommunication revolution in India has been astonishing and it has been a driving force of the economy for the past decade. Today India is the world's second largest telecommunication market thanks to policy clarity, opening of spectrum, encouraging private entrepreneurship, and access to capital, especially FDI. A telecom-like revolution is need of the hour for Indian power sector to sustain and deliver on the government's commitment to *'Quality Power for All'*.

Subhajit Roy

Group Editor

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Electrical India
Annual 2018

contents

Vol. 58 | No. 12 | December 2018

www.electricalindia.in

How to revive the thermal power sector? 48

Ashok Khurana, Director General, Association of Power Producers (APP)

Targets without a deliverable action plan has no meaning 58

Anil Swarup, Former Coal Secretary

Maharashtra to compete with other countries! 92

Subhash Desai, Mining & Industries Minister, Govt. of Maharashtra

[PC11-48E]

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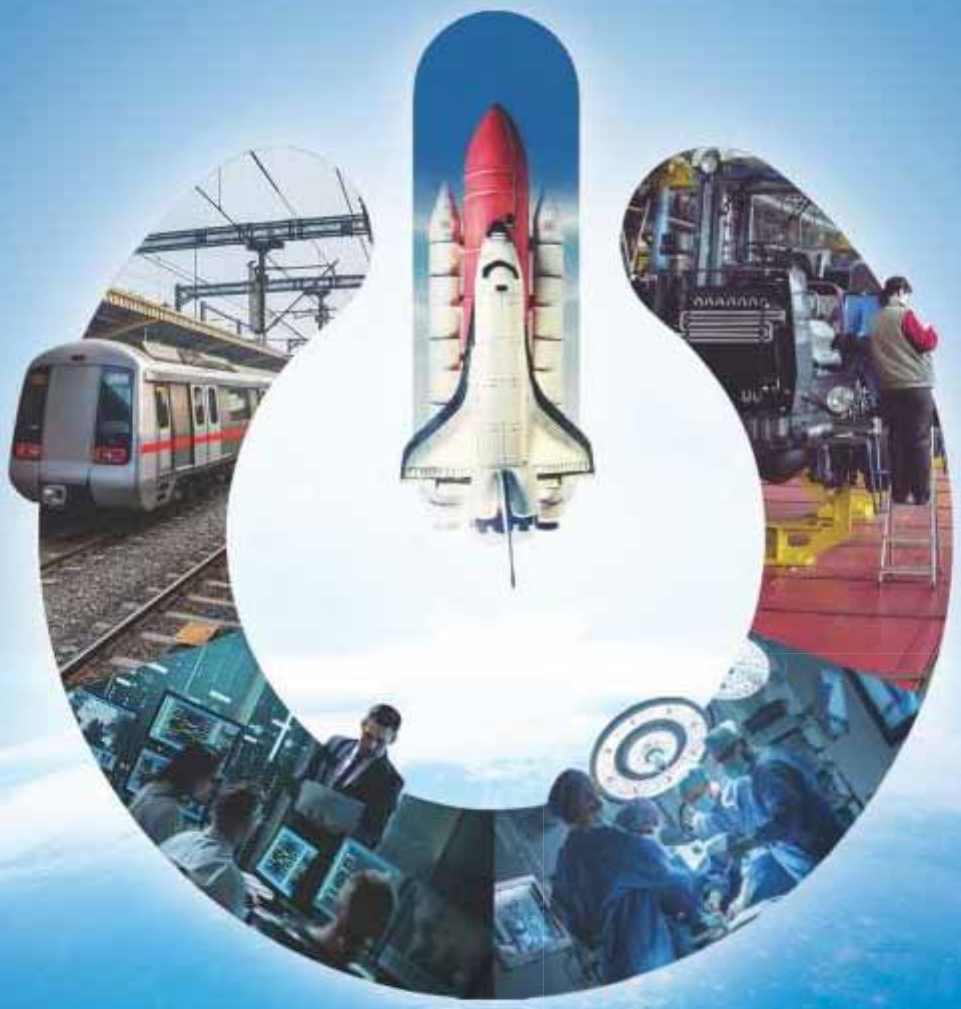

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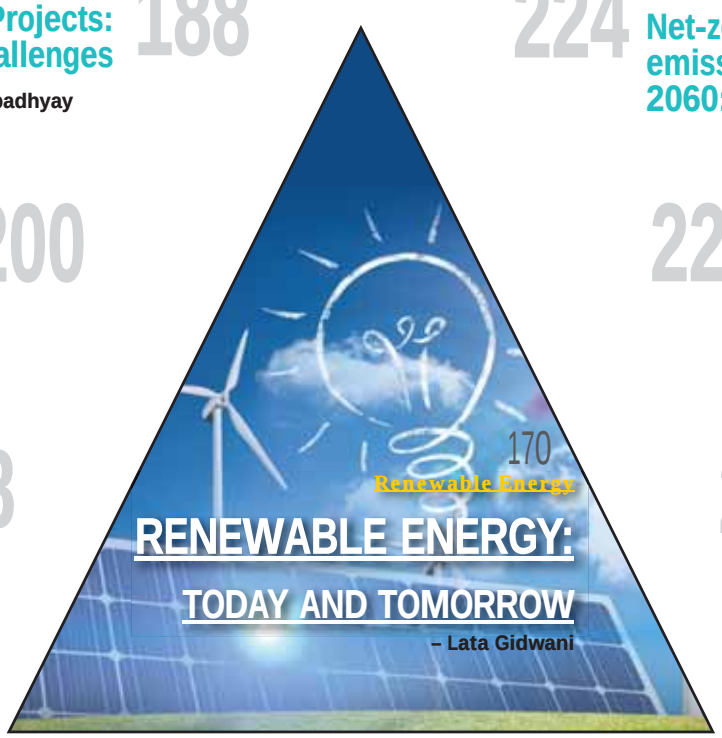

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PCA to promote quality electrical infrastructure in India

India witnessed the start of a movement for quality infrastructure with the launch of Power Cable Alliance (PCA). Two copper rod manufacturers, eight Indian leading power cable manufacturers and one international power cable entity – have come together to form PCA. PCA is an association of organisations and individuals which will work together to push for the creation of safe, reliable and efficient electrical infrastructure in the country.

PCA was formally launched in Mumbai in the presence of Subhash Desai, Mining & Industries Minister, corporate leaders from across industries.

Stressing on the need for a strong power infrastructure in the country, Mr. Desai said, "I appreciate the initiative taken by the organisers. We, the government of Maharashtra are equally concerned about the issue of electrical safety and would be hosting a conference where government and private sector can get together to build a program and have a better control of the situation. I would like to invite all the key members of the industry present here to join us and enrich our deliberation."

PCA Launch Event with Mr. Subhash Desai

Bajaj Electricals appoints Anuj Poddar as Executive Director

Bajaj Electricals announced the appointment of Anuj Poddar as the Executive Director of the organisation. In this role, Anuj Poddar will be responsible for managing all the business verticals and its operations. Anuj Poddar will report to Shekhar Bajaj, Chairman and Managing Director. He takes up this post with immediate effect.


Anuj Poddar

Speaking on his appointment, Shekhar Bajaj, Chairman and Managing Director, said, "Anuj has been associated with Bajaj Electricals as a Non-Executive, Independent Director on the Board since May 2016. During this tenure, Anuj has provided many valuable insights which have benefitted the organisation. He has also ably served as Chairman of the Audit Committee. I'm confident that Anuj's professional experience and business acumen will help us strengthen our market position and take the organisation to greater heights."

Waaree Energies Launches Indigenous Flexible Modules

Waaree Energies announced the launch of the Waaree Light Weight (WLW) Modules. The indigenous modules can be customised to any shape and colour. Coupled with their peel and stick nature and the light weight, WLW modules are easy to install and can highly benefit the transportation sector in India. The modules have specially designed for light weight applications, overcoming the limitations of the heavy glass modules. Being bespoke, Waaree Light Weight Modules find their applications across sectors like BIPV (Building-Integrated Photovoltaics) and architecture, and for transportation solutions including e-vehicles and refrigerated trucks. The modules can also be used in traffic lights and other similar solutions.

The WLW modules are tailor-made as per consumer requirements and have been developed for customised applications. In addition, WLW series also helps save Balance of Solar (BOS) costs for the consumers.

The module will be manufactured at Waaree Energies' manufacturing unit in Surat and will be available at Waaree Solar Experience Centres across India.

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Project highlights:

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BHEL Commissions 120 MW Pulichintala HEP in Telangana

With the commissioning of the fourth and final 30 MW hydro generating unit, Bharat Heavy Electricals Limited (BHEL) has successfully commissioned the 120 MW Pulichintala Hydro-Electric Project (HEP) in Telangana. The other three units of the 4x30 MW Pulichintala HEP, commissioned earlier by BHEL, have been operating successfully. Located in Suryapet district of Telangana, the greenfield project has been set up for Telangana State Power Generation Corporation Limited (TSGENCO) on the Krishna. Power generation from Pulichintala HEP will contribute in reduction of greenhouse gas emissions towards achieving a low carbon footprint.

BHEL was entrusted with execution of the Electro-Mechanical (E&M) package for the project comprising supply and supervision of erection and commissioning of four sets of Vertical Kaplan turbines and generators of 30 MW capacity each. The equipment for the project has been manufactured and supplied by BHEL, while the erection and commissioning on the site has been carried out under the supervision of the company's Power Sector Southern Region construction division.

R K Singh Reviews Buxar Thermal Power Project Progress

Union Minister for Power and New and Renewable Energy R K Singh has directed the concerned officials to expedite the investment approval for the Buxar Thermal Power Project at the earliest so that foundation stone laying ceremony can take place by January, 2019. He was chairing a review meeting of the progress of the 1320 MW project recently.

The project already has all tie-ups in place. The meeting was attended by representatives from SJVN, NITI Aayog, Department of Expenditure, Central Electricity Authority and Government of Bihar. The Project is estimated to cost over Rs 10,000 crore. The project is being executed by SJVN.

Different aspects of the projects were discussed at the meeting. Chairman of SJVNL informed that they have all the clearances, i.e. environment clearance, chimney height clearance, land for main plant, coal linkage, water availability and the project can go ahead in plug and play mode.

Principal Secretary (Energy from Government of Bihar stated that Bihar will take not less than 85 per cent power from the project as Bihar has seen a growth in power demand of 15 per cent in the recent years. Bihar has shown tremendous growth in electricity consumption, as the per capita consumption of Bihar has grown from 145 units in 2012-13 to 360 units in 2017-18.

Agreements Signed for 1900 MW Capacity

A major milestone in the evolution of the medium-term market for power was achieved on 29th October, 2018 with the signing of agreements for 1900 MW capacity under Aggregated Power Procurement Scheme on medium term basis with PFC Consulting as Nodal Agency and PTC India as Aggregator.

The PPAs are expected to lessen the burden and would lead to efficient utilisation of capacities of some of the coal based stressed power plants. This scheme endeavors to achieve a balance in allocation of risk-reward to the transacting parties.

Ministry of Power in April 2018 had issued guidelines for a pilot scheme to facilitate aggregation of procurement of power (2500 MW for three years) from commissioned coal-based power plants through competitive bidding. PFC Consulting conducted the bid process for selection of capacity on DEEP e-bidding portal from different projects. Subsequent to the bidding process tariff was discovered as Rs. 4.24 per unit and projects with aggregate capacity of 1900 MW were declared as the successful bidders.

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NTPC Awards GE Power Four Contracts

GE Power has been awarded four orders by NTPC to supply and install Wet FGD systems for a combined value of INR 1783 crore (USD 247 million). The four power plant projects are:

- Solapur Super Thermal Power Project - 2x660 MW,
- Tanda Super Thermal Power Project Stage II - 2x660 MW,
- Feroze Gandhi Unchahar Thermal Power Project -1x500 MW, and
- Meja Thermal Power Project - 2x660 MW, by Meja Urja Nigam Private Limited (a JV of NTPC and UPRVUNL).

These new awards build on GE Power's expertise in Wet FGD systems with the recent completion of facilities and performance guarantee tests for Wet FGD at NTPC's Vindhyachal Stage V/Unit 13 - 1 x 500 MW thermal power plant and awarded contract for Wet FGD for NTPC's 2x800 MW Telangana Thermal Power Project earlier this year.

These six Wet FGDs together will treat more than 42 million cubic meters per hour of flue gas and will remove more than 540,000 tons of SO2 each year which will be converted into gypsum by-product for use in the construction industry.

"This is an important milestone in the country's progress towards lowering the environmental footprint of its thermal power plants," said Andrew H DeLeone, Managing Director, GE Power India.

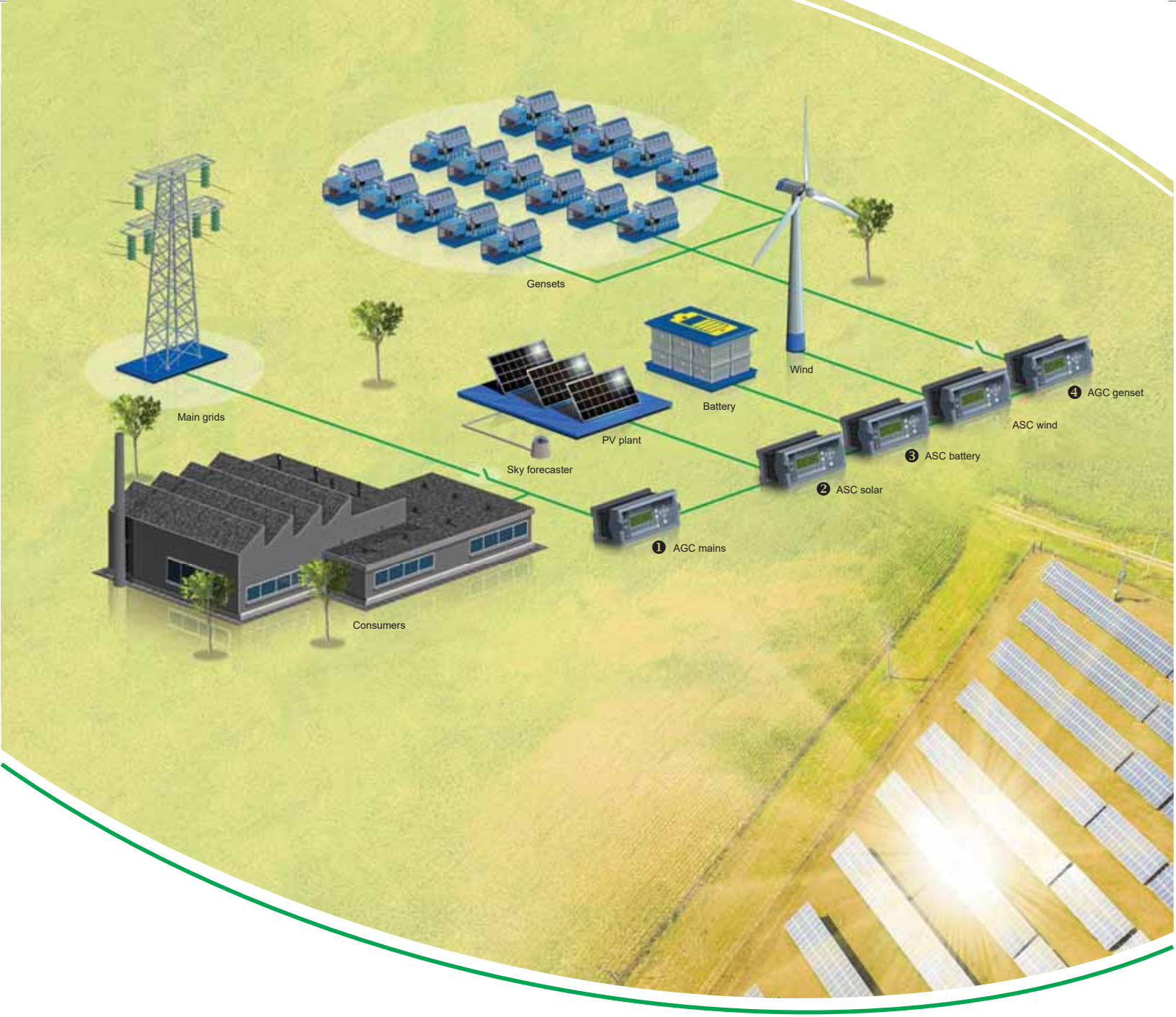
Hartek Bags 400-KV Power Grid Order

Hartek Power has bagged a prestigious order from the Power Grid Corporation of India Ltd (PGCIL) for augmenting an extra high-voltage 400-KV substation project spread over three states. Encompassing Uttar Pradesh, Haryana and Rajasthan, the project will cater to a population of about 7 crore. The scope of work of the project entails complete execution of the substation package involving conversion of fixed line reactors into switchable line reactors with the purpose of curtailing outages. The project, which will go a long way in strengthening the northern grid, is scheduled for completion by February 2020. Hartek Power will convert fixed line reactors to switchable line reactors so that these devices can be optimally used to curtail line outages at 400-KV substations located in Ballia and Sohawal in Uttar Pradesh, Kankroli in Rajasthan and Abdullapur in Haryana. Current-limiting devices which counter rapid variations in voltage, reactors stabilise the frequency at which electricity is transmitted and distributed by filtering the disturbances in the power system. Switchable line reactors have a distinct advantage over fixed line reactors as unlike fixed line reactors.

SUN Mobility & SmartE Partner to Transform EV Adoption

SUN Mobility announced a partnership with SmartETM to deploy its universal energy infrastructure to support SmartE's growing EV operations. In April 2018, SUN Mobility showcased the Interoperable Smart Mobility solution for two and three wheelers and this is the first-of-its-kind deployment in the country for electric three-wheelers. SmartE's fleet of electric three-wheelers will make use of SUN Mobility's solution and will be deployed at SmartE Park & Charge Hubs across the Delhi-NCR to bolster its first and last-mile connectivity services. The partnership will see SUN Mobility scaling the battery swapping infrastructure over the next three months to support 500 electric three-wheelers in Phase 1.

The two companies have come together, leveraging their expertise in product and solution to drive convenient, affordable and zero-emission last mile connectivity for the NCR region. The partnership is an example of collaboration between companies to address India's growing need for clean public transport solutions and aims to rapidly transform the overall EV adoption in the country.



MICROGRID CONTROL

DEIF's ASC Plant Management and AGC Plant Management interface between sustainable power sources and diesel/gas genset controllers/utility power.

Through CANbus communication power output is optimized to meet load requirements, thus ensuring that the sustainable power sources take maximum load share. The system uses DEIF's fixed power mode and mains power import/export mode features to achieve relevant operation philosophy. For example, if the sustainable power sources decreases due to reduced sunlight, the deficit will be met by the diesel gensets through the CANbus communication.

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Artificial Intelligence Will Transform HRM: Sanjay Banga

Sanjay Banga, CEO, Tata Power-DDL focused on the development of machine learning and how AI will transform Human Resource Management (HRM) during his inaugural address at the 'Artificial Intelligence and Digitalisation in HR' program organised by the National Institute of Personnel Management in New Delhi.

Stressing importance to machine and deep learning, the key highlights of the program included discourse on managing expectations of the next-gen workforce through AI-based HR practices, using HR analytics to make effective talent decisions for organisations and guiding HR professionals in the usage of advanced techniques for better business decisions. Banga said, "HRM is of the prime importance for any organisation to achieve its objectives. IoT is going to play a vital role in the way we utilise our manpower. Organisations which embrace technology and reskill their workforce to drive change will reap the benefit and be ahead of the curve. At Tata Power-DDL, we are implementing AI for predictive analysis for employee needs and satisfaction, social media analytics, and default prediction."

SPV of Sterlite Power Raised Rs 3000 crore on BSE Platform

BSE had launched a platform for Electronic Book Mechanism 'BSE BOND' for issuance of debt securities on private placement basis on 1st July 2016. On November 27, 2018, NRSS XXIX Transmission successfully raised Rs 3,000 crore by issuing bonds on private placement basis using the same platform.

"We are proud to have completed this important transmission line project in Kashmir, ahead of schedule. These AAA bonds have been fully subscribed on the BSE BOND platform and will help to deepen the much-needed infrastructure bond market in India," said Pratik Agarwal, Group CEO, Sterlite Power.

BSE has been a market leader for bond issuances and the BSE's platforms have been a preferred choice for companies to raise Debt Capital in India. Since its inception, on July 1, 2016, 131 Issuers have done 1,358 issues of bonds and have successfully raised Rs 5,71,944 crore using BSE Debt platforms. Some of the esteemed issuers include PFC, RECL, IRFC, PGCI, NHAI, HDFC, Axis Bank, PGCI, NABARD, HUDCO, Yes Bank, Reliance Industries Limited, Reliance Jio Infocomm etc.

Eight States Achieve 100 % electrification under *Saubhagya*

"Eight states have achieved 100 per cent saturation in household electrification under Saubhagya namely Madhya Pradesh, Tripura, Bihar, J&K, Mizoram, Sikkim, Telangana and West Bengal. Thus, total 15 States in the country now have 100 per cent household electrification," said R K Singh, Union Minister for Power and Renewable Energy. Singh was speaking to media after the 'Review, Planning & Monitoring (RPM) Meeting with States and State Power Utilities'.

Saubhagya – 'Pradhan Mantri Sahaj Bijli Har Ghar Yojana' was launched in September, 2017 with the objective to provide access to electricity to all the remaining households in the country. The Minister informed that as many as 2.1 crore connections have been released under Saubhagya so far.

"Many more states like Maharashtra, Uttarakhand, Himachal Pradesh, Arunachal Pradesh, Chhattisgarh etc are left with small number of un-electrified households and expected to achieve saturation any time," said the minister adding that with the present pace of electrification, Nation is expected to achieve 100 per cent saturation in the country by 31st December, 2018.

The Minister further said, "Achievement of 100 per cent household electrification in the country would be a major milestone in the direction to achieve 24x7 power for all. The Government is committed to ensure 24x7 access to electricity for all by 31st March 2019." In order to ensure that no un-electrified household is left in the states which have already achieved 100 per cent household electrification, they have been requested to take up campaign to publicise the achievement all across the areas, so that anyone left out for any reasons may avail electricity connection under *Saubhagya.*

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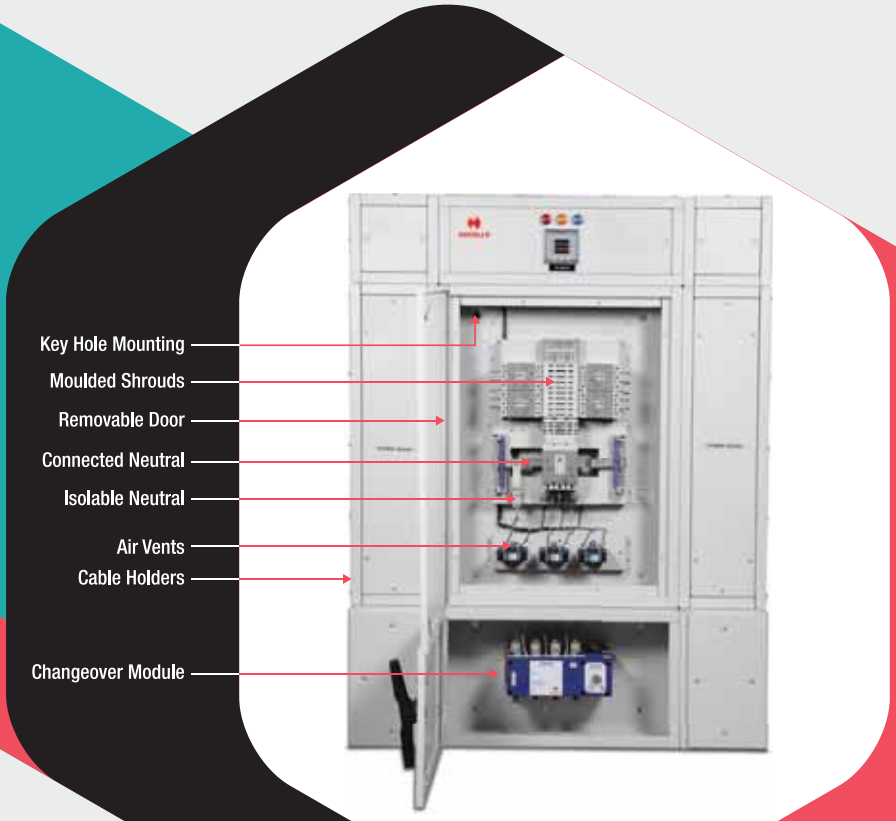

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- **Version:** Single / Double door

ReNew Power Wins Largest Floating Solar Project in India

ReNew Power has won the tender for developing a 3 MW floating solar PV project in Visakhapatnam, Andhra Pradesh. When commissioned, this project will be among the largest floating solar PV projects in India. ReNew won this project after participating in a bidding process conducted by Greater Visakhapatnam Municipal Corporation (GVMC) for installation of a floating solar PV project at Meghadrigedda reservoir located in Visakhapatnam,. This project is being financed by GVMC through a grant received from ADB under their Urban Climate Change Resilience Trust Fund. In total, this project is estimated to generate around 4.2 MU of power annually, offsetting over 3960 tonnes of carbon emissions every year. Prabhat Kumar Mishra, Head - Distributed Solar and Offtake, ReNew Power, said "We are proud to be associated with this project in Visakhapatnam. Floating solar power plants can play a critical role in a country like India. Factors like higher efficiency and lower installation time have also contributed to floating solar that is gaining momentum of late with SECI inviting an EoI to generate 10 GW through this channel. As per industry estimates, if only 10 per cent to 15 per cent of India's water resources are utilised for setting up floating solar plants, it could generate up to 300 GW of power. Our collaboration with GVMC in this initiative reflects ReNew's commitment to deploy innovative solutions ."

Vikram Solar Supplies 52.6 MW of Modules to Southern Current

Vikram Solar announced the shipment of 52.6 MW of solar modules to its US customer Southern Current. The order has been facilitated by Vikram Solar's recently opened local US office in Massachusetts. Southern Current is a developer in residential, commercial and utility-scale markets. Their integrated platform includes project development, engineering, construction, maintenance, finance and asset management.

Vikram Solar's Eldora Grand Ultima Silver 72 cell polycrystalline modules are part of Southern Current's latest 52.6 MW ground mounted solar project. These high output modules for reduced cell to module power loss provide extreme performance reliability and are designed for very 'high-efficiency areas' – an ideal choice for this Southern Current's ground mounted project.

Great Eastern Energy Corporation to venture into Shale Gas exploration

Great Eastern Energy Corporation announced an upgrade in its resources at its Raniganj (South) block, which has been provided by the independent reserve engineers, Advance Resources International. The Government has permitted exploration and exploitation of all types of hydrocarbons including shale resources under the existing CBM Contracts. Prashant Modi, Managing Director and CEO of Great Eastern Energy Corporation, said, "We are delighted to report this significant uplift in the OGIP for our Raniganj (South) block of up to 9.25 TCF with an undiscounted value of USD 13.78 billion and a discounted value of USD 4.31 billion. We believe that the shale gas resources can be explored and developed cost-effectively in tandem with our successful ongoing CBM development program through the sharing of surface and other infrastructure facilities.

We are currently planning the initial exploration program for exploiting shale in our block and will make a further announcement in due course when we commence the same. This is a fantastic opportunity for us to leap to the next level in the unconventional energy space. We continue to be confident and excited about the future of our Raniganj (South) block.

We commend the Government of India's continuing transformational policies for the E&P sector; these will go a long way in attracting investments in the sector, thereby, boosting India's energy security and reducing our dependence on imports."

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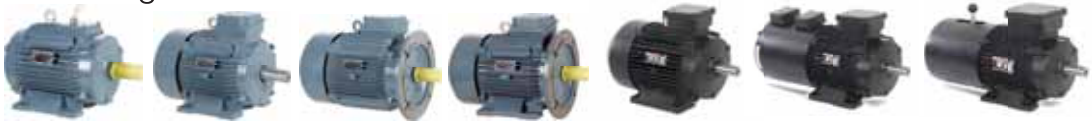

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Tecumseh to Open New Global Technology Centre in India

Tecumseh Products announced their plans to establish a state-of-the-art global technology centre near Delhi. This centre is expected to further strengthen strategic partnerships and collaboration with customers providing them with next-generation and eco-friendly compressor, condensing unit and system related technologies. The new technology centre will join Tecumseh engineering labs in the United States, France and Brazil to further support an increased focus on research, development and customer applications.

(L-R) Doug Murdock - President and CEO Tecumseh Products Company LLC, Michael Bauersfeld - EVP and CFO Tecumseh Products Company LLC and Jegapriyan Govindarajan -MD Tecumseh Products India Pvt Ltd.

After laying the foundation stone for the global Technology centre, Doug Murdock, President and CEO of Tecumseh Products Company LLC said, "We are very excited to expand our global product design and manufacturing capabilities. We are committed to supporting our customers throughout the world meet their rapidly changing local needs, industry regulations, and product requirements."

Essar Completes Capex Cycle For 2×600 Mw Mahan Project

Essar Power announced the completion of the Rs 8,000 crore capex program for its 2×600 MW Mahan power plant project with the commissioning of the plant's second 600 MW unit. Both units of the project are operational and supported by an end-to-end raw material sourcing and evacuation infrastructure.

The second unit is supplied by Harbin Electric and is designed to perform at optimum efficiency with domestic coal from pithead mines in the region. The Gajra Behra siding can handle, at its peak, up to three rakes per day, which will meet the coal requirements of the Mahan plant substantially. The 400-kV transmission line commissioned a fortnight ago is part of the Inter State Transmission System of Power Grid. It has enhanced the transmission capacity of the region by 1,800 MW.

"In the last one year, we have commissioned more than 1,500 MW of operational capacity and 465 km of transmission lines. Our focus has been on sweating our investment and meeting the growing demand for power in the nation," said Pradeep Mittal, Executive Vice Chairman, Essar Power. "With the completion of the capex cycle at Mahan, we now have 3,830 MW of generation capacity, with another 1,260 MW under construction, and a presence in the high-margin transmission sector. We have invested more than Rs 30,000 crore in the power portfolio," said Prashant Ruia, Director, Essar.

KPTL Received New Orders of Rs 1,322 crore

Kalpataru Power Transmission Limited (KPTL), a global EPC player in the power and infrastructure contracting sector has secured new orders or notification of award of Rs 1,322 crore. The details are as follows:

- Transmission and Distribution business has secured orders in India, Bangladesh, Abu Dhabi and Peru totaling Rs 943 crore.
- Composite order for railway infrastructure construction from RVNL for Rs 379 crore in a consortium.

Manish Mohnot, Managing Director and CEO, KPTL, said, "The new order includes large orders from Bangladesh and Abu Dhabi, which reinforces our focus on SAARC and Middle East apart from our established presence in African market. The new order in our railway business reaffirms that Railways will continue to be a key growth driver going forward. Our order book continues to grow with the influx of new orders and we remain confident to meet our revenue and margin guidance for financial year 2018-19."

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Sale of KEC International's Holding in KEC Bikaner Sikar Transmission

KEC International signed a Share Purchase Agreement (SPA) with Adani Transmission for selling its entire stake in KEC Bikaner Sikar Transmission at an enterprise value of around Rs 227.5 crore subject to regulatory and other approvals. KEC Bikaner Sikar Transmission has an operational transmission line of 344 Ckt kms in Rajasthan from Bikaner to Sikar.

This sale is in line with KEC's strategy to focus on its core EPC business. KEC Bikaner Sikar Transmission holds a minimum 25 years concession license to operate and maintain a 400 kV D/C Bikaner- Sikar Line of 344 Ckt kms in Rajasthan. The project was awarded through competitive bidding process and was physically completed almost four months ahead of schedule by KEC International. The line was commissioned in December, 2017 and since then has been in successful operation.

Vimal Kejriwal, MD and CEO, KEC International commented, "We have decided to sell our holding in KEC Bikaner Sikar Transmission to Adani Transmission. With the successful construction and ahead of schedule commissioning of the Bikaner Sikar Transmission Line, KEC has further strengthened its presence in the Tariff Based Competitive Bidding space, the pre-qualifications and experience of which will be leveraged for securing similar upcoming opportunities in India."

Adani Power Registers Growth in Q2 FY19

Adani Power announced the financial results for the quarter and half year ended September 30th, 2018. Average Plant Load Factor (PLF) achieved during the second quarter of FY 2018-19 was 65 per cent higher as compared to 63 per cent achieved in Q2 FY 2017-18. This growth was on account of better coal availability and strong demand from distribution companies.

Consolidated total income for Q2 FY19 grew by 19 per cent to Rs 7,657 crore as compared to Rs 6,415 crore in Q2 FY18. The increase in revenues was due to additional revenue recognition on account of change in law compensation for domestic coal shortfall.

Consolidated total income for first half of FY19 was lower by -3 per cent at Rs 11,617 crore as compared to Rs 12,016 crore in H1 FY18 owing to the lower volumes recorded in Q1 FY 2018-19.

Consolidated EBITDA for the quarter grew by 18 per cent to Rs 2,806 crore from Rs 2,380 crore in Q2 FY18 on account of growth in revenues. Consolidated EBITDA for H1 FY19 was higher by 2 per cent at Rs 4,095 crore as compared to Rs 4,000 crore in H1 FY18.

Finance cost for Q2 FY19 was Rs 1,407 crore as compared to Rs 1,389 crore in Q2 FY18. The increase in finance cost was primarily due to higher borrowing during the quarter.

Mahindra's Igatpuri Plant Is India's First Carbon Neutral Facility

Mahindra Group took a big step forward in its commitment to becoming Carbon Neutral by 2040 with its Igatpuri manufacturing plant recently becoming India's first Carbon Neutral manufacturing facility. This was certified by Bureau Veritas (India). Vijay Kalra CEO - Mahindra Vehicle Manufacturers and Chief Manufacturing Operations at Mahindra and Mahindra, said, "This is the first plant within the Mahindra Group to be certified as carbon neutral. We have been able to achieve this through energy efficiency, a sharp focus on the use of RE and the planting of trees to absorb residual carbon."

Mahindra & Mahindra was the first company in the world to commit to doubling its energy productivity by 2030 signing on to the Climate Group's EP 100 program. Using energy efficient lighting, efficient HVAC, motors and heat recovery projects, M&M has doubled the energy productivity of its automotive business almost 12 years ahead of schedule.

Anirban Ghosh, Chief Sustainability Officer, Mahindra Group, added, "Through the work we are doing on carbon neutrality, we are not only responding on the climate change challenge but our work also results in improved efficiency and innovation."

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DNV GL Certifies Ingeteam's 2MW DFIG Converter

Ingeteam received DNV GL's certification for its Ingecon Wind stator-equipped 2MW DFIG converter. With this latest achievement, Ingeteam completes the range of its products covered under DNV GL certification such as the medium voltage full power converters and the statorless DFIG converters and demonstrates its ability to consistently meet DNV GL's quality and safety requirements.

Ingeteam's low voltage DFIG power converters have been developed with a modular FRT solution to optimise cost-effectiveness and fulfill the strictest international grid codes. It is a mature technology used by many of the main turbine manufacturers, offering key advantages with regards to costs and sizes savings. The DNV GL Component Certificate confirms that ingeteam's converter is designed, documented and manufactured in accordance to design assumptions, specific standards and technical requirements, globally. It also makes the process of new turbine development easier, speeding up the integration of components to wind turbine platforms.

"To this day, DFIG converters remain the most proven, efficient and cost competitive drive train topology. Our DFIG converter series offer cost-optimised products for each market and application. Those converters present a very grid-friendly behaviour, " explained Ion Etxarri Sangüesa, R&D Quality Team Leader of Ingeteam Wind Energy.

Hanergy's Alta Devices Setting New Efficiency Record for its Solar Cell

Hanergy Thin Film Power announced that Fraunhofer Institute for Solar Energy Systems, a German-based solar energy testing laboratory has rated Hanergy's US-based subsidiary Alta Devices' single junction GaAs cells as the world's most efficient. With its record setting 29.1 per cent conversion efficiency, Alta's technology is designed to power a range of products from unmanned aerial vehicles (UAV), electric automotive to smart sensors, due to its unique thin, lightweight, and flexible characteristics.

Alta Devices first broke the record for GaAs single-junction solar cells in 2010 and has now broken seven solar conversion efficiency records. Following this most recent breakthrough, both the efficiency world records for single junction solar cells (29.1%) and solar modules (25.1%) belong to the Hanergy group.

Commenting on the achievement, Mr. Jian Ding, CEO of Alta Devices said, "Our new record for solar efficiency and our long history of breaking records is evidence of our company's commitment to pushing the boundaries of solar technology to power autonomous systems"

He adds, "Alta Devices' vision is to lead the thin film power industry via continuous technological breakthroughs while contributing to the future of autonomous machines and vehicles."

Danfoss Powers Up World's Strongest Electric Ferry

Next year, the groundbreaking E-Ferry will be launched in Denmark with the help of Danfoss. The fully electric powered ferry will have the largest battery capacity at sea and navigate without CO_2 emissions. Ellen is the world's most powerful electric ferry and she is getting ready for her maiden voyage, targeted in the first quarter of 2019. The E-Ferry will be deployed between Ærø and Als, the Danish home island of Danfoss.

On a round trip, Ellen will travel 22 nautical miles, seven times further than any other electric ferry in the world today. She will carry the largest battery capacity of the seas. "Ellen is an excellent example of the future for electric transport: cleaner, greener and more efficient. It is a key project for the EU and demonstrates the potential for electric ferries to end users and the industry itself," says Kimmo Rauma, Vice President of Danfoss Editron, and adds, "We want to change the world by helping to alleviate pollution, and we believe that industry can lead the way. Ellen will be positioning Danfoss as a world leader in the development and delivery of electric ferries."

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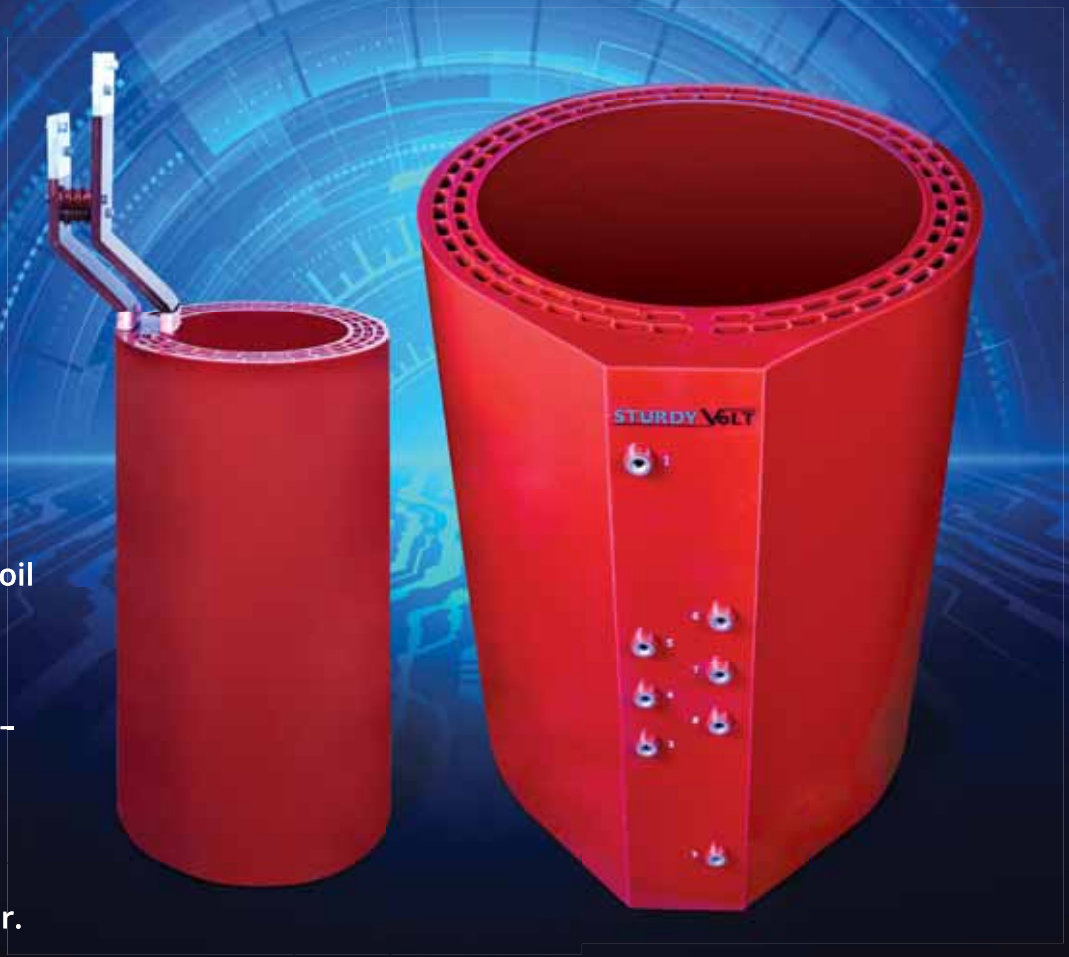

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Fortum eNext to Provide Technology to Plzeň Power Plant

Fortum eNext has been selected to carry out a boiler refurbishment project at Plzeň Power Plant in Czech Republic. The contract with Plzeňská Energetika a.s. for renewal of the existing combustion system, including installation of low-NOx burners and renovation of the flue gas system of boiler K3 was signed. The main target of the refurbishment is to reduce NOx emissions from the lignite fired boiler to meet European emission norms.

The solution is based on primary reduction methods, i.e. the key will be to prevent formation of NOx in the combustion process. This brings a significant benefit for the customer in the long run, as there will be no increase in the operating costs, which would be the case with only using secondary measures for reduction of NOx emissions. The project has already started its design phase and the actual work at the site will take place during summer 2019 with the final project hand over planned for early 2020. "Our expertise will allow the Plzeň power plant to do just that and simultaneously improve its performance," summarises Kari Lahti, Head of Environmental Performance, Fortum eNext.

"Our first international project to reduce emissions was conducted in Czech Republic in 1994 and we see that we can still do a lot with our partners in Central and Eastern Europe to work together towards a cleaner world," he concludes.

EIB Strengthens Backing for Indian Renewables

The European Investment Bank (EIB) confirmed new backing for investments across India. The EIB will increase support for onshore wind investment through expansion of an existing lending program with the State Bank of India. It has approved a new credit line with Yes Bank to accelerate private investments in wind and solar projects and expects to work closely with Indian partners to support offshore wind projects.

The clean energy financing was confirmed by EIB Vice President Andrew McDowell at an offshore energy investment conference in New Delhi earlier. "Scaling up renewable energy investment is crucial for economic growth, improving access to energy and addressing climate change and support for renewable is a key priority for the EIB, the EU Bank here in India. The EIB is pleased to host our first offshore wind investment conference in New Delhi and bring together technical and financial expertise from across India and the EU's unique global experience in the sector. We look forward to broadening cooperation with Indian partners to support new RE projects in near future and enabling offshore wind to contribute to clean power generation in the country," said Andrew McDowell, Vice President of the European Investment Bank responsible for Energy and South Asia.

EMC Launches Electricity Procurement Portal for Singapore Businesses

PowerSelect, which serves customers with an average monthly consumption of at least 10MWh, is the most comprehensive electricity procurement portal in Singapore to date and developed by Energy Market Company (EMC), a wholly-owned subsidiary of Singapore Exchange (SGX), PowerSelect offers different procurement options including a unique 15-minute live auction, houses data from the wholesale and futures electricity markets to help businesses make decisions around their electricity purchases.

SGX CEO Loh Boon Chye says, "EMC has a 15-year track record in enhancing the efficiency and transparency of Singapore's wholesale electricity market. Tapping on this experience, SGX launched Asia's first electricity futures market to support the liberalisation of Singapore's power sector, providing electricity retailers with an avenue to hedge risks. I am delighted that we are now extending our services to benefit business consumers as well."

EMC has been licensed by the Energy Market Authority (EMA) to operate Singapore's wholesale electricity market since 2003.

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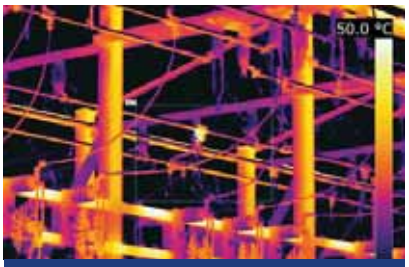

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Schneider Electric Endorses OPC Foundation

Schneider Electric welcomes the OPC Foundation recognition of industry efforts to bring interoperable communications to field level industrial operations.

In the fast-changing industrial space, operations technology and information technology are becoming increasingly interconnected to enable more flexible and agile manufacturing and processing operations to meet evolving market requirements. The recognition of the importance of standards-based communication between operational technologies and information technologies (OT and IT) across device, machine to machine, and cloud infrastructure as the basis for industry to achieve the full benefits of automation is a vital step. "The benefits OT and IT connectivity can only be realised through open, deep interoperability. This drives an urgent need to move away from proprietary communication protocols in favour of open, unified, standards based, Industrial IoT (IIoT) communications between sensors, actuators, controllers and cloud platforms," says Fabrice Jadot, Senior Vice President, Technology and Innovation and CTO for Industry Business at Schneider Electric. Schneider Electric has been working to bring open interoperable communications between devices and systems with a number of market leader partners and supports the Open Platform Communication Foundation (OPC F).

Freyr Energy Raises Funds to Strengthen Technology

Freyr Energy has raised an investment of Rs 27 crore that is a mix of equity and debt. The round was led by C4D Partners, a Netherlands-based Impact Investment Fund. Last year, Freyr Energy had secured seed funding from Doen-Participaties, another Netherlands-based investment company that has a strong track record of investing into innovative and sustainable start-ups.

Freyr Energy believes in making solar energy more accessible for homeowners, businesses and communities around the world. Freyr Energy's technology platform, SunPro, was developed to provide customised solutions to the customers. Freyr Energy currently has more than 1000 installations across 18 states in India and a customer base in USA, Nigeria and Ghana. Saurabh Marda, Co-Founder, Freyr Energy, said, "The funds raised will be used to improve our technology platform, increase strength of our sales and channel partner network and support marketing activities to fuel future growth."

ABB Showcases World's Most Energy-Lean UPS

At SPS Drives 2018, ABB features its uninterruptible power supply (UPS) DPA 250 S4 with its market-leading module efficiency of 97.6 per cent, 30 per cent lower power losses than competitor products, top reliability, zero downtime and low cost of ownership. The DPA 250 S4 features ABB's decentralised parallel architecture (DPA), covers the power range 50 to 1,500 kW and is specially designed for critical, high-density computing environments such as small to medium sized data centers, commercial buildings, healthcare facilities, railway signaling applications and airports.

One DPA 250 S4 250 kW cabinet can host up to six 50 kW modules for 250 kW N+1 redundant power. Up to six 250 kW frames and up to 30 modules can be paralleled for 1,500 kW of uninterrupted, clean power. Secure ring-bus communication ensures there is no single point of failure in the system. The DPA 250 S4's dual conversion mode ensures power going to the critical load is cleansed of any grid noise or fluctuations. Its transformer-free IGBT (Insulated Gate Bipolar Transistor) converters, which feature three-level topology with interleaving controls, mean that the device is lighter and more energy efficient, with reduced cooling requirements. The DPA 250 S4 delivers a market-leading module efficiency of 97.6 percent and a system efficiency of 97.4 per cent, setting the standard for the future of UPS evolution.

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Stefan Hoppe Elected as President and Executive Director of the OPC Foundation


Stefan Hoppe

The OPC Foundation welcomes Stefan Hoppe as its next President and Executive Director. Burke, the former President and Executive Director, nominated Hoppe as his successor before resigning during the last Board of Directors meeting. Hoppe was elected by the board in the same meeting. Burke will remain as an officer on the Board of Directors and will continue his widespread evangelism for OPC UA adoption across various domains. Stefan Hoppe took over the operational activities and responsibility for worldwide adaption of the OPC standards and the further development of the organisation.

Stefan Hoppe is a long-standing member of the control automation industry and the OPC Foundation. As an electrical engineer, he joined BECKHOFF in 1995 where he developed OPC classic server and in 2006 the world first OPC UA server integrated into an embedded controller. In 2008 he initiated and chaired the PLCopen OPC UA Companion working group which results are adopted in process industries and discrete manufacturing by multiple international well-known vendors. In 2010, Hoppe was elected for President of OPC Foundation Europe. Since 2014, he is Vice President of the OPC Foundation and member of the OPC Board. During the following years Hoppe became an OPC UA evangelist increasingly committed to adopting OPC technologies. Experts see OPC UA as a core standard in the emerging Internet of Things and Industrie4.0 movements.

The key qualifications the OPC Foundation looked for in Burke's successor were deep working knowledge of the existing organization, a well-formed long-term vision for the OPC Foundation, a strategic and collaborative mindset. With over 12 years of working with and promoting OPC UA and over eight years of active OPC Foundation leadership - Hoppe was a natural fit for the role.

Dr Rahul Walawalkar Appointed as Chair of GESA


Dr Rahul Walawalkar

The Global Energy Storage Alliance (GESA) has appointed Dr Rahul Walawalkar, Executive Director of India Energy Storage Alliance, as its new Chair. The appointment was announced at the GESA board meeting held recently during Energy Storage North America in Pasadena, California, USA. Dr Walawalkar replaces Janice Lin of the California Energy Storage Alliance (CESA) who served as chairperson since the organisation's inception.

GESA was co- founded in 2014 by six regional energy storage alliances including US Energy Storage Association (ESA), California Energy Storage Alliance (CESA), China Energy Storage Alliance (CNESA), Germany Energy Storage Association (BVES), India Energy Storage Alliance (IESA) and the Alliance for Rural Electrification (ARE). It was founded with a goal of advancing education, collaboration, knowledge and proven frameworks about the benefits of energy storage globally and how to incorporate it into the electric power system in a cost-effective way.

Over the past four years, GESA has worked to foster collaboration among key stakeholders including policy makers, utilities, renewable energy community, financial institutions and environmental organisations. In 2014, GESA facilitated international collaboration between California and Germany. In 2015, the members of GESA worked with International Renewable Energy Agency (IRENA) to hold four international stakeholder meetings that led to the launch of IRENA Energy Storage Roadmap in 2015. In 2016, the alliance selected MICRO- Microgrid Initiative for Campus and Rural Opportunities, by IESA as a flagship initiative to advance energy access. In 2017, GESA released a white paper on Utility Procurement Best Practices to summarize common considerations and best practices in utility energy storage procurement in the United States.

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Transmission Line Tower Stub Strengthening by RPL: Patented technology with patent no. 297450 dated 06/06/2018 ensuring and enhancing the life of line towers, preventing collapsing of towers.

RTV Coating of Insulators: RPL is integration partner of **CSL SILICONS**, CANADA for RTV COATING of insulators.

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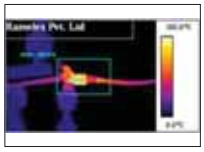

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REC wins Golden Peacock Award for Corporate Governance

REC Limited, the state-owned 'Navratna' financier in the power sector, bagged the prestigious Golden Peacock Award 2018 for Excellence in Corporate Governance on 25th October in London. The award was presented at the 18th London Global Convention in the presence of business leaders

The award, conferred by the Institute of Directors, was received by Dr Shakil Ahamed, Senior Executive Director, REC and J S Amitabh, Company Secretary, at the 18th London Global Convention attended by business leaders, corporate governance experts and policymakers. Golden Peacock Awards, instituted by the Institute of Directors (IOD), India in 1991, are regarded as a benchmark of Corporate Excellence worldwide. The jury panel was chaired by

Dr Shakil Ahamed, Senior Executive Director, REC and J S Amitabh, Company Secretary, at the 18th London Global Convention attended by business leaders, corporate governance experts and policymakers. Golden Peacock Awards.

Justice (Dr) Arijit Pasayat, former Judge, Supreme Court of India & Chairman, Authority for Advance Ruling (Customs, Central Excise & Service Tax).

Nirmala Gets 'Most Influential Leader of the year 2018' Award

Nirmala, Executive Director – Group HR, RSB Group, was bestowed with 'Most Influential Leader of the Year 2018' award for having achieved all round excellence as a Woman Leader in a function held at Imperial Hall, St Regis, Mumbai on the eve of Future Woman Leader Summit and Awards 2018 in the august presence of dignitaries and celebrities.

'Future Woman Leader Summit & Awards' is an annual event organised by Transformance Business, Mumbai. The awards are tribute to those who are woman leaders and passionate in leadership, have contributed significantly and excelled in their roles globally. The Woman Leader Summit pays tribute to

such leaders who are transformational agents. The criteria of selecting award is after intense scrutiny and deliberation of extra ordinary work and record of achievements by a jury panel comprising of top professionals and celebrities, based on the nominations received.

Varanasi Edu-Hub Project bags 5-Star SVAGRIHA Rating

Empowering Rural India through Edu-Hub - a project by ReNew Power Ltd, near Varanasi in Uttar Pradesh has been awarded the coveted 5-Star SVAGRIHA Rating by the Green Rating for Integrated Habitat Assessment (GRIHA) Council.

Edu-Hub is an initiative undertaken by ReNew Power to support talented rural children and youth, by promoting digital literacy, encouraging sports talent through scholarships & imparting skill training to villagers besides disseminating vital community information.

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Smart Grid Market worth USD 61.3 billion by 2023

With the increasing deployment of smart grid solutions in the smart cities, the smart grid market is expected to gain a major traction during the forecast period.

According to Marketsandmarkets research report 'Smart Grid Market by Software, Hardware, Service, and Region - Global Forecast to 2023', the smart grid market size is expected to grow from USD 23.8 billion in 2018 to USD 61.3 billion by 2023 at a Compound Annual Growth Rate (CAGR) of 20.9 per cent during the forecast period. Government policies and legislative mandates, the awareness of carbon footprints, modernisation of aging grid infrastructure, and improved grid reliability and efficient outage response are driving the adoption of smart grid solutions. With the increasing deployment of smart grid solutions in the smart cities, the smart grid market is expected to gain a major traction during the forecast period.

The smart grid distribution management segment is expected to hold the highest market share during the forecast period. Smart grid distribution management is a software platform that integrates Supervisory Control and Data Acquisition (SCADA), Energy Management System (EMS), Distribution Management System (DMS), Demand Response (DR) management, and Distributed Energy Resource Management (DERM) for energy distribution management and optimisation on a real-time basis.

The deployment and integration services segment is expected to have the highest market share and projected to grow at the highest CAGR during the forecast period. Deployment and integration services help in reducing the deployment and integration time. These services are crucial for developing end-to-smart grid solutions for the energy sector. The increasing requirement for upgrading traditional smart grid systems to support various smart cities and smart grids is increasing the growth of the deployment and integration services segment in the smart grid market.

North America is expected to hold the highest market share and dominate the smart grid market during the forecast period. The region has been extremely responsive toward adopting the latest technological advancements, such as Advanced Metering Infrastructure (AMI), smart grid distribution management, smart grid network, and substation automation.

The major factors driving this region are the large-scale investments in smart grid and smart city projects and need for better smart grid and control mechanisms. MEA is in its initial growth phase; however, it is the fastest-growing region in the global smart grid market. The region has huge reservoirs of conventional and renewable energy sources. The high adoption of solutions to minimize outages and revenue losses, and provide better smart grids and controls has led to a wider demand for smart grid solutions in MEA.

The major vendors offering smart grids are GE (US), ABB (Switzerland), Siemens (Germany), Schneider Electric (France), Itron (US), Landis+Gyr (Switzerland), Aclara (US), Cisco (US), OSI (US), IBM (US), Wipro (India), Honeywell (US), Oracle (US), S&C Electric Company (US), Eaton (Ireland), Kamstrup (Denmark), Trilliant Holdings (US), Globema (Poland), Tech Mahindra (India), Enel X North America (US), eSmart Systems (Norway), Tanatalus (US), EsyaSoft (India), Grid4C (US), and C3 Energy (US).

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REWIRING INDIAN ELECTRICITY

Strategic mapping of Indian electrical equipment industry

By Subhajit Roy, Group Editor

India is one of the fastest growing economies in the world and the power sector continues play the pivotal role to this growth. Overall installed power generation capacity on all India basis has increased by CAGR of 10 per cent i.e. from 159 GW as on March 31, 2010 to 344 GW as on March 31, 2018, mainly led by investments in the private sector in thermal

segment during the 11th Plan period (2007-2012) and 12th Plan period (2012-2017).

Of late, the record capacity addition in the last couple of years raised the installed generation capacity to over 346 GW, including 50 GW from renewables. As of October 31, the country's total installed production capacity was 3,46,048 MW. Out of that, thermal power comprising coal, gas and diesel accounted for 64%, hydropower 13% and renewables accounted for 20%.

However, the sector is experiencing turbulence of some sort or another on account of increased gap in the demand-supply position, underutilised capacity, inefficient coal linkages, financial stress to the generating companies, economic health of DISCOMs etc.

This report examines the recent performance of a few key elements of electrical equipment industry in India highlighting the growth drivers. Apart from having a discussion on how technology is defining businesses across the spectrum, the report delves deeper into the future of industry segments beyond 2019.

Transformer

Indian power sector has come a long way and undergone significant progress witnessing growth, upgrading technology and focusing on core issues of T&D (transmission & distribution) loss reduction, as well as increasing the generation through clean technologies.

Keeping pace with this growth, Indian electrical equipment industry has also shown an impressive growth of 12.8 per cent in FY17-18 with power transformers growing at 8 per cent CAGR and distribution sector at 3 per cent CAGR.

Various schemes of the government including UDAY, SAUBHAGYA, SHAKTI, and SAMADHAN are playing a major role in reducing the T&D losses as well as giving a boost to the DISCOMs in strengthening the distribution network. This has certainly improved the demand of the distribution transformers by the DISCOMs, informs Dr. Katsutoshi Toda, Executive Chairman, Toshiba Transmission and Distribution Systems (India) Pvt. Ltd. (TTDI).

Growth in the renewables sector is also giving a fillip to the transformer industry especially for inverter duty transformers and power transformers, for power evacuation and transmission. This sector has seen many new technologies to deliver quality and reliable power to the grid.

However, Dr. Katsutoshi Toda admits, "Transformer industry is facing the biggest challenge on working capital due to irregular payment cycle of the utilities and contractors. Add to that the challenges on the margins arising from an increased gap in the demand-supply position where huge capacity is available and accordingly transformer industries are operating currently with plant loading between 65-70 per cent only. The demand of 765kV transformers and generator has declined in the transmission and generation sector due to slowdown in this segment. Most of the projects in the transmission sector are on the TBCB (tariff-based competitive bidding) route which adds to the price pressure."

TTDI expects a growth of 10 per cent in the transformer industry in the coming future with the increase in the export base and substation expansion projects.

Transformer industry growthy drivers

Transformers' demand is mainly driven by the investments in the generation, transmission and distribution sector. The current projected growth in the power sector backed with schemes like UDAY, SHAKTI, SAMADHAN are the major drivers towards the demand in the transformers.

According to Dr. Katsutoshi Toda, the thrust of the Government of India in initiatives such as 'Make in India' and other infrastructure projects like railway electrification, airports and the renewables sector will certainly contribute towards the growth in the transformer industry.

Tech trends defining the future of transformer business

TTDI has secured a leadership position in India's distribution transformer segment and also made a global presence due to its continuous technology upgradation in its design, process and manufacturing and is widely accepted across the globe, Dr. Katsutoshi Toda claims.

In the energy sector, Toshiba has very wide experience in special transformers for the renewables sector like solar inverter duty, wind application transformers and is contributing significantly to this sector. With the space limitation for expansion of the substation in

various utilities, there is a growing demand on the Gas Insulated Switchgear (GIS) and TTDI is already contributing to this demand from its fully operational state-of-the-art manufacturing facility, he informs.

In the infrastructure sector, with the supply of special transformers like Scott Connected Transformers, TTDI has been able to contribute to railways for its dedicated freight corridor projects.

Future of transformer industry beyond 2019

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, anticipates Dr. Katsutoshi Toda.

He added, "We are expecting very positive outcomes in the power sector and confident that 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."

Wires & cables

The wires and cables market in India comprises nearly 40 per cent of the electrical industry and is growing at a CAGR of 15 per cent as a result of growth in the power and infra segments. Strong demand from several sectors like housing, telecom continue to drive the growth of this sector. Also, Arvind Agarwal, AVP, Havells, said, "The government's Smart City programme is expected to propel large-scale growth in infrastructure, telecom, power generation, T&D, engineering and automotive sectors which augur well for the wire and cable industry, as growth of the industry has direct linkage with growth and developments happening in other sectors."

> *"Transformer industry is facing the biggest challenge on working capital due to irregular payment cycle of the utilities and contractors.*
>
> **Dr. Katsutoshi Toda,**
> *Executive Chairman,*
> *Toshiba Transmission and Distribution Systems (India) Pvt. Ltd.*

Future of wind power sector

According to reports, the wires and cables industry in India is expected to double in size in the next 5 years. The government has taken steps to augment power generation and also strengthen power distribution. Also, large investments are being envisaged in rural electrification, upgrading and strengthening existing distribution networks, industrial capacity expansion, and construction. All these factors will fuel the demand for wires and cables in the country in the long run, asserts Mr Agarwal.

Switchgear

According to 'India Switchgear (LV, MV, HV) Market Overview, 2018- 2023' report, the Indian switchgear market is expected to grow with a CAGR of more than 7 per cent in the forecasted period of next five years from FY 2017-18 to FY 2022-23.

Demand has increased in this sector over a period due to the demand of new consumption centres and development of various renewable energy sources. "We are expecting further increase in the demand following the increased planned capacity addition in the power sector and improvement in technology along with government directives to replace old redundant machinery. Creation of infra structure for rural electrification is also expected to lead to the demand in switchgears. New construction in the urban space in terms of commercial and residential buildings has also contributed to growth," said Sameer Saxena, Director - Marketing, Legrand (Group) India while talking about the recent performance of Indian switchgear industry.

Switchgear industry growth drivers

According to Mr Saxena, the key drivers for the India switchgear industry are:

- Increased electrification in rural

Continued on page 44

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Continued from page 42

and urban areas of India which has fuelled the growing demand for the LV and MV switchgear market.

- The increase in the demand of the installed capacity of transmission and distribution network in the power sector of India, China and other countries from Asia Pacific has also triggered the growth of LV and MV switchgear market.
- Government's plan to reach the renewable energy capacity of 175 GW by 2022, according to NITI Aayog.
- Government directives to replace older redundant systems to achieve operational safety and security in industrial establishments.

"The Indian switchgear market is driving global growth in a market estimated to cross US$ 140 billion by 2024," Mr Saxena said.

Redefining technology

Legrand invests heavily into R&D and 5 per cent of the company revenue is ploughed back into R&D every year. All our product segments are at the leading edge of technology, claims Mr Saxena.

In switchgears, Legrand has digital switchgear which combines the latest digital technologies. They enable easy integration to increase smart functionality such as power management, real-time diagnostics and remote monitoring. Already, Legrand India has a host of products which are high on digital integration. This includes both hardware aspect involving high-end electronics as well as associated software solutions which help clients to optimise their energy consumption.

> *"With major investments expected in the manufacturing sector in India in the upcoming years, the demand for factory automation solutions in the country is also anticipated to rise over the next five years.*
>
> **Sudhir Dembi,**
> *General Manager (Plant Solutions) Schneider Automation, Schneider Electric*

Switchgear industry beyond 2019

The switchgear industry is fast growing, and government schemes likes 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 in beyond 2019.

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 will create demand in the switchgear market and impact the significant renewable energy-based capacity in the next few years, Mr Saxena anticipates.

Automation

According to industry reports, the automation segment in India is projected to grow at a CAGR of around 12 per cent during 2015 – 2020. Growth in the market is anticipated on account of growing deployment of various factory automation systems in automotive, chemicals, and other manufacturing units, along with various government initiatives aimed at increasing domestic manufacturing as well as the focus on digitisation.

> The wires and cables market in India comprises nearly 40 per cent of the electrical industry and is growing at a CAGR of 15 per cent as a result of growth in the power and infra segments. Strong demand from several sectors like housing, telecom continue to drive the growth of this sector.

Talking about the recent performance of automation industry, Sudhir Dembi, General Manager (Plant Solutions) Schneider Automation, Schneider Electric, said, "The industry has been growing at a brisk pace over the last few years, given the growing need for reliable and cost-effective methods of production that are efficient and lead to maximum cost optimisation. In addition to making the processes more controlled, consistent and streamlined, automation solutions provide better productivity

The Indian switchgear market is driving global growth in a market estimated to cross US$ 140 billion by 2024.

Sameer Saxena,
Director - Marketing,
Legrand (Group) India

compared to manual labour."

Automation industry growth drivers

Since new technologies are disrupting the preceding versions, there will be a need for constant upgradations. For example, electric vehicle (EV) charging stations, with increasing uptake of EVs, can majorly disrupt electrical networks. To balance grids in these situations, smart grids become imperative. Hence, Mr Sudhir believes, automation might be the only way to tackle load management issues.

Experts anticipate that the 'Make in India' initiative is also going to play an important role in boosting the adoption of automation solutions in the country. "With major investments expected in the manufacturing sector in India in the upcoming years, the demand for factory automation solutions in the country is also anticipated to rise over the next five years," Mr Sudhir predicts.

Besides availability of copious amount of data, it will also be a major player to drive automation in India. As more and more data are available, there is a need for better data processing (analytical) capabilities.

Tech trends defining the future of automation business

The current decade has seen a fair share of rapid transformations, brought in by innovation in the digital space. These include ever-present wireless connectivity, analytics, smartphones, consumer-driven social media, etc. and, soon, self-driving cars on a larger scale. No sector has been left untouched by this digital revolution.

The world is in the midst of the Fourth Industrial Revolution, which, according to the World Economic Forum, "builds on the digital revolution and combines multiple technologies that are leading to unprecedented paradigm shifts in the economy, business, society, and individually."

The energy management segment is on a similar, life-changing, fast-paced trajectory. In all of these transformed areas, consumers stand at the centre of a disruptive convergence of digital technology advancements; consumer engagement; on-demand, tailored consumption; and a decentralised infrastructure with innovation at the heart of these changes.

The world is in the midst of the Fourth Industrial Revolution, which, according to the World Economic Forum, "builds on the digital revolution and combines multiple technologies that are leading to unprecedented paradigm shifts in the economy, business, society, and individually." Therein lies incredible opportunity for industry, customers, and the broader society as we transform the electricity system. "Electrification, decentralisation and digitisation are the three game changing trends. These three trends act in a virtuous cycle: enabling, amplifying, and reinforcing innovative developments beyond what each trend can do on its own. The trend will only get accentuated as nations move towards building more renewable power resources," Mr Sudhir opines.

Future of automation industry beyond 2019

India is amongst the most rapidly developing nation globally. With the objective of building the nation as the 'Manufacturing hub' of the world, the nation is now under the spotlight. In line with the massive disruption happening all around, the manufacturing and automation sector is one of the most significant contributors to the growth of the country's GDP.

This is further leveraged with the digitalisation trends occurring across industries. Therefore, it is critical for industries to adapt to the emerging technologies and utilise the potential to the fullest.

Automation is already a popular manufacturing process, but given the rapid advances in AI, Operator Augmentation tool, Virtual Reality, manufacturing has been further boosted through remote communication. This practice is likely to explode in the coming years, observes Mr Sudhir. He said, "Digitisation, data analytics and machine learning are the means to reach the next level of connectivity. This revolution will give the industrial automation sector the opportunity of moving from real-time process control to real-time business control."

AI is going to make automation more widespread and even more reliable, based on the trajectory of current automation trends, here, in accordance with Mr Sudhir, what the future of manufacturing may look like:

- More factories will become 100 per cent automated in the near future: Artificial Intelligence, Machine Learning, Virtual Reality and Robotics could make it possible for manufacturing machines to understand far more complex goals than those which they currently execute. This will make it possible for operations to become 100 per cent automated at a given location with regular remote check-ins from a central hub. Already industry has started implementing remote command control centre.
- Automation combined with AI could prevent recall and repair expenses: AI could not only alert a human overseer in the event of a manufacturing failure but possibly correct it as well. This means that more errors will be caught before they cost your business the expense of a recall.
- Automation will make us question basic expenses that were once indispensable: Maybe machines can operate in different wavelengths of light than those that the human eye is suited. This can save money and help the environment by saving energy. The same theory applies to heat. While people may need a comfortable 24-degree-C, we don't have to be held to that standard in an environment made purely for machines.

Keeping this in mind, today's innovations are built on safety, reliability, efficiency, sustainability, and connectivity. "At Schneider Electric, we're uniquely positioned to meet the demand for more efficient and connected energy enabled by the Internet of Things (IoT). Our next generation of active energy management and automation architecture, EcoStruxure delivers IoT-enabled solutions that seamlessly connect, collect, analyse, and act on data in real time," explains Mr Sudhir.

EcoStruxure also facilitates enhanced safety, efficiency, reliability, and sustainability. It is a comprehensive service portfolio designed to improve occupant comfort and asset value while reducing operating costs thereby making it future ready. ■

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HOW TO REVIVE THE THERMAL POWER SECTOR?

> The major difficulties being faced by the coal-based projects are regarding availability of coal and payment delays by the DISCOMs.
>
> **Ashok Khurana,**
> **Director General,**
> **Association of Power Producers (APP)**

In an exclusive interview with *Subhajit Roy*, Association of Power Producers Director General Ashok Khurana outlines the actions to be initiated by the government in reviving the health of Indian thermal power sector.

Thermal electricity accounts for more than 86% of India's total power generation. However, the sector is facing acute fuel shortage. What's your take on this?

The coal-based power plants are facing acute fuel scarcity. Not only the private sector coal plants, but even majority of the

public sector plants too are experiencing difficulty, including NTPC. In fact, a review on 23rd of October by the CEA revealed that 31 plants were having critical or supercritical stock and 90 plants were having coal stock of less than 7 days. This level of low stocks is a matter of serious concern, and according to the norms there have to be 23 days of stock. Many load centre plants are facing shutdown due to non-availability of coal. So, I basically feel that coal shortage is the biggest issue being faced by the power sector today. We expect the power demand to pick up because of the positive impact of SAUBHAGYA (Pradhan Mantri Sahaj Bijli Har Ghar Yojana) and economy growing at 7.5-8 per cent. We need to find a way to augment coal supply and in case the domestic production is not adequate, then import should be resorted to meet the deficit. For the coastal plants there is no rationale of transporting coal from hinterland to a coastal plant and hinterland plants importing coal. This needs rationalisation and the government should allow swaps in the cases where the rationalisation results in gain to consumers by way of high PLFs or low tariffs. This year, our peak power demand grew the most and is expected to rise further as household electrification is being accelerated and elections are on the horizon too.

India has gas-based plants with installed capacity of about 25 GW, of which around 11 GW are stranded. In this context, how do you see the future of thermal power in India?

Gas projects are imperative in our evolving energy-mix wherein the share of renewable is increasing at a very fast pace. The gas-based projects, with low ramp-up time can be used for balancing and ancillary services, to meet the grid requirements.

We do not have sufficient gas and it is very clear that if we import LNG to run the gas-based plants, it will not be affordable. So, the High-Level Empowered Committee (HLEC) has suggested revival of E-RLNG Scheme that will provide subsidy support and tax exemptions on imported RLNG (re-gasified liquefied natural gas). A related proposal has been made to the government previously for price efficient sourcing of gas by way of: ONGC gas from deep water fields – existing 5.45 MMSCMD of ONGC gas be allocated to power sector. A separate bucket for power sector needed for ONGC gas from deepwater fields; ONGC envisages production of another 16 MMSCMD gas from deepwater fields by 2020. An aggregator like GAIL to bid for the gas on behalf of the gas-based power plants.

It is also proposed that, balance gas requirement for stranded power plants to be met from RLNG.

With stranded projects operating at 45 per cent PLF, the variable tariff will be around Rs 4.35 per unit. Eying a target tariff of Rs 4.70 per unit, there is a margin of 35 paisa per unit towards fixed cost recovery. This margin may not be sufficient for debt servicing and hence government support in form of budgetary allocation or PSDF support along with preferential gas price for power sector is very much needed. As the ONGC production from deepwater gas increases, and same can be allocated to power sector, the share of RLNG will reduce thereby making the tariff more competitive.

What are the major difficulties the coal-based projects are facing?

The major difficulties being faced by the coal-based projects are regarding availability of coal and payment delays by the distribution companies (DISCOMs). The payment delays fall into two categories – 'Dues for Power sold' and payment due to 'Change in Law' items. The total dues are upwards of Rs. 38,000 crore. It should be noted that it is impossible for any generator to keep his assets in bank's 'Standard' category, in an ecosystem which stipulates default

even if there is just 1-day's delay in payment of interest or principle, while all payments for inputs are made in advance – such as for coal and evacuation of coal – however at the same time the output payments are delayed beyond 6 months, and are progressively increasing.

In this context, HLEC has also made certain recommendations – coal linkage for short-term power procurement; pre-declared linkages for procurement of power for aggregated demand from states; increase in quantum of coal for the special forward e-auction for power sector; non-accrual of short supplies of coal; mandatory payment of late payment surcharge; among others. if the recommendations can be operationalised within a fixed timeframe, it will contribute towards reducing stress in the sector, and may bring many projects in the 'Standard' category.

Do you feel renewable energy is a threat to thermal's future?

Looking at the power requirements of the country, renewable energy is not a threat. If I take into consideration the recent peak demand figures, it is 180.4 GW – already up by 7.5 per cent and growing. It should be noted that peak requirements cannot be met by renewable at night, and it has to come from thermal. Looking at the variability and intermittency of renewable, we need thermal as back-up during daytime and to meet the peak power requirements at night time. Therefore, I do not see any threat from renewable.

Our power requirements are so huge, that even if we take the power from all sources – gas, hydro, coal and renewable, we would have adequate off-take, provided we have DISCOMs who are financially strong and are willing to meet the demand and pay for the power. Presently, it is their financial capability which is impacting the off-take. The choice before us is very clear, that the DISCOMs have to improve their operational and financial performance and meet the requirements of the consumers, or we shift to separation of content and carriage, as is envisaged in the proposed Electricity Act amendments. This reform will give consumer the opportunity of choosing their supplier.

How to address the challenges?

Issues which are causing acute stress and need immediate consideration are:

- The generator should be allowed to import coal or procure through E-Auction to meet the deficit of coal supply under FSAs, and the tariffs to be adjusted accordingly, to offset the additional cost.
- Setting up an institutional mechanism to ensure that pending receivables from DISCOMs for power sold and regulatory dues, unless stayed by the appellate authority, are paid without any delay.
- Aggregating the demand from different states, and bringing out bids for power procurement against pre-declared linkages.
- Resolving the restrictive coal usage policy conditions, by allowing linkage coal for use against short term procurement of power.

> WE DO NOT HAVE SUFFICIENT GAS AND IT IS VERY CLEAR THAT IF WE IMPORT LNG TO RUN THE GAS-BASED PLANTS, IT WILL NOT BE AFFORDABLE.

Do you feel, if we do not deal with the challenges immediately, there will be many more NPAs?

Yes, the challenges related to coal supply and payment should be addressed without any delay. These issues have been pending since long, and the delay in the decision making is progressively increasing the stress, and may lead to further accretion of NPAs.

What is your outlook for Indian power sector beyond 2019?

With demand increasing and the slowing down of capacity addition, the outlook is very promising, subject to resolution of the above-mentioned issues. It is essential to operationalise an institutional arrangement, by which 'due payments' to Generators are made by any nominated financial institution, be it PFC, REC, or SBI, and the arrangement is backstopped by the state department of finance. Further, a very realistic estimate of coal availability and its evacuation should be in place. Necessary arrangements are to be made to import the deficit, so that the plants can run at high PLFs and meet the growing demand.

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.

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Burning Bright

Strong policy thrust on renewables to drive capacity addition; AT&C loss reduction to remain key for the financial health of distribution utilities

Overall installed power generation capacity on all India basis has increased by CAGR of 10 per cent i.e. from 159 GW as on March 31, 2010 to 344 GW as on March 31, 2018, mainly led by investments in the private sector in thermal segment during the 11th Plan period (2007-2012) and 12th Plan period (2012-2017). This is also supported by the enactment of Electricity Act, 2003 which encouraged the investments in the power sector. The share of private sector in the overall installed power generation capacity has thus increased and now accounts for the highest share i.e. 45 per cent in the ownership mix of installed generation capacity followed by 30 per cent share by state sector and 25 per cent with

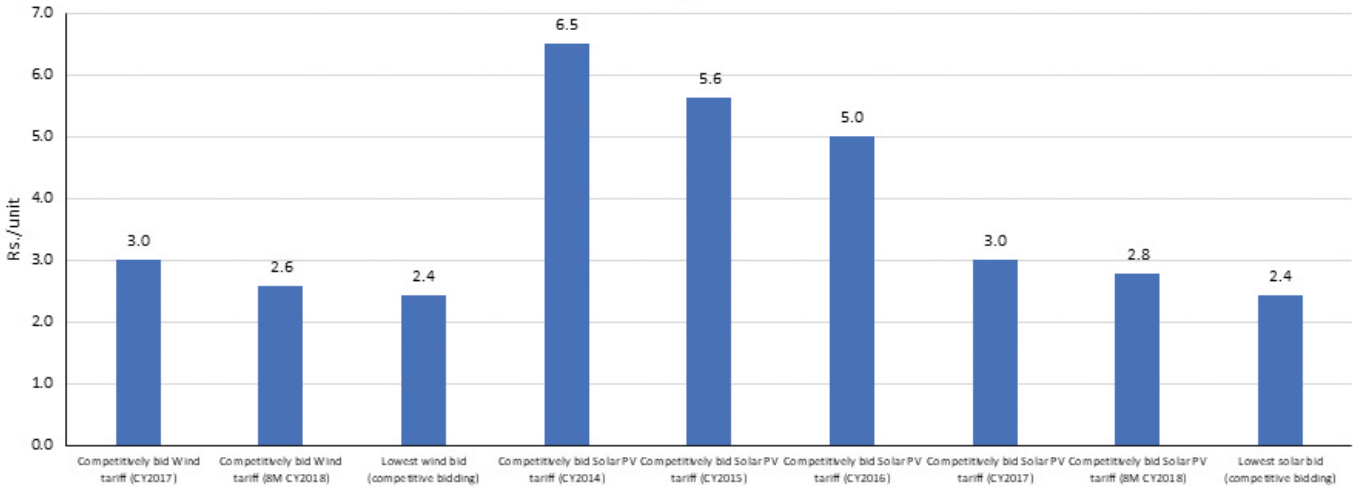
central sector. In our view, the capacity addition from the thermal segment would continue to remain subdued and will be mainly driven by the Central and state sector – going forward. Thermal segment remained the key driver in the generation capacity addition till FY2016. Thereafter, there has been a slowdown in thermal capacity addition owing to several issues adversely impacting credit profile of private sector IPPs arising out of significant cost over-run with delays in land acquisition and approvals, no progress in signing of new power purchase agreements, an inadequate fuel (coal and gas) availability and PPA tariff viability etc.

Long-term energy demand outlook for electricity in India remains strong, given the still low per capita electricity consumption at 1,100 kWh during FY2017. This is also much lower as compared against the average per capita electricity consumption in developed countries as well as the world average. Further the latent demand potential is significant in India, given that a large section of population is without access to electricity. In the past, average energy demand growth (as also co-related with the performance of the overall economy) has remained at about 5.5-6 per cent in last 10-year period. In September 2017, the Government of India has launched the "Saubhagya Scheme" with an objective of providing household electrification, especially in rural areas. Even assuming the consumption of 50 units per family per month for 40 million households, which are currently without access to power, incremental energy demand improvement is estimated to about 24 billion units, which after adjusting for distribution losses, correspond to about 2.5 per cent increase in the all India energy requirement over the next 2-3 year period.

Renewable remains a key driver for the capacity addition

With a strong policy focus on renewable energy sector, supportive regulatory framework and an improving tariff competitiveness of renewables, the renewable energy capacity addition has been significant especially in wind and solar segments in last 3-4 year period and thus remains a key driver for the capacity addition, going forward. While the long term demand drivers for both wind and solar energy segments remain intact, there have been regulatory headwinds and policy uncertainties for the segments impacting the capacity addition for wind energy as well as the bidding activity for solar energy in last CY. In case of wind energy sector, the capacity addition in FY2018 significantly dropped to 1.7 GW from the 5.5 GW in FY2017 mainly due to the transition from feed-in tariff-based PPAs to competitive bid-based PPAs in the wind energy sector, following the large reduction in tariffs discovered through the competitive bidding route against the earlier feed-in tariff regime. The Ministry of New and Renewable Energy (MNRE), Government of India announced the trajectory for award of wind power projects through competitive bidding to achieve the cumulative wind

Trend in wind and solar power bid tariffs



Source: ICRA research

Picture Courtesy: https://blog.forumias.com

capacity target of 60 GW by FY2022. Solar Energy Corporation of India Limited (SECI) and NTPC along with distribution utilities in Gujarat, Maharashtra and Tamil Nadu have issued bids for a wind-power capacity of 8.7 GW over the past 18 months. As a result, capacity addition in the wind power sector is expected to improve to about 3 GW in FY2019 backed by the project awards by SECI and state distribution utilities. In case of solar sector, ICRA expects about 4.5 GW of solar capacity to be added (mainly, comprising of the projects having PPAs with utilities) in FY2019 as against 9GW added in FY 2018. The estimated fall in capacity addition in FY2019 is mainly because of subdued trend in tendering of solar projects mainly in H2-CY2017 in the midst of several factors such as a) GST roll out in July 2017, b) upward pressure on PV module price levels internationally between May 2017 till Dec 2018 and c) uncertainty on safeguard duty.

Improved tariff competitiveness

While the improved tariff competitiveness of both i.e. wind and solar energy remains favourable for the off-takers being the state-owned distribution utilities, project viability from the IPP's perspective remains critically dependent upon a) capital cost, b) PLF and c) debt structuring (i.e. leveraging levels, debt tenure and interest rate).

Solar PV based IPPs remain exposed to near term headwinds

With the decline in module price level internationally and softening in the interest rate in CY 2016 and CY 2017, competitively bid solar tariffs declined sharply with the lowest bid tariff at Rs. 2.44/kwh so far. Nonetheless, the solar PV based IPPs remain exposed to near term headwinds arising from:

- Likely imposition of safeguard duty as per Government of India's notification in July 2018
- Rising interest rate scenario, and
- Steep INR depreciation against the USD in the current financial year by about 13 per cent.

As per ICRA estimates for solar PV project with tariff of Rs. 2.7/ unit, cumulative average DSCR is estimated at about 1.16 time based on prevailing PV module price level (~26 cents/watt and applicable safeguard duty), debt and equity ratio of 70:30, rupee dollar exchange rate of 73, cost of debt at 9.7 per cent post commissioning with debt repayment tenure of 18 years post CoD and plant load factor (PLF) level of 23 per cent (with DC-AC ratio of 1.3 times and degradation factor of 0.5 per cent per year). If the safeguard duty cost were to be passed on through change in law, cumulative average DSCR is estimated to improve to about 1.27 time.

Rising power discoms' subsidy dependence

On policy front to improve the financial health of state owned distribution utilities, Ujwal DISCOM Assurance Yojana (UDAY) was launched in Nov 2015 as a financial rescue package by the central government. Under UDAY, the focus has been mainly on debt refinancing and dev-leveraging (through debt take over for 75 per cent of the debt liabilities and balance to be restructured backed by State Government Guarantee) as well as on the improving the operating efficiencies. Since the implementation of UDAY scheme, progress in debt refinancing and deleveraging has been quite good as there has been a significant reduction in interest cost for the utilities. As a result, the book losses of discoms is estimated to have

Continued on page 56

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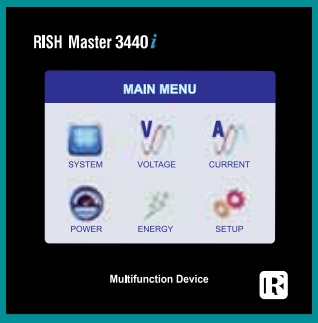

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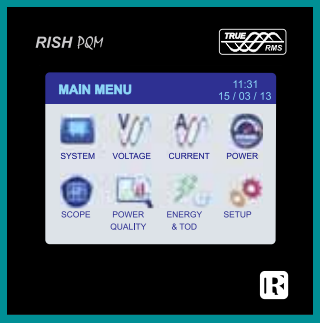

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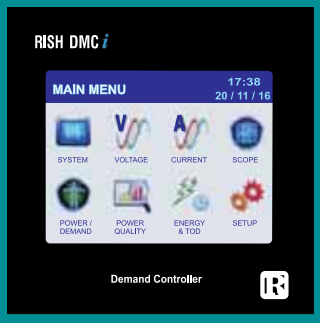

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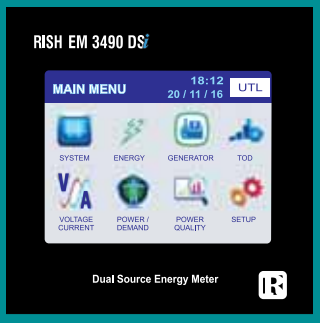

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Continued from page 54

reduced from Rs 600 billion in FY 2016 to about Rs. 180 billion in FY2018 (Source: MOP estimates). While these are welcome initiatives that will help in the emergence of a stronger domestic power sector, state-owned utilities continue to remain dependent on the subsidy support from their respective governments. The states have provided subsidies / concessional tariff rates to certain sections of the society like agriculture and other sections in the residential consumer category. These measures cannot be wished away, so to an extent, discoms dependence on subsidies is inevitable in the Indian power sector. Costs have also risen over a period with the rise in fuel and power purchase cost as well as inflationary impact on the cost overheads. Consequently, the subsidy dependence for the utilities has too increased considerably across the states. Discoms subsidy at an all-India level has been increasing year-on-year (Y-o-Y) at a moderate rate of 7-8 per cent annually. ICRA estimates the total subsidy bill at around Rs 850 billion in FY2019, as against around Rs. 720 billion in FY2016.

Further, the tariff hikes approved by the SERCs over the last 4-year period have witnessed a reducing trend over the years with the median tariff hike reducing from 8 per cent in FY2015 to 4 per cent in FY2017 and further to 2 per cent in FY2019. The same is not in accordance with UDAY scheme as hikes in many key states are lower than stipulated in the Memorandum of Understanding (MoU) signed for participation in the scheme and thus represent another deviation from the UDAY scheme. However, the relatively low tariff hike must be viewed in context of the declining interest burden of the state utilities; and even with such low tariff hikes, the net losses of the state utilities as an aggregate have come down. This apart, commercial loss or the AT&C loss remain high for discoms in several key states like Bihar, Jammu & Kashmir, Jharkhand, Madhya Pradesh and Uttar Pradesh as compared to the target fixed for FY2018. Improvement in AT&C losses for utilities in some states though a positive is still not in accordance with the UDAY scheme. Going forward, the ability of discoms to pare their AT&C losses and ensure that the same within the regulatory targets set by SERCs, coupled with tariff adequacy, remains critical for their sustained financial turnaround. Also, timely and adequate subsidy release from the state governments to the discoms is required. It is also important from the perspective of tariff adequacy, that implementation of the fuel and power purchase cost adjustment (FPPCA) framework is not delayed.

Girishkumar Kadam

Vice President and Sector Head, Corporate Ratings, ICRA Limited

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Coal India has increased its coal production in the recent past. It can do even better if it is not saddled only with "monitoring" by the central government and is provided necessary support in negotiating its problems with the state governments.

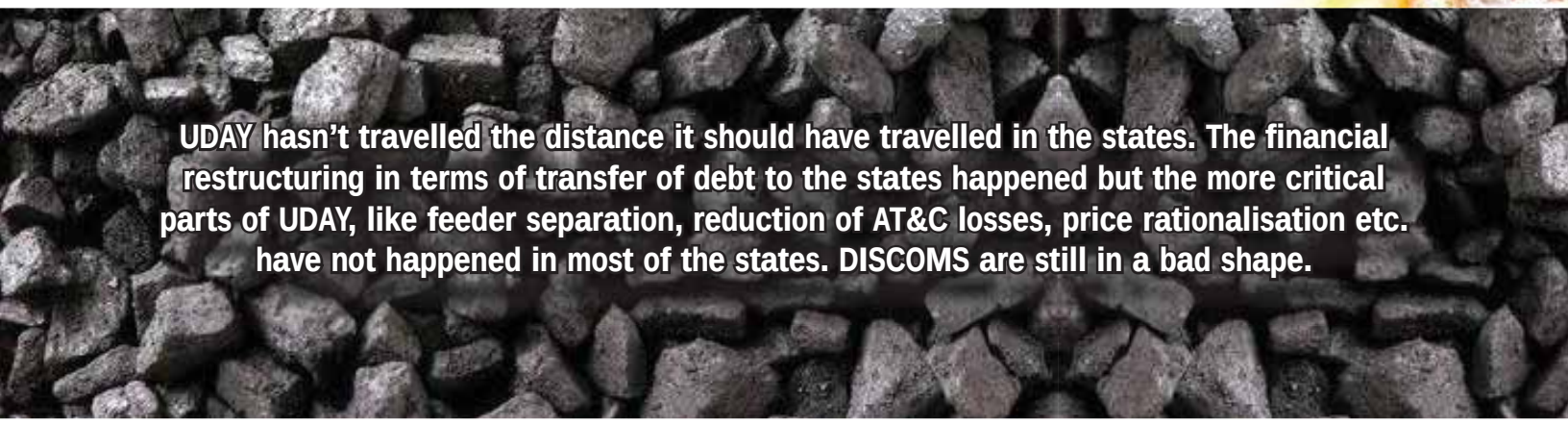
Anil Swarup, Former Coal Secretary

TARGETS WITHOUT A DELIVERABLE ACTION PLAN HAS NO MEANING

Anil Swarup, the man who was entrusted with cleaning up the coal mess, believes that the "coal-gate" would not have happened had there been sufficient supply of coal in the country. In an interview with Subhajit Roy, he also acknowledges that there are serious problems today in the context of energy security in the country. Excerpts:

Being at the helm of coal ministry, you were instrumental in bringing transparency in coal blocks allocation. How do you look at the India's coal sector turnaround post 'coal-gate' saga?

The so called "coal-gate" has precious little to do with the turnaround in the coal sector. In fact, "coal-gate" would not have happened had there been sufficient supply of coal in the country. The mad rush for coal blocks happened because of acute shortage of coal. The real coal story during 2014-15 and 2015-16 was the one relating to the increase in coal production that went up by 34 million tonnes during the first year (more than the cumulative growth during the previous three years) and 44 million tonnes during the following year. Consequent to this increase in production, not a single power plant was critical on account of shortage of coal.



Today, where does India stand in terms of achieving energy security?

There are serious problems today in the context of energy security in the country. And this criticality is not merely on account of shortage of coal which is just one of the factors that constitutes energy component in the country.

Despite several initiatives taken at the policy level, fuel shortage remains the key issue. What it will take to address fuel shortage?

India sits on 300 billion tonnes of coal yet there are shortages. These were overcome during the years 2014-15 and 2015-16 on account of a well-defined strategy that centred around land acquisition, environment and forest clearance and evacuation of coal. Issues relating to these factors were resolved through intensive interaction at the field level and with the stakeholders. Senior officers travelled to the states and sat with the officers of the state government to convey a value proposition and to find solutions to the problems. Strategy of not holding meeting in Delhi to resolve state level issues worked. A web-based monitoring system was put in place to monitor progress on various front and the Coal Project Monitoring was constituted to do so. These steps will need to be revived for increasing coal production.

Has Coal India been succeeded in reducing demand-supply gap?

Coal India has increased its coal production in the recent past. It can do even better if it is not saddled only with "monitoring" by the central government and is provided necessary support in negotiating its problems with the state governments. We all must understand that if strongly worded letters were to solve the problems of the country, they would have been solved long ago. There has to be team spirit and mutual understanding. The gap between supply and demand of coal, however, will depend upon the demand as well.

Coal India has recently revised its 1-billion tonne annual production deadline to 2026 from 2020 earlier. What's your take on this?

Targets have a limited value. What is important is the process. If the processes can be taken care of (as indicated earlier), the production will improve. Just targets without a deliverable action plan has no meaning.

UDAY was launched to rescue the country's ailing state power discoms. Has it been really successful?

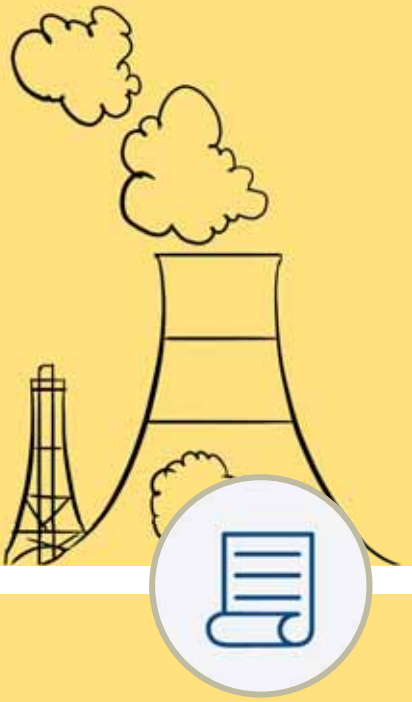
In my view, UDAY hasn't travelled the distance it should have travelled in the states. The financial restructuring in terms of transfer of debt to the states happened but the more critical parts of UDAY, like feeder separation, reduction of AT&C losses, price rationalisation etc. have not happened in most of the states. DISCOMS are still in a bad shape.

Finally, how do you see the future of Indian coal sector beyond 2019?

Coal will continue to be major source of energy in the country. If necessary steps, as outlined earlier, are taken, coal production will see a jump. Efforts will also have to made to get auctioned/allocated coal mines going. These can impact coal production. If commercial mining finally happens, as it should, it would improve the supply of coal.

HEADWINDS

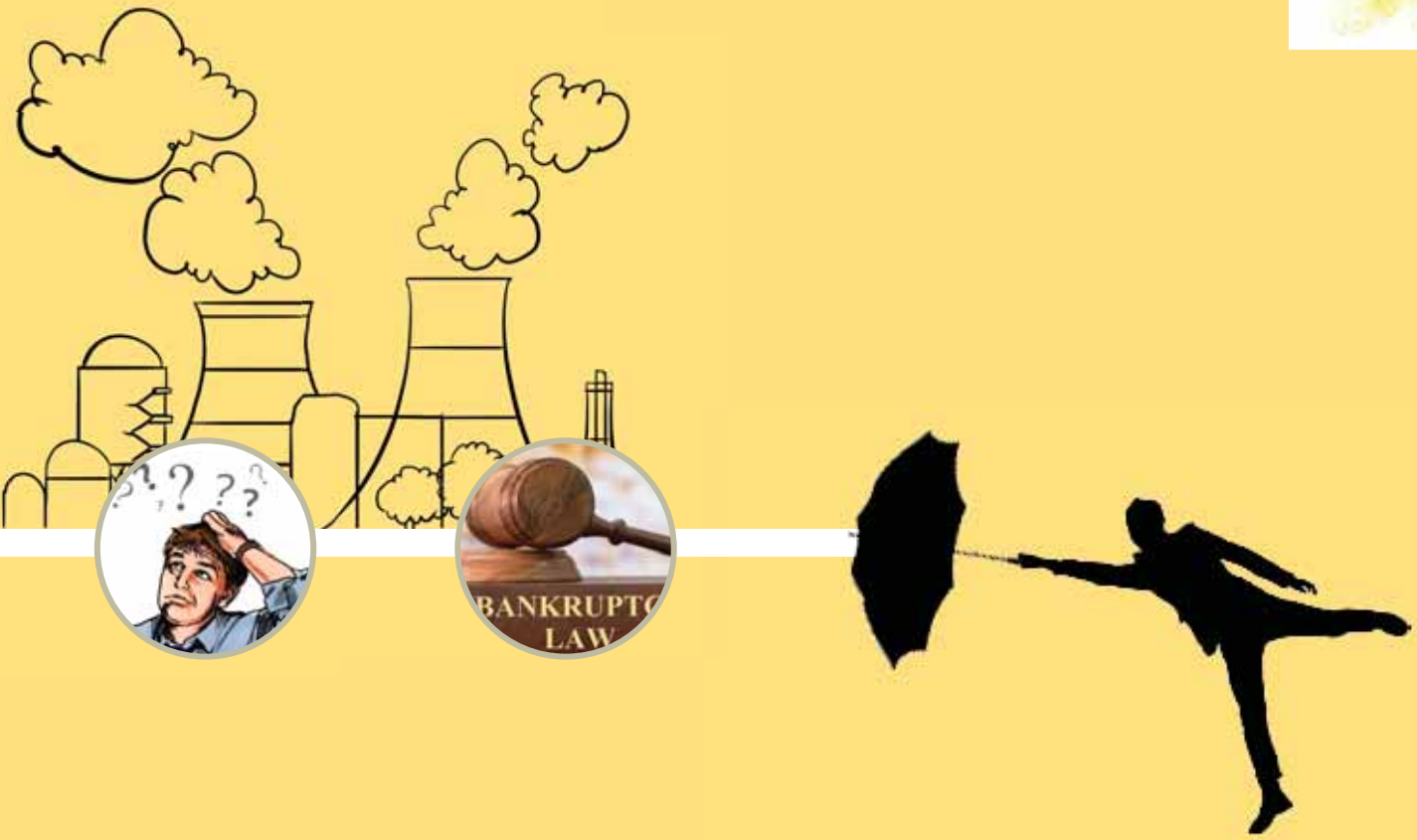
REMAIN FOR THERMAL POWER SECTOR



"As the macro and sectoral factors improve, backed by strong legislative and policy measures - such as amendments to Electricity Act and Insolvency & Bankruptcy Code - stress in the thermal power sector will abate but it is a long road ahead!"

Overview of the Generation sector

Coal based power generation has long been the backbone to meeting India's power needs, and the sector hasmade rapid strides in the recent past, buoyed by an active and exuberant private sector. Oflate, however, it has been facing headwinds, mostly attributed to sector specific



structural and performance issues,and some bad calls made by investors during the period 2006 to 2012: the growth phase for thermal sector in India.

Private investments in the sector, during this period, were driven by sector liberalisation, assumption on unserved demand, policy and regulatory reforms, and easy availability of financing. As a result, overall share of private sector in power generation increased from around 13 GW in 2006 to 157 GW in 2018, growing at 22 per cent per annum.

Soon concern, challenges and risks replaced exuberance - many projects faced land allocation and clearance related issues leading to time and cost overruns, many

Source: PwC analysis

failed to tie-upadequate fuel or power sale agreements, merchant market became unviable, input costs continue to grow and some contractual, legal issues made projects unviable. Lower than expected increases in power demand as well as financial health of utilities also played a part. It led to mounting debt levels, bad debts and stranded capacities, eroding investor confidence.

Over last 5 years, the Government is lending strong support to cleaner and greener sources of energy. As a result of

this push and continued fall in input prices, renewable energy today is cheaper than conventional power (Rs 2.44 per unit for solar and Rs 2.43 per unit for wind) and the shareof renewables has risen from to 14 per cent to over 20 per cent in the last 3 years, limiting the growth of thermal power plants.

As the macro and sectoral factors improve, backed by strong legislative and policy measures - such as amendments to Electricity Act and Insolvency & Bankruptcy Code - stress in the thermal power sector will abate but it is a long road ahead!

Market Trends

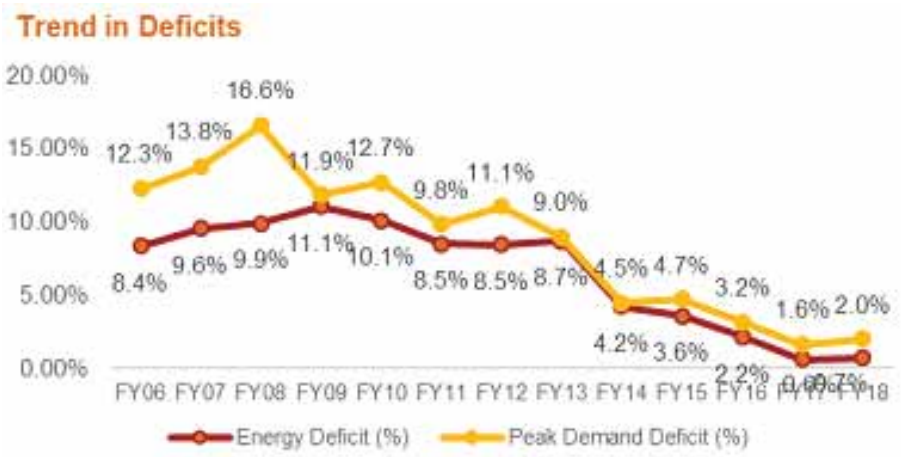
Demand expected to increase

The accelerated pace of capacity addition in the past decade led to an overall capacity addition growth of around 9 per cent per annum (2006 to 2018).Peak demand during the same period, increased at a comparatively slower pace of only around 5 per cent per annum.

Energy deficit and peak deficit has come down to 0.7 per cent and 2 per cent, respectively, from 4 per cent and 4.5 per centaround five years back, and it also led to a slowdown in contracting of long-term capacities by state distribution companies.

The reported demand, however, is restricted, as it does not include potential to supply to un-electrified consumers and the supply itself to rural and agriculture consumers is often rostered - thus an un-catered and un-accounted electricity market exists in India.

As per EPS 19 estimates, the energy requirement in India is expectedto grow at a CAGR of 7 per cent to reach 1,566 BU till FY 22 while peak demand is also expected to grow at a similar CAGR of 8 per cent till FY 2022.



Source: Central Electricity Authority (CEA)

Source: Central Electricity Authority (CEA)

Highest growth is expected in North-Eastern states (around13 per cent), while Western, Southern and Eastern regions shall have a growth of 7-8 per cent.

High latent demand, rapid urbanisation, the government's thrust on rural electrification via the ambitious "SAUBHAGYA" scheme and adoption of electric vehicles, would spur power demand going ahead.

PPA tenureisconfined to short/ medium term

In the past year or so, DISCOMsprefer short- and medium-term procurement instead of long term. Factors for this shift includes growth in industrial open access consumption, rising share of renewable energy andlow tariffs in the merchant market.Further, DISCOMsare circumspect of signing new long term PPAs to avoid tying up for excessive capacities and paying fixed charges, until they see a sustained increase in power demand.

Coal supply to ease over time

Fuel related issues have been a perennial concern for thermal plants and key contributor to the current stress present in the sector. The major issues include -

Continued on page 66

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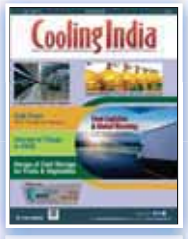

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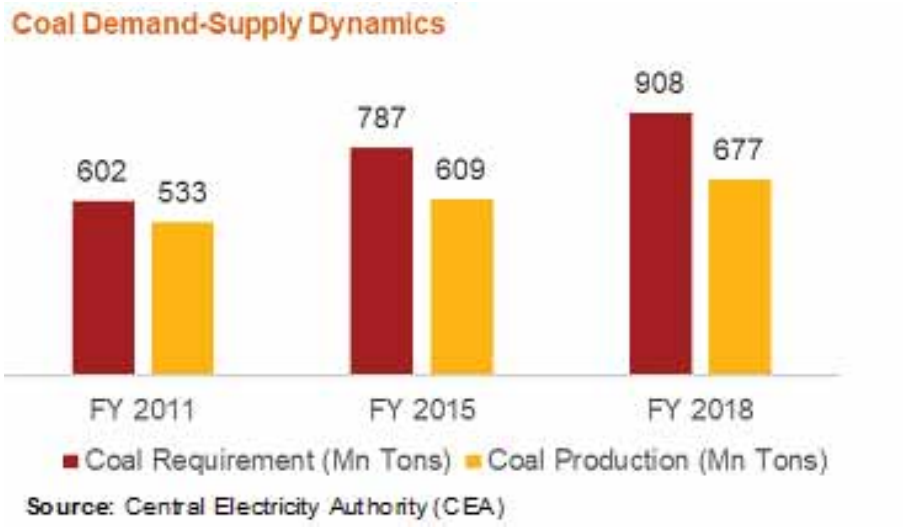


unavailability of adequate Fuel Supply Agreement (FSA), constraints on usage of linkage coal, shortage of coal (coal requirement has grown at a CAGR of 6 per cent over the last seven years, against which production has only increased at a rate of 3.5 per cent) and concerns regarding the quality of coal.

After the Supreme Court cancelled 204 coal-mines in 2014, many coal power projects were left stranded. Others were setup either without adequate coal linkages or have FSA/Letter of Assurance (LoA) but do not have medium/long term PPAs; in absence of which, these plants procure coal from e-auction at much higher rates.

In order to mitigate fuel related risks, the government came out with SHAKTI (Scheme for Harnessing and Allocating Koyala Transparently in India) schemeas a transparent mechanism to provide coal linkages to power plants FSAs through an auction process. Assured coal supply is expected to reduce the dependence of the plants on costlier sources of coal, leading to savings in fuel cost and improvement in operating performance. While the scheme has been positively affecting both generators and consumers, the sustainability of benefits and long-term success depend on adequate production of domestic coal by CIL, which has been unreliable. The onus is on the Government and CIL to augment production and ensure that private IPPs get their share of coal linkage as per the FSAs signed. CIL should also look atconducting auction of coal linkages to plants without PPAs that are either commissioned or to be commissioned, under the SHAKTI scheme.

Curious case of 34 stressed assets

RBI, on February 12, 2018, issued a new circular on Resolution of Stressed Assets – Revised Framework, which scrapped all previous restructuring mechanisms such as Strategic Debt Restructuring (SDR), Corporate Debt Restructuring with an aggregate exposure of above Rs. 20 billion as on March 1, 2018 or file for insolvency under the Insolvency and Bankruptcy Code (IBC) within 15 days from the expiry of the deadline.Department of Financial services (DFS) had identified a list of 34 such projects.

Lenders, following the instructions of RBI, initiated a three-fold action for resolution of distressed assets:

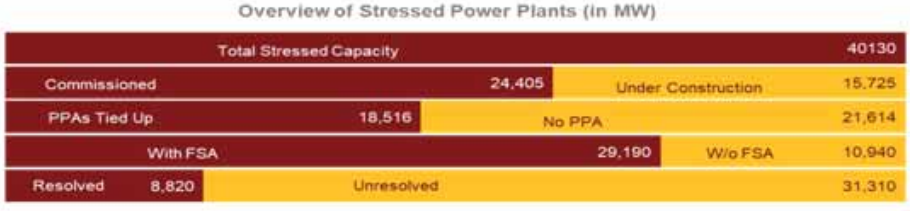
(i) Allowing existing promoters to come up with resolution plans.

(ii) Initiating a transparent auction process for "Change in management," conducted by professional advisors, and

(iii)Referring select cases to National Company Law Tribunal (NCLT), under the IBC, 2016.

They also had developed platforms/schemes like that of SAMADHAN (Scheme of Asset Management and Debt Change Structure) led by SBI and PARIWARTAN (Power Assets Revival Focused Warehousing and Revitalisation) proposed by REC. The idea of these schemes was to prevent sale of these plants at throwaway considerations and put forward steps in reviving the same.

Government of India also constituted a High-Level Empowered Committee (HLEC) on July 29, 2018 to address issues around the assets. HLEC submitted its recommendations in concurrence with various stakeholders/representatives from



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Continued from page 66

companies seeking relief from the RBI circular for Power Sector filed cases in various High Courts. The Allahabad High Court, hearing one of the cases on August 27, 2018 (which was the date of 180th day deadline) rejected the plea and refused to grant any relief or special dispensation for Power Industry. However, on September 11, 2018, the Hon'ble Supreme Court provided asked RBI to maintain status quo for power sector cases providing some respite to developers and lenders. The status quo ruling meant freezing of any insolvency petition being filed to NCLT. The Supreme Court had also fixed up the next hearing date as November 14 and then subsequently revised it to November 28, 2018.

The uncertainty related to the February 12 circular is keeping both, the promoters and lenders jittery. In most cases, the lenders and promoters of assets which have so far not been referred to NCLT are actively trying to come to a consensus and close resolution proceedings before the Supreme Court verdict. The lenders, are in hope of getting better value for the assets (and lesser debt haircut) and promoters, are in hope of holding on to their assets.

Case of Tata, Adani and Essar – A new precedence

The Supreme Court's nod to the imported coal-based plants of Mundra-Adani Power, Mundra-Tata Power and Salaya-Essar Power to approach CERC for amending their existing PPAs of around 10 GW can be perceived as a big positive not just for the developers but also for the power sector as a whole. The High-Power Committee has proposed the burden of hardships to be borne by all the stakeholders (lenders, developers, consumers). CERC has been provided a time of 8 weeks to give a decision on the proposed amendments in the PPAs. If the amendments are accepted, it will be a big relief for both, the developers as well as state DISCOMs.

DISCOM financial health

One of the key reasons for the lower power demand in India has been the poor financial health of the DISCOMs. The basic problem has been the mismatch between the revenues and expenses of the DISCOMs – accentuated by regulatory issues and operational efficiencies. The losses resulted in poor financial condition,which in turn affected its ability to pay the power generating companies resulting in lower offtake.

Government launched the UDAY program in 2015-16, targeted at one time clean-up of balance sheet of the state-owned electricity utilities coupled with a recovery plan and performance targets. The program aimed at improving the operational efficiencies of DISCOMs, reducing the cost of power, reducing interest costs of DISCOMs, and enforcing financial discipline to help DISCOMs make a turnaround. The results have been mixed, although there has been an overall improvement in the financial and operational performance of the DISCOMs.

Other positive initiatives taken by the Government

- Introduction of third-party sampling of coal at both loading and unloading end of coal supply from CIL to Generators – As per the August Standing Committee Report, this has led to considerable improvement in the quality of coal supplied by CIL. This coupled with improvement in the efficiency of plants has led to reduction of 6.5 per cent in specific coal consumption by coal based thermal power plants.
- Coal linkage rationalisation - Coal linkages have been rationalised to optimise cost of transportation of coal. This has helped in reducing generation cost, with NTPC itself realising savings of around INR 862 crore in 2017-18.
- Policy of flexibility in utilisation of domestic coal for reducing the cost of power generation - Objective is to allow flexibility in optimal use of domestic coal in efficient generating stations, resulting in reduction in the cost of electricity generation and reduce the power purchase cost of State DISCOMs. Gujarat and Maharashtra have already operationalised PPAs of 500 MW and 400 MW respectively through this mechanism by use of linkage coal of state GENCOs in more efficient IPPs to get cheaper power generated from

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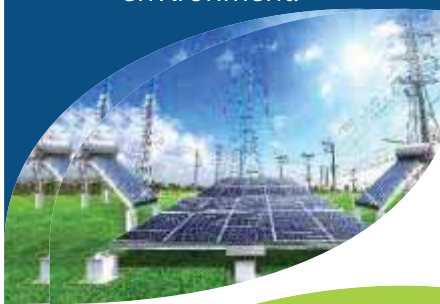

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such coal.

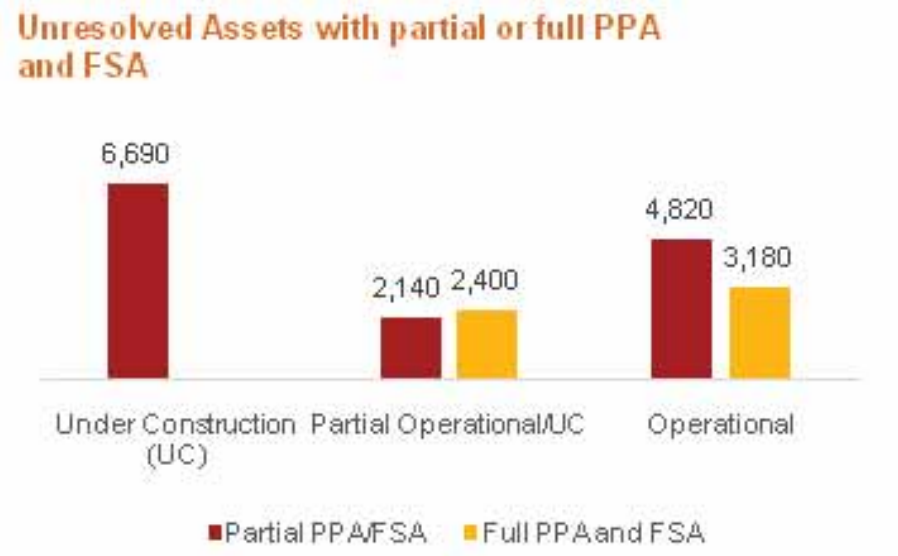
- Pass-through of cost incurred by power plants for meeting environment norms – This removes the uncertainty of developers with respect to additional cost implication and will result in timely implementation of the environment norms.
- Pass-through of any change in domestic duties, levies, cess, and taxes imposed by the government –While the provision for the same was already provided in Tariff Policy 2016, the Ministry of Power directed CERC to determine the per unit impact of any such change in law within 30 days of filing of petition.

Opportunities

Distressed assets sale

The IBC process and the February 12 RBI circular has provided a transparent platform for acquisition of distressed assets. A number of strategic firms and financial investors have already shown interest or taken part in the EoI or auction processes that have taken place so far. Out of the 34 identified stressed assets (40.1 GW), only 8 assets (8.8 GW) have so far been resolved. The valuation discovered, for most power plants fell within the range of around Rs. 1.6 crore/ MW to Rs. 4 crore/ MW.

Opportunity also lies with state owned distribution utilities and generating companies who plan to add new capacities. Acquiring an asset, either through the NCLT mandated process or through the bid process conducted by lenders outside the NCLT would be a better proposition in terms of cost (considering debt haircuts), risk and time prospective compared to setting up a green field power plant. The benefits so accrued would lower the cost of power for the utilities and can be passed on to the consumers.



Phase out and Replacement of Old and Inefficient Plants

There are a number of thermal plants which are over 25 years old. These old plants are inefficient with high heat rate and high specific coal consumption, apart from being non-compliant with environmental norms. Retiring such plants will reduce stress on natural resources like land and water, improve utilisation of scarce resources like coal and also contribute towards curbing pollution. The public sector utilities should consider phasing out such plants and replacing them with new efficient power plants, many of which are currently stranded and available for sale.

FGD Installation Opportunity for OEMs

Central Pollution Control Board has revised the implementation timeline for thermal plants to comply with new emission norms to 2022, providing sufficient time for installation. Considering the timelines, ordering and installation of FGDs by coal-based plants to comply with the emission norms is likely to pick up from end of FY 2019. Central utilities such as NTPC and NLC, few state utilities and IPPs have already floated numerous bids of installation of FGDs.In the current market conditions, where negligible new coal-based power plants are planned, orders for FGDs would support power generation OEMs. It is expected that significant ordering for FGDs would continue for next few years. De-NOx solutions too would present opportunities for power sector OEMs.

Conclusion

While the financial distress in power sector can be attributed to a number of factors, number of projects were impacted due to financial conditions of DISCOMs and power demand – given that its constrained. Successful resolution

of the stressed power assets, whether within or outside NCLT, would largely depend on addressing the key structural issues aided by improvement in power demand and financial health of the distribution companies. Interested buyers to stressed assets are likely to bid for only those plants, which have adequate FSA and long term PPA fit into their evaluation criteria.

Initiatives being taken by the government to provide coal linkages under the SHAKTI scheme or provide medium-term power arrangements under aggregated pilot schemes are steps in the right direction to resolve the intermediate issues for the stressed power plants.Production of coal has to be ramped up and logistic constraints – such as availability of rails and rakes – has to be removed, which requires sustained effort from state owned enterprises.

From a long-term perspective, the government's thrust on providing uninterrupted electricity access to every household and on improving financial health of the DISCOMs with the implementation of UDAY is likely to result in a sustained increase in the demand for electricity, improving financial health of DISCOMs and relieving the stress.

Revival of the thermal power space, which is the backbone of Indian power sector, can happen with concerted efforts from all stakeholders and public sector enterprises, including distribution companies. Even with the changing energy mix, this revival is essential to save crores of public and private money invested in setting up these capacities over the last decade and to meet the growing energy needs of India. ■

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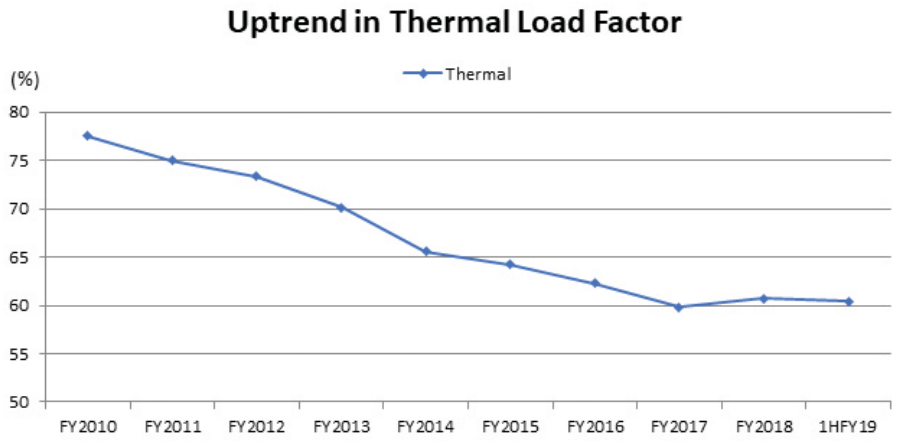
Thermal Sector: Performance & Constraints in 2018

"Thermal industry is on the mend, as stressed IPPs are under various stages of debt reduction through resolution plans or by way of bankruptcy proceedings."

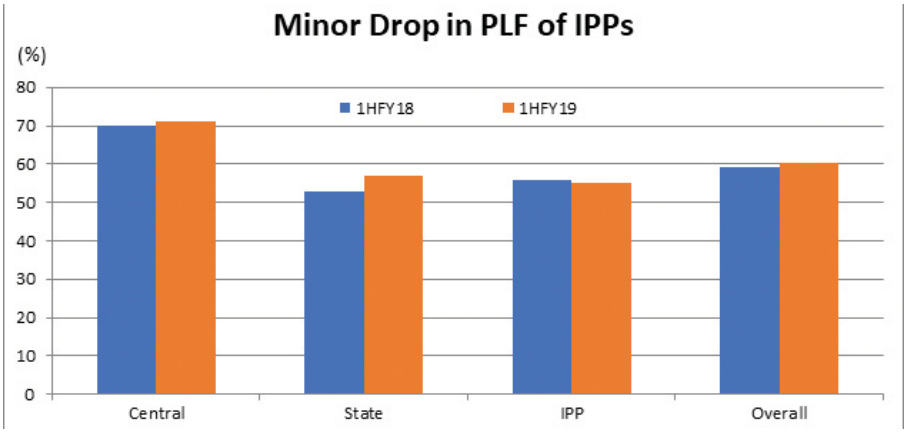
Picture Courtesy: www.smartworkshops.in

Plant load factor (PLF) for thermal plants increased to 60.5 per cent in 1HFY19 compared to 59.0 per cent in 1HFY18. The uptick in thermal PLF is significant as average PLF has been falling continuously since FY2010. The trend reversal can be attributed to muted thermal capacity addition. It is of note that PLF of IPP has dipped a little and might be attributed to coal supply constraints (because of relative preference in coal supply to central or state sector plants) and to constrained operations of debt laden IPPs.

On the back of increasing demand and muted thermal capacity addition, PLF of thermal



Source: Central Electricity Authority (CEA)



Source: Central Electricity Authority (CEA)

plants is likely to increase. If PLF increases sustains, confidence of investors and lenders will improve.

Critical coal supply pressures are affecting the thermal projects, especially the independent power producers (IPPs) whose debt servicing critically depends on their operation. The coal supply situation has been constrained for over a year now. While efforts are in way to improve logistics and mining operation, the criticality of coal inventory is evident in that the coal stock covers only six days of operation as of 31 October 2018. Non-pithead plants are significantly affected because of the coal supply issues.

Since 2014, there has been little demand for long-term power purchase agreements (PPA) from coal based IPPs and that trend has continued in 2018. Out of analysed 82GW of coal based IPPs, about 30 GW of coal based IPPs don't have long-term PPA for above 50 per cent of respective plant capacity. Government's push to sign medium-term PPA for 2500MW is very welcome. Apartment

Gas plants continue to suffer because of high fuel prices and lack of demand from these plants.

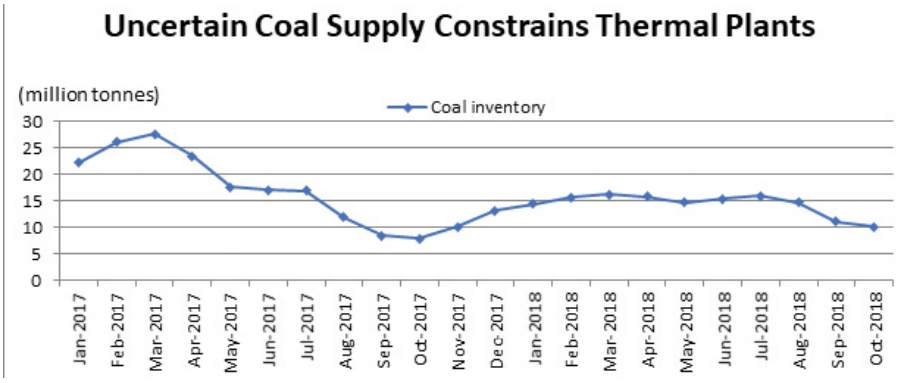
Technology – Competition for Thermal Sector

Supercritical plants will dominate the capacity addition. While generators may explore ultra-supercritical thermal plants, thermal sector faces the headwinds of nimble renewable energy additions. Technology surprises in solar and battery could be a significant factor concerning thermal sector, but such factors will play out over two or three decades. Gas plants may be required for balancing the power supply with load in grid, but such requirement is still way ahead.

Imposing of enhanced emission norms is weighing on thermal sector as the investment for compliance requires investment of about INR6-10 million/MW. Raising this investment is likely to be tough for thermal plants given the current state of lending markets.

Outlook for Thermal Sector

Thermal industry is on the mend, as stressed IPPs are under various stages of debt reduction through resolution plans or by way



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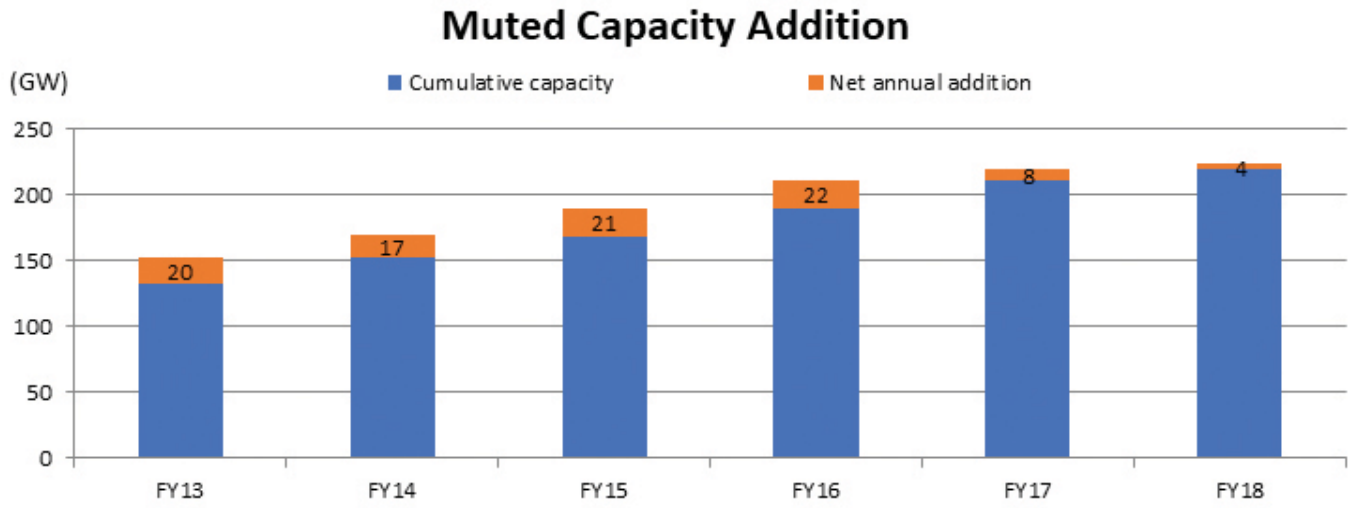

of bankruptcy proceedings. Reduction in debt among power projects is likely to lead to healthy competition among IPPs.

Thermal plants will continue to dominate the energy supply mix for at least another decade and they are the primary generators servicing the base load. Existing thermal plants are likely to enjoy increase in demand and thus profitability from the current levels. However, the balance between conventional and renewable energy is likely to be under pressure, in favour of renewable energy, albeit very gradually. Quantum and timeline of capacity additions in thermal sector have to be planned diligently to avoid significant undersupply or oversupply.

Effort to electrify transportation can also contribute to robust demand increase. Though efforts to electrifying transport has started recently, there could be significant developments on the back of consistent policies on charging infrastructure and consumer-oriented incentives for buying electric vehicles.

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Transformer Trends

Highlighting the key technological developments in Power Transformers and Distribution Transformers.

Picture Courtesy: www.dewesoft.com

A transformer is a static device used either for raising or lowering the voltage of an AC supply with a corresponding decrease or increase in current. By electromagnetic induction, an alternating current of one voltage is transformed to another voltage, without change of frequency. It essentially consists of two windings, the primary and secondary, wound on a common laminated magnetic core. Depending on the number of turns on each winding, transformers are classified as a step-up transformer or a step-down transformer. Step-up transformer has more turnings on the secondary coil than on the

primary coil and therefore the voltage induced in the secondary coil is larger than the primary coil voltage. Transformers are widely used in electrical apparatus of all kinds and in particular in power transmission and distribution.

Power Transformers

A Power Transformer transfers energy between high voltage and very high voltage systems, i.e. between generators and transmission systems and between transmission systems and distribution systems. Also, they are used in transmission network for stepping up or down the voltage level. It operates mainly during high or peak loads and has maximum efficiency at or near full load. A single-phase transformer is basically made out of two separate windings that are inserted into each other into a closed loop of magnetic core. Moreover, the Joules heat effect is proportional to the square of the current transmitted into any ordinary conductor like transformer windings or transmission lines. Both these effects combined at constant power of elevating voltage reduce heat dissipation accordingly by the square of the current, and enable the transmission of power of alternating current and voltage over very long distances from the energy producer to the energy consumer while limiting the power losses in the grid. This is possible due to a key grid component the power transformer. Most of them are the three-phase transformers or the three single-phase transformers. Thus from these electromagnetic principles, with the voltage increase of an electrical network, the Joule losses are reduced and the two main constraints of power transformers are high voltage and high current, depending on whether the HV or LV is observed.

Windings

The active part of a transformer is made of the elements that are in contact with the voltage and the current, and are mainly composed of windings, core, and tap changer bushings. The windings are handmade out of copper coils insulated mainly with several layers of paper between the turns. The two main winding designs and technologies have been developed over time with many variations: the core type and the shell type windings. The electromagnetic basis remains the same in both cases but the mechanical construction is different. In the core type design, the winding is “enclosing” the magnetic core legs, while in the shell type the core is “enclosing” the windings. Every transformer manufacturer has its own experience with these technologies, neither of which is automated. The manufacturing of windings involves a lot of human labour and requires significant experience as well as application of the highest quality standards. This is because winding conductors are covered by a type of insulation such as varnish or insulating paper with a limited mechanical and thermal stability. Nevertheless, this insulation type provides protection from high over-voltages, high over-currents, short-term overheating, and high mechanical stresses in order to prevent reduction of the insulation paper durability. It must be taken into account that the winding insulation cannot be easily repaired or replaced during the service life of a transformer and rewinding has to be performed only in a specialised workshop.

Core

The core is an important part of a transformer and generally the heaviest one. Produced from steel, it has high magnetic permeability and provides low magnetic resistance to the magnetic flux. In power transformer, the flux density is higher than the distribution transformer. It is made from thin steel sheets with the thickness of a few tenths of a mm in order to reduce losses and magnetising current. The main way to produce a core is to stack the sheets, cut to desired size, onto the automatic machines, and then manually stack them to build a core. The main core parts are the legs i.e. vertical parts, and yokes i.e. horizontal parts. The legs are mainly situated in a same plain. Most transformers have additional turns added to the HV windings and some of those turns are linked to a device called the “Tap Changer”. It enables a specific range of the voltage variation during the transformer service life. The electric circuit of the windings and the tap changer has some movable contacts. The two main types of tap changers are the De-Energised Tap Changer (DETC), mechanically quite simple type that changes the voltage while the transformer is not loaded; and the On Load Tap Changer (OLTC), a more complex type which operates

when the transformer supplies the load. It should be noted that the tap changers, the OLTCs in particular, are contributing to an increasing transformer failure rate, mainly due to the movable contacts wearing over the years i.e. hot spots, aging mechanisms.

Bushings

The bushings are the components that link the windings to a network through the grounded tank. High voltage bushings can be technically complex and, in some cases, their failure can lead to a transformer explosion quite rapidly. This is because one of the highest voltage gradients is between the HV bushing central part at full potential, and the grounded tank at the distance of just a few centimetres. The insulating oil just below is very flammable and if the bushing is sparking, it could generate a lot of energy, open the tank slightly and then ignite the oil, which could lead to an explosion. For this reason, the HV bushing is manufactured to withstand very high voltages within a small space filled with paper and oil between the bushing and transformer tank.

Insulating materials

The three major insulating materials for the power transformers are: mineral oil and paper and pressboard in different forms. The mineral insulating oil is weighted in tons within the tank and can be used to assess many essential points about the condition of a transformer and some critical incipient faults. The paper insulates the winding turns, while the pressboard strengthens the electrical insulation and provides dielectric distance at specific locations, for example in the main duct between the windings. Insulating materials, such as paper, pressboard and mineral oil are organic materials subject to aging. As the solid insulation cannot be repaired or replaced easily like other transformer parts and components, it limits the transformer service lifetime. Therefore, the solid insulation lifetime is the lifetime of a transformer.

Trends in Power Transformers

Dryformers

Recently, HV cross-linked polyethylene (XLPE) cables are used in these transformers. Dryformer is an oil free HV transformer based on cable technology used in Powerformer. Forced-air cooled, it has innovative windings made from XLPE cables with circular conductors. The absence of oil means that there is no risk of ground or water pollution in the event of damage and a less risk of fire or explosion. Therefore, Dryformer can be sited closer to the consumer, for example below ground and in urban or ecologically sensitive locations. As the electric field is fully contained within the XLPE cable and the cable surface is at ground potential, Dryformer offers unique opportunities for optimising power transformer design. By using the state-of-the-art of cable technology, XLPE cable can have electric field strengths up to 15kV/mm. From a manufacturing perspective, the Dryformer has the considerable advantage of having the insulation system built up at the cable factory.

Gas-insulated transformers (GITs)

In GITs, SF6 gas is used as insulation media with relatively low gas pressure. The principal solid insulation material for the GIT winding is polyethylene terephtalate (PET) and polyphenylene sulphide (PPS) films which are defined as class E insulating material with a temperature limit of 120 C. It has been initially specified to operate GITs, especially the gas-natural air-natural (GNAN) distribution GIT, with top gas temperature limit of 110 C instead of the maximum conventional 95 C top oil temperature for oil-immersed transformers. There have been a number of such interface problems for those heavily loaded GIT caused by gas temperatures higher than 100 C. Corresponding counter measures, such as oversizing the first section of LV bus bar, adoption of higher temperature class bushing material, and modifying clamping design to absorb higher temperature fluctuation have to be introduced. GIT have the following advantageous:

- Non-inflammable and nonexplosive, hence they are usable for multi-storeyed buildings, underground markets and other overpopulated places.
- Moisture resistant and dust resistant, therefore, they are unaffected by open air moisture, dust and other ambient conditions since the windings and core of these transformers are fully enclosed in mild steel box and sealed

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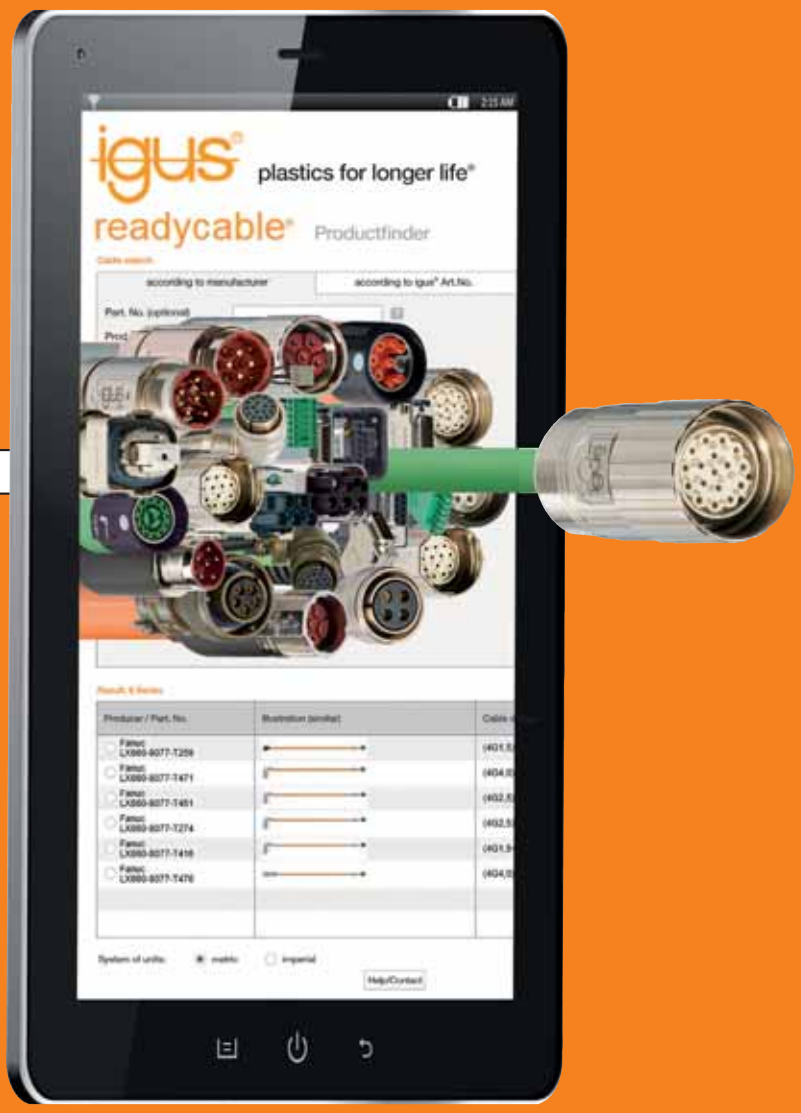

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Continued from Page 78

with SF6 gas. In addition, they have easy maintenance and check because these transformers are hermetic sealed with an inert SF6 gas and materials are scarcely deteriorated.

- Clean as there are no contaminations to surroundings since these transformers are sealed with non-poisonous, odourless SF6 gas, even if the SF6 gas leaks unlike mineral oil-immersed transformers.
- Higher reliability with simple internal structure.
- Better compatibility with gas-insulated switchgear (GIS).

GIT with onload tap changer (OLTC) used to be the most vulnerable part of any power transformer from electrical and mechanical points of view. In line with the use of SF6 gas as insulation media, vacuum switch type OLTC is installed for transmission GIT at 30 MVA and above. These vacuum switches housed inside the gas chamber are used as diverter switches and no arcing product can be possibly produced. Such OLTC is basically maintenance free. In the extreme case when OLTC malfunction due to mechanical defect or connection problem, the damage will be minimal. GIT turn out to be cheaper than oil immersed transformers when maintenance costs are considered. Power-distribution transformers have a high recycling value because they can be easily disassembled and their chief constituents, which are high-purity steel, aluminium and copper, can be recycled indefinitely. GIT are far more easily recycled than oil-immersed types.

Distribution Transformers

Distribution transformers are units of electric power systems, in which electricity is transformed form the voltage level 1 - 50 kV to the voltage level 120 V + 1 kV, in dependence on consumer's needs. Energy efficiency of distribution transformers is very high, typically ranging between 96 per cent and 99 per cent. However, due to a large number of distribution transformers in electric power system and their long lifetime (30 - 40 years), even small improvement in the efficiency of these units could result in significant energy savings. These issues are important both from economic and ecological viewpoints. Increase of energy efficiency of distribution transformers could be obtained reducing three types of transformer losses:

- No-load loss (iron or core loss) can be reduced by improvement in design and assembling processes or in magnetic properties of material core,
- Load loss (copper loss) can be reduced increasing the cross-section of the windings,
- Cooling loss can be reduced by decrease of other types of transformer losses.

Further increase in transformer efficiency is possible to reach by replacement silicon steel cores with new types of magnetic core materials, e.g. amorphous ribbons. These materials are produced by rapid solidification of a liquid alloy, what gives specific magnetic properties, especially very low energy loss. However, these materials have quite low saturation induction and they are thermal unstable.

Trends in Distribution Transformers

Amorphous core transformers

Amorphous cores are usually produced as wounded, one-side cutting ones, due to mechanical properties of amorphous ribbons. This solution ensures the correct location of air gaps inside a core and simplifies electric windings assembling as well. Amorphous transformers are produced as 1-phase or 3-phase units, with 3-limbs or 5-limbs core construction. The capacity of currently produced amorphous transformers is limited up to 10 MVA. The cross-section of amorphous cores is larger in comparison to silicon steel ones, due to lower saturation induction of amorphous ribbons. It results in the increase of transformer dimensions and weight. High efficiency distribution transformers with amorphous core become more and more popular. The energy savings from amorphous transformers have a great influence on the scope of electricity production and consumption.

High temperature materials

A new technology for the transformer industry involves the use of high temperature materials to provide a variety of economic, environmental and safety benefits to the user, including: lighter weight, smaller size, reduction in fluids, improved safety, less flammable, more capacity and lower energy losses. A new IEEE Standard has been published to provide guidance to manufacturers and users regarding the production

Continued on Page 82

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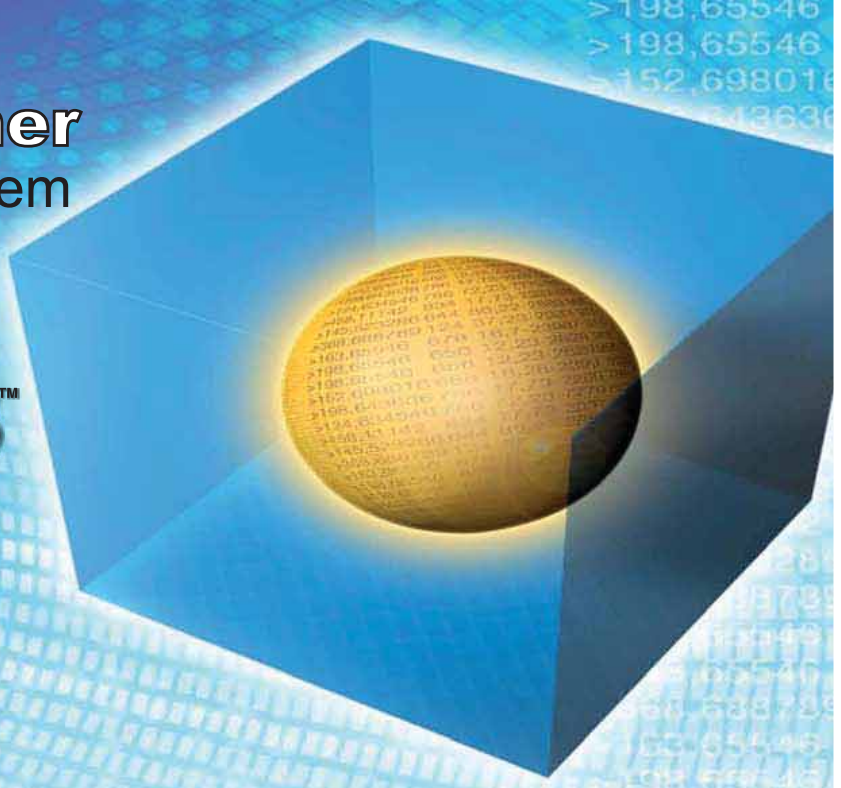

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The measurement of electric power and energy at high voltages and currents at low power factors is becoming increasingly important economically as a way to reduce costs in an ever-growing industrial economy. Today the transformer purchaser subjects the transformer manufacturer to an economic penalty for losses that occur in load and no-load conditions. To keep these penalties as low as possible, it is important that the manufacturer accurately measure these losses.

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Continued from Page 80

Comparison between Power Transformer and Distribution Transformers

	Power Transformer	Distribution Transformer
Uses	Used in transmission network of higher voltages for step-up and step down application (400 kV, 200 kV, 110 kV, 66 kV, 33kV) and are generally rated above 200MVA.	Always as step down used for lower voltage distribution networks as a means to end user connectivity. (11kV, 6.6 kV, 3.3 kV, 440V, 230V) and are generally rated less than 200 MVA.
Size	Big and large	Smaller size
Full load operation	Near full load operation (100% full load)	Operates at 60-70% full load all day
Efficiency	High (98-99%) Efficiency = output power (kW) / input power (kW)	Low (50-70%) All day Efficiency= output power (kWhr) / input power (kWhr) in 24 hrs
Tap changer	• On - load tap changer • Points:17 points and more • Operation: automatic using separate control • Media surrounding the taps: oil filled cylinder for arc extinguish placed in parallel to the windings • Arc extinguish occurring during tap change: Oil	• Off - load tap changer • Points: 3-5 points • Operation: Manual after source (voltage) is disconnected from transformer • Media surrounding the taps: transformer oil • Arc extinguish occurring during tap change: transformer must be disconnected from any voltage source
Protection	• Buchholz relay • Explosion vent pressure relief • Temperature indicators • Oil level gauges • Lighting arrestors • Differential protection, over current, over flux, restricted earth fault	• HRC fuse • Over current, Buccholz relay and restricted earth fault protection for large transformers larger than 500 kVA

and application of these transformers. The high temperature materials and boards can be used with conventional fluids in an economic way for power and distribution transformers for increased capacity and improved reliability. They can also be used with less flammable or higher temperature fluids for dramatic reduction in size and weight, with greater safety and environmental reliability.

Hybrid Insulation Systems

Thermal aging studies have given rise to, hybrid insulation systems. It is found that these systems reduced evolution of gases and much longer life expectancies with the use of "hybrid" insulation systems, which use paper and board in the hot winding area and cellulose materials in the cooler, bulk insulation areas of power transformers. These systems also eliminate the furan compounds, which evolve from the degradation of cellulose in the hot windings. The cells were designed to duplicate the material ratios of a 25 MVA transformer, including hot winding insulation, cool bulk insulation, copper and core steel. The hybrid systems include paper on the conductor and spacers of the winding, with cellulose board in the cooler sections of the cells.

- Power transformers are used in transmission network so they do not directly connect to the consumers, so load fluctuations are very less. These are loaded fully during 24 hours a day, so copper losses and iron losses takes place throughout day, the specific weight i.e. (iron weight)/ (cu weight) is very less. The average loads are nearer to full loaded or full load and these are designed in such a way that maximum efficiency at full load condition. These are independent of time so in calculating the efficiency only power basis is enough.
- Distribution transformers are used in distribution network so directly connected to the consumer so load fluctuations are very high. these are not loaded fully at all time so iron losses take place 24-hour a day

Continued on Page 84

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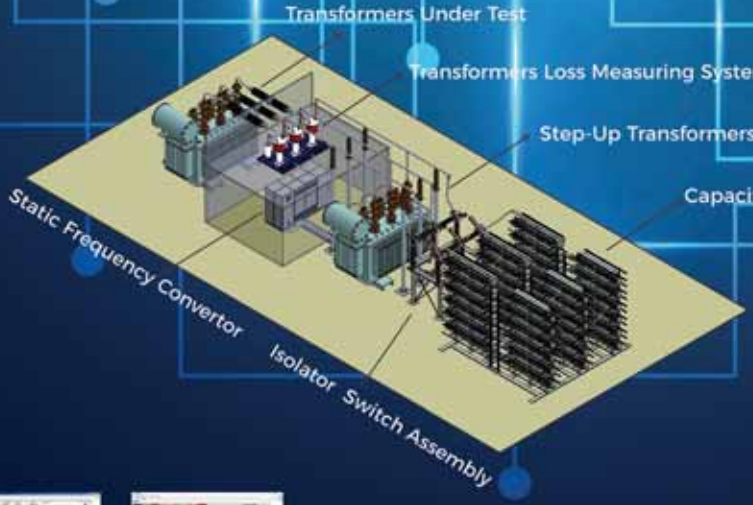
Continued from Page 82

and copper losses takes place based on load cycle. The specific weight is more i.e. (iron weight)/ (cu weight). Average loads are about only 75 per cent of full load and these are designed in such a way that max efficiency occurs at 75 per cent of full load. As these are time dependent the all-day efficiency is defined in order to calculate the efficiency.

- Power transformers are used for transmission as a step up devices so that the I2r loss can be minimised for a given power flow. These transformers are designed to utilise the core to maximum and will operate very much near to the knee point of B-H curve (slightly above the knee point value). This brings down the mass of the core enormously. Naturally these transformers have the matched iron losses and copper losses at peak load (i.e. the maximum efficiency point where both the losses match).
- Distribution transformers obviously cannot be designed like this. Hence the all-day-efficiency comes into picture while designing it. It depends on the typical load cycle for which it has to supply. Definitely core design will be done to take care of peak load and as well as all-day-efficiency.
- Power transformer generally operated at full load. Hence, it is designed such that copper losses are minimal. However, a distribution transformer is always online and operated at loads less than full load for most of time. Hence, it is designed such that core losses are minimal.
- The main difference between power and distribution transformer is distribution transformer is designed for maximum efficiency at 60 per cent to 70 per cent load as normally doesn't operate at full load all the time. Its load depends on distribution demand. Whereas power transformer is designed for maximum efficiency at 100 per cent load as it always runs at 100 per cent load being near to generating station.

Dr G D Kamalapur
Professor, Dept of Electrical and Electronics Engineering
Shri Dharmasthala Manjunatheshwar College of Engineering and Technology, Dharwad, Karnataka

Integrated Transformer Testing Solutions



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Switchgear

Preparing for a Sea Change

How we can expect the Indian switchgear industry to evolve in the future? Here's an overall analysis of market status, growth drivers and future outlook.

By Subhajit Roy, Group Editor

The power generation capacity in India has grown at a rate of over 10 per cent in the past few years, while the transmission and distribution network has witnessed a moderate growth. This has translated into a growing demand for robust power system equipment such as switchgear in the country which helps in protecting against situations of overload, short circuit,

insulation failure etc. India's switchgear market is anticipated to witness robust growth due to surging power demand from industrial, commercial and residential sectors and developing infrastructure across various sectors including residential and commercial. "The market for switchgears is well established in India and has the necessary capacity to produce quality switchgear equipment and meet the expected demand from the smart cities," said AV Jagdish, Senior Vice President, Havells India Ltd.

Syed Sajjadh Ali, Managing Director - India, Electrical Sector, Eaton estimates that the switchgear industry has been growing at a rate of 5-7 per cent. However, as the overall economic growth picks up and the demand for electricity increases, the switchgear industry is expected to gain further momentum. India is still in the grid expansion mode with the government's primary focus on rural electrification. Ongoing issues with power generating assets and the precarious state of our DISCOMs continue to limit the growth of our industry, observes Syed. Commenting on the recent performance of switchgear industry in India, he adds, "Recently, we have seen increased competition from the unorganised sector in the LV (low-voltage) segment. While this does build a healthy industry ecosystem, the focus on product quality and safety of users should not be compromised."

India's switchgear market is anticipated to witness robust growth due to surging power demand from industrial, commercial and residential sectors and developing infrastructure across various sectors including residential and commercial.

According to "India Switchgear (LV, MV, HV) Market Overview, 2018- 2023" report by ResearchAndMarkets.com, the Indian switchgear market is expected to grow with a CAGR of more than 7 per cent in the forecasted period of next 5 years from FY 2017-18 to FY 2022-23. Demand has increased in this sector over a period due to the increase in the demand of new consumption centres and development of various renewable energy sources, informs Sameer Saxena, Director- Marketing, Legrand (Group) India.

On the technology front, there is an upward curve around awareness of connected and digital technologies. However, Syed feels, the adoption and implementation of the same may require longer timelines.

The need to have a safe, reliable and efficient power distribution at both micro and macro levels will provide growth opportunities to the low- and medium-voltage switchgear market in India.

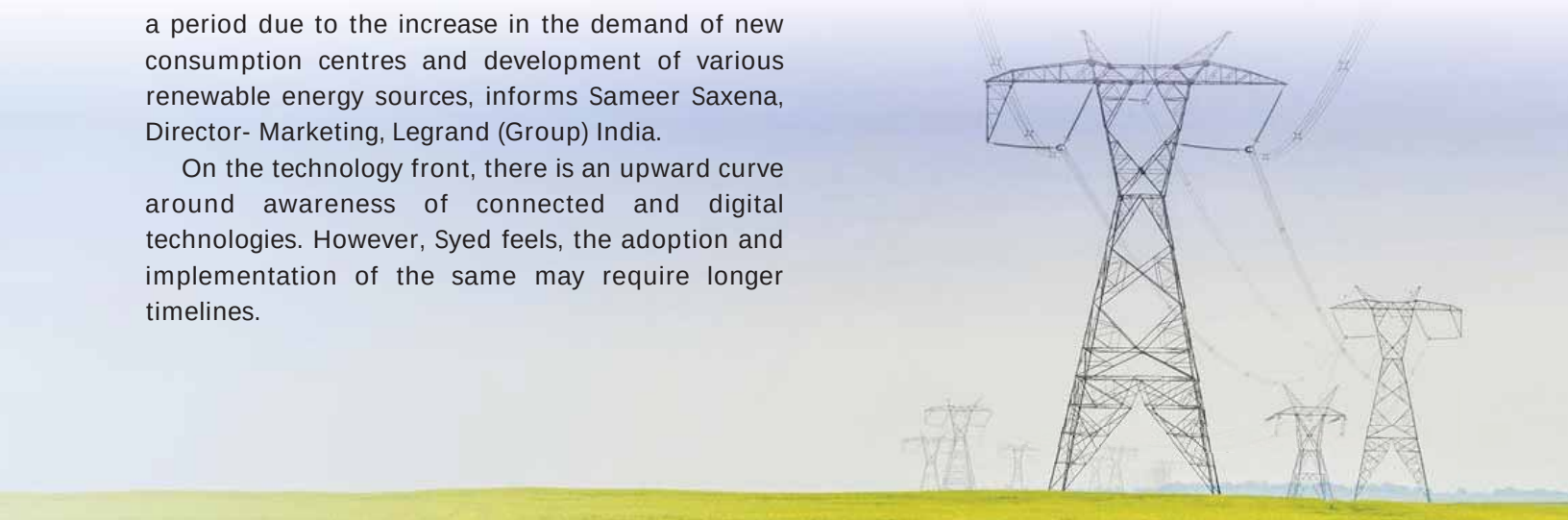
AV Jagdish, Senior Vice President, Havells India Ltd.

Growth drivers for LV & MV switchgears

It is estimated that the switchgear industry in India will reach Rs. 21,500 crore by 2019 on the back of strong infrastructure development including Smart Cities and various schemes launched by the government in the past like Make in India, Digital India, Integrated Power Development Scheme and Atal Mission for Rejuvenation and Urban Transformation, among others. All these schemes are committed towards development of new infrastructure and revamping of the existing infrastructure in the country thereby improving India's standing on the global arena, asserts AV Jagdish of Havells India.

He also adds, "The need to have a safe, reliable and efficient power distribution at both micro and macro levels will provide growth opportunities to the low- and medium-voltage switchgear market in India."

As transmission and distribution networks get upgraded, the switchgear sector witnesses higher demand too, which includes both LV and MV (medium-voltage) switchgears. Today, according to Anil Kadam, General Manager (Solutions Architect) at Schneider Electric, it is imperative to have an entire portfolio of compact and environmentally-sustainable LV and MV switchgears for better growth. He adds, "Rising deployment of smart grid technology and accelerating rural electrification are all poised to be key growth



Rising deployment of smart grid technology and accelerating rural electrification are all poised to be key growth drivers for LV and MV switchgears.

Anil Kadam, General Manager (Solutions Architect), Schneider Electric

drivers for LV and MV switchgears." Sameer Saxena of Legrand also opines that the increasing electrification in rural and urban areas of India has fuelled the growing demand for the LV and MV switchgear market. Moreover, he adds, "Increase in the demand of the installed capacity of transmission and distribution network in the power sector of India, China and other countries from Asia Pacific has also triggered the growth of LV and MV switchgear market."

India is world's fastest growing major economy. But interestingly we still are a developing country. This positions the power distribution industry for robust growth. At this juncture, we foresee commercial and industrial growth continuing to be the primary driver for the switchgear industry, anticipates Syed Sajjadh Ali of Eaton. He also expects major investments directed at rapidly improving the quality of distribution infrastructure, which would be critical for sustaining the industrial growth rate.

At different levels there are government directives to replace older redundant systems to achieve operational safety, and security in industrial establishments. Under these developments on the consumption side, India is emerging as a significant market for switchgear within the global switchgear landscape. The Indian switchgear market is driving global growth in a market estimated to cross USD 140 billion by 2024.

Switchgear gets renewable energy push

Considering the universal concerns on climate change and global warming, the emphasis is now on deploying technologies that have a minimal carbon footprint and offer sustainable solutions. "The rise of renewable energy and the changes witnessed therein will also be reflected in the switchgear industry, which will need to focus on sustainable, energy-efficient solutions possessing a lower carbon footprint," says Kadam.

India is aiming to achieve 227 GW of renewable energy capacity by March 2022, much ahead of its target of 175 GW as per the Paris agreement. As India looks to meet its energy demand on its own, renewable energy along with electrical equipment such as switchgears will also play a critical role in achieving the targets.

According to Syed Sajjadh Ali, increasing the proportion of renewable energy in the grid introduces significant challenges in terms of managing peak demand and stability. The only way to address this is through the use of sophisticated demand response methods, distributed energy resource management systems, usage of energy storage systems and to some extent, at least initially, the use of gas and small coal fired power plants. "From a switchgear industry perspective," Syed says, "We feel the growth of renewable energy will drive customers to deploy intelligent, connected switchgears controlled by artificial intelligence driven management software, which will function autonomously to maintain the grid."

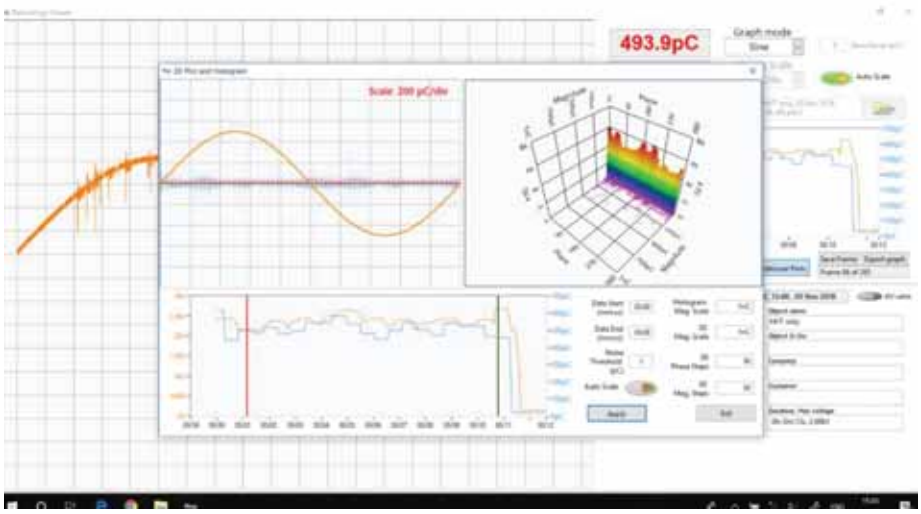
Further, the rapid advancement in the smart grid technologies and increasing focus towards energy efficient products is giving rise to more intelligent devices and innovative solutions from switchgear

Recently, we have seen increased competition from the unorganised sector in the LV segment. While this does build a healthy industry ecosystem, the focus on product quality and safety of users should not be compromised.

Syed Sajjadh Ali, Managing Director - India, Electrical Sector, Eaton

Continued on page 90

Partial Discharge Measuring System



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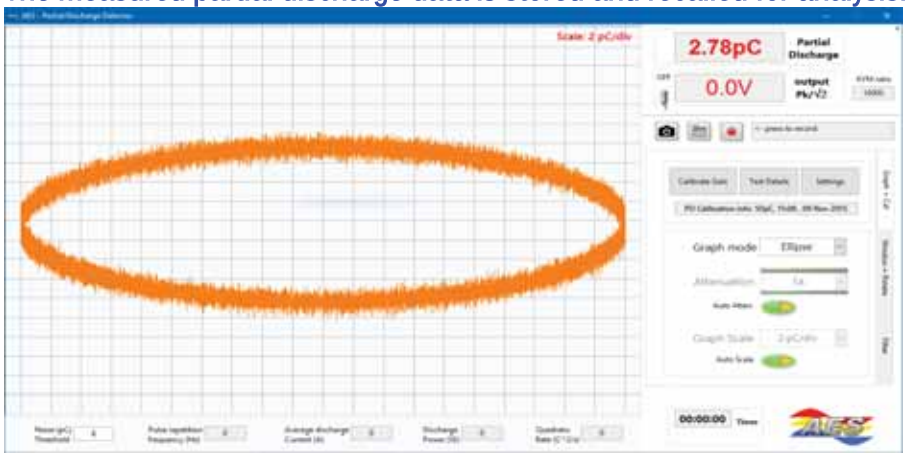

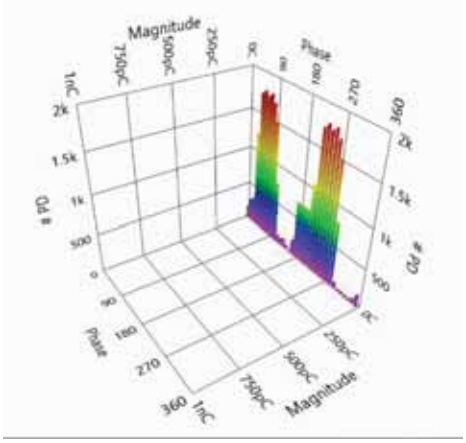

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Continued from page 88

manufacturers. Today, the load characteristics are changing, for example, use of LED lamps and higher efficiency motors, which calls for switchgears to evolve in-line with these changes. This is also fuelling switchgear demand by way of replacement of old energy guzzling devices, equipment and the associated switchgear with it, informs Saxena.

Manufacturers switching to green

Schneider Electric possess an entire portfolio of compact, environmentally-sustainable LV and MV switchgears. From medium voltage switchgear and transformers to energy automation, Schneider delivers specific solutions for utilities, oil and gas, mining, data centres and critical buildings, covering all power distribution needs for energy management.

Havells manufactures world-class industrial switchgears that offers close protection of devices such as motors against overload, single phasing etc. The entire range of Havells industrial switchgear include switches, circuit breakers and conventional devices that are designed and manufactured according to world-class standards and the user-friendly wide range of devices are built to meet varied application needs in motors, distribution circuits and automation systems.

Increasing electrification in rural and urban areas of India has fuelled the growing demand for the LV and MV switchgear market.

Sameer Saxena, Director- Marketing, Legrand (Group) India

Globally, Eaton has been one of the pioneers in developing microgrids, energy storage systems (both at grid scale and behind-the-meter), and power converters or components for the renewable energy segment. The microgrid deployed by Eaton at its India Innovation Center in Pune was the first of its kind in the country. Recently, Eaton has also launched the e-Mobility business group with the objective of building the required infrastructure for a rapid transition to electric vehicles.

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Maharashtra to compete with other countries!

"In next 5 years you will see Maharashtra competing with other countries, not with other states of the country. And we are heading towards this.

Subhash Desai,
Mining & Industries Minister,
Govt. of Maharashtra"

Maharashtra government aspires to provide 24/7 uninterrupted power supply for all, says **Maharashtra Minister for Industries and Mining Subhash Desai**.He also observes that there should be no relaxation for obtaining fire NOCs. Edited excerpts from his exclusive interview with **Subhajit Roy**:

Maharashtra is a major industrial hub of the country. How do you look at the industrial development in the state over the last 5 years?

Maharashtra has witnessed strong growth during the last 4 years and we could attract foreign direct investment to the tune of more than 30 per cent of the total national FDI inflow. That is one proof that Maharashtra is a leader and will remain one. We have introduced many industry-friendly policies and these policies are attracting more and more investments from countries abroad as well as domestic investments. We are also focusing on infrastructure development and safe and quality infrastructure is need of the hour. Our government wants not only growth but quality growth and we want to see safer India. With the proper infrastructure (in place), we shall be realising this dream soon.

When you talk about safe infrastructure, there's a growing number of fire incidents in Maharashtra. Your comments...

Yes, that's a concern. While promoting 'Ease of Doing Business', the number of required approvals were brought down from 75 to 25. However, after these incidents, we feel that we shouldn't give any relaxation atleast in case of obtaining fire no-objection certificates (NOCs). We are reviewing on withdrawing this.

Maharashtra is the powerhouse of India's economy. How is the power sector contributing to this growth?

Power sector is performing well. In Maharashtra there is power surplus and there is no problem in power availability. Now we want to focus on the quality of power supply – 24/7 uninterrupted power supply for all – is our dream.

Is the industry happy with the kind of power available today?

Naturally. In all industrial areas they crave for uninterrupted power and our supply of power is also of high quality.

Any message to power sector of Maharashtra – the power players especially?

Yes. The power supply should be uninterrupted – it should be safe and of high-quality. At the same time, we want to see that power becomes affordable, that is our priority.

As the Minister for industries, what is your dream for Maharashtra for next 5 years?

In next 5 years you will see Maharashtra competing with other countries, not with other states of the country. And we are heading towards this.

Are you talking about competing with developing countries?

Yes.

Lighting up over half a million homes in J&K

GE Power's Grid Solutions business announced the completion of a first-of-its-kind project for a 400/200 kV Gas Insulated Substation (GIS) at Magam village in the Baramulla block of north Kashmir. Part of the Northern Region System Strengthening 29 (NRSS 29) project, this project was awarded to Sterlite Power by the Indian Government through tariff-based competitive bidding in May 2014. Sterlite Energy recently shared that the commissioning of the project was two months ahead of schedule despite challenging mountainous terrain. The project will provide over half a million Jammu and Kashmir (J&K) citizens access to reliable power sources year-round. The project was led by GE T&D India Limited, the listed entity of GE Power's Grid Solutions business in India.

The Kashmir valley region in Northern India suffers from blackouts during the harsh winter months – leaving many families exposed to severe cold. The transmission lines spread over 400 km from Samba in Jammu to Amargarh in north Kashmir's Baramulla district and passes through 11 major towns and districts of J&K.

GE has commissioned more than four hundred 400kV GIS bays across India, but this project was the first time the company delivered a solution under harsh weather and sub-zero temperatures in India. Situated at an altitude of 1,710 metres (5,610 ft) in the snow-covered hills of Amargarh, this project was implemented in record time amidst tough conditions.

"Specially designed vehicles were used to transport the heavy equipment from different locations across India and deliver them safely to the site, overcoming several considerable constraints like narrow tunnels and rough terrains," said Shailesh Mishra, Business Unit Head, Turnkey Solutions South Asia for GE Grid solutions. "Transporting the material through Jawahar Tunnel was especially challenging. For transportation of transformers we had to dismantle the entire lighting rail and fixtures of Jawahar tunnel and re-do it within a limited time window." Underdeveloped local markets, limited availability of power from the grid and extreme weather conditions all posed significant challenges for the teams.

"GE is committed to develop and improve India's electrical infrastructure to ensure that the citizens have access to consistent and reliable power year-round, no matter what the weather conditions are. Our partnership with Sterlite Energy is just the next step in meeting the growing energy demand of the country," said Sunil Wadhwa, Managing Director, GE T&D India Limited and Leader of GE's Grid Solutions business in South Asia. "Every team member that was involved in this project should be incredibly proud of what we have achieved – delivering a critical solution, under severe conditions and in record time."

Ved Mani Tiwari, CEO, Sterlite Power said, "Sterlite Power is committed to empowering humanity by addressing the toughest challenges of energy delivery. NRSS-29 project is testament of the same. This is one of the largest private sector transmission projects awarded in the country and is critical for meeting the power requirements of the state. This is especially true in Kashmir, which suffers massive load-shedding during winters when electricity demand rises sharply. The GE team has done a phenomenal job in achieving this feat, particularly given the tight project timeline and rough, mountainous terrain."

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Electrical Distribution Network for Smart Cities

This article focuses on the electrical distribution network design for a Smart City focuses on providing a reliable, expandable and techno-savvy solution.

Picture Courtesy: www.huawei.com

Smart City Mission is an initiative of Govt of India to drive economic growth and improve quality of life. Assured electricity supply is one of the core infrastructure elements of a Smart City along with water supply, sanitation, robust IT connectivity, public transport etc. In 2015, Govt of India announced a list of 100 smart cities. The requirements of a Smart City are defined under Smart City Mission of Ministry of Housing and Urban Affairs. A Smart City would include gardens, parks, water bodies, river fronts and also different types of land uses like residential, commercial,

Table 1: Load Estimation (Based on Noida Power Corp Ltd Norms)

Type of building	Load estimate in watts/ per sqm	Diversity factor
Residential	30	0.4
Commercial	75	0.4
SEZ	120	0.7
Industrial	75	0.4
Institutions	45	0.35
Transportation	30	0.7
Green area	5	0.7
Institutional green area	15	0.6

industrial, IT, hospitals, hotels etc. This article covers the various aspects of power distribution system design in smart cities.

Key Features

The key features of the power distribution system shall be as follows:

- Reliability- Uninterrupted and Quality supply
- Smart
- Sustainable
- Expandable.

Power Distribution Arrangements

The power distribution arrangements consist of different options. Some of the options are:

Option 1: State electricity distribution company (DISCOM) or other distribution licensee shall develop, operate and maintain the entire electrical infrastructure up to the consumer meter.

Option 2: Special Purpose Vehicle (SPV) formed for the implementation of a Smart City Project shall acquire a franchisee license from a Distribution Licensee or itself can become a Distribution Licensee to develop, operate and maintain the entire electrical infrastructure for the power distribution beyond the supply point of DISCOM till the metering points of the end-users.

Option 3: Local private developer shall acquire a Franchisee license from Distribution Licensee to develop, operate and maintain the entire electrical infrastructure for the power distribution beyond the supply point of DISCOM till the consumer metering points. This will be applicable for private townships.

Load Estimation

The load estimation for different types of land uses will be based on guidelines available from state electricity boards/local power supply agencies/supply codes of state regulatory body. The estimate will take in to account the load density, area wise diversity factor, FSI and occupancy factor. Some typical values for estimate are given for reference in Table 1.

The total load estimate for the entire set up is calculated based on the built-up area of individual types of land use and as per the load considerations mentioned above. Each type of consumer will have different diversity factors based on which the operating load is estimated. Further there will be an overall diversity factor between different types of land use. This will give the estimated maximum demand for the city/area.

Depending upon the scale of the project the period of implementation can extend up to more than 20 years and the project is likely to be implemented phase wise. In such cases the demand estimation will be done phase wise and a modular expandable system shall be designed.

Selection of voltage level

The selection of voltage level depends upon the guidelines of state electricity supply code formulated by State Electricity Regulatory Commission (SERC). A typical case for Madhya Pradesh is mentioned here for reference. However the same is case specific and will have to be discussed with local electricity board depending upon the location of the project. Typical values for supply voltage level are given in Table 2.

The supply voltage of the project at every level i.e. from individual plot to the entire development area in the city shall be decided based on the above.

Table 2: Selection of voltage level based on data for Madhya Pradesh

Maximum contract demand	Supply Voltage
0-3kW	230V
2-112kW	400V
50-300kVA	11kV
100-10000kVA	33KV
5000-50000kVA	132kV
Above 40000 kVA	220 kV

Scheme for Transmission Line

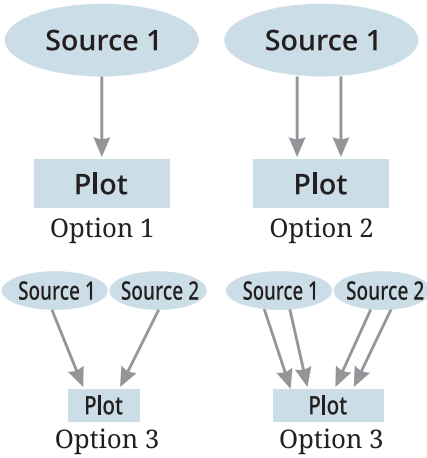
After deciding the supply voltage level as mentioned above, a survey shall be carried to identify the source in consultation local EB. Following options shall be considered:

Option 1: Single circuit transmission line from one power source in substation.

Option 2: Double circuit transmission line from one power source in substation.

Option 3: Single circuit transmission line from two different power source substations.

Option 4: Double circuit transmission line from two different power source substations.



The pros and cons will be evaluated based on the criticality of the project, contract demand and the extent of redundancy required before arriving at a final decision.

Scheme for EHV Switchyard

The EHV switchyard could be either be GIS or AIS. The decision will be based upon space/time and cost constraints. Further two alternatives are possible viz a single switchyard for the entire premises or two switchyards. The single switchyard will be planned as far as possible at the load centre. In case of two switchyards both will be interconnected for better redundancy. The schematic for Alternative 1 is given in Fig 1 and that for Alternative 2 is given in Fig 2.

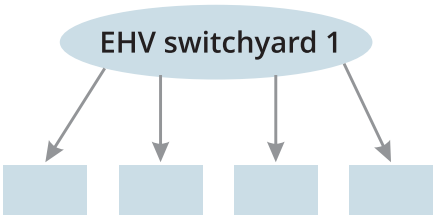


Figure 1: Single EHV switchyard in one plot

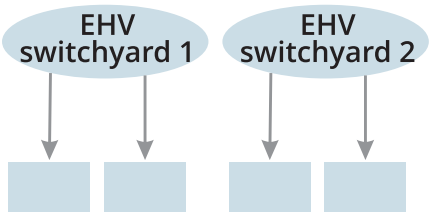


Figure 2: Two EHV switchyards in one plot

The pros and cons of Alternative 1 and 2 are indicated in Table 3.

Table 3: Pros and cons of Alternative 1 & 2

	Alternative 1	Alternative 2
Pros	Can provide redundancy	Can provide more redundancy
Cons	Less costly	More costly

Single EHV switchyard

The switchyard will comprise of line bays, bus bays and trafo bays. The transformer selection can be either 2 x 100% or 3 x 50%. The distribution voltage will be either 11kV or 33kV based on the consumer loads and SERC norms. For a combination of 11kV and 33kV consumers the primary distribution will be 33kV and secondary distribution will be 11kV. For secondary distribution 33/11kV substation will considered. The 33/11kV substation can either be location within the EHV substation or can be distributed as per the load centres.

Two EHV switchyard

In case Two Switchyards are considered, the configuration of the Switchyards can be same as described in the single switchyard option. Further 33/11kV distribution shall also be similar to that indicated in single EHV switchyard option. An EHV tie may be laid between the two EHV substations for further redundancy.

HV power distribution network

33kV and 11kV distribution

The 33KV distribution can be either a radial or a ring network. The cabling can be either directly buried or in trenches. If cabling is planned in cable tunnels then adequate provisions for fire detection, lighting, ventilation, fire barrier etc shall be considered as per statutory requirements. A typical ring network is indicated in Figure 3.

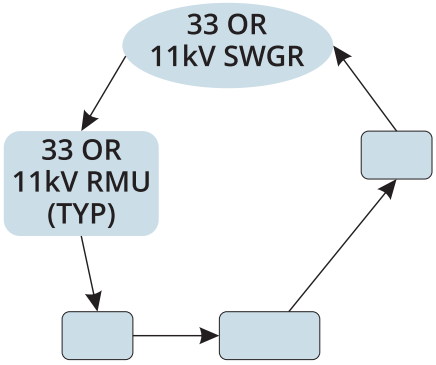


Figure 3: Ring network

The pros and cons of radial and ring network are indicated in Table 4 and pros and cons of different types of cabling system are indicated in Table 5.

The 11kV distribution can either

Continued on Page 100

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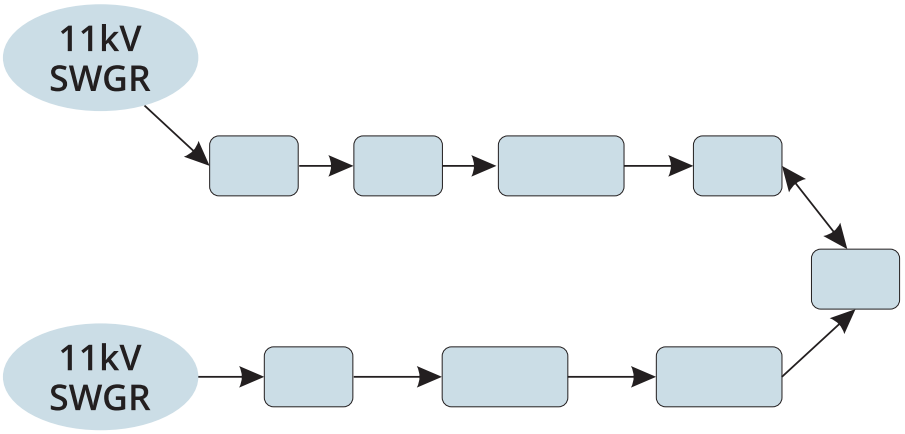
Continued from Page 98

Table 4: Pros and cons of radial & ring network

Radial network	Ring network
Less redundancy since cable failure or feeder breaker failure will result in to loss of power supply	In case of cable failure or feeder breaker failure, the supply can be restored by alternate path
Less costly	More costly

Table 5: Pros and cons of directly buried cables and cables in trenches

Directly buried cables	Cables in trenches	Cables in tunnels
Suitable only when the work is to be executed at one go. For phased load growth redigging work is involved	Suitable for phase wise load growth. The planning can be done for all the phases while execution can happen phase wise without causing major disturbance to the functioning of the premises	Suitable for phase wise load growth. The planning can be done for all the phases while execution can happen phase wise without causing any disturbance to the functioning of the premises Most suitable from aesthetics point of view
Less costly	More costly	Most costly since provisions for fire detection, lighting, ventilation, fire barrier etc shall be considered as per statutory requirements



Arrangement at consumer premises

be radial or ring network or in case of multiple 33/11kV substations option the 11kV distribution can be in a mesh (tie) option. The mesh option will be cheaper than ring option.

The HT supply to the consumer premises shall be supplied/ tapped from the nearest RMU for radial, ring or tie feeders or shall be directly terminated at the consumer's point of supply breaker in case of a dedicated feeder. A common RMU with adequate number of outgoing feeders can be considered for two or three plots based on availability of necessary number of outgoings and site suitability.

Power Supply for Common Utilities

Intermediate substations for common infra works i.e. outdoor lighting, water supply, solid waste management shall be planned. These substations shall be tapped from the nearest existing ring or tie network. Suitable tariff metering arrangement shall be considered for energy accounting. The LT supply shall be derived from these substations with adequate capacity of transformer. Suitable DG back-up will be considered if required depending upon the criticality of the utility.

Smart Features of Electrical System

Following features shall be considered for the electrical equipment/system:

- All revenue metering shall be through Smart Meter and Advanced Metering Infrastructure (AMI).
- All meters of EHV switchyard and in 33 and 11 KV switchgear shall be with communication ports for SCADA connectivity.
- All relays in EHV switchyard and in 33 and 11 KV switchgear shall be numerical type and suitable for SCADA connectivity.
- All operating equipment like breakers, Isolators, RMU and CSS equipment shall be suitable for SCADA connectivity.

Vijay Barve

Discipline Head – Electrical - Infra BU
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CLARIANT FRAKO

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Or

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As per revised Electrical Power Tariff Structure

Consumers will be adversely affected if Reactive Power Management Systems are not corrected. Most of the consumers who were availing Unity Power Factor incentive were doing so with varying amounts of overcompensation either with fixed capacitors or by coarse auto correction. This is no more possible with revised Tariff Structure which calls for close monitoring of Leading Power Factor.

Comparisons of some typical previous Bills and New Bills as per Revised Tariff without corrective measures reveal minor overcompensation to extreme levels of overcompensation.

Old Tariff	New Tariff		
PF 1 Incentive 7%	PF 0.833 Lead	Penalty 4%	Rice Mill
PF 1 Incentive 7%	PF 0.996 Leading	Incentive 0	Steel & Iron
PF 1 Incentive 7%	PF 0.206 Leading	Penalty 35%	Food Processing

Main Points of New Tariff Structure

- Power Factor Incentive of 7% for Billed Power Factor of Unity has been reduced to 3.5%.
- The PF incentive available earlier to PF between .96 lead to Unity has been withdrawn
- PF Penalty has been introduced for Average Monthly Leading PF below 0.9 Lead
- The PF penalty was applicable earlier only to Average Monthly Lagging PF below 0.9 Lag
- Recording of Leading RKVAH units has been introduced to assess extent of overcompensation.
- Earlier improvement of PF with any amount of overcompensation was permitted and full incentive was made available to consumers irrespective of extent of overcompensation. Recording of Leading RKVAH units disallows this.
- When Lagging RKVAH units only were being recorded overcompensation remained unnoticed.

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SMEs battling multiple headwinds: IEEMA

SMEs which account for around 85 per cent of the electrical equipment industry, are battling multiple headwinds today.

Harish Agarwal, President, IEEMA

Poor financial health has limited the ability of most state-owned DISCOMs to undertake last-mile reforms which in turn has weakened demand for the MSMEs whose products find use in last-mile power distribution applications, informs Harish Agarwal, President of Indian Electrical & Electronics Manufacturers' Association (IEEMA) – the apex association of the Indian electrical equipment manufacturing industry. Edited excerpts from his interview with Electrical India:

Power sector in India is expected to attract an investment of Rs 11,55,652 crore by 2022. How do you see the opportunity for electrical equipment business?

India is likely to attract a massive investment of Rs 11,55,652 crore in power generation sector in the five-year period between 2017 and 2022 in setting up projects across thermal, hydro, nuclear and renewables segment. So, it is great opportunity for the industry. The policy initiatives of Power Ministry like coal auction, renewable policies for generation, schemes like IPDs, DDUGJY etc, for T&D have helped the sector. Also, support from government through procurement policies, more capital in-flows domestically and increased competitiveness of Indian manufacturers vis-à-vis imports thereby reducing imports in some sectors. Moreover, the electrical equipment manufacturing technology is witnessing significant modernisation while new technology is also being adopted in the manufacturing processes. Technological advancements, like smart grids and policies on emission reduction will influence the future direction taken by the power sector and

electrical equipment industry in various countries.

Which are the segments will drive the growth?

The demand in renewable has supported to overall demand and will open new demand for new products and solutions in all segments. The Government of India has wholeheartedly backed the renewable sector in India by announcing a target of 176 GW by 2022, of which 100 GW has been allotted to solar, 66 GW to wind and the remaining 10 GW to the development of other renewable energy sources like biomass, geothermal and small hydro power projects. The corporate too have shown interest to commit huge investments towards this goal. Besides this, enabling amendments have been proposed to the Electricity Act, including open access reforms and enhanced Renewable Purchase Obligations.

Have the government initiatives like 'Make in India' and '100 Smart City' started delivering as far as electrical equipment industry is concerned?

"Make in India" is perhaps one of the most important programmes being pursued by the Government of India. The central theme is about transforming India into a manufacturing hub with world class technology while creating additional employment. IEEMA being one of the proud partners of the 'Make in India' campaign has identified a four-point agenda, which includes, mandatory vendor development program by utilities, mandatory testing of all imported electrical equipment in Indian labs (non-tested at origin), standardising equipment across all utilities and national competitive specifications for bidding for any tenders against domestically funded projects.

The energy infrastructure is arguably the single most important feature in any city. If unavailable for a significant enough period of time, all other functions will eventually cease. IEEMA helps modernise power systems for the smart cities through self-healing designs, automation, remote monitoring and control, and where practical and economic establishment of micro grids. We have all required technologies and skill set.

How 'Make in India' is benefitting SMEs in electrical equipment segment?

Electrical equipment industry and the SMEs are going to be the game changer for tomorrow. For any industry to sustain and adopt new technology, they require finance and SMEs are no different. In this current scenario, there is a huge trust deficit between the banking segment and any industry. SMEs which account for around 85 per cent of the electrical equipment industry, are battling multiple headwinds today. Poor financial health has limited the ability of most state-owned power distribution companies (DISCOMs) to undertake last-mile reforms — for improvement of quality of supply voltage, distribution loads, the billing process and prevention of pilferage. This has weakened demand for the MSMEs whose products find use in last-mile power distribution applications.

Could you brief us on Indian electrical equipment industry's preparedness on the 'Power for All' front?

IEEMA has been vigorously pursuing with the policy makers, so as to positively impact made in India products with state-of-the-art technology. Moreover, the electrical equipment manufacturing technology is witnessing significant modernisation while new technology is also being adopted in the manufacturing processes. Technological advancements, and policies on emission reduction will influence the future direction taken by the power sector and electrical equipment industry in various countries. We need to however keep an eye on utilising existing manufacturing capacities first before adding new.

Finally, what's your outlook for Indian electrical equipment industry beyond 2019?

India is firmly set on a path of economic growth that is estimated to usher in prosperity like never before. This economic prosperity will need to be built on the back of significant transformations across several facilitating elements, the primary ones being infrastructure build-out, energy availability and sustainability. The government's 'Make in India' program has placed India on the world map as a manufacturing hub and give global recognition to the Indian economy. India is expected to become the fifth largest manufacturing country in the world by the end of year 2020. The Government of India has set an ambitious target of increasing the contribution of manufacturing output to 25 per cent of Gross Domestic Product (GDP) by 2025, from 16 per cent currently. India's manufacturing sector has the potential to touch US$ 1 trillion by 2025. There is potential for the sector to account for 25-30 per cent of the country's GDP and create up to 90 million domestic jobs by 2025.

Top 10 IoT Technologies and Trends Through 2023

Gartner shortlists the 10 most strategic IoT technologies and trends that will enable new revenue streams and business models, as well as new experiences and relationships.

"The IoT will continue to deliver new opportunities for digital business innovation for the next decade, many of which will be enabled by new or improved technologies," said Nick Jones, research vice president at Gartner. "CIOs who master innovative IoT trends have the opportunity to lead digital innovation in their business."

According to the Gartner report titled "Top Strategic IoT Trends and Technologies Through 2023," by 2023, the average CIO will be responsible for more than three times as many endpoints as this year.

Therefore, they must ensure they have the necessary skills and partners to support key emerging IoT trends and technologies.

Gartner report shortlisted the 10 most strategic IoT technologies and trends that will drive digital business innovation from 2018 through 2023:

1. Artificial Intelligence (AI)

Gartner forecasts that 14.2 billion connected things will be in use in 2019 and the total will reach 25 billion by 2021. This will be producing immense volume of data. "Data is the fuel that powers the IoT and the organisation's ability to derive meaning from it will define their long term success," said Jones. "AI will be applied to a wide range of IoT information, including video, still images, speech, network traffic activity and sensor data."

The technology landscape for AI is complex and will remain so through 2023, with many IT vendors investing heavily in AI, variants of AI coexisting, and new AI-based tolls and services emerging. Despite this complexity, it will be possible to achieve good results with AI in a wide range of IoT situations. Thus, CIOs must build an organisation with the tools and skills to exploit AI in their IoT strategy.

2. Social, Legal and Ethical IoT

As the IoT matures and becomes more widely deployed, a wide range of social, legal and ethical issues will grow in importance. These include ownership of data and the deductions made from it; algorithmic bias; privacy; and compliance with regulations such as the General Data Protection Regulation. "Successful deployment of an IoT solution demands that it's not just technically effective but also socially acceptable," said Jones. "CIOs must, therefore, educate themselves and their staff in this area, and consider forming groups, such as ethics councils, to review corporate strategy. CIOs should also consider having key algorithms and AI systems reviewed by external consultancies to identify potential bias."

3. Infonomics and Data Broking

Last year's Gartner survey of IoT projects showed 35 percent of respondents were selling or planning to sell data collected by their products and services. The theory of infonomics takes this monetisation of data further by seeing it as a strategic business asset to be recorded in the company accounts. By 2023, the buying and selling of IoT data will become an essential part of many IoT systems. CIOs must educate their organisations on the risks and opportunities related to data broking in order to set the IT policies required in this area and to advise other parts of the organisation.

4. Shift from Intelligent Edge to Intelligent Mesh

The shift from centralised and cloud to edge architectures is well under way in the IoT space. However, this is not the end point because the neat set of layers associated with edge architecture will evolve to a more unstructured architecture comprising of a wide range of "things" and services connected in a dynamic mesh. These mesh architectures will enable more flexible, intelligent and responsive IoT systems — although often at the cost of additional complexities. CIOs must prepare for mesh architectures' impact on IT infrastructure, skills and sourcing.

5. IoT Governance

As the IoT continues to expand, the need for a governance framework that ensures appropriate behavior in the creation, storage, use and deletion of information related to IoT projects will become increasingly important. Governance ranges from simple technical tasks such as device audits and firmware updates to more complex issues such as the control of devices and the usage of the information they generate. CIOs must take on the role of educating their organisations on governance issues and in some cases invest in staff and technologies to tackle governance.

6. Sensor Innovation

The sensor market will evolve continuously through 2023. New sensors will enable a wider range of situations and events to be detected, current sensors will fall in price to become more affordable or will be packaged in new ways to support new applications, and new algorithms will emerge to deduce more information from current sensor technologies. CIOs should ensure their teams are monitoring sensor innovations to identify those that might assist new opportunities and business innovation.

7. Trusted Hardware and Operating System

Gartner surveys invariably show that security is the most significant area of technical concern for organisations deploying IoT systems. This is because organisations often don't have control over the source and nature of the software and hardware being utilised in IoT initiatives. "However, by 2023, we expect to see the deployment of hardware and software combinations that together create more trustworthy and secure IoT systems," said Jones. "We advise CIOs to collaborate with chief information security officers to ensure the right staff are involved in reviewing any decisions that involve purchasing IoT devices and embedded operating systems."

8. Novel IoT User Experiences

The IoT user experience (UX) covers a wide range of technologies and design techniques. It will be driven by four factors: new sensors, new algorithms, new experience architectures and context, and socially aware experiences. With an increasing number of interactions occurring with things that don't have screens and keyboards, organisations' UX designers will be required to use new technologies and adopt new perspectives if they want to create a superior UX that reduces friction, locks in users, and encourages usage and retention.

10. New Wireless Networking Technologies for IoT

IoT networking involves balancing a set of competing requirements, such as endpoint cost, power consumption, bandwidth, latency, connection density, operating cost, quality of service, and range. No single networking technology optimises all of these and new IoT networking technologies will provide CIOs with additional choice and flexibility. In particular, they should explore 5G, the forthcoming generation of low earth orbit satellites, and backscatter networks.

9. Silicon Chip Innovation

"Currently, most IoT endpoint devices use conventional processor chips, with low-power ARM architectures being particularly popular. However, traditional instruction sets and memory architectures aren't well-suited to all the tasks that endpoints need to perform," said Jones. "For example, the performance of deep neural networks (DNNs) is often limited by memory bandwidth, rather than processing power." By 2023, it's expected that new special-purpose chips will reduce the power consumption required to run a DNN, enabling new edge architectures and embedded DNN functions in low-power IoT endpoints. This will support new capabilities such as data analytics integrated with sensors, and speech recognition included in low cost battery-powered devices. CIOs are advised to take note of this trend as silicon chips enabling functions such as embedded AI will in turn enable organisations to create highly innovative products and services.

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QuEST Global partners with Siemens for Digital Manufacturing

Partnership to augment Digital Manufacturing expertise of QuEST Global and offer benefits of real-time data insights to clients

QuEST Global has announced it has joined Siemens' MindSphere Partner Program to develop innovative connected solutions using MindSphere, the Cloud-based, open IoT operating system from Siemens. This partnership will enable QuEST to deliver on the connected engineering objectives of its customers across industries using data insights from advanced engineering analytics. It is an expansion of the ongoing partnership with Siemens, providing customers with a closed-loop end-to-end digital twin capability and a complete range of connected manufacturing solutions.

MindSphere connects products, plants, systems and machines, enabling businesses to harness the wealth of data generated by the Industrial IoT and provide powerful industry applications and digital services to help drive business success. The platform delivers a wide range of device and enterprise system connectivity protocol options, advanced analytics and an innovative development environment with access to private and public Cloud platforms.

QuEST will initially roll out solutions and services built on MindSphere for customers in the Aerospace and Power verticals. IoT and digital transformation have already gained significant traction in these industries, however the volume of data generated is not effectively utilised. Connected engineering solutions built with MindSphere using advanced engineering analytics can address this challenge and deliver the benefits of the convergence of mechanical and software capabilities.

QuEST aims to improve the competitiveness of OEMs and manufacturers in automotive, industrial and hi-tech industries by tapping into the real-time data generated by their products and manufacturing plants. This will be complemented by the insights gained from after-sales usage of devices and also real-time consumer insights.

Commenting on the partnership, Todd Ashley, Vice President, Digital and Industrial Solutions, QuEST Global said, "QuEST joining the MindSphere Partner Program is a part our commitment to enhance the value of our digital and software offerings to customers. With the convergence of digital and mechanical worlds, there is an increasing need for industrial companies to accelerate their digital journeys and deliver innovative services. QuEST's existing partnership with Siemens, focusing on Digital Manufacturing Solutions, is now augmented by the advanced capabilities of MindSphere, as we can add more value to customers in their digital transformation journeys."

Paul Kaeley, Senior Vice President, Global Partner Ecosystem at Siemens PLM Software said, "Siemens is delighted to expand our existing partnership with QuEST Global and welcome them to the MindSphere partner ecosystem to develop innovative connected solutions. QuEST's new solutions built with MindSphere can help our joint customers evaluate and utilise the data from their products to generate new insights and provide value-added digital services and solutions. It is this type of innovation that helps our joint customers accelerate their digital transformations."

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- Frequent START/STOP cycle applications
- Manual brake release (as standard)
- Hexagonal hole on non drive end of the shaft for manual rotation
- Single speed or two speeds motors
- All motors designed for inverter duty

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  One stage worm, helical/worm and double worm.
- RD helical gearboxes: 50 to 2300 Nm. Two and three stages.
- RN parallel shaft gearboxes: 180 to 3300 Nm. Two and three stages.
- RO-RV bevel/helical gearboxes: 180 to 3300 Nm. Three stages.
- RG precision planetary gearboxes: 10 to 230 Nm.
  One and two stages.
- VR dry friction speed variators: IEC63 to IEC90
  1 to 5 stepless speed range, 300 to 1500 rpm.
- VS planetary speed variators: IEC71 to IEC112
  1 to 5 stepless speed range, 200 to 1000 rpm.

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"Esennar contributes to infrastructural advancement"

Sridhar Reddy Arumalla, Managing Director, Esennar Transformers sheds light on Indian power and distribution transformers in an e-mail interaction with **Electrical India**.

What has been the journey of Esennar Transformers so far?

Esennar is one of the reputed transformer manufacturers in India with a comprehensive world-class design and manufacturing facility in Hyderabad. Since set up in 2000, Esennar powered its way into the elated league delivering world-class transformers with BIS or ISI 1180 license. We are also certified ISO 9001, ISO 14001 and OHSAS 18001 company. With more than decade of experience, we understand the challenges of industry and always strive to find innovative solutions. We have state-of-the-art facilities in design, manufacture and testing to supply custom-built oil cooled, dry type or cast resin transformers. Pan India with 14 regional offices provide comprehensive sales and service activities.

What evolutions have you witnessed in Indian power and distribution transformers sector?

Power sector in India has grown significantly since independence, both in the installed capacity and transmission and distribution (T&D) system. The total power generating capacity (utilities and non-utilities) has increased from a meager 1362 MW in 1947 to about 399 GW at the end of March 2018 playing a major role in economic growth of the country. The energy consumption is increasing with increased population, industrialisation and urbanisation. At present, India is the third largest producer and third largest consumer of electricity in the world. Power and distribution transformers have shaped the electrical energy supply industry, allowing generations to be located remotely from points of demand. Increasing demand for electrical energy driven by emerging economies and extensive power plant capacities along with the economic growth are some of the key drivers driving the demand for power and distribution transformers.

What are the products offered by the company catering to power and distribution transformers industry?

Esennar equipped with BIS or ISI 1180 license, our manufacturing range includes Oil Filled Transformers from 100 KVA to 16 MVA upto 33 KV class and 25 MVA upto 132 KV class, Dry type or Cast resin transformers upto 5MVA, 33 KV class, Transolar – Multi-winding Transformers for solar power, Furnace Transformers, Rectifier transformers, Compact or Packaged or Unitised Substations, Mining Transformers, Earthing

Transformers, and Converter duty Transformers.

Esennar successfully carried out dynamic short circuit test upto 12.5 MVA, 33/11 KV at CPRI, Bhopal and lightning impulse voltage test upto 11MVA, 66/11 KV at CPRI, Hyderabad. Also, we successfully got short circuit test passed in first attempt of solar inverter transformer for 5.3MVA, 0.500x2/33kV and 2.5MVA, 0.350x2/33kV.

What is the current scenario in power and distribution transformers segment?

The increasing demand of electricity, upgrading transmission networks, cross border transmissions are fuelling investments in power and distribution transmissions infrastructure driving a growth in power and distribution transformer market. Frequent technology update is encouraging transformer manufacturers to further innovate and enhance product designs, increasing the competition in the market. Leading transformer manufacturers are employing innovative technologies to differentiate their products from others and consolidate their positions in the global market. Maximising the output and performance remains a challenging task, and transformers are no exception. Complexity in the designing process continues to be one of the major challenges in power and distribution transformers.

What technological innovations are incorporated in your products in order to make them more superior and competitive as compared to your peers?

Esennar is the best equipped in its class with present day technologies resulting in continual improvement. Our invention relating to Cast Resin Transformers with Direct Mounted Tap Changers first-of-its-kind in the world, our innovative core building without yolk studs which promote noiseless functioning and reduce eddy current losses are some of the glimpses of our technological innovations. While the German machinery ensures flawless end products, the Swiss automated testing systems reassure the quality of transformers. Computerised and fully automated testing, the revolutionary winding process powered by the L and S bend machines inspires robust and the most efficient products. Our distinctive assembling process guarantees superior resistance to short circuitry forces and heating at brazing points.

How does digitisation help in improving performance and reliability of products?

Esennar firmly believes that digitisation is a smart way to increase productivity of an organisation and cope up with competition. It helps in streamlining business more effectively. In cooperating innovative technology to our strategies will boost the efficiency and performance of an organisation. Digitisation can help in monitoring the transformers in real time. As a result, the condition of the systems can be evaluated with much greater speed, efficiency and consistency. Digitisation also will improve the efficiency of the electricity system and better meet the customers' diverse needs.

What kind of opportunities do you envisage for your company with the government's project of 100 smart cities, 'power for all' scheme etc?

Incorporation of the smart grid technology in the smart cities project will offer a unique opportunity to jump to an improved electricity environment and provide reliable 24X7 electricity to consumers. Innovation for combating space constraint, Esennar indigenously designed dry type transformers will help setting up the infrastructures where alternative spaces are not available.

Governments of emerging economies are not only focusing on raising production capacities but also emphasising on transmission and distribution infrastructure. Increasing government support has boosted the adoption of renewable sources of power across the residential and industrial sectors, which are expected to drive the power and distribution transformers market. Esennar as a power and distribution transformer manufacturer approved by most of the state and central power utilities will grab these opportunities. We have a strong team of design, manufacturing, quality control and assurance who consistently caters to the demands of the industry.

What is your outlook for the sector?

The power sector is pivotal for global energy and economic outlook, it will play a huge role in ensuring the challenges in India's unprecedented growth. Energy demand in India is projected to soar over the coming decades, propelled by an economy that grows to reach more than five-times to its current size by 2040. Increasing number of transmission and distribution infrastructure, grid interconnection and overhaul of existing ones are the major drivers for transformers market. Esennar contributes to the infrastructural advancement and innovates new technology to enrich customer contentment.

Wires & Cables Industry: Betting Big on Infra

Picture Courtesy: www.pixabay.com

The growth of infrastructure generates scope for further development of the wires and cables industry in India.

*By **Supriya A Oundhakar**, Associate Editor*

The Institute for Energy Economics and Financial Analysis (IEEFA) forecasts India's gross domestic product (GDP) to double over the next 10 years, growing at 7 per cent annually. Electricity demand is forecast to nearly double over this period. This has generated the need for the development of quality electrical infrastructure supporting its growth for several years to come. It augurs well for the development of wires and cables industry in India. Being one of the key segments of power sector, wires and cables sector is experiencing an escalating demand owing to the growth in power generation infrastructure.

The wires and cables market in India comprises nearly 40 per cent of the electrical industry and is growing at a CAGR of 15 per cent as a result of growth in the power and infrastructure segments. The

segment has been witnessing unprecedented growth owing to the boost provided by the recent policy and regulatory initiatives as well as Government schemes like Ujjwal Discom Assurance Yojana (UDAY), the Deendayal Upadhyay Gram Jyoti Yojana (DDUGJY), the Integrated Power Development Scheme (IPDS) and the Pradhan Mantri Sahaj Bijli Har Ghar Yojana Saubhagya. Further, Indian Railways' Railway Mission 41K has generated the potential for Indian wires and cables industry through electrification of 38,000 km route. Under DDUGJY, the government has envisaged the electrification of all villages.

Growth Drivers

The Transmission and Distribution sector continues to remain in focus, especially, with the outlay of Rs. 2.6 lakh crore announced by the Government for the five-year period ending FY2022. There is also a sharper focus on high voltage transmission lines along with the Government's aims to provide 24x7 power, which is opening up opportunities in the sector. DISCOMS which have joined the UDAY scheme are expected to improve their T&D infrastructure through renewed investments. The government's target of generation of 100 GW of solar energy by 2022 and measures such as excise duty exemption for ferro-silicon magnesium used for manufacturing components for wind-operated electric power generators have augmented the demand for electrical wires and cables.

According to Randeep Narang, President - International (T&D, Solar) and Cables, KEC International, the Government's focus on Power for All, rural electrification, improving infrastructure, robust spurt in the number of electrified households, improved life-styles and new opportunities are propelling the demand of domestic cables and wires and electrical items. RPG Cables has grown over the last six years and now is amongst the key suppliers of high-quality power and telecom cables, not only in India but also in markets such as UK, Australia and Africa.

On the one hand, we see a lot of new power generation due to the new climate politics. This results in substantial adaption of the transmission network. A general there is to replace overhead lines with underground cables, which is more environmentally friendly. A big trend as well are the upcoming projects for HVDC connections.

Samuel Ansorge, CEO, Brugg Cables

Arvind Agarwal, AVP, Havells informs further, that the government's 'Smart City' project is expected to propel large-scale growth in infrastructure, telecom, power generation, T&D, engineering and automotive sectors which augurs well for the wire and cable industry, as growth of the industry has direct linkage with growth and developments happening in other sectors. According to reports, the wires and cables industry in India is expected to double in size in the next five years.

Cable manufacturers, both power and telecom, have been shoring up their capacities in anticipation of the demand growth. "KEC has built significant capabilities over the last few quarters by consolidating its Silvassa manufacturing unit with the state-of-the-art Vadodara plant. "We have also commenced manufacturing catenary & contact conductors and signaling cables for Railways," informs Narang.

Apart from right of way (RoW), space constraints in the cities generates the scope for underground cables as a solution. Brugg Cables wants utilities to learn about future trends and to have the latest technology.

"On the one hand, we see a lot of new power generation due to the new climate politics. This results in substantial adaption of the transmission network. A general trend is to replace overhead lines with underground cables, which is more environmentally friendly. A big trend as well are the upcoming projects for HVDC connections. In the renewable segment we see huge on and offshore wind parks coming up," informs Samuel Ansorge, CEO, Brugg Cables.

Technology

Global investors are envisaging India as the potential market for high voltage (HV) and extra high voltage (EHV) cables. They leverage their investments in the Indian cable market through technical collaboration with Indian cable manufacturers for production of EHV cables up to 400 kV. Due to lack of congenial policies and

"We expect a pick-up in manufacturing activity and capacity expansion in segments like steel, cement, pharma etc. additionally, in line with the supreme court directive to reduce emissions as per BS-VI norms, petrochemical companies are expected to invest in plant modernisation and expansion, thus increasing the demand for cables."

Randeep Narang, President - International (T&D, Solar) & Cables, KEC International

technology for investments in local manufacturing, the country still depends on imports cables of 66 kV and 33 kV. So, Indian Electrical and Electronics Manufacturers' Association (IEEMA) suggests that the domestic manufacturers must explore the possibility of manufacturing these items to meet likely demand. There is a burning need for standardisation of specifications across this segment, which would lead to improved efficiencies in this segment and also reliability and replaceability of products. With increasing focus on renewables, the industry is now looking forward to supply cables for solar and wind power applications in addition to oil and gas, railways and other specialized segments. As per IEEMA, Indian power cable manufacturers have attained maturity in terms of technology for HV cable up to 220 kV and have been found competitive in the global scenario, despite having higher local costs, as well as local taxes and duties being paid on their products.

In the near future, there appears to be no viable alternative for cables for bulk power transmission. But trends such as Smart Grids or Distributed Generation has a potential to change the demand for cables, although they are yet to be fully established in terms of long term commercial viability.

For KEC, bulk of its business comes from LT and HT cables, which are technically mature and fully standardised. "EHV cables, particularly, the 220 kV and higher segment, is seeing development in terms of improving long term reliability and making them more compact. This know-how is limited to very few companies like ours, which have been supplying EHV cables for over 20 years. Another area that we see development in is E-beam cables, which are being favored in sectors such as solar, railways and shipping, where cables are required with cross linked polymeric insulation with lower insulation thickness for high temperature applications," informs Narang of KEC International.

Ansorge opines that the electrical power business is undergoing substantial changes and generally accelerating. The early adaption of latest technologies is, therefore, a must. These are new cable and cable accessories technologies like HVDC, 800 kV cable systems etc and the need for digitisation, which will enhance efficiency of the network. Not only will technologies be an important aspect, but also market-oriented services.

Conclusion

The Government's impetus on infrastructure sectors such as power, railways, roads and petrochemicals will in turn spur demand for more power, and hence more power cables. Growing market potential, increased adaption of new technologies by the utilities, growing importance of services that may be linked to digital technologies have generated further scope for the growth of wires and cables industry in India.

The government's efforts of introduction of Goods and Service Tax (GST) has brought unorganised players in the sector under the tax net by narrowing the price difference between organised and unorganised market.

Moving forward, Narang of KEC International expects a pick-up in manufacturing activity and capacity expansion in segments like steel, cement, pharma etc. additionally, in line with the supreme court directive to reduce emissions as per BS-VI norms, petrochemical companies are expected to invest in plant modernisation and expansion, thus increasing the demand for cables.

Brugg Cables considers India as a highly attractive market and has established a sustainable market presence which they will keep and expand in the future.

As cable networks become wider, the demand for improved efficiency and reliability will drive future trends in India. The improved financial health of the discoms will fund and drive latest technology know how advancements, giving better services to the consumers.

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- Solar Power Cables
- Bare & Insulated Copper Conductors
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— Supporting —

MAKE IN INDIA

Power Distribution Cables: History & Future Trends

This article is a brief overview of some of the most important milestones in Indian power distribution cables and a few key trends defining its future.

11 KV AB Cable well-installed

PILC Cables

The first underground power cables to be used in India were probably at Shivanasamudram hydel power station in the erstwhile Mysore sub-station in around 1902. This was Asia's first hydro-electric generating station, commissioned in 1902. While there is no official record, it is probable that underground cables had to be used to bring the electricity from the generators to the open outside. However, it is on record that in about 1920 Shimla installed underground cables fed from the

sub-station that still stands on the Ridge, and has an official Heritage status. The switchgear still stands though not in use, but some of the cables connecting to it are still in use after 90 years.

These cables are rated 2 KV and made of copper conductor, with oil impregnated paper insulation encased in a lead sheath – the venerable PILC cables. Although the construction was very susceptible to failure due to entry of moisture through any crack in the lead sheath, they were extremely resilient due to the "self-healing" nature of the oil impregnated paper. Any local electrical breakdown or partial discharge caused the insulating oil to heat and flow into the void and restore the insulating property. Initially liquid mineral oils were used. These later gave way to grease type "non-draining" oils. Cables using these were described as PILC MIND cables. They were used at voltages up to 110 kV.

However, the vulnerability to moisture was such that cable jointers were sometimes disqualified for having excessively sweaty hands, while cable jointing was done during humid monsoon conditions in temporary huts with coal stoves to heat them to keep moisture away. The jointing itself was encased in a bitumen tar compound melted at site over coal or wood fired stoves and poured into a cast iron case, sometimes protecting a lead sleeve soldered or "plumbed" to the cable. In spite of all these problems the cables were extremely robust and tolerant of overloads. CESC in Kolkata (then Calcutta) had an extensive network of PILC cables well into the 1990's with some of them in service for over 50 years.

PVC Cables

PVC cables started being used extensively in India in the late 1950's following the setting up of a PVC cable factory in Mumbai (then Bombay) by a Siemens'-backed venture with CCI (Cable Corporation of India). Initially the voltage was limited to 1.1 KV, but gradually

11 KV AB Cable damaged due to sparking between cores

increased to 3.3 KV and 6.6 KV/11KV. While 1.1 KV cables were quite satisfactory, within the temperature and ageing limitations of PVC. The easy handling and jointing and resistance to moisture or even water immersion was appreciated. However, 6.6/11 KV cables pushed the technology to its limits. The need for screening at 6.6/11 KV was met with conductive graphite coating and carbonised paper beddings under the metallic copper screens. Electrical problems of screening and limitations of thermal short circuit withstand levels limited their popularity and success. PILC cables continued to be preferred for their reliability and longevity in spite of all the installation difficulties.

XLPE Cables

Things began to change in the end 1970's with the advent of XLPE cables in India when Universal Cables and CCI decided to expand into manufacturing of XLPE cables. Just at that time a very major project to mine and export iron ore was being set up with funding from the Shah of Iran in Kudremukh in Karnataka. The electrical consultants were Canadian. The consultants were apprehensive about use of PILC cables given the high humidity and heavy and extended rainfall in the area. They would have preferred XLPE cables, but the project commissioning date did not permit waiting for the XLPE cable plants to be commissioned.

As luck would have it, the Shah of Iran was overthrown, and the project completion date had to be pushed back. CCI and Universal used the opportunity to push for the adoption of XLPE cables for the project. The XLPE cables also offered higher operating temperatures, higher short-term short circuit induced temperatures, and better ageing than PVC cables while continuing to offer the same ease of use.

This very visible use of the new type of cables in a very high-profile project encouraged other leading organisations such as BHEL and NTPC to also adopt XLPE cables for their project. In response to the increase in demand many other leading manufacturers of medium-voltage power cables also set up plants to manufacture XLPE cables.

Extrusion and Peroxide crosslinking technologies

All of these first-generation plants used steam curing of peroxide-based compounds in pressurised catenary chambers. Some of them employed only two-layer extrusion of conductor semi-con and XLPE insulation being extruded in one pass, while the outer semicon over the insulation was extruded in a separate run. A few began with triple extrusion from the start. But in all cases the outer semicon was of the strippable variety to facilitate jointing.

Over a period of time triple extrusion and bonded semicon screens became the norm being technically superior. Another parallel development was that the larger cable manufacturers pushed the concept of "dry curing" of the XLPE as opposed to wet steam curing. This was projected to better eliminate micro voids in the XLPE and reduce water treeing.

Chlorine corrosion of Contact following PVC fire

Sioplas Technology

The next major revolution happened in the late 1980's with the advent of Sioplas Technology for cross-linking of XLPE cables. This technology eliminated the need for expensive and complicated extruders and catenaries required for thermal cross-linking of XLPE. Simple and inexpensive modifications to PVC cable production lines enabled them to make XLPE cables. Initially Silane cross-linked cables were limited to low-voltage applications. The need for moisture curing by steam or hot water immersion to cross-link the XLPE lead to apprehensions about their use at higher voltages. But as manufacturers of compounds presented more evidence of the performance of silane compounds at higher voltages, backed by experience in Europe at 11 and 33 KV, many second-tier Indian manufacturers also adopted this technology for 11 KV cables.

Some of the cables performed well, others did not. In discussions with a leading global manufacturer of cable compounds, both conventional and Sioplas based, the manufacturer expressed their opinion that the problem with using Silane cross-linked cables at 11 KV were more related to lack of cleanliness than limitations or unsuitability of the technology. Many manufacturers of LT PVC cables who found themselves having the equipment to produce MV cables using Silane technology did not realise the importance of excluding contamination during the storage and handling of the compounds prior to feeding into the extrusion.

FRLS Cables

Another significant milestone has been introduction and evolution of FRLS cables in India. A major cable fire took place at the Obra Thermal Power Station in UP in 1985. It started in the cable gallery and probably burn unnoticed for an hour or two. By the time fire-fighting operations commenced it became impossible to approach the fire, not just because of the heat from the fire, but because of the dense smoke

Heritage 2 KV sub-station at Shimla

that made visibility zero, but the toxic fumes that caused people to fall unconscious. In fact, the toxic fumes not only affected people in the affected unit, but smoke and fumes travelled through the cable gallery to two adjoining units and necessitated the evacuation and shutdown of those units also.

A study team that visited the UK for discussions with leading manufacturers and the Central Electricity Generating Board became aware of the need for cables that limited spread of fire and generated significantly lesser quantities of smoke and toxic fumes, predominantly chlorine.

Unfortunately, the non-availability of technology in India and the unwillingness of the foreign firms to share the knowhow resulted in the drawing up of Indian FRLS cable specifications based on the then limitations of Indian cable manufacturers. These were based on improved PVC compounds. PVC is inherently flame retarded. The flame retardancy of PVC arises from the chlorine liberated in the fire. This blankets the fire and cuts off supply of oxygen. But at the same time, it is highly toxic to humans and vey corrosive to metal structures and specially reactive with copper conducting parts. The FRLS cables incorporate alternative chemicals that impart flame retardance without generating so much smoke or toxic gases.

Zero Halogen Cables

The current international standards have moved from low toxicity FRLS specs to Zero Halogen specs with very high flame retardance and very low smoke generation. Insulating Compounds and technology are more widely available globally. On the other hand, a few fires in India that caused major loss of lives have increased demand for such safer cables. The Indian cable industry is capable of producing such improved cables, and if the demand for them increases these can become the norm for internal power distribution, especially in high rise buildings. Leading cable companies can take the lead to catalyse this movement by drawing up and proposing specs that could eventually be incorporated in national Indian Standards.

Aerial Bunched Cables

The early years of the current


11 KV AB Cable well-installed

century saw a major thrust on improving the availability of power in India, both in quantity and in reliability. Power theft was identified as a major constraint to investment in improving distribution systems. Privatisation of distribution, especially in Delhi, led to a focus on preventing theft and improving safety through the use of Aerial bunched cables in place of bare conductors, both for low voltage and at 11 kV. The increase of environmental concerns and restrictions on tree trimming also aided the adoption of an insulated network, and installation of aerial cables was found to be faster and less expensive than installing underground cables.

Experience with low-voltage aerial bunched cables have been largely satisfactory with a significant reduction in power theft. At the 11-kV level the system performance has been mixed. In part this is due to some issues of UV degradation of HDPE cable sheaths. This has been addressed through better UV stabilisation where PE is used for jacketing, or by staying with PVC jackets where the technology is well known and proven. Another major reason for problems has been the use of poor installation techniques. Contractors used to install bare conductors overhead have not taken the necessary care in handling insulated cables at the stage of stringing, tensioning, and supporting by suspension and dead-end clamps. Cables damaged during installation have experienced frequent tripping shortly after energising as the locally damaged weak spots begin to fail in an unpredictable and frequent manner. On the other hand, cables installed with due care using proper installation techniques and tools have performed reliably.

Another major cause of 11 kV AB cable failure has been poor jointing, including poor earthing of the cable screens. Improperly earthed screens result in capacitively induced voltages on the phase jackets. With voltage difference on adjoining jackets there is sparking between cores when the air between them breaks down. This sparking has been physically observed, both as

audible chattering and in some cases as visible sparking. The consequence is damage initially to the cable jacket, and then progressing to damage to the metallic screen and then the insulation underneath till the cable fails. Mid-span straight joints have also been found to have a shortened life due to continuous vibration as the cable swings due to wind.

Improvements in cable screens

MV cable screens in India are specified and found to be much less in thickness compared to European practice. This makes them both mechanically and electrically weak. One contractor observed in a seminar that the screen resistance was found to increase significantly between the value on the drum and after installation. Since the author has seen an instance of partial tear of the copper tape of a screen in an apparently undamaged cable, it is postulated that the increase in resistance is due to such tearing. The likely cause of the tearing is a combination of the very thin screen and possible over-bending during installation.

Some future trends

As cable networks become more widespread the demand for improved reliability will drive future trends in India. The improved financial situation of the DISCOMs will permit funding of such improvements, and the demand for better electricity supply by consumers will drive the DISCOMs to pay more attention to the cable networks. The quality of cables will improve through use of better compounds, and greater sophistication in extruding them. FRLS Standards will tighten up on both smoke and toxicity requirements and perhaps become mandatory for closed environments such as climate-controlled buildings. Most importantly cable companies will find it necessary to extend their support services to educate and train installers in better installation techniques so that controversial cable failures do not harm their brand image. Cables will truly have to play their part in the desired improved distribution system of the country.

Ashok Saigal

Managing Director &
Co-founder
Frontier Technologies
Pvt Ltd

Essar Power completes 1,200 MW Mahan project

Essar Power recently announced the completion of the Rs 8,000-crore capex programme for its 1,200 MW Mahan power plant project with the commissioning of the plant's second 600 MW unit. Both units of the project are operational and supported by an end-to-end raw material sourcing and evacuation infrastructure.

The second unit is supplied by Harbin Power and is designed to perform at optimum efficiency with domestic coal from pithead mines in the region. The project is expected to provide direct employment to about 250 people, and indirect employment to around 1,250 more, thus spurring ancillary development in the area.

The Gajra Behra siding can handle, at its peak, up to three rakes per day, which will meet the coal requirements of the Mahan plant substantially. Being just 18 km away from the facility, it will reduce the transportation distance by about 90 per cent, as well as help curb pollution. It will enable the plant to obtain domestic coal from Coal India mines, as well as from NCL, besides being able to receive imported coal by being connected to both the east and west coasts of the country.

"The cancellation of the coal mine assigned to us severely affected the Mahan project. Though it led to project delays and cost overruns, we doubled our equity investment to Rs 3,300 crore to ensure the project is completed.

This demonstrates our policy to follow through on our investment commitments and develop world-class assets despite all odds. With the completion of the capex cycle at Mahan, we now have 3,830 MW of generation capacity, with another 1,260 MW under construction, and a presence in the high-margin transmission sector. We have invested more than Rs 30,000 crore in the power portfolio, which includes Rs 10,000 crore of equity, and are now among India's largest private power producers," said Prashant Ruia, Director-Essar.

Use the right cable wires, avoid disaster fires

Electrical cables play a vital role in the safe delivery of power in an electrical network. Keeping in mind the health & fire safety aspects of cabling, one should pay more attention to the type of cables being installed for different uses. The performance of a fire system depends heavily on the cabling.

Understanding the types of cables and their applications

Flame Retardant Cables	Fire Resistant (FR) Cables	Fire Resistant Low Smoke Cables	Low Smoke Zero Halogen Cables	Fire Survival (FS) Cables
Standard Installation conditions	Non - Hazardous Industry	Chemical or Refinery	Theatres, Hospitals, Shopping Malls, Airports etc.	Fire Alarm Systems, Elevators, Fire Fighting Systems, Metro Lighting Systems, Mines etc

Cost of human life is much more than the cost of a cable.
Support all cables with a strong backbone of 'Copper' to complete the life span.

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THE FUTURE IS DIGITALISATION

> Digital and power electronics supported technologies will prove to be a game changer for the energy management and power sector in India.
>
> **Dr. Harald Griem, Executive Vice President and Head - Energy Management Division, Siemens Ltd.**

The current level of AT&C losses incurred by the distribution companies (DISCOMs) is a matter of concern. According to **Dr. Harald Griem**, EVP and Head - Energy Management Division, Siemens Ltd, the DISCOMs need to increase transparency and bring efficiency into their operations. Edited excerpts from his interview with *Subhajit Roy*:

The average AT&C losses, that should be 15 per cent for all the participating states by 2018-19, presently stands at 25.41 per cent. Do you feel that UDAY scheme has failed in this context?

The UDAY scheme has the right levers in place for improving the performance of DISCOMs by reviving their financial health so that they can start investing in upgradation of distribution infrastructure, increase their billing efficiencies via digital interventions like smart metering, inculcate financial discipline to sustain the improvements and gain access to reduced cost of power.

The AT&C losses as per the UDAY website for 27

states and 5 UTs on Sep 30, 2018 was 21.84 per cent versus the 2015 starting levels of 24.62 per cent. We believe that the UDAY program is beginning to show results at an all India level. However, the results are mixed for different states. Here is where, a deeper look is needed to analyse the difference in performance in various states and take appropriate corrective actions to improve the performance of the laggards while learning from the best practices followed by the leaders.

Apart from policy reforms, what are the other actions to be initiated to reduce AT&C losses?

The DISCOMs need to increase transparency and bring efficiency into their operations. Apart from bridging the gaps in the requisite distribution infrastructure, there is also a need to focus on metering of consumers. The benefits of a smart grid start with smart meters. Smart meters bring in greater efficiency and data transparency to monitor the losses in power grids.

Smart Meters can be a game changer in India by enabling DISCOMs to reduce their AT&C losses. These losses are driven by a combination of inadequate billing, theft and sales below costs to certain consumer segments. Smart meters in combination with Meter Data Management and collector solutions ensure increased reliability, accurate data readings, elimination of losses due to frauds, allow revenue recovery and eliminate the cost of manual readings. Smart metering also improves the connectivity and demand side management, where many customers would like to pay for uninterrupted power supply.

What role is Siemens playing in the area of energy management?

As Siemens Energy Management division, we have been driving a lot of innovative technology transformations over the last decade – for example we are implementing the high-voltage direct current (HVDC) transmission system connecting Pugalur to Trichur, India's first direct current link using voltage-sourced converter (VSC) technology which enables economic bulk power transmission and interconnection of asynchronous AC grids with black start capability. Similarly, we just commissioned the world's largest STATCOM (static synchronous compensator) installation for PGCIL in Rourkela, Odisha to increase the reliability of the AC grid. It regulates the transmission variations according to grid conditions leading to availability of stable power to the consumer network in the state.

The innovation also extends to the distribution space with the smart city order from DMIDC for 33/11kV Power Distribution AIS (Air Insulated Switchgear) s/s, Renewable Energy Management order for Western region from PGCIL and Meter Data Management System (MDMS) by TPDDL.

We have a high degree of local manufacturing in the country and are constantly investing in bringing latest green technologies into India. We are also engaged with various stakeholders including the government, public and private organisations to increase awareness of the latest technologies and global best practices for procurement processes.

What is the market size for energy management industry in India? What is the growth rate be in 2020?

The market size for energy management industry in India for 2018 is approximately Rs 40,000 crore. The growth is different for different segments of the industry. Demand from government driven programs on infrastructure, railways and so on is buoyant. Green shoots in core industry such as minerals and metals are beginning to show signs of recovery. The distribution segment is experiencing double-digit growth driven by investments in upgradation and modernisation of grids.

On the other hand, the investment in the central transmission sector is reaching the end of its investment cycle. Together with high achievement in the 12th Plan end 2017, we foresee subdued demand from transmission sector for the near term of 2 years, post which the next investment cycle will kick in.

How is the Indian energy management market different than the other developed market?

India is leapfrogging dynamically by driving basic electrification while installing latest technology for power quality and smart grids and coping with the integration of large-scale renewable energy. This leapfrogging is remarkable and unique given that the global electrification transition has seen more of a conventional and evolutionary development.

On one hand, we have seen a lot of technology transformations over the last decade – HVDC, STATCOM, adoption of the latest digitalisation

technologies such as MDM (Meter Data Management) solutions. Clearly, innovation and ingenuity are deeply ingrained in the Indian DNA.

Yet, the fact remains that while energy consumption in India has doubled since the turn of the century, access to reliable power from a power grid is still not universal. It is inspiring to see the Government of India committed to the cause of providing 24x7 affordable and environment friendly 'Power for All' by 2019 with clear steps for strengthening the sub transmission and distribution infrastructure, including metering at all levels.

Indian government has ambitious targets in terms of capacity addition. How digitalisation can help the country reach its targets?

The government targets 40 per cent power generation from renewables by 2030 and envisages an installed capacity of 175 GW for renewables by 2022. This drives the need for grid integration solutions that allow integration of renewable energy sources with the grid. Since one-way flows are evolving into multi-directional flows of energy and digital information, the resulting complexity requires a new, integrated and secure approach to delivering the right information technology solutions. We are completing the Western Region Renewable Energy Center which will serve exactly this purpose. It also enables the preservation of the grid data for future references by fusing IT capabilities and protecting the grid against cyberattacks.

While advanced and scalable SCADA systems further allows remote monitoring of the grids and data collection, Big Data technologies are used to analyse the massive data generated by the smart grids and support in decision making. This high technology, data supported approach to grid operations and maintenance presents a tectonic shift in thinking in the energy transmission sector in India. Grid operators can now manage the performance of energy transmission assets, lower operation and maintenance cost, and reduce failure.

Could you discuss about Siemens's preparedness in the field of digitalisation?

Siemens is one of the leading companies in the field of digitalisation. We have a complete end-to-end spectrum of technologies, products, services and solutions, designed for all partners to enable success towards a smarter, interconnected and distributed future grid. We are constantly innovating and building local solutions for local challenges.

MindSphere is our Cloud-based open IoT Operating System that connects the real world with the virtual world and provides a platform as a service to the developers. We already have close to 1 million assets connected to MindSphere. We have set up the MindSphere Application Centre in India to enable our customers and Siemens domain experts to come together, identify specific customer pain points, run simulations and develop proofs of concepts that will culminate in customised digital solutions.

Digitally enhanced GIS with non-conventional instrument transformers make available real time digital data for IoT applications enabling remote grid and predictive asset management.

Self-healing network solution in distribution network, by ensuring automatic fault localisation, isolation and restoration, allows re-supply of power in less than a minute in the event of an outage. Siemens Cyber Security Solutions protect critical assets on the grid by offering integrated advanced cyber security at the product, system and solution level meet the most stringent security requirements globally.

Our E-Mobility Infrastructure management solution allows charging station management, execution of customer contracts and services and ability to manage the EV re-charges in a smart way based on real time demand on the grid coupled with the price of energy.

How do you see the future of energy management industry beyond 2019?

The future is digitalisation. In the coming years, we find digitalisation technologies increasingly enveloping almost every equipment, network planning, operation and maintenance. All equipment will be digitally connected; utilities will deploy digital twin systems for network planning and upgradation. The wide scale digitalisation will fundamentally alter business models such as transition from CAPEX to availability or use based fee in both operations and maintenance. These changes will usher significant user efficiency and price advantages.

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.

“30% cost saving with new data cable for use in e-chains”

New chainflex CF8821 data cable with guaranteed service life and UL approval for moving applications

Cost-effective, guaranteed and UL-certified.
The new chainflex CF8821 data cable from igus.

With more than 1,300 products, igus claims to have the largest portfolio of tested cables for use in energy chains, for every industry. igus has developed the CF8821 data cable as a cost-effective alternative for builders of low duty cycle machines. “With the new cable series, machine builders can not only save up to 30 per cent on costs, but also receive a cable with UL approval that is guaranteed to work,” the company claims.

Data cables are used in a wide variety of sectors. From machine tools to robots. The cables must always withstand forces when running in energy chains. igus has developed a new, especially cost-effective data cable specifically for applications without high mechanical requirements, such as adjustment devices, encoder units, and wood or stone processing machines. According to igus, by selecting the chainflex CF8821, machine builders can save up to 30 per cent cost when compared to standard chainflex data cables. Offered with small cross-sections, the new cable is suitable for use in e-chains with a bend radius of 12.5 x d. Shielding protects them from interference. The highly flexible PVC outer jacket is silicone-free and flame-retardant. Like all cables from the motion plastics specialist igus, the new data cable has also been tested in the in-house 2,750 m2 test laboratory. This makes igus the only manufacturer in the market to offer a 36-month guarantee on its entire cable range. For the new data cable, igus promises a service life of up to 5 million cycles. In addition to the guarantee, UL approval of the CF8821 cables opens up possibilities for machine builders exporting to other countries.

Double safety thanks to chainflex cables with UL approvals

With more than 1,300 types, igus offers a wide range of energy chain cables with the world’s most extensive selection with international approvals, including cables with the UL certification. One of the biggest challenges for international plant manufacturers is the different technical standards and norms on the OEM and operator side across the world. The motion plastics specialist igus makes an important contribution towards the harmonisation with 1,044 out of the total 1,354 cables in its portfolio having UL-certification. Thanks to UL approval, small to medium-sized companies as well as large OEMs can export their machines to other country more easily and commission them without any problems. UL stands for Underwriters Laboratories which is the most well-known and comprehensively accepted test organisation in the USA. It regularly publishes standards and certifies products such as the chainflex cables. If there are test certificates for the cables, commissioning is quick and smooth.

For more details, visit www.igus.in

Blockchain enabled Smart Metering in 2019

Blockchain technology is expected to extend the benefits of investments in renewable energy microgrids and a change of ecosystem to the consumers. The year 2019 would be seeing blockchain enabled smart metering technologies with in-built smart contract functionality.

With per capita energy consumption reaching 1,150 kWh, India is now the 3rd largest producer and consumer of electricity. Renewable power plants constitute one-third of 350 GW – the total installed capacity. Renewable energy constitutes 15 per cent of the total generation. Though India has surplus capacity it lacks adequate infrastructure for supplying electricity to all needy people. One of the hurdles faced by distribution

companies (DISCOMs) are the extremely high Aggregate Technical & Commercial (AT&C) losses.

The government has been enabling smart grids to establish its goal of pan India universal electricity access, while offering affordable power and other benefits to the consumers. Implementation of Advanced Metering Infrastructure (AMI) is the first step towards realising smart grids that can significantly increase the efficiency of energy usage. In spite of sincere attempts, the government has been unable to show results. What mistakes are being committed in its implementation? Here's an attempt to answer this, hoping that the government would learn, improvise and implement tasks differently in the new year 2019.

India is also the third largest emitter of greenhouse gases in the world, and if India continues with the current mix of fuel sources, the impact on world environment would be devastating. To address this grim situation, the government made plans to install 175 GW of additional renewable capacity by 2022, of which 100 GW would be solar. Coupled with a drop in the average price of solar electricity below the that of its coal-fired counterpart, we anticipate a good future for solar if the producers are given adequate opportunities to sell their surplus power. New concepts in energy trading and metering such as blockchain represent such opportunities. Blockchain enabled smart metering technology is explained later in this article.

Challenges that Indian utilities face with AMI

Though Indian utilities have experimented with AMI, they are yet to reap the benefits. The major challenges that AMI presents are:

- Recovery of high capital costs: AMI requires high expenditures for procurement of all hardware and software components (such as meters, DCUs, MDMS), along with cost associated with the installation and maintenance.
- Increase in complexity: AMI is a complex system of technologies that must be integrated with

utilities' information technology systems.

- Lack of standardisation: With no interoperability standards being defined and non-uniform requirement specifications, different AMI technologies are being deployed that are incompatible.

Unless the above challenges are addressed, it would be extremely difficult for the utilities in India to successfully connect, operate, and maintain an AMI-based grid system. Without a fully operational AMI system, utilities would find it difficult to reduce their AT&C losses and the justify the investments made in AMI. No wonder that AMI is viewed by many as a heavy financial burden that cannot be recovered. Let us first try to understand the initiatives taken in India to help promote AMI.

Indian Initiatives promoting AMI

India Smart Grid Forum (ISGF)

To achieve accelerated development of smart grid technologies in the power sector, India Smart Grid Forum (ISGF), a public-private partnership initiative was set up with a mandate to advise government on policies and programs for promotion of smart grids. ISGF is working closely with government institutions such as CEA, CPRI, CERC, MNRE, state governments, utilities and regulatory commissions.

Energy Efficiency Services Ltd (EESL)

EESL is the world's largest public energy service company (ESCO) and a joint venture of state-owned NTPC Ltd., Power Finance Corp., REC, and POWERGRID. EESL was formed to facilitate energy efficiency projects and innovative business and implementation models. India's energy efficiency market is estimated at US$12 billion. With a net worth of over Rs 2.144 billion, EESL has successfully implemented projects such as UJALA LED lamps, agricultural programme with smart pumpsets, etc.

With regard to AMI, EESL has been helping utilities reduce billing inefficiencies through 'Smart Meter National Programme' (SMNP). The SMNP aims to replace India's 250 million conventional meters with smart meters. The smart meter procurement has commenced from November 2017 for Haryana and Uttar Pradesh, with AT&C losses 28.42 per cent and 34.36 per cent respectively.

EESL has a proven model of bulk procurement, aggregation of demand, and monetisation of savings. The roll-out smart meters is under the build-own-operate-transfer (BOOT) model, wherein EESL undertakes all the capital and operational expenditure with zero upfront investment from states and utilities. EESL, on its investment, earns a nominal Internal Rate of Return (IRR) through a mutually agreed automated payback structure.

Ujwal DISCOM Assurance Yojana (UDAY)

The GoI launched UDAY in November, 2015. It envisages financial and operational turnaround of DISCOMs of the country.

Case Study: Deployment of 10 mn prepaid meters in UP

In November 2017, EESL floated a global tender to procure 10 million prepaid meters for deployment in Uttar Pradesh under 'Saubhagya' scheme. With an outlay of Rs. 16,320 crores, it aims to add more than 40 million below-poverty-line households to the power grid by December 2018. Prepaid meters offer the poor consumers a facility to recharge electricity (similar to recharging mobile).

In March 2018, 12 bidders,

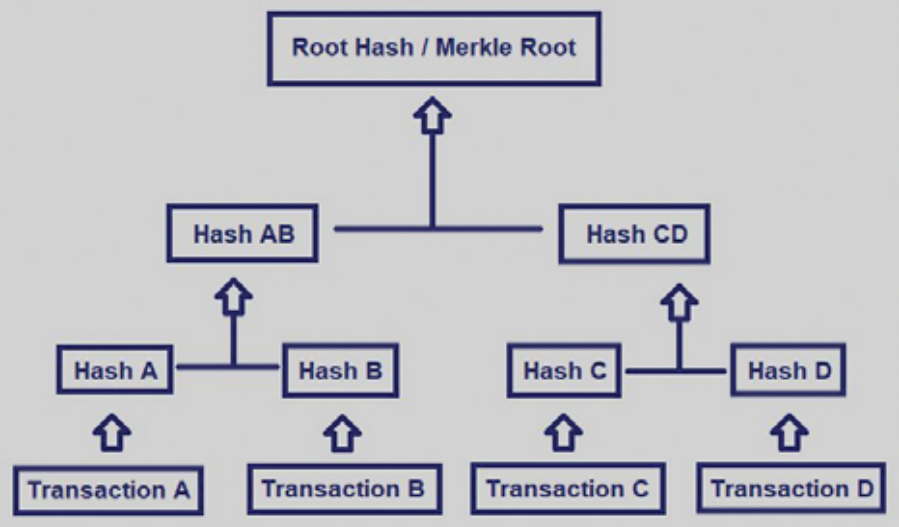
including ITI, Larsen & Toubro, Genus, submitted interest for participating in the reverse bidding. Some large players did not join the race expressing concerns on product safety and tariff regulations. According to them, prepaid meters work on a singular tariff and UP has more than a dozen tariff slabs. However, states such as UP, have regulations for prepaid metering and a tariff that is lower. Quality is a concern, since large players sub-tender the contract to private companies not having BIS certificates. Another cause of concern arises from the sheer volume of meters to be installed. How can a state such as UP, that typically installs 1 million meters annually, possibly install, let alone service, 10 million prepaid meters a year? Third concern is attributed to technology. Why is EESL not opting for smart meters and configuring them as prepaid meters instead of investing heavily on inane prepaid meters lacking smart capabilities?

Expectations of Asian Development Bank from EESL projects

ADB has extended a US$ 200 million loan for EESL to implement various demand-side energy efficiency projects in India. The confidence that the Varanasi DISCOM has obtained, is thanks to an ADB assisted pilot running in a village with smart meters installed in 5,000 households.

ADB finds the Varanasi smart metering project to be a win-win solution for several stakeholders, including the consumers as well as the discoms. Dr. Yongping Zhai, Chief of Energy Sector Group sustainable development and climate department of ADB, is considering scaling up the Varanasi project through a proposed second plan. ADB expects that EESL smart metering projects would bring benefits to all key stakeholders.

Rural consumer would enjoy improved power quality, shorter outage durations, and flexible payment options (prepaid or post-paid). These smart meters provide real-time information about the electricity usage through a mobile app, so consumers can detect any



Merkle Trees

wastage and optimise electricity consumption to save money. These meters also prepare rural households for distributed and decarbonised future of energy systems.

With more rural households installing distributed solar photovoltaic panels on their rooftops, ADB expects that the smart meters be used for net metering – where surplus solar power can be transferred to the grid, allowing customers to offset the electricity bills. ADB would also like that the smart meters be used for time of use tariffs.

ADB expects accurate billing from the DISCOMs. The smart meters can bill accurately without human intervention and can be remotely set to disconnect customers who fail to pay bills on time. With this support, ADB expects the DISCOMs to improve their billing and collection efficiency and reduce AT&C losses from around 30 per cent to 15 per cent. In addition to tracking losses, ADB would like that DISCOMs monitor other parameters such as power availability, voltage fluctuations, reliability of restoration, and load redistribution based on results monitored from the smart meters.

Besides this, with smart meters, DISCOMs can predict power purchase requirements and thus can use energy more optimally. Smart meters are affordable, costing about US$ 35 (around Rs 2,560) to buy and another US$ 35 to deploy for five years. This is fully paid as an initial investment by EESL, which in turn gets Rs 100 (US$ 1.3) per meter per month from local distribution companies out of savings realised over the expected eight-year lifespan of each device, generating a 14 per cent return on equity for EESL. Dr. Zhai, terms it as an innovative business model – invest-own-operate – that can be replicated elsewhere in India and many other developing countries that suffer from high system losses, as it does not burden local distribution companies upfront.

Smart meters benefit the whole society through reduced carbon emissions and positive environmental impacts. ADB is thus supporting EESL's smart metering initiative that is part of a larger low-carbon energy transition program by the Indian government.

Is the smart metering initiative by EESL showing results?

EESL's smart metering initiative under UDAY scheme hoped to address the ailing

operational and financial health of DISCOMs. It mandated the installation of smart meters – for consumption above 500 units per month (by December 2017) and above 200 units per month (by December 2019).

The scheme aimed at improved data tracking and monitoring in order to reduce AT&C losses. But despite several initiatives and mandates under UDAY, as per CSTEP, Bengaluru, the uptake has been substantially low. In Karnataka for instance, under the 500 units/month category, only 610 of 137,456 consumers (0.4 per cent) targeted have installed smart meters. Similarly, in the 200 units/month category of consumers, only 1,876 of 2,91,650 consumers (0.6 per cent) have installed smart meters.

DISCOMS attribute reasons, such as high cost of implementation, lack of skilled manpower and data integration and inter-operability issues, to the slow uptake. Whatever be the reason, the slow uptake means that the smart meters are geographically widely dispersed. Hence, they pose considerable operational, logistical and project management challenges for both DISCOMs and the implementing agency. Since the meters are dispersed across

multiple feeders and widely scattered, they do not allow actual auditing of energy consumption. Without a proper audit mechanism, it is not possible to calculate the AT&C losses at the feeder level or consolidate them at the section office level. The absence of consolidated data at the feeder level affects the efficiency and accuracy of billing and collection. Therefore, the objective of reduction the losses are not met.

Feeder-wise deployment as an implementation solution

Instead of targeting the consumers based on their consumption category, if the smart meter installation is carried out by picking up an entire 11 kV feeder at a time, then audit, AT&C loss calculation, and reduction of losses, all become possible over the feeders thus targeted.

ISGF also promotes such a deployment of smart meters for all consumers associated with a feeder. Reduction in AT&C losses with such a deployment has been experimented and verified by CESC in Karnataka, EPDC of Andhra Pradesh in Vishakhapatnam, consolidating data at the feeder level reduces not only the implementation cost but also allows the DISCOM to understand challenges to loss reduction specific to the area. More importantly, it will help DISCOM witness the improvement in efficiency that smart metering brings in and thereby motivates them to take up bigger projects. An impact assessment of the feeder level project reveals the gaps therein which help DISCOMs assess whether the project can achieve the desired objectives. These need to be taken into consideration and addressed before a large-scale roll out of the project for best results.

It is believed that the implementation solution described above is consistent with the expectations of the project planners (EESL) and funding agencies (ADB). Only when the DISCOMs act and implement accordingly will they be able to reap the benefits as per the full potential of the smart metering project. Else, DISCOMs would find yet another technology to blame

for their poor performance.

A powerful tool in the form of smart metering is available to the DISCOMs. Now it should be used wisely so that ADB's loan gets repaid from the savings in losses.

Application of blockchain technology to metering

The Reserve Bank of India (RBI) issued a circular in April 2018, prohibiting all financial entities regulated by RBI, from dealing in Virtual Currencies (VCs) or cryptocurrencies including Bitcoins. This meant the end of road for Bitcoins as well as VC exchanges (Zebpay closed down).

RBI's crackdown on VCs was aimed at combating money laundering and terror financing. However, RBI itself is considering issuing its own digital currency called Lakshmi. The government is thus looking to develop and encourage our own research and development of blockchain technology. This is a good sign since this would build an ecosystem where cryptocurrencies would be central, and once its potential is felt, then there is no going back. However, being essentially decentralised ledgers, bitcoins lose meaning if centrally controlled by RBI.

What is a blockchain?

Before its use in cryptocurrency, it had humble beginnings as a concept in computer science — particularly, in the domains of cryptography and data structures. A very primitive form of the blockchain is the hash tree or Merkle tree. This data structure was patented by Ralph Merkle in 1979, and functioned by verifying and handling data between computer systems. In a peer-to-peer network of computers, validating data was important to make sure nothing was altered or changed during transfer. It also helped to ensure that false data was not sent. In essence, it is used to maintain and prove the integrity of data being shared.

In 1991, the Merkle tree was used to create a "secured chain of blocks" — a series of data records, each connected to the one before it. The newest record in this chain would contain the history of the entire chain. And thus, the blockchain was created.

In 2008, Satoshi Nakamato conceptualized the distributed blockchain. It would contain a secure history of data exchanges, utilise a peer-to-peer network to time stamp and verify each exchange, and could be managed autonomously without a central authority. This became the backbone of Bitcoin.

How blockchain works?

- Blockchain keeps a record of all data exchanges — this record is referred to as a "ledger" in the cryptocurrency world, and each data exchange is a "transaction".
- Every verified transaction is added to the ledger as a "block".
- It utilises a distributed system to verify each transaction — a peer-to-peer network of nodes.
- Once signed and verified, the new transaction is added to the blockchain and cannot be altered buying and selling power using blockchain.

The blockchain technology (BCT) has found its application in the electricity sector. For buying and selling power, blockchain offers the following benefits:

- Customers can turn into service providers by selling surplus energy produced through solar roof tops; opens up entrepreneurship avenues for many.
- Process of energy generation and distribution becomes more direct between
- suppliers and consumers requiring minimum interface and no middlemen. This will, among other things, reduce bills.
- Eliminates scope for any error or manipulation of the bill amount.

Using BCT, one can sell the surplus power generated from his solar rooftop to a neighbour rather than to the grid without the involvement of any middleman, including a DISCOM. All this can be done in a completely decentralised system, automatically balancing demand and supply and transacting against a set of pre-coded set of rules.

UP government has come forward to implement blockchain technology for renewable energy generation and supply. Critics believe that executing the idea might not be that easy in UP which had not been able to fully operationalise the open access system (where buyers have a choice) even 15 years after it was provided in the Electricity Act. They feel that UP needs to tackle various legal and regulatory issues before the blockchain idea is put to practice.

The UP Electricity Regulatory Commission (UPERC) feels

otherwise and organised a conference in October 2018. UP plans to produce a lot of solar power that would make it the greenest pasture for investment in the renewable energy and distribution sector. Hence, BCT is expected to play a significant role in extending the benefits of these investments and a change in ecosystem to the consumers. During the seminar, UPERC sought and compiled information on:

- Business model for increasing metering billing & collections in rural area using BCT.
- Use of BCT to scale up distributed rural energy generation and supply in rural area.
- Use of BCT in providing quality reliable uninterrupted power by mini grids having different generating technologies (solar, wind, biomass).
- Regulatory framework for creating enabling environment for distributed renewable energy developers.

Blockchain enabled smart meters

Implementation of the idea requires smart meter technology and blockchain with inbuilt smart contract functionality. These blockchain-enabled smart meters know when to buy and sell power and record all the transactions between various households. The payments will be made using traditional methods or cryptocurrencies in a transparent, secure and decentralised set up without any intermediaries.

Conclusion

Year 2019 would see consumers having access to the best technological tool to reduce AT&C losses, namely blockchain enabled smart meters. To promote renewable DERs, it is necessary to create an ecosystem using such meters. Small pilots need to be implemented and tested. Private energy players should be given an opportunity by providing essential infrastructure like micro grids, smart meters and a blockchain platform. They can then act as an aggregator to bring all energy producing points in a village or a community together. Such a move would promote competitive pricing and make energy more accessible for everyone in the country.

Dr. Vithal N. Kamat

Director, Centre for Apparent Energy Research, Anand

Securing Smart Grid from Cyberattacks

This article discusses the major challenges and strategies to protect smart grid against cyberattacks.

The recent discovery that hackers have inserted software into the U.S. electrical grid, which would allow the grid to be disrupted at a later date from a remote location, clearly demonstrates the fact that the utility infrastructure is quite vulnerable and that its overall mission of serving the population could be severely compromised as a result of unexpected manmade or natural disasters. As other industry sectors are already experienced with arming automation systems with modern

information technology (IT), the power grid is also facing the trend of integrating the electrical infrastructure with information infrastructure, and it is experiencing a profound change toward the smart grid. This change not only moves power automation systems from outdated, proprietary technology to using common technologies—personal computers, Microsoft Windows, and TCP/IP/ Ethernet, but also brings the isolated and closed network of power control systems into the public network. The integration of different systems, originally without consideration of security protection and mechanism, results in tremendous cost and performance benefit to the power industry, as well as arduous challenges of protecting the automation systems from security threats, especially when the public network is used. It is misleading to suggest that IT people should take the full responsibility for power grid network security including automation and control networks. Compared with regular IT systems, power automation systems have different goals, objectives, and assumptions on what needs to be protected. It is important to understand what "real time performance" and "continuous operation" of a power automation system really means and to recognise that power automation systems and applications were not originally designed for the general IT environment. Therefore, it is necessary to embrace and use existing IT security solutions where they fit, such as communication within a control center, and develop new solutions to fill the gaps where IT solutions do not work or apply. This paper discusses conceptual layered framework for protecting power grid automation systems against cyberattacks.

Scope and Functions of the Power Grid

From the power flow viewpoint, the input to the power grid is high voltage (100 kV or above) power, stepped up by the power plant transformer from the low voltage power produced by the generators. The output of the power grid is electricity at medium or low voltage (less than 100 kV), stepped down by transformers in substations, and delivered to commercial, industrial, and residential consumers.

The major functions of power grid are performed in three different levels: corporate, control center, and substation. At the corporate level, the following major functions of both business management and operation management are performed:

- Planning—plan of equipment and line upgrades based on forecast of load and generation sources, market conditions, and system utilisation.
- Accounting—management of contracts and bids with other market participants.
- Engineering—system design and engineering for transmission and distribution lines and automation systems.
- Asset management—monitoring, replacement, and maintenance plan of equipment and lines.
- Historical information system—an online historical database is commonly used to retain all telemetry data, operator actions, alarm summaries, etc., for a periodic of time that ranges typically from 3 to 24 months.

At the control center level, the following major real-time and non-real-time functions are performed:

- Forecast—short-term forecasting of load and power generation sources.
- Monitoring—monitoring of system state, activity, load, equipment conditions.
- Operation—switching operation, changing setups, starting emergency procedure, performing system restorations, etc.
- System analysis—model update, state estimation, contingency, and stability analysis, power flow analysis.
- Recommendation—recommendation of preventive, corrective, and optimised operations.
- Fault/alarm processing—locating fault and intelligent processing of alarms.
- Training—operator training.
- Logging—archiving logs and reports.
- Data exchange—exchanging data with ISO (independent system operator)/RTOs (regional transmission organisation), power plants, consumers, and peer transmission and distribution system operators.

At the substation level, the following major real-time and non-real-time functions are performed:

- Normal operation—collecting

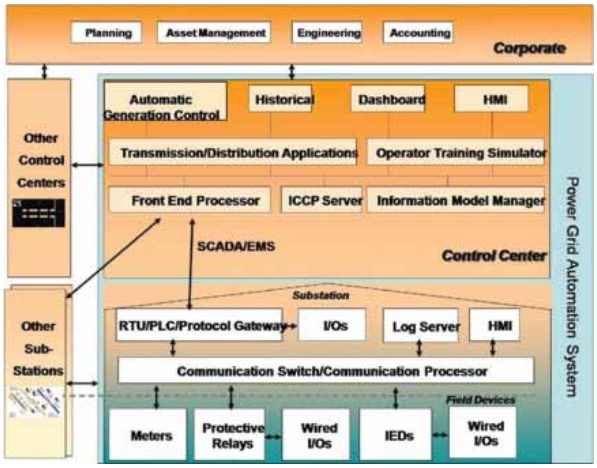


Figure 1: Power grid automation system

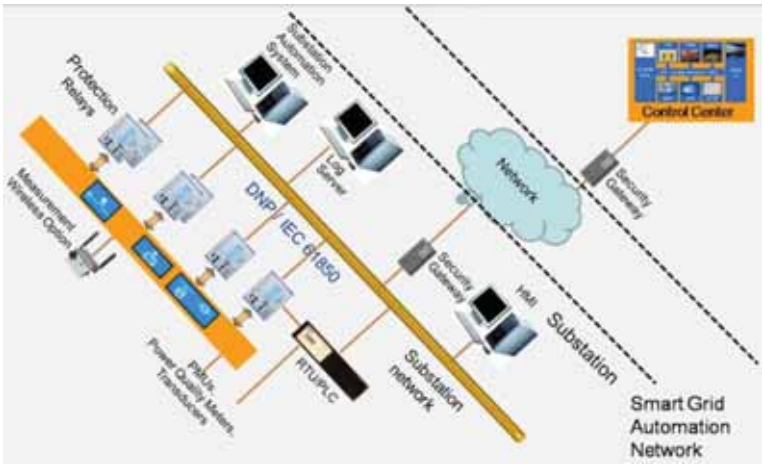


Figure 2: Gateway security solution

data and alarms and sending them to control center, executing commands issued by control center.

- Exchange of protection data between the RTU and IEDs within the substation. Relay devices perform protection, control and indication gathering functions.
- Emergency operation—power system protection, load shedding, recovery from load shedding, shunt control, compensation control, etc.
- Engineering—protection engineering, automation engineering, line engineering.
- Logging—archiving logs.
- Maintenance—equipment and line maintenance.

Power Grid Automation Systems

A typical grid automation system, as shown in Fig. 1, is an integration of one or more control centers, with each center supervising multiple substations. The power grid automation system is a layered structure and performs data collection and control of electricity delivery. At "corporate" level, some functionalities are related to the automation system. For example, "planning" plans for the amount of electricity that must be generated for the next day. A control center typically includes devices such as an energy management system (EMS), human-machine interfaces (HMIs), and a front-end processor (FEP) which translates different communication protocols—for instance some legacy RTUs in substation use DNP 3 and new ones use IEC 61850. Substations contain remote terminal units (RTUs), programmable logical controllers (PLCs), global positioning system (GPS) sync timers, HMIs, communication devices (switch, hub, and router), log servers, data concentrators,

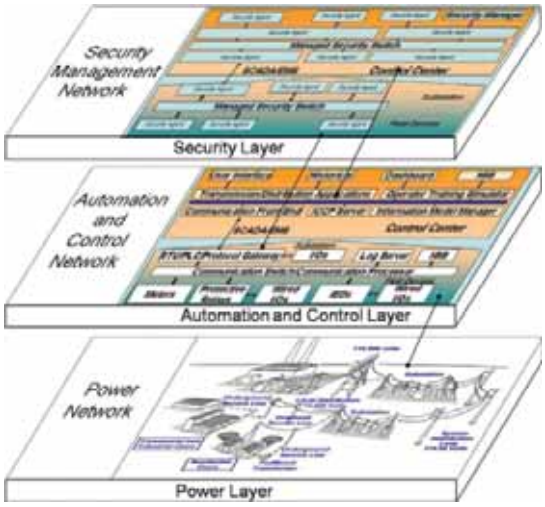


Figure 3: Proposed three-layer architecture

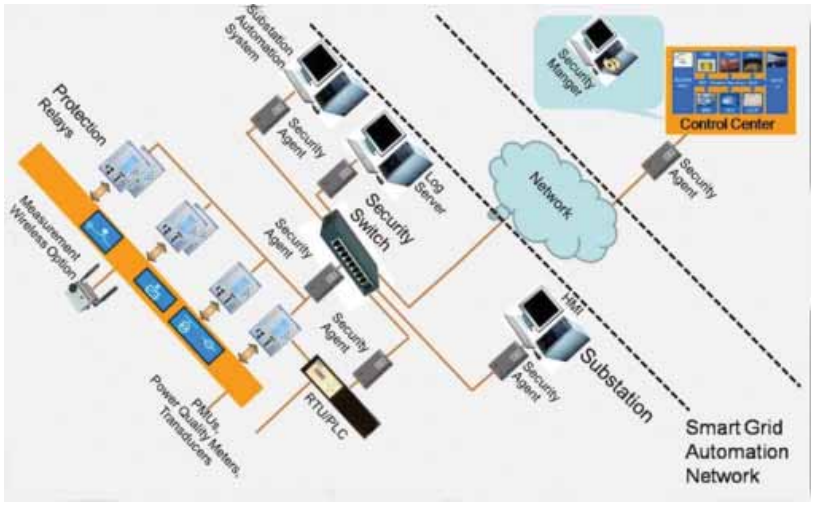


Figure 4: Security service proxy solution

and a protocol gateway. Other intelligent electronic devices (IEDs) include field devices, such as instrument transducers, meters, tap changers, circuit reclosers, phase measuring units, and protection relays.

Power Grid Communications Systems

In order to deliver electrical power from power producers to consumers economically, power grid system operators have to exchange data with power producers, ISOs, RTOs, consumers, and peer system operators. As shown in Fig. 1, at control/ operation center level, dedicated lines are widely used and Inter Control Center Protocol (ICCP) is deployed as the communication protocol. Local area network (LAN) and Internet Protocol (IP)-based protocols are usually used for the communication link between corporate and control center; IP-based protocols, such as DNP3.0 over TCP, are widely used for the communication link between control center and substations. Wireless technology is also deployed for this communication link. The current SCADA systems provide HTTP(S), Secure Shell (SSH) ports for remote connections.

Current Security Solution

A "gateway" security solution, as shown in Fig. 2, is currently widely used to protect power automation system from external cyberattacks. All incoming data packets to a substation are inspected by the security gateway.

Major Challenges and Strategies of Security Solutions for the Smart Grid

To address security issues of the smart grid, it is necessary to identify those unique challenges.

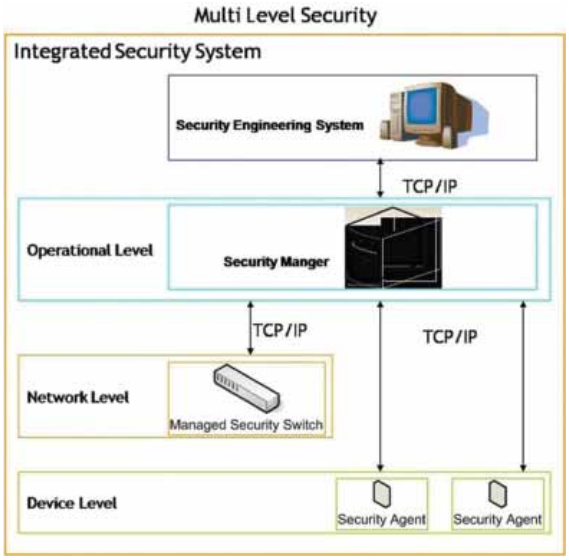


Figure 5: Multilayered integrated security framework

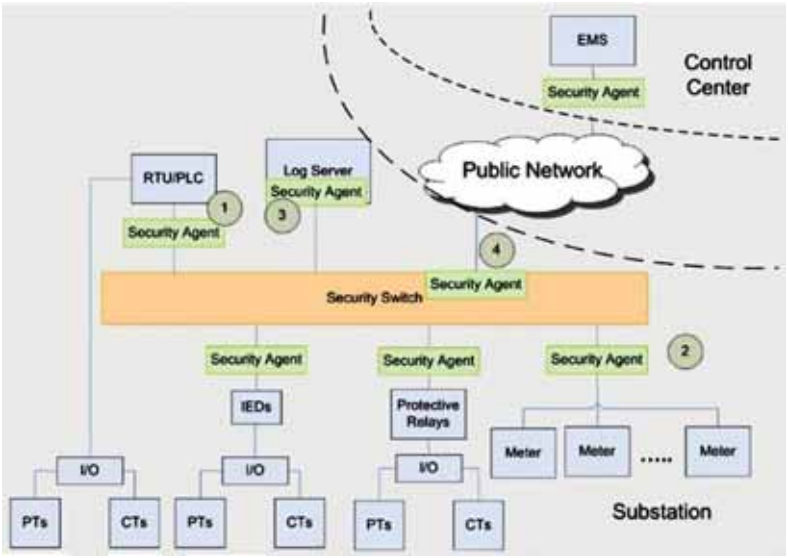


Figure 6: Different implementations of security agents

There are four major challenges when developing new network security solutions for power grid automation systems.

- Many automation components (such as RTU) use proprietary operating systems, which are designed for control functionality and performances, but not security.
- Automation systems use heterogeneous network technologies, such as ProfiBus, ModBus, ModBus Plus, ICCP, DNP. Most technologies and protocols were designed for connectivity, without consideration of cybersecurity.
- Most automation systems are combinations of new and legacy components with many systems expected to run up to 20 or 30 years, perhaps even longer.
- Since power grid is experiencing a profound change and moving to smart grid, there are new applications (such as using phasor measuring units and smart meters) and corresponding new requirements for data communication in terms of bandwidth, delay, and new communication protocols.

The strategies to design a security solution for smart grid are as follows:

- Scalability is the system's ability to increase or decrease its capacity to protect larger or smaller size of power grid automation systems in a graceful manner.
- Extensibility—which refers to a system designed to include hooks and mechanisms for expanding and enhancing the system without having to make major changes to the system infrastructure.
- Interoperability—a property referring to the ability of diverse systems to work together. Since power grid automation systems use various technologies with respect to hardware, operating systems, and communications protocols, the security framework and components must be able to work together regardless of the technology on which they are executed or developed.
- Non-intrusiveness—which refers to the system's ability to be subject to security activities without compromising its control functionalities and performance.
- Flexibility—which is the ability to adapt to various needs in the development and at runtime.

The Integrated Security System

To meet the challenges discussed in the previous section, an integrated security framework with three layers (power, automation and control, and security) is proposed, also called common security platform, as shown in Fig. 3. The automation and control system layer monitors and controls power grid processes, while the security layer provides security features. Since the security layer provides clear demarcation of responsibilities, control functionalities and security functionalities can be decoupled during design stage. Data related to security management flows on

this layer. Another important idea is that the proposed security solution replaces the "gateway" security solution by a "security service proxy" solution, which is shown in Fig. 4. There are three key security subsystems: Security Agent, Security Switch, and Security Manager. Security Agents and Security Switches, which are security enforcement devices, run as security service proxies; and Security Manager runs as a security management device either in the control center or in a substation. The proposed integrated security framework operates on three hierarchical levels, as shown in Fig. 5. Each of these levels is protected by a component of our security system listed below:

- Device level, in which electronic devices, such as RTU and IED, are protected by the Security Agent.
- Network level, in which communication bandwidth is protected and delay is guaranteed by the managed security switch.
- Operation level, in which security policies are orchestrated and managed by the security manager.

Security Agent

The security agents bring security to the edges of the system by providing protection at the device level—it applies to both wired and wireless devices. These agents are firmware or software agents depending on the layer of the control hierarchy. At the field device layer (e.g., IEDs), these agents will be less intelligent—containing simple rules and decision-making capabilities—and whose primary responsibilities consist of event logging and reporting. At the substation level (e.g., RTUs), these software agents will be more intelligent with more complex rules for identification and detection of intrusive events and activities within the controllers. In particular, a security agent will be commissioned to accomplish the following functions:

- Translate between different

protocols.
- Acquire and run the latest vulnerability patches from its security manager.
- Collect data traffic patterns, system log data and report to the security manager.
- Analyse traffic and access patterns with varying complexity depending on the hierarchical layer.
- Run host-based intrusion detection.
- Detect and send alarm messages to the security manager and designated devices, such as HMI.
- Acquire access control policies from the security manager and enforce them.
- Encrypt and decrypt exchanged data (end-to-end security).

Managed Security Switch

Managed switches are used across the automation network to protect bandwidth and prioritise data packets. These switches, working as network devices, will connect controllers, RTUs, HMIs, and servers in the substation and control center. Managed security switches possess the following functionalities:
- Separate external and internal networks, trusted and non-trusted domains.
- Run as a Dynamic Host Configuration Protocol (DHCP) server.
- Run network address translation and network port address translation (NAT/NPAT) and to hide the internal networks.
- Acquire bandwidth allocation patterns and data prioritisation patterns from the security manager.
- Separate data according to prioritisation patterns, including operation data, log data, trace data, and engineering data.
- Ensure QoS for important data flow, such as operation data, guaranteeing its bandwidth, delay, etc.
- Manage multiple virtual local area networks (VLANs).
- Run simple network-based intrusion detection.

Security Manager

Security managers, with a graphical user interface (GUI), reside in the automation network and directly or indirectly connect to the managed switches across the automation networks. They can be protected by existing IT security solutions and will be able to connect to a vendor's server and managed switches via VPN. The security manager will possess the following functionalities:
- Collect security agent information.
- Acquire vulnerability patches from a vendor's server and download them to the corresponding agents.
- Manage keys for VPN.
- Work as an authentication, authorisation, and accounting (AAA) server, validating user identifications and passwords, authorising user access rights (monitor, modify data), and recoding user changes to controllers.
- Collect data traffic pattern and performance matrix from agents.
- Collect alarms and events.
- Generate access control policies based on collected data (using data mining techniques) and download them to agents.
- Run complex intrusion detection algorithms at control network levels.
- Generate bandwidth allocation patterns and data prioritisation patterns (possibly through data mining techniques) and download them to managed switches.

Security Engineering System

Security engineering system is used to create, configure, manage, monitor, and troubleshoot the integrated security system project. The project navigator is the common view for all tools of the engineering system. It offers a common list of all controls and data, and generates the runtime configuration data. The engineering system acts as a centralised data and program administration. In this project, the security engineering system was not developed. Some functions of the security engineering system will be implemented in the security manager.

Intrusion Detection

Traditionally, automation systems are subject to more constrained behaviour as compared to enterprise networks. Automation networks possess:
- Relatively static topology.
- Regular communication patterns.
- Limited number of protocols.
- Simple communications protocols.

Implementations of Security Agents

It would be very costly if one standalone security agent protects each electronic device. To make it more cost effective, security agents are implemented in four different ways, as shown in Fig. 6:

- An individual two-port module—the internal is connected to the protected device (such as RTU and HMI), the external port connected to a network device (such as switch, router).
- An individual two-port module—the internal is connected to a group of electronic devices (such as meters or protection relays), the external port connected to a network device (such as switch, router).
- Agent resides in a managed security switch—a virtual security agent runs on an internal port connected to the protected device.
- Agent resides in all newly developed devices (such as log server, PLC, RTU)—runs independently of control firmware.

Conclusion

This article first introduces functionalities of power grid, its automation and control system, communications. Potential cyberattacks and their adverse impacts on power grid operation are discussed, a general SCADA cyberattack process is presented. This article discusses the major challenges and strategies to protect smart grid against cyberattacks.

Dr L Ashok Kumar

Professor, Dept. of Electrical & Electronics Engineering, PSG College of Technology, Coimbatore

RR Kabel to enter MV cables segment

> Expansion is a continuous process for us at RR Kabel. We are the only wire brand to export to over 75 countries.
>
> **Shreegopal Kabra,**
> **Managing Director, RR Kabel**

RR Kabel, founded by the Kabra family in 1999, is one of the leading players in low-voltage cables business. Now the company plans to enter medium-voltage cable segment commencing March next year, informs **Shreegopal Kabra**, Managing Director, RR Kabel in an interview with *Subhajit Roy*.

In September, TPG Capital acquired a significant minority stake in RR Kabel with an estimated investment of Rs 650 crore. How do you look at this step?

TPG has been one of the most active private equity investors in India for the past one and a half decade. We feel, TPG is the right partner for us to help RR Kabel reach the next level. The partnership will strengthen our financial and management capability.

What is the kind of revenue growth expected during the current fiscal?

We achieved a revenue of Rs 1,615 crore for the fiscal ended March 31, 2017 with a net profit of Rs 86 crore. This year we will grow by about 20 per cent.

How will the partnership with TPG impact on your revenue growth?

It will obviously have a positive impact – that is the basis of any partnership. We are concentrating on further expanding our wires and cables as well as electrical business in the foreign markets and plan to achieve 25 per cent to 30 per cent growth over the next few years.

What's your take on the recent performance of wires and cables industry in India?

The wires and cables industry in India is performing well and it will continue to do so. The government is investing a lot of money on 'Housing for All' and 'Electricity for All'. These are the major avenues that will continue driving the demand for next 5-6 years.

What is your market position as of now?

We are in to the business of wires and low-voltage cables. Today we are in top 3 companies in India in this segment. Now we are entering into a new range of medium-voltage (MV) cable. It is also pertinent to note that we are of the foremost companies that have more than 29 certifications from across North America, Europe, Middle East, Africa and Asia.

What prompted you entering a new business segment?

Increasing our product basket, thereby looking to be identified as a complete electrical solution provider.

When are you going to start commercial production of your MV cables?

We are all set to make an entry in MV cables segment by March 2019. We will be producing this range of cables in our new facility at Waghodia, Vadodara.

How much you are investing in this project?

We will be investing around Rs 400 crore in the next 3-4 years.

How is the industry growing? What is the growth rate as of now?

It is 12-14 per cent approximately.

What is the market size for LV and MV wires and cables?

About Rs 2,000 crore.

You are in top 3 in LV and getting in to MV business now. Is attaining the No.1 position on your radar?

No, we are not into the volume game, we are basically into quality game. We do not compromise on quality. Our target is to maintain the top quality in which we are a leader.

Are you expanding your export market presence?

Yes, expansion is a continuous process for us at RR Kabel. We are the only wire brand to export to over 75 countries. Also, we are the only company who have 29 investment approval from 30 countries.

How do you see the future of your industry beyond 2019?

As 2019 is the election year, we expect the same government will come back to power. The growth initiatives initiated by this government will continue to support industry growth. Even if something goes wrong, what they have started, the new government cannot stop it and it can be slow.

Talking about RR Kabel, what sort of roadmap do you have beyond 2019?

For next 5 years, we target to grow by 20-25 per cent CAGR.

After entering in to MV cables market and joining hands with TPG, do you have any other investment plan in pipeline?

Yes, there will be many...you need to wait for that.

LIGHTING MARKET SHINES BRIGHT

LED lights have carved a niche in the Indian lighting market owing to several advantages over conventional lighting, but what is the future?

By Supriya A Oundhakar, Associate Editor

The lighting industry has been undergoing evolution since the invention of the first incandescent lamp by Thomas Edison and Joseph Swan in the 19th Century. Inclination towards efficiency and cost savings, followed by the tilt towards clean energy in the fight against pollution and global warming has paved the way for energy efficient lights beginning with fluorescent lamps and now Light Emitting Diode (LED) lights.

According to a report by Electric Lamp and Component Manufacturers Association of India (ELCOMA), the lighting industry is expected to reduce energy consumption for lighting from the present 18 per cent of total power consumption to 13 per cent by 2020 by introducing more energy efficient products and working more closely with the government to execute various schemes and awareness programs. LED lights have carved a niche in the Indian lighting market owing to several advantages over conventional lighting. LED lights are set for growth over the next few decades.

Energy efficiency awareness program is fueling the growth of LED. Acceptance of LEDs is reflected in progress of the lighting industry in India registering a growth of US$ 29.6 billion in 2016 to around US$ 33.1billion in 2017. This industry expected to reach US$ 37 billion in the year 2018. This is because of affordable pricing of the LED products.

According to Raju Bista, Managing Director, Surya Roshni, "The Indian LED lighting industry is on a rapid growth path and expected to grow tremendously on account of the demand for a smart or connected lifestyle and for energy-efficient products. The market for energy-efficient products such as LED lights is bound to grow. LED market is bound to multiply manifold as all the conventional products such as lamps, tubes, down lights, street lights, outdoor lighting products are being changed to LED based lighting products."

LED lighting provides cost effective solutions with innovative design in the commercial space. Infrastructural development such as roads, offices, real estate, commercialisation, increasing disposable income and growing preference of people towards energy efficient and innovative lighting solutions will be accelerating growth in coming years.

Gurumukh Uttamchandani, Executive Director, Syska Group, says, "Companies like Syska are focused towards providing customised LED products for the commercial sector. Due to the strong government support and aggressive promotion by the manufacturers, there is a growth of smart LED systems at both local and international level."

Government initiatives

The roll out of smart cities project has generated potential for the lighting sector. Congenial government initiatives coupled with declined prices has brought about a sea change in the sector. In order to cut emissions, the government has set the target of distribution of 770 million LEDs by March 2019 across 100 cities under the Unnat Jyoti by Affordable LEDs for All (UJALA). This is one of the largest LED distribution programs in the world.

Moreover, with the objective of achieving energy saving of typically 50 per cent, the government has initiated the replacement of India's 14 million conventional street lights with Smart LED variants under Street Lighting National Program (SLNP) by 2019. Under the Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY), 27.3 million

LED bulbs have to be distributed to BPL households. According to a statement issued by Ministry of Power, over 2.1 million conventional streetlights have already been replaced with LED streetlights across the country.

Anil Bhasin, Executive Vice President, Havells India, informs, "Adding to the growth would be government's flagship programs such as Rural Electrification and 'Power For All' along with the investment to be made in the 'Smart Cities' program. Another reason of rapid growth of lighting sector is the government's drive in implementing LED lighting across the nation which will help the LED Lighting industry to grow in a good pace."

Raju Bista, of Surya Roshni also asserts, "Other drivers are the Smart Cities project, and the increasing demand for a smart, connected lifestyle and energy efficiency measures. Being energy efficient remaining the core principle of growing India, we have converted our CFL production facilities to LED manufacturing facilities for contributing towards the nation's growth by energy conservation."

State	Number of streetlights	Energy saved per year (kWh)
Rajasthan	704,891	99,054,808
Andhra Pradesh	586,037	82,352,849
Delhi	264,185	37,124,579
Gujarat	200,536	28,180,321
Goa	94,856	13,329,639
(Source: Ministry of Power)		

Emerging Technologies

With the advent of technology and innovation along with the growing use of internet, automation has changed the landscape of lighting industry with the overall lighting experience with respect to control, monitoring or sensing and connectivity and improved aesthetics.

For instance, in India, to curb the energy wastage, a team of students from the Indian Institute of Technology Madras (IIT-M) has developed an intelligent lighting system that ensures the street-lights illuminate to 100 per cent brightness once the sensors on the lighting system detects vehicular movement. Otherwise the lights go dim by 30 per cent. It is a fully automated lighting system. i-lighting is an integrated system with a control module, sensor module and LED driver.

According to Bista of Surya Roshni, the latest technology in the LED products is DMOV technology. This technology helps to fight high voltage and electric surges in rural areas. The LED lights can operate at a low voltage and makes a popular option where high voltage supply is limited. The lights are energy-efficient and consumes less electricity than a traditional light source thus saving costs. Safer than the traditional lights, ergonomically designed LEDs, longer lifespan of about 25,000 hours or more, durable product with inbuilt DMOV technology which protects the product in case of voltage surge or fluctuations.

Talking about digitisation in LED, he elaborates, "Our LED lamps are outfitted with a Central Control Monitoring System (CCMS), which allows remote monitoring and operation of individual lights or a group of lights. The system sends alerts for each light that needs attention, reducing the chances of failure and sudden repair and can help us to do light scheduling based on day times, day light and power saving needs. It can generate reports and MIS for decision making. This enables an additional energy saving."

Leading brands are paving the way with smart LED bulbs and

The Indian lighting industry will continue to grow at a higher rate per annum, ranging between 13 per cent and 15 per cent until 2020.

Raju Bista
Managing Director,
Surya Roshni

switches that connect to WiFi and offer app, button and voice controls over the positioning, brightness, warmth and colour of connected bulbs. The major technology behind smart connected homes is Internet of Things (IoT). Currently, smart tech is adapting to seamlessly integrate into smart home systems.

Further, Power over Ethernet (PoE) lighting uses an Ethernet cable to power light fixtures (luminaires). The Ethernet cable transmits data between the fixture and the control software. PoE technology has application in indoor lighting owing to its benefits like energy savings, space optimisation, productivity enhancement and security alerts. Sensors on light fittings of PoE give information about energy consumption. Moreover, features like automatic on or off, movement detection, occupancy alarms, and daylight harvesting lead to energy saving and productivity.

Havells India has elevated its lighting product range using PoE. Bhasin of Havells informs, "Our product innovations in Connected Lighting enable integration of all lighting amenities with other facilities such as telephony, Internet, electricity, HVAC and building automation using PoE. We also offer a centrally-controlled monitoring system (CCMS) which enables remote-monitoring and scheduled operations of the lights, energy analysis, fault monitoring etc. This can again be integrated to water, sewage and other facility services. In the outdoor lighting segment, our smart street lighting LED solutions help save thousands of watts."

> *The future of LED lighting is bright as every sector from the automobile industry, to health and agricultural sector among many other sectors seem to be embracing LED technology with the help of government support.*
>
> **Gurumukh Uttamchandani,**
> *Executive Director, Syska Group*

Keeping in pace with the latest emerging trends, Syska has introduced smart home LED products like Syska Smart Table Lamp and Syska Smart bulb compatible with Amazon Alexa and Google assistant.

Syska Smart Table Lamp having long lasting life (up to 30,000 hours) and 90 per cent energy saving has features like 3 Stages Dimmable that can adjust brightness according to requirement and mood with the touch of a button suiting to lighting needs. Its Feather Touch Control helps to switch it on or off, control its colour temperature, and its dimness (brightness) for a seamless experience. It has hands-free control with Alexa. The 2-mood setting in Syska Smart Table Lamp allows the user to fix lighting requirements between reading and night.

Further, Syska Smart Bulb connects user to WiFi and controls every aspect of lighting from his or her smartphone or tablet. It helps user with setting the light of his or her home as he wants from anywhere. In addition to using voice commands, users can also download the Syska Smart Home app to control the lights. The App gives the user the option to choose shade of light from a spectrum of 3 million colours. User can also set alarms of switching on and switching off lights to create his or her own preformatted lighting theme.

Further, advancement in technology has brought application of Bluetooth mesh in lighting industry, a completely new technology, thus eliminating the need for the traditional lighting control box. It enables the luminaires in buildings to be connected into a grid. In this, hundreds of devices, such as lights, switches and sensors are able to communicate with each other over long distances. It is a mesh topology, so the enabled luminaires don't need to be in direct radio range as messages are relayed from device to device at the speed of light.

Human Centric Lighting (HCL)

Lighting technologies continue to evolve, giving greater freedom and flexibility in how lighting is applied and controlled in the workplace. The impact of lighting

We have also started the process of phasing out the CFLs and focussing on the manufacturing of LED lights which have huge growth potential and currently contribute 75 per cent to our lighting division's turnover.

Anil Bhasin
Executive Vice President, Havells India

on human beings, and its effect upon emotions, well-being and productivity is the subject of numerous ongoing studies, as humans spend most of their time awake indoors. These are apt places to implement Human Centric Lighting (HCL) Solutions.

HCL can improve the workplace experience by thinking about building design in an entirely new way. Workplace lighting can, in addition to providing sufficient light to conduct work-related visual tasks, affect employees' alertness, mood, cognition, sleep-wake pattern and health. The objective of HCL is not only to maximise the value of LED lighting but also to adjust the intensity of the light and colour quality – correlated colour temperature (CCT) and colour rendering.

LED-based HCL is controllable and tunable across a spectrum of CCTs to evoke particular human biological responses and behaviour in well-designed indoor environments. In order to incorporate HCL into a building, one requires to install both tunable fixtures and smart lighting controls to drive intensity and CCT.

Outlook

The development of smart cities, increasing usage of wireless technology, and increasing awareness of energy efficiency are driving the growth of smart lighting technology. India's focus on the development of smart cities also provides further scope for the development of energy efficient smart lighting technology. The Indian government has announced plans to invest in smart cities and in 2018 also allocated over USD 2.3 billion in smart cities.

"The future of LED lighting is bright as every sector from the automobile industry, to health and agricultural sector among many other sectors seem to be embracing LED technology with the help of government support," states Uttamchandani of Syska Group.

The new trends in the market such as growing demand for IoT technology and emergence of light fidelity (Li-Fi) technology has a direct impact on the dynamics and market of smart lighting technology.

"Technologies such as Li-Fi, which is basically like WiFi but with light and indoor positioning which tracks people's positions to use luminaires are on the basis of visible light communication. The Indian lighting industry will continue to grow at a higher rate per annum, ranging between 13 per cent and 15 per cent until 2020," anticipates Raju Bista of Surya Roshni.

Havells India is bullish on promoting energy-efficient LED products and greener fuels. "In order to tap the growth potential in the power sector in India, we have already enhanced our manufacturing capabilities from 5 lakh lamps to 25 lakh lamps per month. We at Havells are all set to support government's initiatives. We have also started the process of phasing out the CFLs and focussing on the manufacturing of LED lights which have huge growth potential and currently contribute 75 per cent to our lighting division's turnover," concludes Bhasin.

K-LITE

India's Lighting Company

www.klite.in

IoT WILL DRIVE THE LIGHTING INNOVATION

> Last year, we have seen the trade had slowed down due to the GST implementation. Now the LED lighting has been growing.
>
> **Gautam Seth,**
> **Joint Managing Director,**
> **HPL Electric & Power Ltd**

Electric equipment manufacturing major HPL Electric & Power Ltd is leveraging IoT to add intelligence in its product range. The company has completed the smart city lighting project in Bhopal and installed over 20,000 smart LED lights and 400 CCMS there. In an interview with *Subhajit Roy*, HPL's Joint Managing Director **Gautam Seth** gives an overview of the LED industry in India and the technology trends. Excerpts:

Could you brief us on the present demand-supply scenario of the lighting business?

We find that the lighting industry to be at a much better level compared to last 3 to 4 years. In terms of demand, it is going to pick up. The awareness levels of LED at a very high level so people know what are LEDs and the inherent benefits what LED is providing. But the LED industry has seen an influx of lot of new players coming in and the prices diving down. Also, at the same time, there have been lot of changes in technology that are happening. And players like us who have been backward integrated in manufacturing and who have their own R&D, design including electronic manufacturing for drivers stand to the end. In the current scenario, the demand is picking up, there are much more serious players, the competition is much more serious. The players who were disrupting the market are not seen around today. Prices are stabilised. So, on the whole ecosystem is better today for players including for traders because in falling prices it is not beneficial for trade to participate. Government purchasing is at a good level. So, the overall industry scenario is very good and we definitely see a lot of demand coming in.

In terms of products, we are seeing an all-around growth right from the LED bulbs are growing in trade segment in a

very large manner. This is despite the government also participating in distribution of LED bulbs through EESL. Apart from that, we are seeing a good movement in all luminaires whether its consumer, industrial, commercial or even on the street lights. So, I would say there is an all-around demand coming and although every industry is competitive and so is the LED industry. At HPL Electric because of our inherent strengths in our design and development into backward integrated manufacturing, we have an edge over competitors.

How is the performance of HPL in the lighting business?

Last year, we have seen the trade had slowed down due to the GST implementation. Now the LED lighting has been growing. In second half of the last year, we have seen double-digit growth and that is continuing in current year also. We have been expanding our channel network and we have increased our promotional spend in last 2 years. That is aiding our growth in the trade segment. Mostly we have seen a lot of growth in LED coming in through the dealer and distributor channel segment.

What about technology? How Internet of Things is driving the lighting segment?

IoT is here to stay and grow and we are seeing that integration happening in our products. Today we are able to integrate the communication and electronics into street lighting and office lighting systems where we are having much smarter solutions.

HPL's Gurgaon Factory

In fact, this year we completed one of the first smart city lighting projects in Bhopal where we have installed over 20,000 smart LED lights and 400 CCMS (Centralised Control Monitoring System). Here each and every street light is connected to centralised server and can be centrally monitored using 6LoWPAN communication technology. This is something which is good and we are seeing more and more cities adopt same kind of technologies. We had earlier done the Ujjain Kumbh Mela on a larger scale.

Do you see that Connected Lighting or IoT will be the prime mover for lighting segment in times to come?

Yes, in times to come, IoT will drive the lighting innovation though it is still too early for mass adoption. For people to actually operate smart lighting and have equipment to monitor their homes is very easy thanks to smartphones. So, technology adoption will take some time but it is moving in that direction.

How is the preparedness of Indian manufacturers in the IoT front?

I would say, it's very good. Since last 4 years when government started giving a push on LEDs the Indian manufacturers have come up in a different way. Earlier we were seeing industry dependent upon imports. But today the overall industry right from making the components to the finished goods, the manufacturing has improved. So, I would say companies like us because of our manufactured products, are looking to export LED lighting to many countries and that is where our focus both on consumer side and also on a project basis for our street lighting and other areas of lighting products.

> Copper is a barometer of the economic growth of the nation and if we wish India's growth story remains intact, then the usage of copper must grow simultaneously.
>
> **Sanjeev Ranjan, Managing Director, International Copper Association India**

HAS THE COPPER INDUSTRY HIT A ROAD BUMP?

Copper is one of the most widely used metals in India and its usage is next only to steel and aluminium in volume terms. On the sidelines of the Power Cable Alliance (PCA) launch event, Managing Director of International Copper Association India (ICAI) Sanjeev Ranjan speaks to *Subhajit Roy* and briefs about present and future scenario of the industry.

How do you look at the demand-supply scenario of copper post closure of Sterlite's Tamil Nadu factory?

There is a supply issue. The closure of the Sterlite plant, one of the three primary copper producers in the country, has impacted supply. It has forced more material to come from outside India through imports. Hence, the sooner we start the better it is. It will help us to conserve forex (foreign-exchange).

Has the industry hit a road bump because of Sterlite plant closure?

Copper rods are used as raw material for the manufacturing of various electric and engineering applications like wires and cables. It is the ultimate product from plants like Sterlite, Hindalco, Hindustan Copper, and other copper producers in the country. Post the closure of Sterlite's plant at Thoothukudi, any application and production that is related to copper rod has been impacted in terms of the local supply. The wire manufacturers in South India are facing difficulties in terms of

meeting their copper requirement and are increasingly becoming import-dependent. Further, the rupee's depreciation makes copper imports costlier. This is a challenge!

What is the overall impact on the electrical industry and more specifically the wire and cable industry?

The overall copper usage in the electrical applications sector in India accounts for about 54 per cent. There are two sources of copper raw materials supply- primary producers and secondary suppliers. In the case of some secondary suppliers, where sources and origins of materials are unknown, there are chances of compromised quality of the final output – whether it is a wire, cable, a motor or a transformer. When we talk about electrically reliable and safe products and building infrastructure, such challenges should be addressed strictly and as immediately as possible.

As an association, are you taking up this issue with the government?

Yes, we have shared our views and comments with the concerned government authority requesting and urging them on the need to resolve the issue as soon as possible. The local copper users are strongly dependent on the plant and closure has impacted them as this plant addresses the requirements of the local fabricators. Further, the local fabrication industry and employment is also getting impacted.

Copper is a barometer of the economic growth of the nation and if we wish India's growth story remains intact, then the usage of copper must grow simultaneously. If copper growth is not growing in line with the GDP growth, then that should show we lack something behind during our progress.

So how is the supply-demand being met?

If we look at the quarter-on-quarter data, there is a certain increase in the import of less than 6 mm copper rods. Similarly, the imported finished goods from the Association of Southeast Asian Nations (ASEAN) regions come under the duty-free route as per the Free Trade Agreement (FTA). This could lead to a rise in imports of finished goods at the cost of domestic producers. Now the question is: Why should it come from outside when we have enough potential? Decisions should be reached quickly as the industry is suffering.

The wire manufacturers in South India are facing difficulties in terms of meeting their copper requirement and are increasingly becoming import-dependent. Further, the rupee's depreciation makes copper imports costlier.

How do you promote local manufacturing?

At ICA India, we cannot set the roadmap, we can only help encourage the use of copper. We promote generating fresh or sustaining demand of copper in various applications towards the infrastructural development of the country. We help the local manufacturers by training and working with them in sharing knowledge about the right electrical practices; encouraging them to switch to copper motors and transformers for its lifetime warranty and properties like anti-corrosion, durability and efficiency. We encourage local suppliers to meet the demand whether it is in the motors, transformers, wires and cables, pumps, or the air-conditioner tubes and simultaneously work with the government to help standardise and implement stringent norms for a better tomorrow.

You have recently launched Power Cable Alliance. What was the need?

India is the fastest growing economy and its energy consumption is likely to double in the next six years. This makes it important for the country to develop quality electrical infrastructure which will support its growth for several years to come. Power Cable Alliance or PCA is our endeavour to bring like-minded people together right from rod producers to actual users and policymakers. We are proud to present PCA as a voice for quality electrical infrastructure in India to answer the many unanswered questions which must be addressed. The alliance will work with policymakers, regulators industry, academia, and civil society to push for safe, reliable and efficient electrical infrastructure. It is an advocacy group towards the creation of an infrastructure that is advanced. Ultimately, PCA provides a platform to raise our concerns towards a safer, reliable and efficient India as a movement for quality electrical infrastructure is in alignment with Government of India's "Make in India" initiative. EI

Artificial Intelligence: An Advanced Approach in Power Systems

This article elucidates the application of Artificial Intelligence methods in power system expansion.

Early to mid-1980s, providing a solution to complex problems in many areas of power system engineering was tough and tedious. Presently with Artificial Intelligence (AI), many constraints can be handled easily such as economic load dispatch, load forecasting, optimisation of generation and scheduling, transmission capacity and optimal power flow, real and reactive power limits of generators, bus voltages and transformer taps, load demand in interconnected large power system and their protections etc. Now, most of the efforts in power system analysis

have been successfully reduced by AI techniques.

Power Systems

Power system engineering is an important branch of electrical engineering that deals with the generation, transmission, distribution, and utilisation of electric power.

Artificial Intelligence

AI is the science of automating intelligent behaviours presently accomplishable by a computer interfaced with machines like robots. Artificial General Intelligence (AGI) is the intelligence of a hypothetical machine or computer which can accomplish any intellectual assignment successfully which a human being can accomplish.

Necessity of AI in Power Systems

For industrial development with power system expansion; stability, strengthening, reliability, technical advancements, selection and dynamic response of the power system are essential. With the growth of the power system, complexity in the networks is increased tremendously. As a consequence of this power system analysis by conventional techniques and conclusions from the acquired data, the process for the information, management of remote devices and utility became more complicated and time-consuming.

As necessity is the mother of invention, AI is developed with the help of sophisticated computer tools and applied to resolve all aforesaid problems for large power systems.

AI Techniques

Modern AI technologies include the following techniques:

- Artificial Neural Networks (ANNs)
- Expert System Techniques (XPS)
- Fuzzy Logic systems (FL)
- Genetic algorithm (GA)

These are the major families of AI techniques which are considered in the field of modern power system.

Artificial Neural Networks

Artificial Neural Networks (ANN) are biologically inspired systems. ANN mathematical models simulate the human biological neural network for processing information where each neuron produces one output as a function of inputs. Each type of neural network is capable of some specific work after being trained and is able to conclude a function from observations faced in real life such as function approximation, classification, data processing, etc. Its primary advantage is the capability to learn algorithms, an online adaption of dynamic systems, quick parallel computation, and intelligent interpolation of data. They are classified by their architecture, a number of layers, topology, connectivity pattern, feed forward, back propagation and radial basis function or recurrent, etc.

A neural network consists of some layers of artificial neurons linked by weight connections.

- Input Layer: The input units do not process the data and information but distribute other units.
- Hidden Layer: The hidden units provide the ability to map or classify the nonlinear
- problems.
- Output Layer: The output units encode possible values to be allocated to the case under consideration.

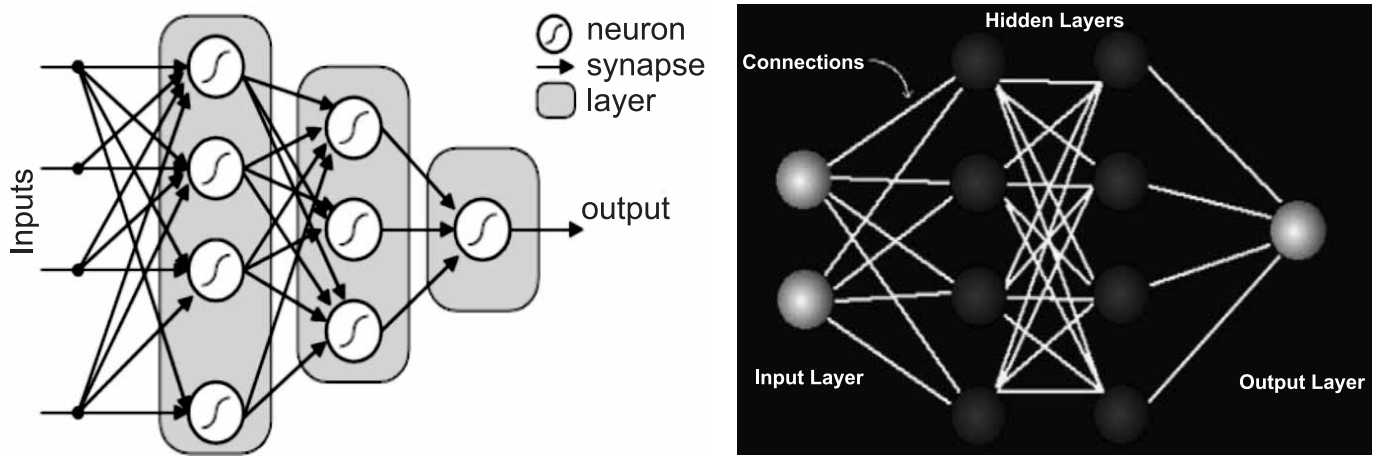


Figure 1: Architecture of a feedforward ANN

ANNs Characteristics

ANNs are fast and robust and do not need any appropriate knowledge of the system model. Since they are fault tolerant, they can handle situations of incomplete or corrupt data and information. They have learning and data adaptation ability. On the other hand, ANNs cannot perform a task other than the one for which they are trained. For any other task, they have to be retrained. ANNs always generate the result although the inputs data is unreasonable.

Applications

ANNs can be particularly useful for problems which require quick results, like those in real time operation. ANN techniques can be applied to power system protection.

Methodology

Real world problems in generation, transmission, and distribution of electricity can be fed to the ANNs to obtain a solution.

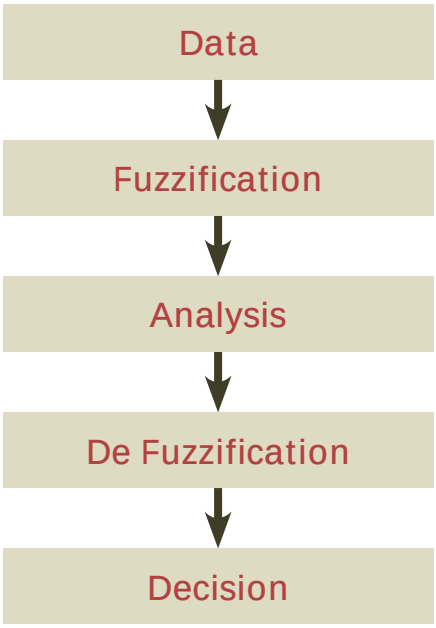


Figure 2: Fuzzification

Fuzzy logic

Fuzzy systems were developed in 1965 and had become popular in technical problem-solving. They are considered as mathematical means of describing ambiguity in linguistic terms instead of exact mathematical description.

Since it performs and can take a decision like a human brain, it can be standardised and systematised approximate reasoning. Therefore, with certain or even approximate information and data, it produces accurate solutions. Hence, this technology is used in machines so that they can perform like a human.

Fuzzy Logic Characteristics

Fuzzification provides oversimplification, superior expressive power, and an improved capability to model a complex problem at low cost. It allows a particular level of uncertainty throughout an analysis, as a consequence of allowed uncertainty it minimises problem complexity and available specifies information.

As most of the power system analysis is performed either with an approximation or with assumption-based data, Fuzzy logic can be of great use to derive a stable and exact output free from uncertainty.

Applications

Fuzzy logic has suitable applications in power system, like reactive power and voltage control, system stability analysis and control, fault analysis, security assessment, load forecasting, power system protection, etc. It can be used to increase the efficiency and for designing physical components of power systems from small circuits to large mainframes.

Methodology

Fuzzy logic provides the conversions from numerical to symbolic inputs, and back.

Expert systems

Expert systems were developed

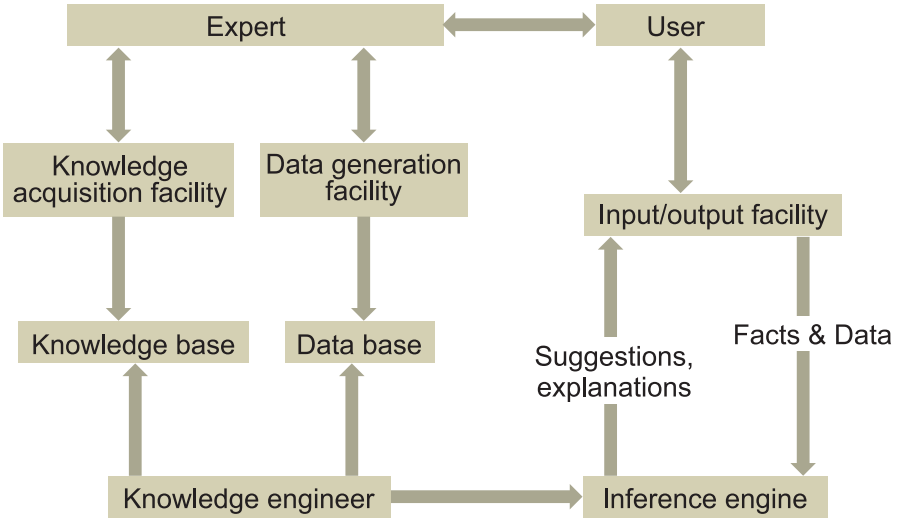


Figure 3: Structure of the Expert system

during the 1960s and 1970s and commercially applied throughout the 1980s. It is also called knowledge-based systems or rule-based systems. It is a computer program that incorporates knowledge derived from experts in a specific subject to provide problem analysis to users. This knowledge is generally stored in one of the many forms, like rules, decision trees, models, and frames. It uses this knowledge and interface mechanism to solve problems which cannot be or difficult to be solved by human skill and intellect. The common form of an expert system is a computer program containing the rules for analysis and recommendations for users.

Characteristics

Since expert systems are basically computer programs, it is based on the process of writing codes which is simpler than actually calculating and estimating the value of parameters. Therefore, any modifications even after design can be easily done. These systems are incapable of accepting new problems or situations other than programmed.

Applications

Expert systems are especially useful for problems when a large amount of data and information have to be processed in a short time. Many applications in power systems related to Power system designing and analysis match the abilities of expert systems.

Methodology

The methodologies of expert systems can be classified into the categories of rule-based systems, knowledge-based systems, neural networks, object-oriented methodology, case-based reasoning, system architecture, intelligent agent systems, database methodology, modelling, and ontology.

Expert systems are also combined with fuzzy systems to fuzzy-expert systems or combined with neural networks to neuron-expert systems. Recently, with the development of computer techniques, expert systems are

also applicable to online applications of the power system. The structure of the expert system is shown in figure 3.

Genetic Algorithms (GA)

The Genetic algorithm gives a global technique based on biological metaphors. It is an optimisation technique based on the study of "Natural selection and natural Genetics." Several methods for increasing the efficiency and analysis of power system to increase power output can be proposed, but out of these methods, Genetic Algorithms withstands all selected constraints. It is the best method for solving complex and nonlinear problems. it is used for planning of power generation, transmission and distribution. It adjusts the parameters of excitation to solve the voltage control problem and reactive power compensation.

AI – Exposure in Power System

Several problems in power systems cannot be solved by conventional techniques. Therefore, AI techniques in power system applications are being focused widely. Particular emphasis has been put on Artificial Neural Networks (ANN), Fuzzy Logic (FL) and Expert system (XPS). Some of the areas of the power system applications are highlighted here.

- Economic load dispatch, generation and operational planning based on load forecasting, optimisation of hydrothermal generation scheduling.
- Power transmission capacity and optimal power flow, real and reactive power limits of generators, and system reliability.
- Control of voltage and frequency for system stability, sizing and control of FACTS devices.
- Analysis of electricity markets and strategies for bidding.
- Automation for power restoration and management, fault diagnosis, and security margins.
- Planning and operation of distribution, network reconfiguration, demand-side response and management, operation and control of smart grids.

Some typical application of power system protection, ANN application, have been introduced to CT and VCT transient correction. For digital relays, fuzzy criteria signals, fuzzy settings, and multi-criteria decision making have been applied. FL and ANN application is applied for Differential protection for power transformers.

AI - Techniques for Transmission Line Performance Improvement

A practical application to improve the performance of transmission line is described with the help of a combination of AI techniques.

To improve the performance of a transmission line, the following functions are allotted to various AI techniques as:

- Fuzzy systems: To diagnose the fault.
- ANNs: Trained to change the values of line parameters based on environmental conditions.
- Expert systems: To deploy outputs as a value of line parameters.
- Environmental sensors: To sense the environmental and atmospheric conditions and provide input to the expert systems.

If any fault occurs in the transmission line, the angular difference between phasors of fault and pre-fault current is detected and fed to the fuzzy system for diagnosis.

The environmental sensors sense the environmental and atmospheric conditions as inputs to the expert systems. The expert systems provide the value of line parameters to be deployed as the output. ANNs improves and check the performance corresponding to the parameters provided by environmental sensors, if needed it changes the line parameters within the specified range to achieve the desired performance of the line.

Since the processing speed is directly proportional to the number of neurons, therefore, to improve the performance up to the desired level, a number of hidden layers and a number of neurons in each layer can be varied.

To acquire desired output, networks take different activation functions between input and hidden layer and hidden and output layer. Similarly, different neurons can also be taken for different layers.

AI - New Applications in Power Systems

Many problems in power systems are based on several non-

feasible requirements. Therefore, AI techniques are the only option to solve them. Current approach of AI in power system applications are:

- Planning for Generation expansion, power system reliability, transmission expansion, and reactive power.
- Control of voltage, frequency and stability, and power flow.
- Control of a Fuel Cell and thermal power plant.
- Automation for restoration management, fault analysis and network security
- Planning and operation of the distribution system, demand-side response and management, smart grids operation and control, and network reconfiguration.
- Forecasting for electricity market, solar power, and wind power.

Saving Potential in AI

To avoid an impact on the environment, reliable and efficient power supply has become an important need of the world. This is being achieved by close monitoring of the power system equipment and consumption. It needs AI-based techniques which are highly reliable, accurate and automated systems such as EMS, Intelligent sub-station ornamented by high-speed protection, monitoring, and communication systems. With the promotion of these developments by AI techniques, savings can be achieved in the field of remote monitoring of equipment, operation, maintenance, and production. Plenty of research has been performed, and a lot of research is yet to be performed to derive full advantages of AI technology for cost reduction by improving the efficiency of the power system, distributed control and monitoring system, renewable energy resources system, and electricity market and investment system also.

Rajesh Chourishi

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& Power System Analyst
Corporate Technical &
Energy Services
Aditya Birla Group

Energy Efficiency in Iron Ore Mining

The study aimed at assessing energy (electrical) performance of various equipment and systems having significant energy consumption and find scope for reduction in Iron ore open cast mines.

The fourth common element and second most abundant metal on Earth's crust is iron. About five per cent of the Earth's crust is composed of iron. The metal is chemically active and is found in nature combined with other elements in rocks and soils. In its natural state, iron is chemically bonded with oxygen, water, carbon dioxide, or sulphur in a variety of minerals.

Iron ore mining is basically cascade array of ore extraction, ore preparation (crushing and grading/sizing), storage and transportation. To carry out extraction operation mines division is equipped with various classes of machineries ranging from deep bore driller, explosives and blasting equipment, earth movers like

dozers, loaders, dumpers etc. Ore preparation is about bring the ore within a range of particular size or grade suitable for downstream operation. The preparation plant is equipped with crushers, screens, and conveyors etc. The transportation involves use of loaders, trucks, dumpers, rail etc.

The operation support services ranges from maintenance facility for earth movers and other vehicles, electrical supply to crusher and belt drives, water pumping and distribution for sprinklings in operation areas and domestic use, Operation Control Centre, Mines Admin Offices etc. The study aimed at assessing energy (electrical) performance of various equipment and systems having significant energy consumption and find scope for reduction in Iron ore open cast mines.

Iron ore mining industry in India

The production of iron ore consisting of Lumps, Fines and Concentrates at 192 million tonnes in 2016-17 increased by 21.5 per cent as compared to the previous year.

FY	No. of Mines	Production (Million Tones)
2012 - 13	310	136.62
2013 - 14	322	152.43
2014 - 15	320	129.32
2015 - 16	297	155.91
2016 - 17	296	192.08

Odisha was the leading producer of iron ore accounting for 52 per cent of total production followed by Chhattisgarh (16 per cent), Karnataka (14 per cent), Jharkhand (11 per cent) and remaining (7 per cent) production was also reported from Andhra Pradesh, Goa, Madhya Pradesh, Maharashtra and Rajasthan. Public sector mines contributed about 36 per cent of total production and share of private sector in the total production was 64 per cent in 2016-17. (Source: IBM)

Production and Consumption of Iron and steel products is a direct indicator of development index of any country. Though Iron/ Steel is technically an infinite times recyclable element the process of production/recycle is highly energy intensive and calls for immediate attention as huge scope exists in the life cycle of iron for energy efficient technological intervention.

About iron ore mining process

The forms of Iron Minerals, Ores, and Rocks Iron occur mainly in iron-oxide ores. Some ores are a mixture of minerals rich in iron. Other iron ores are less rich and have a large number of impurities. The most important iron ore forming minerals are:

- Magnetite - Magnetite (Fe_3O_4) forms magnetic black iron ore.
- Hematite - Hematite (Fe_2O_3) is a red iron ore
- Goethite - Goethite ($Fe_2O_3.H_2O$), a brown ore, contains iron.
- Limonite - Limonite ($Fe_2O_3.H_2O$) is a yellow-brown iron ore. Limonite is a collective term for impure goethite and a mixture of hydrated iron oxides.

Process Overview: There are two basic methods of mining iron ore:

- Surface mining or open-cast mining
- Underground or shaft mining.

To be competitive, iron mining must be done on a very large scale. Surface mining is the preferred choice, although there are exceptions. The mines under energy audit study are open cast mines. The entire manufacturing is termed as 'Mining', where Iron ore is produced by open-cast mining. After removal of over-burdens, the ore is crushed to suitable size for further process.

Extraction

Explosives of high and mild intensity are used by drilling deep bore into earth surface to blast off in order to loosen and dislodge the iron ore deposit to be easily collected using various classes Dozers and Loader available at the site and subsequently the discharge is loaded onto Dumper to be transported to the crusher house. Forms of Energy utilised: Diesel.

Crushing

Since by the primary extraction of iron ore the lump size is often very big which poses difficulty for transportation through belt, thus it is imperative to reduce the size of lumps to a grade which becomes readily transportable and ready for use in integrated or secondary steel production plants. Forms of Energy utilised: Electricity.

The Crusher house has two streams of crushing lines where lump size is reduced by jaw crusher and Cone crusher. This charge is then ready for transportation through. Conveyor lines, vibrating mesh are operated in series for size segregation and storage.

Transportation to stock yard/ rail siding for dispatch

(-) 10 mm size is termed as fines while 10 to 40 mm size is lump. All size of materials contains >60 per cent Fe. Recovery percentage of (-) 10 mm size is 47.39 per cent by

weight while the balance 52.61 per cent by weight is 10 to 40 mm size. The finished products are transported by road to yard area and Railway siding for final dispatch to buyers. Wherever the mines not having railway siding facility the entire dispatch are done through roadways. Forms of energy utilised is diesel.

Major energy consumption area in iron ore mining

The electrical energy accounts for less than 5 per cent of energy used in iron ore production. The major energy consumption is contributed by diesel used for transportation. Though scope exists for energy performance improvement in both forms of energy consumption, Diesel consumption is highly dependent on driving practices apart from proper maintenance of earth movers. This requires periodic sensitisation about energy consumption among drivers and performance assessment of engines.

Though electrical energy consumption quantitatively less, it does not lose priority being the most sophisticated form of energy available today. The average price of electricity at mines range between Rs.7.80 – Rs. 8.03 per kWh. The major electrical energy requirement for mining is accounts for following heads:

- Prime movers of crusher house and conveying systems
- Lighting (outdoor and indoor)
- Water pumping system
- Other industrial support services like electric motors, drive systems and transformer compressors, ACs etc.

The energy consumption per tonne of ore varies from mines to mine as it is completely dependent on level of mechanisation and distance of stockyard from mining area. While the study team has witnessed highly mechanised mine having Ore Handling plant and transporting conveyor of more than 3km distance, in other mines portable crusher units are deployed for ore preparation at mining site only. Hence it is difficult to define a range of SEC.

Water Pumping System

Identified scope for energy conservation options

Savings by improving load side power factor for distribution loss reduction

For the mine under study had the present operating power factor at incoming main distribution panel of the plant is maintained at 0.68 levels. The operating power factor and loads at these panels were measured and it is proposed to partly increase the capacity of the installed capacitors from LT incoming panel to load- side panels as per operating load and PF to maintain consistent 0.97 PF in the system for effecting annual distribution loss reduction.

Transformers load distribution and replacement

The loading (average and observed) in various transformer were substantially low, under these conditions the equipment are subjected to high Iron or No load losses, which can be eliminated by either merger/load sharing or equipment resizing. It was found that various transformers are substantially under loaded due to over rated design parameters thus existing high Iron loss/No load loss. Most of the transformers were found to be in operation for more than 4 decades. Phase wise replacement also has been suggested with energy efficient transformers.

Water Pumping System

During the study, trials were conducted on all the pumps where water flow, discharge and suction heads and electrical power consumption for each of the pumps were measured and their specific power consumption and combined efficiency were computed. It was found that pumps were performing by far

from design parameters and were in very dilapidated condition. The pumps were in operation more than 4 decades. Immediate replacement was suggested with energy efficient pump sets.

Lighting system

One major load in mines division are of lighting system, used for indoor illumination in office cabins, control rooms, crusher and drive house, store and workshop etc as per requirement and outdoor illumination in form of streetlight or high mast lights used for night operation. Separate Trials were carried out on lighting systems for Indoor and Outdoor lighting system including area wise lux survey of the entire plant area and after thorough analysis few recommendations were made in the lighting system for proper lighting requirements and replacement with efficient lighting.

Air-conditioning system

Air-conditioning in mines division is limited to window and split ACs of different ratings. Trial runs were conducted on various AC units on sample basis under which the thermal load and electrical load were measured by using instruments like digital thermometer, hygrometer, and anemometer and power analyser ultimately computing their efficiency parameters kW/TR. The analysis found various ACs if replaced with new energy efficient ACs would return payback within acceptable period.

All the above recommendations for five mines attract a saving potential up to 5 MU given the required investments expected payback less than three and a half years.

Kishor H. Bhusal

Assistant Director (Energy & Environment Division), National Productivity Council, Bhubaneswar

Avijit Nayak

Deputy Director (Energy Management), National Productivity Council, Bhubaneswar

The government policies like Startup India, Make in India, and UDAY will accelerate growth, informs **Narendra Goliya, Chairman,** Rishabh Instruments in an email interaction with **Electrical India**.

Leading Innovations

Kindly take us through the journey of Rishabh Instruments in India so far.

Rishabh Instruments started its journey in 1987 with technology tie-up with BBC Metrawatt (Germany) for Analog Meters with a capacity of 400 instruments. The initial challenges were to make accurate components demanded by German technology and to develop moulds and tools. Since then, we have either developed many products in-house or by adapting imported technology for products like multimeters, electrical transducers and isolators, multi-function instruments, solar inverters, cam switches, controllers for DG sets, power supplies, battery chargers and current transformers with many more products to come. Many of our erstwhile collaborators are our large customers today. We have established an independent R&D centre in a separate premise with a full-fledged testing set up with EMI-EMC Lab consisting environmental testing, reliability testing etc necessary for product approvals to meet Indian and international standards requirements.

It has been a long journey for us, which led us to build the expertise in various arenas of analog and digital instrument world. The canvas covered by our products begins with the very simple requirement like measurement and display of basic electrical parameters to endorsing requirements of high-end applications wherein communication with centralised

system is required. Our product portfolio provides solution for both, portable as well as panel mount requirement as the case may be.

Some statistics have also revealed that, today we are one of the world's largest manufacturers of panel meters considering volume. We make close to about 125,000 analog products and about 30,000 digital products in a month. Added to that, we can also manufacture about 50,000 current transformers in a month. So, considering this kind of production capacity, quality and service followed for various product segments, Rishabh has a strong market presence in both domestic and international markets. Our products have an exceptional response in the world market. Our customers worldwide appreciate our patented designs in the TMI domain. Owing to the fact that 60 per cent of revenues of Rishabh stems from international market. We have a healthy ratio of international to domestic sales based on products and services. Rishabh has adapted the philosophy of one product for both markets, that is, we sell the same product manufactured in international as well as Indian market. This proves the quality and reliability of product, irrespective of the region of sale. Therefore, a dominant position has been established across the globe by our business principles and the core values.

What kind of transformations have you witnessed in Indian electronic testing and measurement market in last decade?

India is slowly progressing from price to features to specifications to reliability to safety and the market is maturing at all levels of the test and measurement industries. The era started with measurement and display of electrical parameters (single or multiple) which now has shown motion towards concerns on power quality. Parameters like harmonics, events such as voltage sag, swells or interruptions, flicker etc are now a point of concern and a new scope of measurement, display and record (time-based with user's discretion or choice).

Rishabh has been a leading player in test and measurement since 1997. The company has witnessed substantial evolution in the products meant for power sector since its inception. Innovation is the key focus of Rishabh Instruments wherein Rishabh had unique product features like automatic blocking system in digital multimeters, rotating jaw – a patented technology for digital clamp meters, operations in a live substation of 400kV with Rishabh's insulation testers, latest development of Bluetooth communication and Android app for multimeters promoting wireless communication and safe operation.

5KV Digital Insulation Tester is extremely suitable for field-testing and has proven operation in switchyards where the induction voltage field upto 600V is present. We have plans to come up with more products required by power sector to cater to the requirements of similar sectors, become a prominent player, and provide next generation equipment or instruments for future needs. We continue to lead innovations in all aspects of design and manufacture of instrument.

What technological innovations would you incorporate in your products for making them more superior and efficient?

State–of–the-art manufacturing facility and the manufacturing expertise has been core strength for Rishabh. Over decades, we learnt through various experiences and have optimised our designs, engineering, material selection, manufacturing processes, technologies and implementation techniques. The cost competitiveness begins with R&D by selecting the most efficient way of product designing and utilisation of the advance material science. The philosophy has been carried forward when it comes to the engineering and manufacturing. Optimisation of the bill of material and adaption of newer technologies and skilled work force are key elements of product cost competitiveness. Apart from this, one of the most important dimensions is quality control as it plays a vital role and has a direct impact on the costing. Zero defects, adaptation of 5s principles and right on time are levers to deliver the most cost competitive products with unmatched quality.

Features and functionality were added in the beginning with high-end products, which are then brought down to the low end as required. Example: energy import export features were only in some products but today it is a standard feature. Few Multimeters had RMS, wide band frequency function but now many models have it customers demand for it has also increased. People want higher crest factor with power electronics to produce more and more distorted waveform, SMPS as auxiliary has nearly become an industry standards instead of linear power

supplies etc.

How does digitisation help in improving performance and reliability of your products?

Industrial growth in India has seen a major hike recently with a major shift towards innovation and technology. As we all have witnessed the shift from the use of old telephone to smart phone, Rishabh has also been continuously adapting to the new technologies and innovations.

Right from raw material like polycarbonate to ICs (Integrated Circuit Chips) the change has been reflected in every product sufficing need of users and customers globally. Rishabh has been successful in creating Touch Screen multifunction meters, power supplies with three different protection modes, Bluetooth functionality, wireless data transmission and many more such features. Our perspective in global supply has always initiated and adapted the change. Our major products, which are manufactured, undergo a testing procedure that is completely automated and has no manual intervention. Even our analog meters are tested through a closed loop system called as Analog Test Setup and a test report is generated for each and every meter calibrated and tested.

How would you differentiate Indian electrical test equipment markets from the global markets, particularly, European and American markets while offering your services and products?

It is difficult to compare the electrical requirements of global markets but individually could be understood. European countries have cold environmental conditions whereas US conditions are both different. As you are aware, India and major European countries work with 50Hz frequency whereas America has operations with 60Hz frequency. These kind of difference, although peculiar to their respective countries or regions make it difficult for comparison.

As said earlier, Rishabh has been involved in product design and sale of products in all market; one product complying with international standards is our motto. Since inception, Rishabh has adapted the manufacturing of products considering the extreme ranges of various parameters, which make the product robust, self-contained, efficient and reliable. Moreover, the product quality assured is blessed with the help of vigorous testing methods and calibration procedures.

What are your expansion plans in India with the government's 'Make in India' program? What potential do you foresee for your company with the Indian Government's focus on development of infrastructure like smart cities, roll out of power projects, etc.?

'Make in India' is one of the colossal campaign taken by Government of India. To just brief about this campaign, I think it will lead to an increase in exports and manufacturing providing many new opportunities to the young blood in India. It will boost the economic growth in India along with GDP and will solve the employment issues faced by the young generation. It also fosters the entrepreneurial skills within India and many potential business amateurs are turning into successful entrepreneurs. There is a lot of work being done on innovation on both the technology side and business side.

'Make in India' creates a higher brand value of Indian products in the international markets. Rishabh has started leveraging the same, as the export business of Rishabh comprises of 60 per cent of the overall business of the company. It conjointly says that all the foreign make companies has to have their 60 per cent manufacturing set up in India. Indian products will also have global level specification and will comply with all international products available in the market with neck-to-neck match to the global players. In India, around 98 cities and towns are in the blueprint to transform as smart cities. There are opportunities for the industries in India to play a catalyst role for this enormous transformation of cities. Rishabh mainly deals in electrical sector and under Smart City initiative; the major transformation would be with electrical grids, energy conservation initiatives, energy utilisation and other such crucial factors. Rishabh has good opportunities with these government initiatives as we are already into the industrial control products and test and measuring instruments.

The government policies like Start-up India, Make in India, Clean Energy, and UDAY will accelerate the growth in this sector with a good pace and would form a sustainable roadmap for this sector. At the same time, it would be prudent to have realistic energy price levels for the non-conventional energy sources to sustain the business model.

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PROJECTS EXPERIENCES

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SERVICE EXPERIENCES

OPERATION & MAINTENANCE ,PLAN SHUTDOWN, UP TO 400KV SUBSTATION, SWITCHYARD, LINE MAINTENANCE, HOT LINE MAINTENANCE, LIGHTING MAINTENANCE, EOT CRANE, POWER & DISTRIBUTION SYSTEM, MALLS, WIND SECTOR, SOLAR SYSTEM AC & DC, HOSPITALS, OIL & GAS SECTOR, GOVERNMENT UTILITIES,

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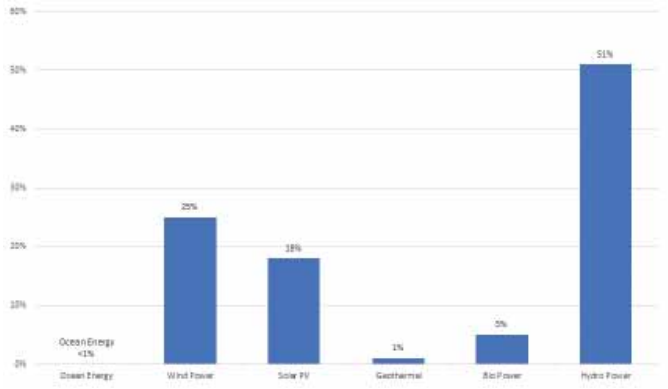
Renewable Energy: *Today and Tomorrow*

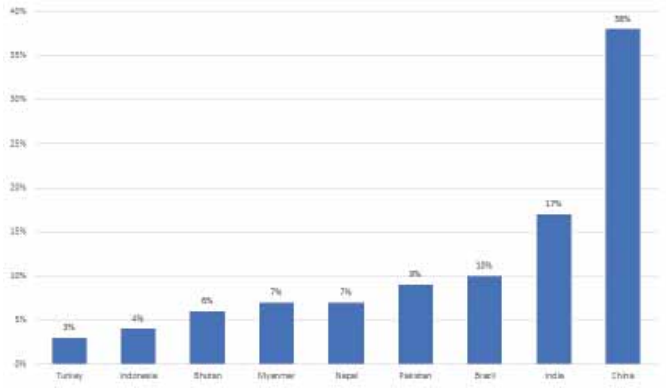
The renewable energy sector has seen rapid growth over recent years. This article takes an in-depth look at how renewable is shaping our energy future in India.

The year 2017 was record-breaking one for renewable energy, characterised by the largest ever increase in renewable power capacity, falling costs, increases in investment and advances in enabling technologies. Many developments during the year impacted the deployment of renewable energy, including the lowest-ever bids for renewable power in tenders throughout the world, a significant increase in attention to electrification of transport, increasing digitalisation, jurisdictions pledging to become coal-free, new policies and partnerships on carbon pricing, and new initiatives and goals set by groups of governments at all

Renewable Energy Scenario (2017)



Hydropower capacity in 2017 (MW)



levels. As of 2016, renewable energy accounted for an estimated 18.2 per cent of global total final energy consumption, with modern renewable representing 10.4 per cent. The number of countries with renewable energy targets and support policies increased again in 2017, and several jurisdictions made their existing targets more ambitious.

Today, the prominent renewable are hydropower, wind power and solar PV. So, in this article we will talk about hydropower, wind power and solar PV.

Hydro Power

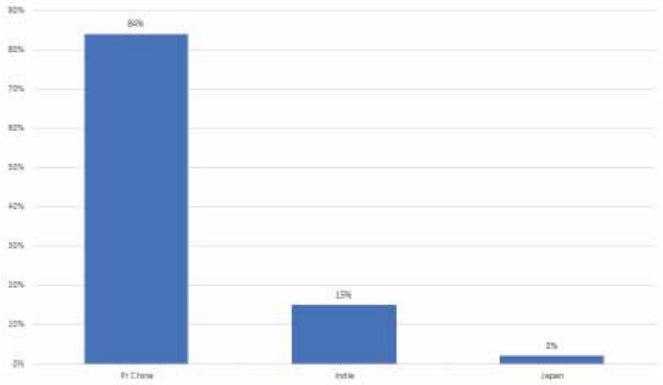
During 2017, an additional 21.9 GW of installed hydropower capacity was added worldwide, with China once again making up for the largest share of newly commissioned projects. Total installed capacity worldwide has now reached 1,267 GW, producing an estimated 4,185 TWh in clean electricity – two-thirds of all renewable electricity generation. A record 4,185 terawatt hours (TWh) in electricity was generated from hydropower in 2017, avoiding approximately 4 billion tonnes of greenhouse gases as well as harmful pollutants. Worldwide hydropower installed capacity rose to 1,267 gigawatts (GW) in 2017, including 153 GW of pumped storage. During the year, 21.9 GW of capacity was added including 3.2 GW of pumped storage. Growth was fastest in East Asia and the Pacific, with 9.8 GW of capacity added in 2017, followed by South America (4.1 GW), South and Central Asia (3.3 GW), Europe (2.3 GW), Africa (1.9 GW) and North and Central America (0.5 GW). China is the world's largest producer of hydropower, and accounted for nearly half of global added installed capacity, at 9.1 GW. It was followed by Brazil (3.4 GW), India (1.9 GW), Portugal (1.1 GW) and Angola (1.0 GW). 58.4 per cent of surveyed hydropower decision-makers and professionals expect to expand their company's installed capacity in the next three years, while 51.7 per cent of respondents expect to increase investments in hydropower over the next three years. This year, 2018, is shaping up to be a milestone year for the hydropower sector. Firstly, IHA and partners are preparing to launch an expanded Hydropower Sustainability Assessment Protocol covering climate change mitigation and resilience, as well as a new tool for undertaking targeted, cost effective assessments of projects. This represents an important development in the toolbox available for reviewing, understanding and communicating the social, economic, environmental and technical performance of hydropower. In addition, during 2018, it is expected to see the completion of new green bond eligibility criteria for hydropower, which will provide much needed clarity for this important financial market.

Wind Power

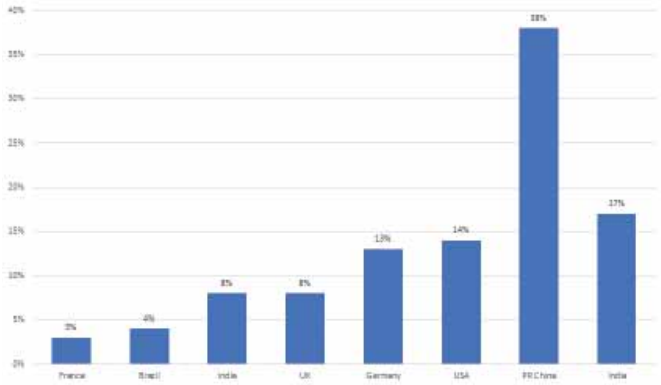
The global wind power market remained above 50 GW in 2017, with Europe, India and the offshore sector having record years. Total installations in 2017 were 52,492 MW, bringing the global total to 539,123 MW. The annual market was in fact down 3.8 per cent on 2016's 54,642 MW; and the cumulative total is up 11 per cent over 2016's year-end total of 487,279 MW. The offshore segment had a record year with 4,334 MW of installations, an 87 per cent increase on the 2016 market, bringing total global installations to 18,814 MW, and representing a 30 per cent increase in cumulative capacity. Offshore is still only about 8 per cent of the global annual market, and represents about 3.5 per cent of cumulative installed capacity, but it's growing quickly.

China, the largest overall market for wind power

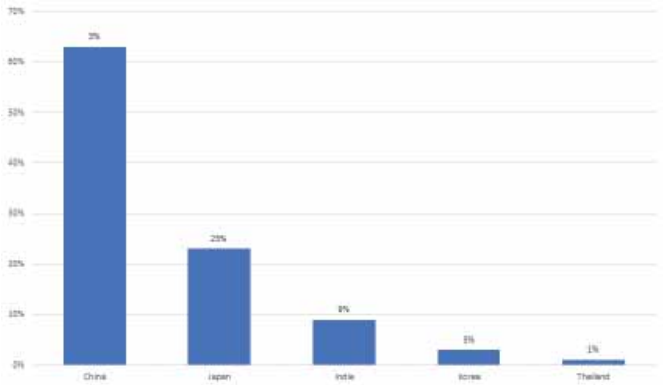
Wind Power Capacity in ASIA (2017)



Top 10 new Installed Capacity (2017)



since 2009, retained the top spot in 2017. Installations in Asia once again led global markets, with Europe in the second spot, and North America in third. Once again in 2017, as has been the case since 2010 (except for 2012), the majority of wind installations globally were outside the OECD. China will cross the 200,000 MW mark in 2018, adding another milestone to its already exceptional history of renewable energy development since 2005. For the ninth year in a row, Asia was the world's largest regional market for new wind power development, with capacity additions totalling 24.4 GW. China's wind market reached 188 GW by the end of 2017, reinforcing China's lead in terms of cumulative installed wind power capacity. India had a record year in 2017, adding 4.15 GW, the first time the country has broken 4 GW in a single year, taking total capacity to 32.8 GW and cementing its position as the world's fourth largest wind market. Additionally, the Ministry of New and Renewable Energy (MNRE) has asked state governments to consider feed-in tariffs for Micro, Small and Medium Enterprises (MSME) for projects below 25MW at tariffs to be determined by the states. First assessments of offshore wind potential in India together with pre-feasibility studies for two key coastal states of Tamil Nadu and Gujarat have been conducted by GWEC led FOWIND (Facilitating Offshore Wind in India) project. Offshore wind power could play an important role in India due to the large wind resources available near centers of high-energy demand. The key challenges faced by the Indian wind industry include the lack of a system to trade and transfer wind power from windy states to other parts of the country and insufficient grid connections.



Solar PV Capacity in 2017 (MW)

Key findings

Total installed capacity 32,848 MW; Wind power capacity added in the country in 2017 4,148 MW; Wind-generated electricity produced in 2017 53,726 GWh; Share of wind generated electricity in India's total electricity consumption 4.35 per cent; People employed by the wind industry at the end of 2017 0.2 million; Number of turbines 32,136; Leading turbine suppliers in 2017 Siemens Gamesa, Suzlon, Inox Wind Limited.

Solar PV - Key Findings

In 2017, the U.S. produced approximately 260 MW of PV cells and 970 MW of PV modules—a decrease of 66 per cent and 43 per cent, respectively, year over year. Global PV installations reached 415 GW-DC, an annual increase of 98 GW-DC from 2016. At the end of 2017, global CSP installations reached 5.6 GW, an increase of 400 MW. BNEF estimates that approximately 10 GW of PV was installed in India in 2017, bringing cumulative deployment to 21 GW. An increase in module prices and the ambiguity over tax rates delayed installation of several projects in H2 2017. India aims to bring 80 GW of PV (and 28 GW of wind) to auctions in 2018 and 2019 as they try reach their 175 GW targets of renewables by March 2022. While

most analysts estimate an increase in PV installations in 2018, projections range from 87 GW to 111 GW. In 2018, analysts expect China (~50 GW), the United States (~10 GW), and India (~8 GW) to remain the three largest markets; however, ROW is expected to significantly expand.

Bio Power

Bioenergy is renewable energy made available from materials derived from biological sources. Biomass is any organic material which has stored sunlight in the form of chemical energy. As a fuel it may include wood, wood waste, straw, and other crop residues, manure, sugarcane, and many other by-products from a variety of agricultural processes. Recently, a new company called Mango materials used bacterial fermentation to produce an intracellular biopolymer, polyhydroxyalkanoate from methane. The great advantage of biopolymers is that it is biodegradable which makes it environment friendly. Because methane is being used that decreases the price of polymers that it would compete with traditional plastics. Also, because methane would be converted into biopolymer that would reduce methane emissions. Chief Executive Officer Molly Morse said that the unused methane would be enough to produce more than three billion pounds of biopolymer. Morse announced in 2017 that using this polymer will reduce the waste in the textile industry because it will be reproduced as biopolymer again in every effective industrial loop.

Geothermal

Geothermal power is ranked as the fifth biggest renewable energy source. The installed power production capacity from geothermal sources is about 13.438 GW as of 2016 [90]. One-third of the geothermal energy resources provide electricity generation, and the remaining two-thirds are used for direct heat generation. Globally, the geothermal power generation is dominated by the US, Philippines, Indonesia, New Zealand, and Italy.

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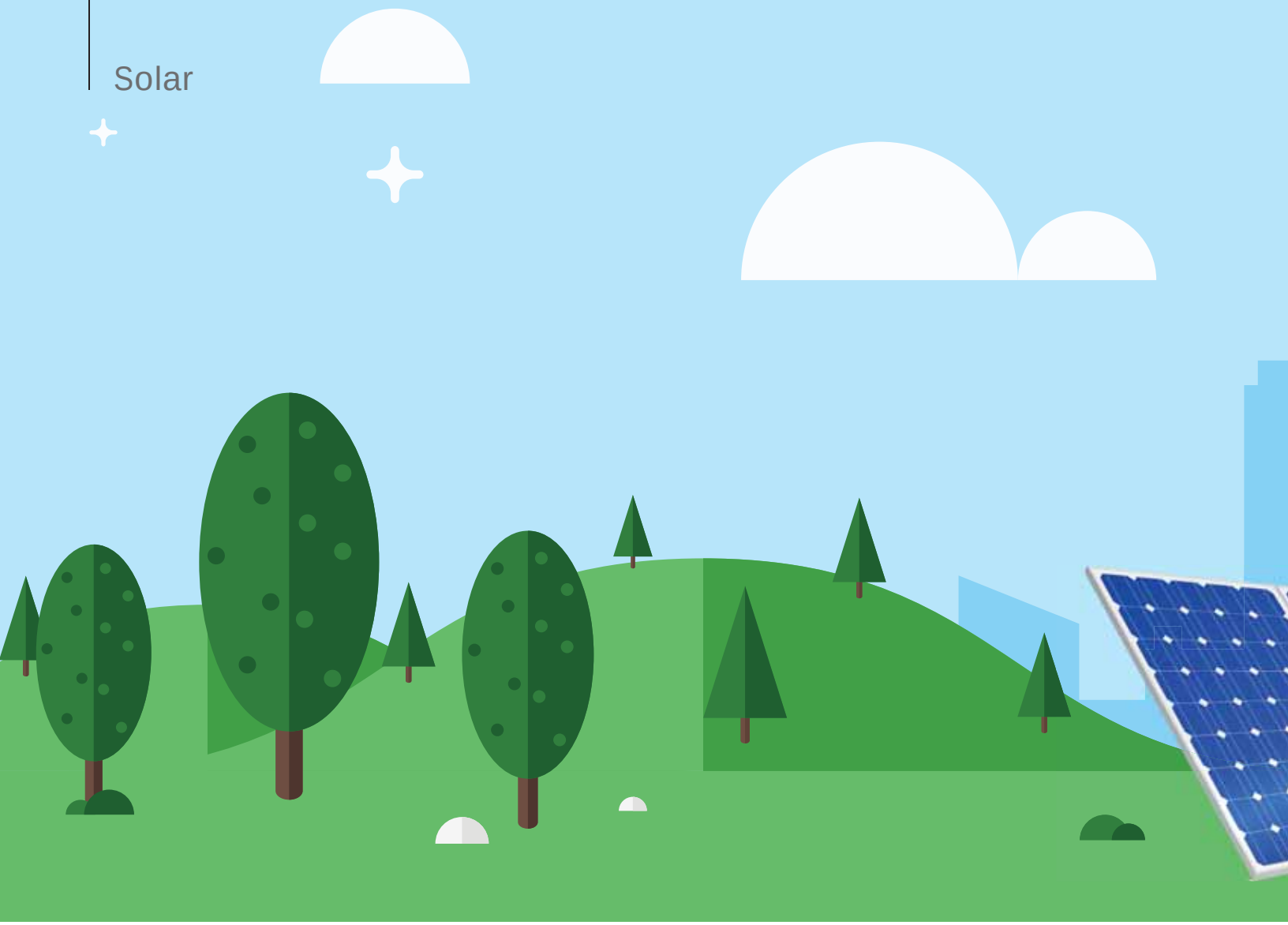

Shedding light on various intricacies of Indian solar sector.

SOLAR SHINES BRIGHT

By Supriya A Oundhakar, Associate Editor

Burgeoning greenhouse gas emissions have pushed India to make a commitment at Paris to reduce its carbon footprint by a third by 2030. As a part of this, Indian energy sector has been witnessing a shift from conventional energy to clean, renewable energy. In renewables, solar photovoltaic (PV) energy is making rapid strides with installed capacity of 25 GW as of August 2018. Indian solar sector has observed a growth momentum of

75 per cent in 2017-18 with 10 GW of solar capacity installation that was higher than that of all other energy sources.

The Ministry of New and Renewable Energy (MNRE) is expected to commission about 11-12 GW of solar power capacity in the financial year 2018-19. Tenders close to 12 GW are expected, mostly under central schemes from Solar Energy Corporation of India (SECI). This generates great opportunities to all solar players due to lower off-take risk. Under the MNRE's Solar Cities program, 60 solar cities will be developed thereby adding to the overall capacity of the country.

The World Bank notes that India is having among the best conditions in the world to capture and use solar energy. Moreover, due to Central and state governments' congenial policies, India is on its way to become a solar energy hub for mega solar parks. Huge solar power projects are being developed due to provoking interest of domestic and foreign investments in the sector as a result of ease in land acquisition and other legal approvals from the government. Indian solar sector achieved the successful commissioning of then the world's largest solar project of 648 MW in Kamuthi, Tamil Nadu in September 2016. The 2,225 MW Bhadla solar project in Rajasthan will be the world's largest solar installation when completed. In April 2018, Chief Minister of Gujarat Vijay Rupani gave approval for setting up a 5,000 MW capacity solar park on 11,000 hectares at the Dholera Special Investment Region (SIR) with an investment of Rs 25,000 crore.

India fulfils its requirements for solar modules or cells through imports from China and Malaysia. In order to encourage the domestic solar module manufactures, the government had in July imposed a

Indian Government commitment at international level and progress on the ground show potential for India to become a global leader in renewable energy especially with Government initiatives like establishment of International Solar Alliance.

Amit Gupta,
Director, Legal & Corporate Affairs, Vikram Solar

25 per cent safeguard duty for a year from July 30, 20 per cent for the following six months and 15 per cent for six months after that. However, it can be a deterrent for capacity additions.

According to Sunil Rathi, Director, Waaree Energies, "The implementation of the duty has provided a level playing field to domestic manufacturers and allowing them to showcase their capabilities of offering quality products. It also allows flow of investments, which would provide an impetus to manufacturers and aid in bringing to the sector latest technologies and R&D."

The safeguard duty imposition has been counterproductive to the units set up in Special Economic Zones (SEZs), as these units were also made liable to pay safeguard duty. 60-70 per cent of the domestic solar manufacturing capacity is situated in SEZs. Amit Gupta, Director, Legal & Corporate Affairs, Vikram Solar, says, "It is pertinent to note that the safeguard duty has been levied for two years and during this period, solar panels for already bid out projects will be procured mostly, for which pass through of duty under the change in law provision of the Power Purchase Agreement has been provided. This has negated the impact of safeguard duty." The prices of solar modules of domestic manufacturers and importers are nearly competitive, but as the pass through of duty is available for imported modules, developers prefer procurement of imported modules over domestic ones. Thus, safeguard duty has failed to accord intended protection to the domestic manufacturers rather it is promoting imports, he adds.

Manoj Gupta, Vice President – Solar Business, Fortum India says, "Uncertainties regarding Government policies regarding the sector with respect to GST rate, Safeguard duty, ISTS project, grid approvals, cancellation of various bids, timelines of new solar parks etc still loom over the future of the sector. Clarity on all these issues will greatly boost the annual rate of installation and India can emerge as second largest solar player globally after China."

Growth Drivers

There are a lot of factors driving the Indian solar PV industry. One of the factors that is contributing to the growth of the sector is decline in the cost of solar PV modules across the globe.

According to the International Renewable Energy Agency (IRENA), by 2020 the price of energy production in large solar power plants could fall to around three US cents per kWh in many regions of the world. Photovoltaic has, therefore, become more accessible. In 2017, costs continued to fall for solar panels due to various factors related to the manufacturing cost of modules price, various new technology advancement in PV sector and not least the change in policy by China which created the oversupply of module, according to Manoj Gupta of Fortum India.

Stiff competition among solar power developers leading to reduced tariffs pushed Acme Solar Holdings to win the Bhadla bid at Rs 2.44 a unit. It again bid the same price for 600 MW in a 3,000 MW auction held by the Solar Energy Corporation of India (SECI).

The decline is usually attributed to increase in efficiency of material, optimisation of production and ability to achieve economies of scale.

Capital costs are expected to decline further in the next few years as old technologies continue to be replaced by new ones. The more cost effective and efficient the technology is, the better the chances of it driving mass production.

Going ahead, Crisil Research expects solar power capacity additions to ramp up to 44-46 GW over the next five years (FY 2018-

The industry would witness more stability and sustainable business models, spurred by the various initiatives and policies from the Government.

Sunil Rathi,
Director, Waaree Energies

22) as compared to 11.4 GW over the last five years (FY2013-2017).

The capacity augmentation will be due to state solar policies. With the thrust from the Central Government for the growth of the sector, states have rolled out conducive policies for achievement of targets by 2022. Government focus on intra-state transmission is also going to be positive in terms of supporting infrastructure for upcoming capacities, according to Crisil. Further, the government's push for cash rich PSUs for setting up of renewable energy projects has helped NTPC for commissioning of a total of over 870 MW of capacity. Moreover, Indian railways has committed to generate 5 GW of solar power by 2025.

It is further estimated that Rooftop Solar projects will add 8 GW of rooftop projects by 2022. Further, the capacity additions would be supported by improvement in the discoms infrastructure, continuation of net metering regulations or benefits and other regulatory incentives.

Further, the government of India's declaration at Paris through Intended National Determined Contribution (INDC) is a positive driver for the growth of renewable energy.

The Government of India has declared at Paris Agreement in 2015 to achieve 30 per cent of the total energy demand through renewable energy by 2030. Renewable energy transition in India is inevitable with clean energy becoming available at below average procurement price of power in India. Therefore, switching to renewables along with storage is the future of energy in India. New capacity addition in power is being ensure through renewable energy solution, says Amit Gupta of Vikram Solar.

Technology

The solar sector is dynamic with constant focus on developing new emerging technologies. Cost-effective technology and efficient manufacturing processes are the main factors driving the mass production. Industry players are giving due emphasis to technological advancement and innovation to continuously improve their products. It is the innovative technology that makes a difference to sustainability and cost effectiveness of solutions and products.

The solar market is prospering at a great pace. According to the latest report by the International Energy Agency (IEA), it is expected that the photovoltaic sector will drive the renewable energy market in the coming years, beating hydroelectric and wind sector.

Waaree Energies was the first company in the sector to bring floating solar and Merlin technology to India. Sunil Rathi of Waaree Energies elaborates, "We are continuously striving to better our offerings and develop indigenous products and solutions, whether it is flexible Module technologies or D-I-Y kits (Pronto). We also need to keep ourselves aligned to the latest technologies which are changing the growth curve in the industry. The advent of mono PERC technology is aiding the evolution of solar power in India."

Keeping in line with Vikram Solar's focus on adopting pioneering and innovative technologies, the manufacturing facility of the company has the finest machinery and equipment imported from United States, Switzerland, Germany and Japan.

Amit Gupta informs, "The company introduced mono-crystalline module line with higher energy generation capacity (at least 10 per cent more than poly crystalline modules) and the product is named 'SOMERA' in 2017. In June 2018, we launched Tigo Integrated Smart Module - Solivo - at Intersolar Munich 2018. In September 2018, we launched half-cut cell module at REI 2018."

Vikram Solar also intends to start production of AC Modules and

The future of the industry can be bright if right investments happen in this sector. India is currently emerging the most preferred destination for investment in solar energy.

Manoj Gupta,,
Vice President – Solar Business, Fortum India

Bi-facial modules by Q3 FY18-19. "We have also introduced automated silicon glue sealed junction boxes for enhanced durability and made a transition from 4-busbar to 5-busbar in module manufacturing," he adds.

Outlook

Solar energy is all set to change the energy landscape of India. Industry players envisage the potential for solar industry in India as the country is already the second most attractive market for solar equipment globally with rising RE share in energy mix. As per the Ministry of Power, India's energy mix is evolving slowly with fossil fuels meeting 82 per cent of demand; coal remaining the dominant fuel with a 57.9 per cent share of total production in 2018. In order to bring about a clean energy revolution, India needs to focus and implement strategies for the long-term growth besides succeeding in achieving current solar deployment targets.

Indigenous solar panel and cell manufacturers should take the imposition of safeguard duty as an opportunity to step up their R&D to come up with more cost-effective and efficient technologies that give them an edge over their Chinese counterparts.

Investing in domestic manufacturing can help in building supply chain, control prices, and earn foreign exchange through exports besides creating jobs, increasing GDP for the country and stabilising adverse balance of payments.

Investing in power evacuation and dispersion infrastructure building is also needed to attain last mile connectivity in the farthest corners of the country. Indian Government commitment at international level and progress on the ground show potential for India to become a global leader in renewable energy, especially with the Government initiatives like establishment of International Solar Alliance, suggests Gupta of Vikram Solar.

India can function on a fully renewable electricity system by 2050 due to an abundance of renewable resources, according to a new research by Lappeenranta University of Technology (LUT). Manoj Gupta of Fortum India states, the future of the industry can be bright if right investments happen in this sector. India is currently emerging as the most preferred destination for investments in solar energy.

Sunil Rathi of Waaree Energies foresees an expedited adoption of solar power as the dominant power source in India. In addition, the industry would witness more stability and sustainable business models, spurred by the various initiatives and policies from the Government. The current safeguard duty will also help bring domestic solar manufacturers to the forefront, and we will see a robust manufacturing hub in India for solar equipment. The solar sector is on the right track to enhancing its capacity to 100 GW installations. However, ambiguity over its achievement within the proposed timeline still looms large. With solar prices reaching an optimum level, Indian solar will continue to attract new players. Players with large and cheaper capital, especially, global players, can give tough competition to domestic and medium and small players.

Bloomberg New Energy Outlook 2018 also predicts that by 2050, wind and solar technology provide almost 50 per cent of total electricity globally – '50 by 50' – with hydro, nuclear and other renewables taking total zero-carbon electricity up to 71 per cent.

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Future looks positive for RE

Ashish Khanna, President, Tata Power (Renewables) shares his views on the growth of Indian solar PV industry in an interaction with **Electrical India**.

What are the trends shaping solar PV industry?

The Indian solar PV market has witnessed tremendous growth in recent years in terms of new capacity addition. With 11 GW, India is set to become the second largest solar PV market this year as global demand reaches 113 GW as per the IHS Markit report. Solar PV market in India is slated successfully to achieve the target of 100 GW solar power generation capacities by 2022 with a key focus on the development of renewable energy sector in India.

Mega solar power plants are developing in full swing with ample domestic and foreign investments in the sector due to ease in land acquisition and other legal approvals from the central and state government.

Various subsidies and incentives provided by the government have created good amount of awareness and pact among the end users for adopting solar power as an alternative source of energy over conventional sources.

How technology does play a key role in escalating the growth of solar business?

Today, India has moved up to be the fourth from being the seventh largest energy consumer in the world. Despite the growth, the country's major population has limited or no access to electricity and has the world's lowest per capita consumers of electricity. The rapid growth of demand has overtaken the supply, leading to power shortages in spite of the manifold growth in power generation over the years. To meet this demand, India plans to ramp up solar power generation to 100 GW by 2022.

This step in the right direction will not only support the demand requirements but also help bring sustainable, clean, climate-friendly electricity to millions of Indians. Latest technological developments in solar rooftop PV plants such as Net-Metering, Feed-In Tariff, Accelerated Depreciation Mechanism, Generation Based Incentives have facilitated the use of clean and renewable solar energy amongst consumers at a small scale. This is expected to boost the solar rooftop PV market in the coming years.

What are the growth drivers of the Indian solar PV industry?

India's renewable industry has achieved a significant growth and solar sector, in particular, has emerged to be the primary growth driver to meet the targets. Today, our country aims to have an installed capacity of 175 GW renewables by 2022, of which 100 GW is outlined for solar power.

According to the recent report by Centre for Policy Research, Indian carbon dioxide (CO_2) emissions from energy generation in 2030 could be nearly double 2012 levels but will still meet its international commitments. Central Electricity Authority (CEA) has pledged that no new coal-fired power plants will be proposed and focus on expansion of solar parks. The authority also stated that renewables will contribute to about 20.3 per cent and 24.2 per cent of the total energy requirement in 2021-22 and 2026-27.

India is well on its way to achieve the solar energy targets; 60 GW is from large solar parks and 40 GW from solar rooftops. The installation of large-scale solar is by far on the schedule, however, solar rooftops need to be given a thrust. The Government's strong commitment to expand solar sector by providing it with supportive regulatory framework has helped India to be the global outperformer for investments to build solar capacity. With this, the solar capacity is expected to grow at an annual average rate of 16.0 per cent between 2018 and 2026.

What is your outlook for solar industry?

India is fast transitioning towards a renewable-focused economy reflecting a national commitment towards green energy. With nearly 293 global and domestic companies committing to generate 266 GW of solar, wind, mini hydel and biomass-based power in India over the next decade, the future looks positive. Indian power sector boasts the potential of investing Rs 15 lakh crore over the next four to five years, which indicates immense opportunities in power generation, distribution, transmission and equipment segment. The renewable energy storage system market is expected to witness robust growth, over the next decade, once the cost of storage declines, which is likely to happen because of the sheer volume growth through the electric vehicle route. EI

The Sun rises in the Northeast

This article attempts to review the renewable energy programme in the region of solar technology and suggests measures for development of the sector in Northeast India.

The Indian renewable energy sector is the fourth most attractive renewable energy market in the world. The country ranks fourth in the world in terms of total installed wind power capacity. Installed renewable power generation capacity has increased steadily over the years, posting a CAGR of 9.29 per cent over FY 08–18. India added record 11,788 MW of renewable energy capacity in 2017-18 and 1,832.26 MW (grid interactive and off-grid)

Table 1: Growth of installed capacity in India (Source: MNRE)

Installed Capacity as on	Thermal (MW)				Nuclear (MW)	Renewable (MW)			Total (MW)	% Growth (on yearly basis)
	Coal	Gas	Diesel	Sub Total thermal		Hydro	Other Renewable	Sub Total Renewable		
31 Dec 47	756	–	98	854	–	508	–	508	1,362	–
31 Dec 50	1,004	–	149	1,153	–	560	–	560	1,713	8.59%
31 Mar 56	1,597	–	228	1,825	–	1,061	–	1,061	2,886	13.04%
31 Mar 61	2,436	–	300	2,736	–	1,917	–	1,917	4,653	12.25%
31 Mar 66	4,417	137	352	4,903	–	4,124	–	4,124	9,027	18.80%
31 Mar 74	8,652	165	241	9,058	650	6,966	–	6,966	16,664	10.58%
31 Mar 79	14,875	168	164	15,207	640	10,833	–	10,833	26,680	12.02%
31 Mar 85	26,311	542	177	27,030	1,095	14,460	–	14,460	42,585	9.94%
31 Mar 90	41,236	2,343	165	43,764	1,565	18,307	–	18,307	63,636	9,89%
31 Mar 97	54,154	6,562	294	61,010	2,225	21,658	902	22,560	85,795	4.94%
31 Mar 02	62,131	11,163	1,135	74,429	2,720	26,269	1,628	27,897	105,046	4.49%
31 Mar 07	71,121	13,692	1,202	86,015	3,900	34,654	7,760	42,414	132,329	5.19%
31 Mar 12	112,022	18,381	1,200	131,603	4,780	38,990	24,503	63,493	199,877	9.00%
31 Mar 17	192,163	25,329	838	218,330	6,780	44,478	57,260	101,138	326,841	10.31%
31 Mar 18	197,171	24,897	838	222,906	6,780	45,298	69,022	114,315	344,002	5.25%

in April-July 2018. The focus of Government of India has shifted to clean energy after it ratified the Paris Agreement. With the increased support of government and improved economics, the sector has become attractive from investors perspective. As India looks to meet its energy demand on its own, which is expected to reach 15,820 TWH by 2040, renewable energy is set to play an important role.

Renewable energy in India comes under the purview of the Ministry of New and Renewable Energy (MNRE). India was the first country in the world to set up a ministry of non-conventional energy resources, in the early 1980s. Solar Energy Corporation of India (SECI) is responsible for the development of solar energy industry in India.

Life on Earth is heliocentric as most of the energy is derived from

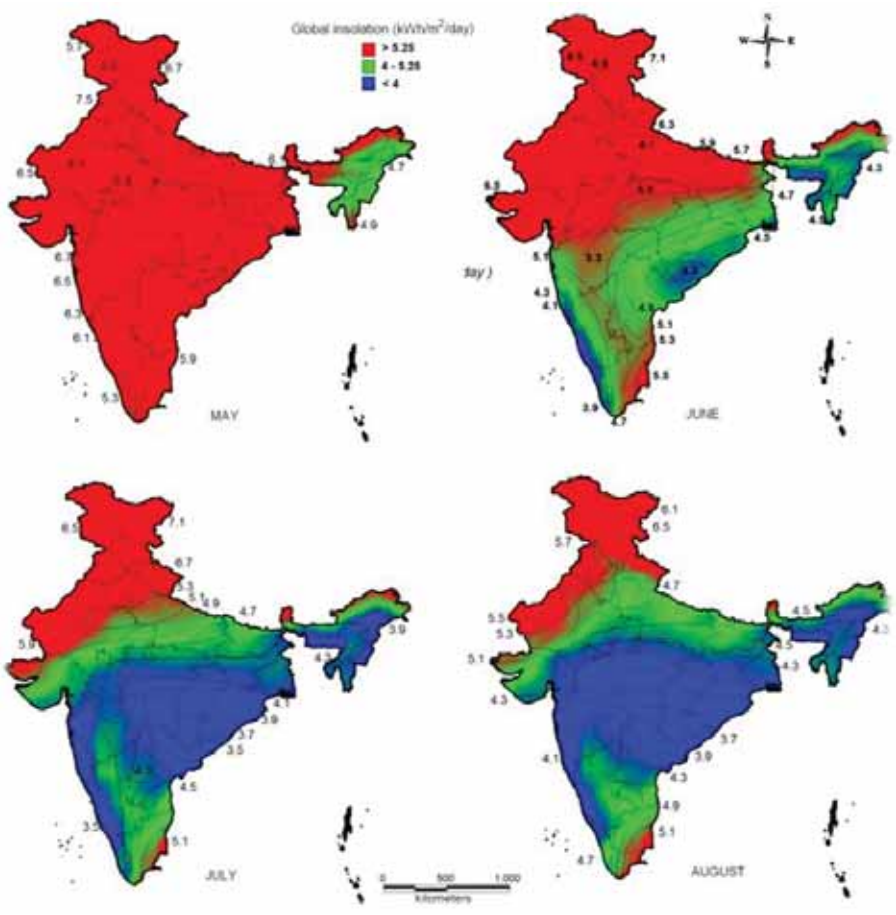

Figure 1: Solar hotspot in India (Source: GRDSS-IISC)

Figure 2: North East India

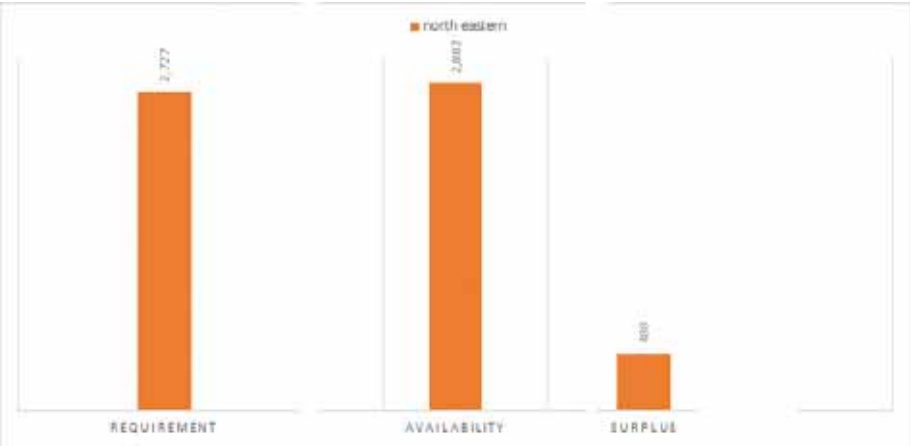

Figure 3: Anticipated all India power supply position in terms of energy (Source: www.cea.nic.in)

the Sun. Imminent climate changes and demand of clean energy has raised up significantly. The proper dissemination of technologies for large scale power generation is determined by the true potential of identified solar hotspots. The power generation with the emission reduction potential aiming to achieve the long term target of NSM (national solar mission) considering the techno-economic and organisational aspect in the dissemination of solar power technologies like SPV (solar photovoltaic) cells and CSP (concentrated solar power).

The electricity generated by SPV cells in proportional to area exposed and intensity of global insolation received. Component selection and system design plays a pivotal role in SPV power-based system. CSP technology preferentially utilises the direct component of global insolation which could be forwarded to the receiver using lenses or mirrors. The receiver being of smaller area decreases heat loss and hence increases the efficiency. With the help of high-resolution data from NASA SSE the solar hotspots based on exploitable potential in India across the federal boundaries of India and agro climate zones are identified.

Direct insolation with minimum threshold value of 1800Kwh/m2/year is the best recommended for CSP in order to achieve levelised electricity costs. CSP technologies perform better in semi-arid and arid regions. Direct insolation with respect to global insolation varies season wise.

Energy Scenario in Northeast India

The seven sisters and one little brother (Sikkim) region of India are less developed region of the country. The Ministry of Development of North Eastern Region has improved the electrification status of Northeast India. The North Eastern states are achieving greener grid.

From Figure 3 and 4, it is observed that the surplus energy is anticipated of the order 3 per

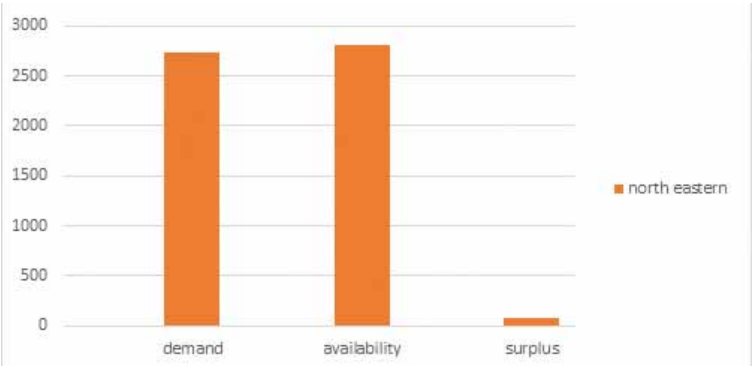

Figure 4: Anticipated all India power supply position in terms of peak (Source: www.cea.nic.in)

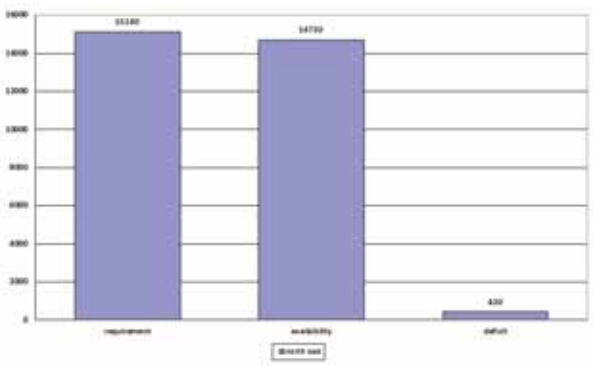

Figure 5: Acute power supply in north east India in terms of energy (Source: www.cea.nic.in)

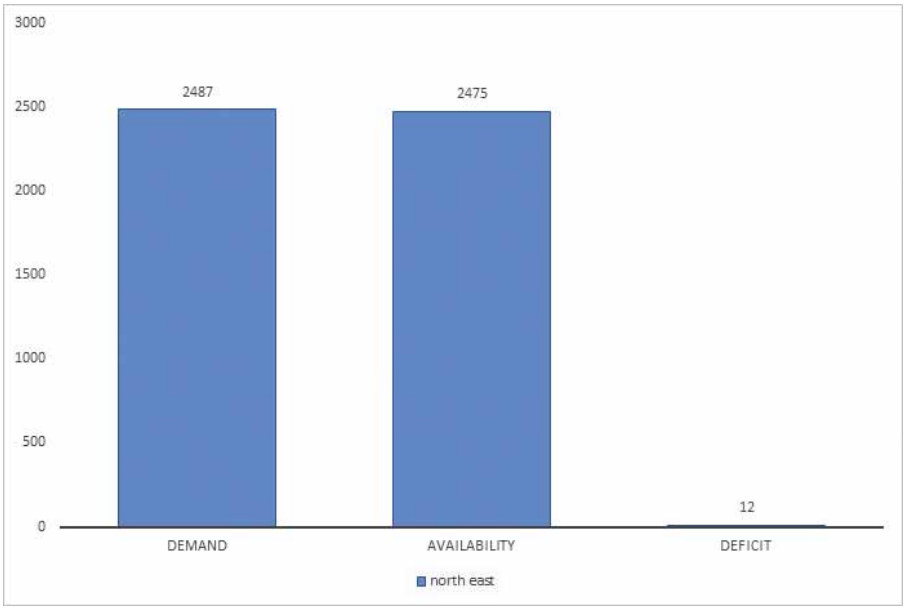

Figure 6: Acute power supply in Northeast India in terms of peak
(Source: www.cea.nic.in)

cent in the north eastern region whereas the peaking surplus is likely to prevail in the north eastern region tunes to 2.7%.

The actual energy requirement, energy availability, peak demand and peak demand met in North Eastern Region during 2016-17 was lower than anticipated Central Electricity Authority LGBR: 2017-18 9 by 6.5%, 0.9%, 11.2% and 8.2% respectively. The actual energy shortage in the Region was 2.8% as compared to forecast shortage of 8.3%. The actual energy shortages in Arunachal Pradesh, Assam, Manipur and Nagaland were 2.1%, 3.6%, 3.4% and 1.9% against the anticipated shortages of 8.9%, 22.4%, 3.6% and 15.0% respectively.

The main reason for lower energy shortages than the anticipated were lower actual energy requirement and higher actual energy availability than the anticipated figures. The actual energy shortages in the case of Mizoram and Tripura were 2.6% and 1.3% against anticipated surplus of 10.6% and 73.9% respectively due to lower energy availability than the forecast. The lower energy availability was due to net export of power by Mizoram and Tripura through bilateral contracts or through traders. Meghalaya did not face any energy shortage against an anticipated shortage of 6.8% due to lower energy requirement.

Out of all the above-mentioned techniques use of solar energy is easily available, clean and economic way to generate electricity. In India solar radiation is available sufficiently over the country. The dependency on non-renewable sources, will be decreased if extraction of solar power is increased. In long term it will also reduce carbon dioxide emission to the environment.

The extraction of electricity from solar energy in the north eastern region can be portrayed in different ways such as solar grid programme (table 2), solar parks (table 3), grid connected roof top and small solar power plant programme in the north eastern states (table 4).

The state-wise solar energy potential and solar capacity installed in the north eastern region states is given in the above table 2. The national solar mission aims to achieve a target of 100 GW. The ministry has selected the capacity of phase-II grid connected projects through various schemes such as bundling, generation-based incentive (GBI), viability gap funding (VGF). Depending upon the availability of resources the target capacity may be altered.

The following solar parks are been approved under the mentioned states in the north east region.

Table 2: Solar Grid Program

State	Solar potential (GWP)	Installed capacity(MW)
Arunachal Pradesh	9	4.39
Assam	14	12.45
Manipur	11	1.33
Meghalaya	6	0.06
Mizoram	9	0.02
Nagaland	7	0.05
Sikkim	5	0.01
Tripura	2	5.09
Total		23.4

(Source: MNRE)

Table 3: Solar parks

State	Capacity (MW)	Name of the solar power parks developer	Land identified
Assam	80	APGCL	Amguri in Sibasagar district
Meghalaya	20	MPGCL	Thamur, West Jaintial hills and Suchen, East Jaintial hills district
Nagaland	23	Directorate of new and renewable energy, Nagaland	Ganesh Nagar of Dimapur and Jalukie of Paren district
Arunachal Pradesh	30	APEDA	Tezu township in Lohit district
Manipur	20	Manipur tribal development corporation ltd	Bukpi village, Pherzawl district
Mizoram	20	ZEDA	Vankal, Mizoram
Total	193		

(Source: Annual Report 2017-18, MNRE)

Table 4: Grid connected roof top and small solar power plant programme in the north eastern states

States	Installed capacity (MW) as on 31.01.2018
Assam	24
Arunachal Pradesh	10
Manipur	5.715
Mizoram	3.855
Tripura	0.5
Total	44.07

(Source: Annual Report 2017-18, MNRE)

Conclusion

Having enormous potential, Northeast India acts as a role model of renewable and efficient energy process. The main reason behind solar energy generation of Northeast region is clear weather which adds up to huge generation of solar potential. As per NELIVE, solar power extracted in these regions is 5KWh per square metre. The Solar City Programme of MNRE will host the development of Guwahati and Jorhat (Assam), Dimapur and Kohima (Nagaland), Agartala, Tripura and Itanagar (Arunachal Pradesh). NEEPCO aims to generate at least 1,500 MW of power from renewable energy in Northeast by 2020 under the united nation's clean development mechanism initiative. From this it is clear that efficient use of solar energy in Northeast region will help India earn the dream of "renewable super power" in the near future.

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Nuclear Power Projects: Prospects & Challenges

Despite the strong rationale for reducing GHG emissions, the installation of nuclear power projects is slower than other projects. A closer look.

Picture Courtesy: www.pixabay.com

The emission of greenhouse gases (GHGs) and their implications to climate change have sparked global interest in understanding the relative contribution of the electrical generation industry. According to the Intergovernmental Panel on Climate Change (IPCC), the world emits approximately 27 giga tonnes of CO2e from multiple sources, with electrical production emitting approximately 37 per cent of global emissions. In

addition, electricity demand is expected to increase by 50 per cent over the next 20 years. This substantial increase will require the construction of many new power generating facilities and offers the opportunity to construct these new facilities in a way to limit GHG emissions.

There are many different electrical generation methods, each having advantages and disadvantages with respect to operational cost, environmental impact, and other factors. In relation to GHG emissions, each generation method produces GHGs in varying quantities through construction, operation (including fuel supply activities), and de-commissioning. Some generation methods such as coal fired power plants release the majority of GHGs during operation. Others, such as wind power and nuclear power, release the majority of emissions during construction and decommissioning. Accounting for emissions from all phases of the project (construction, operation, and decommissioning) is called a lifecycle approach. Normalising the lifecycle emissions with electrical generation allows for a fair comparison of the different generation methods on a per gigawatt-hour basis. The lower the value, the less GHG emissions are emitted.

Nuclear power as one of the significant options for meeting future world energy needs at low cost and in an environmentally acceptable manner. Nuclear power is the fourth-largest source of electricity in India after thermal, hydroelectric and renewable sources of electricity. Nuclear power plant (NPP) uses the sustained nuclear fission to generate heat and electricity. Nuclear power plants provide about 6 per cent of the world's energy and 14 per cent of the world's power, with the U.S., France and Japan together accounting for about 50 per cent of nuclear generated power.

Inevitably, there will be a high degree of government involvement in nuclear power, even in market economies, to regulate safety, waste, and proliferation risk. This is, in itself, another challenge for nuclear power. There is considerable variation in how different countries approach the issues of safety, proliferation, and waste management. This often complicates the role of governments in setting international rules – especially for preventing proliferation, but also for safety and waste management – that serve common interests. Poor safeguarding of nuclear materials or facilities in any nation could result in acquisition of nuclear explosives by a rogue state or terrorist group for use in another nation. The Chernobyl accident demonstrated the potential for radioactivity to spread across borders and thus the importance of uniformly high safety standards and advanced safety technologies in nuclear power projects. Nuclear energy as a safe source of energy has been still a subject of constant debate.

Need of Nuclear Power Generation

The generation of electricity from fossil fuels, is a major and growing contributor to the emission of carbon dioxide – a GHG that contributes significantly to global warming. Although natural gas, and to some degree oil, had noticeably lower GHG emissions, biomass, nuclear, hydroelectric, wind, and solar photovoltaic all had lifecycle GHG emission intensities that are significantly lower than fossil fuel-based generation. At least for the next few decades, there are only a few realistic options for reducing carbon dioxide emissions from electricity generation:

- Increase efficiency in electricity generation and use.
- Expand use of renewable energy sources such as wind, solar, biomass, and geothermal.
- Capture carbon dioxide emissions at fossil-fuelled (especially coal) electric generating plants.
- Increase use of nuclear power.

Nuclear power plants achieve a high degree of safety through the defence-in-depth approach where, among other things, the plant is designed with multiple physical barriers. These additional physical barriers are generally not built within other electrical generating systems, and as such, the GHG emissions attributed to construction of a nuclear power plant are higher than emissions resulting from construction of other generation methods. Even when emissions from the additional safety barriers are included, the lifecycle emissions of nuclear energy are considerably lower than fossil fuel-based generation methods. Averaging the results of the studies places

nuclear energy's 30 tonnes CO2e/ GWh emission intensity at 7 per cent of the emission intensity of natural gas, and only 3 per cent of the emission intensity of coal fired power plants. In addition, the lifecycle GHG emission intensity of nuclear power generation is consistent with renewable energy sources including biomass, hydroelectric and wind.

In view of the above, it is observed that GHG emissions of nuclear power plants are among the lowest of any electricity generation method and on a lifecycle basis are comparable to wind, hydro-electricity and biomass. Lifecycle emissions of natural gas generation are 15 times greater than nuclear whereas lifecycle emissions of coal generation are 30 times greater than nuclear which shows that the nuclear power generation is environment friendly. Moreover, the operational cost of electrical generation from nuclear power station is lower than coal-based power stations.

India's as well as Asia's first nuclear reactor was the Apsara research reactor commissioned on August 4, 1956. The agreement for India's first nuclear power plant at Rajasthan, RAPP-1, was signed in 1963, followed by RAPP-2 in 1966. India is a major nuclear energy player in South Asia. The nuclear programme in India is conceived on a unique sequential three-stages essentially envisaged to use thorium, an abundantly available resource in the country. This sequential three-stage programme is based on a closed fuel cycle, where the spent fuel of one stage is reprocessed to produce fuel for the next stage. The closed fuel cycle thus multiplies manifold the energy potential of the fuel and greatly reduces the quantity of waste generated. Currently, India has an installed capacity of approximately 5,780 MW from nuclear sources.

Issues with Nuclear Power

Despite the strong rationale for reducing GHG emissions that contribute to global warming, for meeting increasing demand for electricity, and for improving the national security aspects of energy supply, the installation of nuclear power projects is slower than other projects. There is considerable anti-nuclear sentiment in the country. There are several reasons why nuclear power has not met the expectations for capacity growth projected several decades ago. One factor is that the public perception of nuclear energy is unfavourable, in part due to concern about effects of radiation that the public associates with nuclear energy. These challenges are:

Need of independent Regulator

The Atomic Energy Regulatory Body (AERB) has functioned as regulator in-charge of the nuclear power reactors in the country. AERB draws professionals from Department of Atomic Energy facilities as one cannot doubt the technical competence of AERB professionals. However, recently, AERB's role and its importance as a regulator become prominent in public discourse on account of its structural dependency. With the separation of the military and civilian nuclear programme, it is imperative that the regulator is independent financially as well as statutorily.

A close tie between the regulator and regulated is never desirable. A move towards this has been made with the draft legislation on "Nuclear Safety Regulatory Authority Act" under consideration. This will help to provide the statutory independence to the regulator. However, a major challenge is finding suitable scientists with relevant knowledge outside the ambit of the nuclear establishment. However, it must be mentioned that the lack of any major accident have shown that the regulator in the India has been effective. The question thus is the perceived subordination lead to erosion of public confidence on AERB?

Nuclear Fuel Availability

Domestic availability of uranium, the only fuel source as of now, is one of the major concerns in going ahead with the nuclear programme. Presently it is mined only in Jharkhand and Andhra Pradesh, which is also of low quality. A few other sites, including in Karnataka and Meghalaya, reportedly have uranium deposits. The techno-eco feasibility of opening new mines would however very much depend on the eco-sensitive nature of these sites and the public perception in the area. An estimate of resource availability is also a matter of contention. The possibility of import of uranium, which has opened up now, could ease the situation. The concern here is the somewhat varied

perceptions and approaches on part of the potential exporting countries.

Import Cost

Nuclear power has higher overall lifetime costs compared to natural gas with combined cycle turbine technology and coal, at least in the absence of a carbon tax or an equivalent "cap and trade" mechanism for reducing carbon emissions. The India is planning to import high capacity reactors from abroad. The cost of these reactors is considerable higher compared to domestic ones. If a domestic reactor costs around five to seven crores per MW the estimated cost of an imported reactor is found to very between 16 crore/MW to 36 crore/MW based on the technology. This could have a significant impact on the cost of power.

Higher Capital Cost

New nuclear power plants typically have high capital costs for building the first several plants, after which costs tend to fall for each additional plant built as the supply chains develop and the regulatory processes settle down. Fuel, operational and maintenance costs are relatively small components of the total cost. Most operating nuclear plants are economical to operate when costs going forward are considered, i.e. when sunk capital and construction costs are ignored. However, new plants appear to be more expensive than alternate sources of base load generation, notably coal and natural gas fired electricity generation, when both capital and operating costs are taken into account. Coal plants have capital costs intermediate between those of gas and nuclear. However, if CO2 emissions were in the future to become subject to control and a significant "price" placed on emissions, the relative economics could become much more favourable to nuclear power.

Waste Disposal

Nuclear power has perceived adverse safety, environmental, and health effects, heightened by the Three Mile Island and Chernobyl reactor accidents, but also by accidents at fuel cycle facilities in the United States, Russia, and Japan. There is also growing concern about the safe and secure transportation and disposal of nuclear materials and the security of nuclear facilities from terrorist attack. There are many radioactive waste streams created in various parts of the nuclear fuel cycle. Nuclear power has unresolved challenges in long-term management of radioactive wastes. The United States and other countries have yet to implement final disposition of spent fuel or high-level radioactive waste streams created at various stages of the nuclear fuel cycle. Since these radioactive wastes present some danger to future generations. The management and disposal of high-level radioactive spent fuel from the nuclear fuel cycle is one of the most intractable problems facing the nuclear power industry throughout the world. The spent fuel from nuclear reactors contains radioactive material that presents health and environmental risks that persist for tens of thousands of years. At present, no nation has successfully demonstrated a disposal system for these nuclear wastes.

International Policies

Opening up the possibility of trade has helped India secure fuel supply for those reactors which are under the IAEA safeguard. A growing dependency on imported fuel could be a cause for concern in future as imports are contingent on international sentiments.

Currently the NSG has made an exception for India, through there are regular voices of disclosure due to this, for instance, both Australia and Japan have expressed reservations about India's position on the CTBT and NPT, with several within the countries demanding for more stringent controls on the Indian nuclear programme. While current administrations in the two countries are more interested to fix a deal with India (uranium exports from Australia and technology from Japan), the negotiations have been protected. Strategic considerations also become important while considering uranium imports.

Land-related Issues

Difficulties in acquiring land and issues faced in commencing work in previously acquired land are some of the crucial issues stalling the development of new power plants, as well as opening up of new mines. Public protests have been seen in Jaitapur, Kudankulum, and in Domiasiat in Meghalaya. Protest against large-scale infrastructure projects has been faced in several other sectors as well. While some of the reasons for these protests are systematic-insufficient compensation, bad implementation of rehabilitation and resettlement, no social impact assessments are carried out to gauge the impact of resettlement of people, insufficient consultation with the public etc. in the case of nuclear these larger systemic issues are also back-grounded with public perception against nuclear. There is need to develop more robust and exclusive programme for all sectors to address the concerns of public around large infrastructure facilities.

Public Acceptance

Expanded deployment of nuclear power requires public acceptance of this energy source. Nuclear in India, due to the international isolation, hitherto, had been a subject removed away from the public eye. There seemed to be very little information coming out of the administration or the government about the programmes. There have been very little efforts in the part of the nuclear establishment to engage with the public at large. However, globally as well, post the Fukushima accident, the people's opinion about the nuclear energy was on a decline, with increasing safety concerns about nuclear. Reflection of this trend was seen in India as well, with a growing discontent against nuclear projects. A strong negative public perception regarding the nuclear power and its effects has stalled the development of new sites at several places.

Nuclear Law

The Civil Liability for Nuclear Damage Bill was passed by the Parliament and notified on 11th November, 2011 (Act No. 38 of 2010). The Civil Liability for Nuclear Damage Rules, 2011 have also been framed in respect of few provisions and was notified along with the Act. The conformity of the Act and the Rules with the internationally accepted principles of nuclear liability law, however, is an issue that is yet to be settled. The Rules that were made pursuant to the Act have not clarified the issues particularly the right of recourse provisions and liability limit. The international suppliers led by the US argue to introduce amendments to the law to harmonise it with the international principles. However, France and Russia through have reservations publicly, stated that they are willing to work within the Indian domestic legal framework. Issues related to right of recourse and supplier liability and extend of liability need to be addressed.

Observations and Recommendations

Unlike other energy forms, the risk debate on nuclear energy is due the fear of radiation consequences as a result of nuclear power plant operation and/or from an unfortunate event or an accident. The perception or reality of fear of extreme radiation that exist today is the outcome of multiple events and accidents. The benefits of nuclear energy for power production and its allied applications on the one side and the risks posed by nuclear energy to public health and safety, and to the environment on the other side have been a source of concern. The Government of India has taken a policy view that nuclear energy is necessary to meet the growing energy needs of the country. However, there are challenges on many front which need to be addressed in a pragmatic manner. Some of key steps required in this regard are:

- Undertake assessment of the safety vulnerabilities of nuclear power plants in the light of lessons learned to date from the accident.
- Strengthen the effectiveness of

operating organisations with respect to nuclear safety.

- Review and strengthen IAEA Safety Standards and improve their implementation.
- Improve the effectiveness of the international legal framework.
- Facilitate the development of the infrastructure necessary for States embarking on a nuclear power programme.
- Strengthen and maintain capacity building.
- Ensure the ongoing protection of people and the environment from ionising radiation following a nuclear emergency.
- Enhance transparency and effectiveness of communication and improve dissemination of information.
- Effectively utilise research and development.
- Considering the large-scale expansion, the Government plans to empower AERB through a legislatively mandated independent regulator. The Government also needs to develop and strengthen supporting regulatory infrastructure.
- It is also essential to develop a robust and transparent communication programme. This should focus on regular engagement of the people around existing nuclear facilities to address their concerns and informs them about the energy sector in their background.
- There needs to be an increased effort to spread awareness and information about nuclear across the country as well as provide platforms for discussions.
- Taking over the developmental works of affected villages and also nearby villages to create a positive atmosphere. Establishing schools and vocational training facilities in the villages around the power plant.

Way Forward

Today, nuclear power is not an economically competitive choice. Moreover, unlike other energy technologies, nuclear power requires significant government involvement because of safety, proliferation, and waste concerns. If in the future carbon dioxide emissions carry a significant "price," however, nuclear energy could be an important indeed vital option for generating electricity. But we believe the nuclear option should be retained, precisely because it is an important carbon free source of power that can potentially make a significant contribution to future electricity supply. The role of nuclear power becomes very important to sustainable meet the growing energy of the country. It also has the potential to reduce the dependency on fossil fuels.

Conclusion

The growing demand for clean and commercial forms of energy has brought into focus the urgent need for reforms and policies that would have to be formulated for nuclear power projects. However, the government is yet to find a solution to the increasing public anxiety on nuclear energy expansion, which is only likely to aggravate if a credible, sustainable and impactful strategy for socialisation and nuclear education is not formulated. While the spontaneous resistance to nuclear energy has woken up the elitist establishment to new realities and ensured that the nuclear affairs can no longer be run behind closed doors, the critical Challenge is to convince the population on the imperative of nuclear energy for a country which is not just a fast-growing economy, but also slated to be the most populous in a few years' time.

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The main feature of the Indian project (Kudankulam) is a unique combination of active and passive safety systems that provide maximum resilience against external and internal impacts, including tornadoes, hurricanes, earthquakes and even an aircraft crash.

Andrey Shevlyakov, CEO, Rosatom South Asia

Kudankulam project is the single largest nuclear power station in India, is being built by the NPCIL and Russia's ASE Group of Companies, an engineering division of Rosatom State Atomic Energy Corporation. In an interview with Electrical India, Andrey Shevlyakov, CEO, Rosatom South Asia talks about how the Indo-Russian relationship is strengthening in the field of nuclear power. Excerpts:

What is the current status of the Kudankulam project? How far you have progressed in construction of Unit 3 to 6?

Kudankulam Nuclear Power Plant (KKNPP) is scheduled to have six VVER-1000 reactors with an installed capacity of 1,000 MW each. The Unit 1 of the plant was synchronised with the southern power grid in October 2013 and is generating electricity. The second unit with capacity of 1,000 MW had become critical for the first time in July 2016. It was connected to the grid in August 2016 and it started commercial operation in October 2016.

The construction of Unit 3 and 4 is underway. The 'first pour of concrete' for Unit 3 of the KKNPP, which marks the beginning of the construction of the project, happened on June 29, 2017. The Units 3 and 4 Reactor

buildings foundation slabs have already been made. The construction is on schedule.

The delivery of equipment has already started. In March 2018 the first batch of equipment for turbine building of Unit 3 of KKNPP was completed and shipped out. Particularly, the first two high pressure heaters (HPH) were dispatched for turbine building of KKNPP. Also, the reactor pressure vessel for KKNPP Unit 3 will be delivered by the end of the current year followed by KKNPP Unit 4 that will be completed next year.

Last year, during the 18th annual India-Russia summit held in St Petersburg, both countries signed the general framework agreement for the construction of Units 5 and 6 of KKNPP and an inter-governmental credit protocol necessary for the implementation of the project was also signed. Currently intensive ground and infrastructural work is underway for Unit 5 and 6.

How safe is the Kudankulam project?

VVER reactors are considered to be among the safest in the world, this technology is the base of the Russia's nuclear power development program and contributes to the export growth. Over the 50 years of their operation, the NPPs (Nuclear Power Plants) with VVER reactors (VVER-440, VVER-1000) have proven their reliability, stability and competitiveness in the international energy market, ensuring stable growth of the nuclear industry. The experience of successfully operating NPPs with VVER-type reactors has already exceeded 1,400 accident-free reactor-years.

The Russian nuclear power plant projects use light water reactors of the VVER type (water-cooled water-moderated shell-type reactors with pressurised water). At present, VVER nuclear power plants are under various stages of construction in Iran, Belarus, Hungary, Bangladesh and other countries. This type of reactors uses water both as a neutron moderator and as a reactor coolant.

On India's request, additional safety measures are being put in place in Units 3 and 4 to withstand even higher seismic, climatic and technical impact. All power units are equipped with the modern diagnostics systems, which prevent the anticipated operational occurrences before they start. The main feature of the Indian project is a unique combination of active and passive safety systems that provide maximum

Rooppur atomic plant in Bangladesh being developed under tripartite agreement between India, Russia, and Bangladesh. (File photo)

resilience against external and internal impacts, including tornadoes, hurricanes, earthquakes and even an aircraft crash. Therefore, we can firmly state that presently India possesses the safest NPP in the world.

Passive safety systems are able to function even under conditions of complete power failure ensuring complete safety even without the contribution of the active safety systems or (human) operational intervention. For example, the Passive Heat Removal System (PHRS) provides long-term heat removal from the reactor core in case of all the power sources' shutdown. A molten core catcher (MCC) or a "melt trap" is designed to keep the molten core material inside and cool it down in case of a hypothetical accident that could lead to the core damage. A core catcher ensures the integrity of the containment vessel, preventing radioactive leaks into the environment, even in case of a hypothetical severe accident.

The huge attention has been focused towards preservation of biological diversity around KKNPP and save local flora and fauna of the Mannar Bay. NPP cooling sea water intake structures are equipped with the special fish protecting facilities, which preserve not only fish but also fish food plankton. Sea water is supplied from the so called "bucket" constructed in the sea into the special facilities and systems which ensures that fish and plankton return to sea.

Rosatom's fuel company TVEL has introduced the new fuel TVS-2M for VVER-1000 reactors which is expected to be installed at the Kudankulam plant. What is the difference between the old fuel and the new one?

TVS-2M gives an opportunity to shift the nuclear power plant from operation in 12 months to 18 months fuel cycle. Right now, the fuel campaign consists of three cycles, each lasting for 12 months. After introduction of TVS-2M, we will have three cycles lasting for 18 months, so instead of three years, the fuel campaign will last for 4.5 years (54 months instead of 36 months).

Also, TVS-2M fuel bundles have more advanced thermal-mechanical behaviour during the whole fuel life. This fuel model is more robust, it has a higher stiffness. So, during the exploitation in the reactor core a fuel bundle does not bow and preserves its initial shape. Thus, we have made the reactor operation safer and more reliable.

Have you signed the contract for the supply of TVS-2M to India?

Together with our Indian colleagues from NPCIL, we have come a long way and we hope that this year we will have the contract signed for the introduction of TVS-2M for Units 1 and 2 of the Kudankulam NPP. TVS-2M is supposed to be loaded into the reactors of Units 3,4,5 and 6 of KKNPP from the very beginning.

Is this new fuel TVS-2M licensed?

Yes, we already have the international license but not in India. Before we receive the license, we have to do a certain scope of work already agreed by. This work takes approximately one year and a half, and after that, we will be able to receive a license from the Atomic Energy Regulatory Board (AERB). That work will start after the contract is signed.

How many more units is ROSATOM planning to build in India?

The Strategic Vision adopted in December 2014 for strengthening cooperation in the peaceful use of atomic energy between Russia and India stipulates that at least 12 units of Russian design are to be commissioned in India within the next 20 years. As far as we know, the Indian government is actively searching for sites to build new power plants. In 2015, India declared its intent to allot a new site for the construction of power plant of Russian design with enhanced-capacity units. We are awaiting the new site to be officially presented by the Indian side to the Russian side and further signing of the contracts. Now we are holding talks on the design of the new nuclear power plant units as well as preparing the proposal regarding the localisation of the equipment.

Are there any plans for to work together with India on other markets?

Besides the KKNPP, we are working together with India for the construction of the first nuclear power plant in Bangladesh at Rooppur. This year in March the trilateral agreement was signed by India, Russia and Bangladesh. The document establishes the basis for the interaction of the Russian contractor ASE Group of Companies with Indian and Bangladeshi specialists in the implementation of the project. In particular, the parties plan to cooperate in personnel training, experience sharing and consulting support. Under the agreement, Indian companies will participate in construction and installation work, supply of non-critical materials and equipment for the project.

Improved Monsoon Winds Help Power Producers in 2018

After a prolonged period of decline, 2018 monsoon season brings significantly higher than average wind speeds across India.

Wind speeds in India during the 2018 monsoon season were significantly higher than normal, and up to 20 per cent higher than long-term averages in some regions, according to wind performance maps published by Vaisala. These higher wind speeds will benefit wind farm production; this is welcome news for wind energy operators and investors, who have faced several years of lower-than-normal wind energy production during the monsoon period.

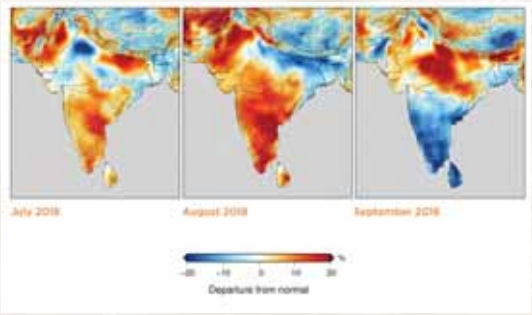
Because the monsoon season typically has the highest wind speeds of the year, the below-average wind resource in recent years has had a disproportionate impact on wind energy production and has caused concern in the sector.

Increased wind speeds counter recent pattern of decline

In contrast to recent years, Vaisala's measurements and analysis of the monsoon season show that wind speeds across India were up to 20 per cent higher than the long-term average for periods of July, August and September – with notably strong performance in key wind power producing states, Tamil Nadu and Andhra Pradesh. The increase runs counter to an observable trend over the past 20 years of declining wind speeds, and stands in sharp contrast to resource data from the monsoon season in three of the past four years, which shows that wind speeds dropped well below the historic average.

Increasing investor confidence with a data-driven approach

This recent change in fortune will be welcomed by renewable energy investors in India and may help adjust perceptions



of wind sector under performance at a time when many energy assets are under scrutiny by lenders. Investment in the renewables sector has slowed following the recent cancellation of several large wind and solar tenders where the bids did not achieve the benchmark ceiling tariff.

While this year's monsoon wind performance was good news for power producers, wind energy developers must still find a way to demonstrate the value of investment in their wind projects, faced with long-term variability in wind speeds. Key to this is a scientific, data-driven approach to wind resource assessment.

"Improved resource performance over this past monsoon season, when set in the right context, can show investors the sector has real potential, and should signal a boost to investor confidence in India's wind industry," said Rajnikanth Umakanthan, Managing Director of 3TIER India, a Vaisala subsidiary. "The variability we see in resource performance underlines the value of using a long-term climate context when performing wind resource analysis. Currently, financial performance is judged against ever-lower tariffs – even in less windy states – so it is important to contextualise that with a longer-term view of climate effects."

Wind industry installations plummet

Overall wind industry installations plummeted to 1,766 MW in FY18 (32% of FY17 installations) due to stagnant volumes, uncertainty on PPAs and policy environment.

Over the years, renewable energy has grown from a fringe player to a mainstream actor in the energy sector. In the last 3 years, installed renewable energy capacity in India has more than doubled from 32 to around 71 GW. Wind energy is leading the pack, contributing more than 50 per cent of this with cumulative installed capacity of around 34 GW.

However, the last year had been challenging as the wind industry witnessed slowdown due to the transition from Feed-in tariff (FiT) to competitive bidding, which impacted margins and created temporary uncertainty in terms of volumes. As a result, the overall wind industry installations plummeted to 1,766 MW in FY18 (32 per cent of FY17 installations) due to stagnant volumes, uncertainty on PPAs and policy environment.

Talking on the recent performance of wind energy industry, Dr Sanjiv Kawishwar, Sr. Vice President - Technology & System Certification, ReGen Powertech Pvt Ltd, outlines few points:

- Project activities have slowed down in India.
- Many players, mainly OEMs, are in the red (loss making) and are struggling to manage cash flows for survival.
- Wind turbine has highly complex certification and regulatory processes for registration in India.
- Focus on quality at every step of type certification from concept to commissioning as well as operation and maintenance makes it time consuming and expensive.
- Uncertainty at various stages of project execution spoils the financing and cash flow. Therefore, the recent tariffs are not sustainable.
- Wind typically has higher quality components and higher PLF compared to solar.
- The sharp decline in solar tariffs recently witnessed is due to reliance on cheap imports from China.
- Wind has an established supply chain with a high

degree of localisation thus has an entirely different cost structure compared to solar, and has a tendency towards increasing costs unlike solar.

Therefore, he suggests, the government needs to prioritise wind power by temporarily reintroducing incentives till the bidding mechanism stabilises.

Growth drivers

According to Dr Kawishwar, some of the factors driving the Indian wind energy industry are:

- Availability of low cost (interest), long-term financing from other countries are driving the Indian players to bid at such low price and maintain project economics.
- The existence of a strong project opportunities is an encouraging sign for investors and developers.
- While the reverse bidding mechanism has driven tariffs to unsustainable levels, developers have been able to bid with strategic understanding of resource data and costs. Currently, there is a steady increase in tariffs.
- The industry also now has a little better transparency on the regulatory environment than in the past. There're the less spikes of project execution activity in this environment.
- The best wind sites have been taken, and more tenders are expected to be floated for sites in low wind areas.
- Larger capacity wind turbines with better technological options are being sold now, that are optimised for low wind conditions, but at times require higher upfront investment.
- The auction mechanism has encouraged more direct OEM involvement with IPPs in the bidding and development process, leading to slightly less downward pressure on margins.

However, he suggests, "Better tariff structure will play crucial role in making the industry sustainable."

Tech trends defining the future of wind energy business

Dr Kawishwar lists some of the technology trends that are defining the future of wind energy business:

- The tendency towards larger turbine capacity has been continuing with the 10MW mark recently breached.
- Much of the impetus for this has been the mature European offshore industry, where increased size helps offset high installation and infrastructure costs.
- Load bearing component manufacturers have been continuously innovating on enabling better monitoring, diagnosis as well as ease of operation and maintenance (O&M).
- With involvement from IoT and analytics providers, it is now possible to have predictive maintenance of wind farms.
- Further, IEC 61400-25 standards on information exchange for wind turbines has become widely adopted, meaning that large wind farms can be monitored, controlled and better integrated into the power system.

"Better tariff structure will play crucial role in making the industry sustainable."

Dr Sanjiv Kawishwar
Sr. Vice President - Technology & System Certification, ReGen Powertech Pvt Ltd

According to Dr Kawishwar, these are some welcome developments since O&M is a major contributor to costs both in magnitude and uncertainty. "Investors and developers are increasingly willing to consider larger turbines for both onshore and offshore deployments," he added.

Future of wind power sector beyond 2019

The government has focused strongly on solar PV technology leading to a relative neglect of the wind sector. Wind is also facing increased capital costs and fewer high wind sites. However, Dr Kawishwar observes, "The government's commitment to 75 GW wind power by 2022 is achievable under current manufacturing capability, if appropriate tariff and incentives are carefully reintroduced with a focus on reaching the target."

He goes on to explain: "If economies of scale are achieved, then competitive bidding can continue to be the basic mechanism for discovering price. Alternative approaches like wind-solar hybrid and offshore wind will become more prominent in the near future. Large solar farms are already in development and such sites tend to have high wind potential. The prior existence of evacuation infrastructure makes the hybrid approach cost-effective. Another related development is the interest in storage systems, which are highly suited to wind, solar and hybrid technologies. MNRE has indicated that it might subsidise development of the same. We can thus look forward to a larger share of renewable energy in the grid in the near future." EI

India's hydro power potential

This article deals in brief with the hydro power potential and status of development, projects in operation/ under implementation/ under planning, largest head hydro power plants, small hydro power plants in India.

Picture Courtesy: www.allnigeriabanks.com

Water is one of the nature's best renewable gifts in India, which can be harnessed for cheap power generation. Hydro power potential of India is estimated at 84,000 MW (at 60% load factor) and ultimate possible installed capacity of 145,320 MW in stations with installed capacity over 25 MW. While water is a State subject, electricity is a subject in Concurrent List. Development of hydro power in India is governed by Indian Electricity (Supply) Act, 1948 and its amendment Indian Electricity Act, 2003.

Power supply position

Power demand during last decade has increased a lot, but its

Table 1

Year/Period	Energy Supply Position (MU)				Peak Demand/Peak Met (MW)			
	Requirement	Availability	Deficit (-)	Deficit (-) (%)	Peak demand	Peak Met	Deficit (-)	Deficit (-) (%)
April - August, 2018	547611	544403	-3208	-0.6	172381	170765	-1616	-0.9
August, 2018	111970	111443	-527	-0.5	170976	170182	-794	-0.5

Table 2

Region	Assessed (MW)	Status of Hydro Electric Power Potential as on 31.03.2012							
		Developed		Under Construction		Developed+ In Construction		Balance	
		MW	%	MW	%	MW	%	MW	%
Northern	52263	19023.3	36.40	5516.5	10.56	24539.8	46.95	27723.2	53.05
Western	8131	5552.0	68.28	400	4.92	5952.0	73.20	2179.0	26.80
Southern	15890	9658.9	60.79	1090	6.86	10748.9	67.65	5141.1	32.35
Eastern	10680	4922.5	46.09	1253	11.73	6175.5	57.82	4504.6	42.18
N-Eastern	58356	1427.0	2.45	2744	4.70	4171.0	7.15	54185.0	92.85
Total	145320	40583.7	27.93	11003.5	7.57	51587.2	35.50	93732.9	64.50

production has not been able to keep up pace with increasing power demand. India is experiencing a shortage in energy supplied as well as peak met. Electricity requirements vis-à-vis its availabilities and peak power demands vis-à-vis peak met in India during the period April 2018 – August 2018 and in August 2018 are mentioned in Table 1.

Contribution of hydro power resource to total

India has conventional as well as non-conventional energy resources: thermal, hydro and renewable. Contribution of hydro installed capacity is low as compared to thermal. At the end of August 2018, contribution of hydro installed capacity to total installed capacity in India is 13.2 per cent.

Hydro power potential & status of development

Hydro potential for hydro power schemes above 25 MW: First systematic and comprehensive study carried out by Power Wing of erstwhile Central Water & Power Commission during 1953-1959 assessed hydro power potential of India as 421,00 MW at 60 per cent load factor. Re-assessment study for hydro potential was completed in 1987, in which hydro potential was placed at 84,040 MW at 60 per cent load factor. It corresponds to 148,701 MW in terms of installed capacity including small hydro schemes. Excluding small hydro projects up to 25 MW, hydro power potential works out to 145,320 MW. In additions, 94,000 MW potential was also identified for development of pumped storage schemes.

Region-wise break-up of hydro power potential assessed, potential developed, under development and balance to be developed is given in Table 2. North-Eastern Region has the largest potential (58356 MW: 40 per cent) followed by Northern Region (52263 MW: 36 per cent), Southern Region (15890 MW: 11 per cent), Eastern Region (10680 MW: 7.4 per cent) and

Table 3

Region	Number of Stations	Installed Capacity (MW)	IC % of Total IC
Northern	71	19023.27	41.9 %
Western	28	7392.00	16.3 %
Southern	69	11664.50	25.8 %
Eastern	23	5862.45	12.9 %
North-Eastern	13	1427.00	3.1 %
Total	204	45369.22	100 %

Table 4

Sector	Number of Stations	Installed Capacity (MW)	IC % of Total IC
Central	41	15046.72	33.1 %
State	145	3364.00	59.4 %
Private	18	26958.50	7.5 %
Total	177	45369.22	100 %

Table 5

S. No.	Name of Plants	Installed Capacity (MW)		State	Organization
1	Nathpa Jhakri	6x250	1500	Himachal Pradesh	SJVNL
2	Sardar Sarovar	6x200	1200	Gujarat	GSECL
3	Teesta - III	6x200	1200	Sikkim	TUL
4	Sharavathy	10x103.5*	1035	Karnataka	KPCL
5	Tehri Stage -I	4x250	1000	Uttarakhand	THDC
6	Karcham Wangtoo	4x250	1000	Himachal Pradesh	JPKHPL
7	Koyna - IV	4x250	1000	Maharashtra	MAHAGENCO
8	Indira Sagar	8x125	1000	Madhya Pradesh	NHDC
9	Dehar	6x165	990	Himachal Pradesh	BBMB
10	Srisailam LBPH	6x150	900	Andhra Pradesh	APGENCO
11	Purulia PSS	4x225	900	West Bengal	WBSEDCL
12	Kalinadi (Nagjhari)	3x135+3x150*	855	Karnataka	KPCL
13	Nagarjuna Sagar	1x110+7x100.8*	815.6	Telangana	TSGENCO
14	Kol Dam	4x200	800	Himachal Pradesh	NTPC
15	Bhakra Right	5x157	785	Himachal Pradesh	BBMB
16	Idukki	6x130	780	Kerala	KSEB
17	Srisailam	7x110	770	Andhra Pradesh	APGENCO
18	Salal I&II	6x115	690	Jammu & Kashmir	NHPC
19	Ranjit Sagar Dam	4x150	600	Punjab	PSPCL
20	Upper Indravati	4x150	600	Orissa	OHPC
21	Koyna – I & II	4x70+4x80	600	Maharashtra	MAHAGENCO
22	Bhakra Left	2x108+3x126*	594	Himachal Pradesh	BBMB
23	Chamera -I	3x180	540	Himachal Pradesh	NHPC
24	Omkareshwar	8x65	520	Madhya Pradesh	NHDC
25	Parbati-III	4x130	520	Himachal Pradesh	NHPC
26	Balimela	6x60+2X75*	510	Orissa	OHPC
27	Teesta - V	3x170	510	Sikkim	NHPC
	Total		22214.6		

* After up-rating of generating units of the plants.

Western Region (8131 MW: 5.6 per cent).

Note: In addition to above, 1,840 MW in Western region, 2,005.6 MW in Southern region and 940 MW in Eastern region (total 4,785.60 MW) has also been added in pumped storage schemes. Thus, total installed capacity of hydro power stations works out as 45,369.22 MW as on 31 August 2018.

From Table 2, it is observed that 27.93 per cent of the total hydro potential has been developed and 7.57 per cent is under development. Thus, about two-third of the potential (64.50 per cent) remains to be developed. Therefore, there is a large scope for hydro power development in India.

Hydro projects in operations

All India hydro installed capacity in operation: 204 hydro power stations (individual station capacity over 25 MW) aggregating to an installed capacity 45,369.22 MW are in operation India.

Region-wise: Region-wise break-up of hydro stations in operation in India and their aggregated installed capacity is given in Table 3. Northern Region has the largest installation, followed by Southern Region, Western Region, Eastern Region and North-Eastern Region.

Sector-wise: Sector-wise breakup of hydro stations in operation in India with aggregated capacity is given Table 4. State Sector has largest installation followed by Central and Private sectors.

Stations with installed capacity over 500 MW: 27 hydro stations as mentioned in Table 5 with individual capacity over 500 MW and aggregating to capacity of

Table 6

S. No.	Size MW	Name of Plants	IC (MW)		State	Organization
1	250	Nathpa Jhakri	6x250	1500	Himachal Pradesh	SJVNL
		Tehri Stage-I	4x250	1000	Uttarakhand	THDC
		Karcham Wangtoo	4x250	1000	Himachal Pradesh	JPKHPL
		Koyna - IV	4x250	1000	Maharashtra	MAHAGENCO
2	225	Purulia PSS	4x225	900	West Bengal	WBSEDCL
3	200	Sardar Sarovar	6x200	1200	Gujarat	GSECL
		Kol Dam	4x200	800	Himachal Pradesh	NTPC
		Teesta - III	6x200	1200	Sikkim	TUL
4	180	Chamera - I	3x180	540	Himachal Pradesh	NHPC
5	170	Teesta- V	3x170	510	Sikkim	NHPC
6	165	Dehar	6x165	990	Himachal Pradesh	BBMB
7	157	Bhakra Right	5x157*	785	Himachal Pradesh	BBMB
8	150	Baglihar	3x150	450	Jammu & Kashmir	JKSPDC
		Ranjit Sagar Dam	4x150	600	Punjab	PSPCL
		Srisailam LBPH	6x150	900	Andhra Pradesh	APGENCO
		Kalinadi	3x150*	450	Karnataka	KPCL
		Bhira PSS	1x150	150	Maharashtra	Tata Power Co.
		Upper Indravati	4x150	600	Orissa	OHPC
		Baglihar-II	3x150	450	Jammu & Kashmir	NHPC
9	135	Kalinadi (Nagjhari)	3x135	405	Karnataka	KPCL
		Ranganadi	3x135	405	Meghalaya	NEEPCO
10	130	Dulhasti	3x130	390	Jammu & Kashmir	NHPC
		Idukki	6x130	780	Kerala	KSEB
		Parbati-III	4x130	520	Himachal Pradesh	NHPC
11	126	Bhakra Left *	3x126	378	Himachal Pradesh	BBMB
12	125	Indira Sagar	8x125	1000	Madhya Pradesh	NHDC
		Ghatgarh PSS	2x125	250	Maharashtra	MAHAGENCO
13	120	Uri-I	4x120	480	Jammu & Kashmir	NHPC
14	115	Salal – I &II	6x115	690	Jammu & Kashmir	NHPC
		Lower Sileru	4x115	460	Andhra Pradesh	APGENCO
		Varahi	4x115	460	Karnataka	KPCL
15	110	Nagarjuna Sagar	1x110*	110	Andhra Pradesh	APGENCO
		Srisailam	7x110	770	Andhra Pradesh	APGENCO
		Kishanganga	3x110	330	Jammu & Kashmir	NHPC
16	108	Bhakra Left	2x108	216	Himachal Pradesh	BBMB
17	105	Bassagar Tons	3x105	315	Madhya Pradesh	MPGPCL
18	103.5	Sharavathy	10x103.5*	1035	Karnataka	KPCL
19	100.8	Nagarjuna Sagar	7x100.8	705.6	Andhra Pradesh	APGENCO
20	100	Chamera - II	3x100	300	Himachal Pradesh	NHPC
		Koteshwar	4x100	400	Uttarakhand	THDC
		Baspa - II	3x100	300	Himachal Pradesh	JPHPL
		Vishnu Prayag	4x100	400	Uttarakhand	JP Ventures Ltd.
		Kadamparai PSS	4x100	400	Tamil Nadu	TNEB
		Total		26524.6		

* After up-rating of generating units of the plants.

22214.6 MW are in operation. They contribute about half (55.7 per cent) of total hydro installation in Country.

Largest generating units in operation: Unit of size 100 MW and above installed in various hydro power stations in India are listed in Table 6 in descending order. They contribute to about two-third (66.6 per cent) of the total installed capacity in the country.

Largest head hydro power projects: Highest head hydro power plant commissioned so far in India is Suruliar (979.15 m) followed by Kodayar-I (947.62 m), Vishnu Prayag (947.5 m), Sanjaya (Bhaba) (887.2 m), Pykara (867. 46 m). Top ten highest head power

Table 7

S. No.	Name of Station	Head (m)	Installed Capacity (MW)	State
1	Suruliar	979.15	1x35 = 35	Tamil Nadu
2	Kodayar PH-I	947.62	1x60 = 60	Tamil Nadu
3	Vishnu Prayag	947.50	4x100 = 400	Uttarakhand
4	Sanjaya (Bhaba)	887.20	3x40 = 120	Himachal Pradesh
5	Pykara	867.46	3x6.65+2x11+2x14 = 69.95	Tamil Nadu
6	Teesta -III	780.33	6x200 = 1200	Sikkim
7	Kundah PH-II	713.23	5x35 = 165	Tamil Nadu
8	Sabarigiri	710.00	6x50 = 300	Kerala
9	Idukki	660.00	6x130 = 780	Kerala
10	Kuttiadi	643.29	3x25 = 75	Kerala

plants commissioned in India are listed Table 7.

Hydro power projects under implementation

Hydro power projects under construction: As on 30th June 2018, 38 hydro stations (station capacity above 25 MW) with an aggregate installed capacity 12,208.50 MW are under construction in the country. Sector-wise details are listed in Table 8.

Projects Concurred by CEA and yet to be taken under Construction: As on 31st August 2018, 41 hydroelectric schemes (station capacity above 25 MW) aggregating to an installed capacity of 26,460 MW have been concurred by CEA, but not taken for construction mainly due to pending environment/forest clearances by MoEF or due to some other reasons. Sector-wise details are mentioned in Table 9.

Hydro power projects under planning

DPRs are under examination in CEA for concurrence: As on 31st August 2018, 7 schemes (station capacity above 25 MW) aggregating to 1,654 MW are under examination in CEA for according concurred. Sector-wise details are mentioned in Table 10.

DPRs examined and returned for resubmission after compliance of observations: Detailed projects reports (DPRs) of 29 hydroelectric schemes aggregating to an installed capacity of 9,852 MW submitted by various developers for concurrence were examined by CEA and the same were returned to the concerned developers for resubmission after compliance of comments of CEA/CWC/GSI. Sector-wise details are mentioned in Table 11.

Table 8

	Central	State	Private	Total
No. of stations	10	13	15	38
Installed Capacity (MW)	6715	2367.50	3126	12208.50
Percentage (%)	55 %	19.4%	25.6 %	100 %

Table 9

	Central Sector	Joint Venture	State Sector	Private Sector	Total
Number of Stations	10	2	6	23	41
Installed Capacity (MW)	6104	1164	4162	15030	26460

Table 10

	Central Sector	State Sector	Private Sector	Total
Number of Stations	3	3	1	7
Installed Capacity (MW)	343	881	430	1654

Table 11

	Central Sector	State Sector	Private Sector	Total
Number of Stations	1	11	17	29
Installed Capacity (MW)	130	2538	7184	9852

Prime Minister's 50,000 MW Hydro Initiative

Preparation of pre-feasibility reports: Under the programme launched by Prime Minister of India on 24th May 2003 for preparation of Preliminary Feasibility Reports (PFRs) of hydroelectric schemes under 50,000 MW Hydroelectric Initiative, FPRs for 162 schemes aggregating to 47,930 MW in 16 States were

Table 12

S. No.	Name of State	Numbers	MW	S. No.	Name of State	Numbers	MW
1	Jammu & Kashmir	13	2675	10	Orissa	4	1189
2	Himachal Pradesh	15	3328	11	Sikkim	10	1469
3	Uttarakhand	33	5282	12	Ar. Pradesh	42	27293
4	Chhattisgarh	5	848	13	Manipur	3	362
5	Madhya Pradesh	3	205	14	Meghalaya	11	931
6	Maharashtra	9	411	15	Mizoram	3	1500
7	Andhra Pradesh	1	81	16	Nagaland	3	330
8	Karnataka	5	1900		Total	162	47930
9	Kerala	2	126				

Table 13

S. No.	Region	As per CEA Study (MW)	Assessed by Min. of New & Renewable Energy	
			Number of Stations	MW
1	Northern	1132	1813	6284.25
2	Western	797	1036	2732.85
3	Southern	568	1077	2671.38
4	Eastern	269	714	1379.33
5	North-Eastern	615	1071	2309.07
6	Andaman & Nicobar	0	7	7.27
	Total	3381	5718	15384.15

prepared by seven CPSUs/ State agencies as consultants, viz. NHPC, WAPCOS, SJVNL, NEEPCO, KPCL, HPSEB and UJVNL. These schemes were selected based on preliminary ranking study done by CEA. State-wise break up is given in Table 12.

PFRs prepared would serve useful purpose of fixing the inter-se priority for implementation of schemes and also as a basis and reference for taking up on surveys and investigations and preparation of detailed project reports of these hydroelectric schemes.

Small hydro power development

Small Hydro Power (SHP) is generated from flowing/ falling water from rivers/ rivulets/ storage dams/ canal drops. Ministry of New & Renewable Energy (MNRE) is responsible for development of SHP projects (station capacity up to 25 MW) for following uses:

Water mills for local use: Up to 5 KW	Mini for village Electrification & grid: 101 kW-2000 kW
Micro for village electrification: up to 100 kW	Small for grid: 2001kW - 25000kW

Hydro potential for hydro power schemes up to 25 MW: As per CEA's study carried out during1987-1996, small hydroelectric schemes (capacity up to 25 MW) aggregating to 3,381 MW were identified. In addition, MNRE has also identified 5,718 sites aggregating to 15,384.15 MW for development of SHP (Table 13).

Conclusions

India has been the pioneer country in the development of hydro power. Every type of hydro power scheme has been developed, viz. run-off- river and storage, surface and underground, conventional and pumped storage, base load and peak load, high/ medium head and low head, large/ medium and small/ mini/ micro schemes. India has hydropower potential of 145,320 MW. 35.5 per cent of this hydro power potential has been developed/ being developed. This necessitates accelerating the process of development of remaining 64.5 per cent of potential. Development of this renewable, clean and non-polluting power would help in bridging the gap between the electricity demand and supply in the Country. Development of small hydro power projects would facilitate in developing the remote locations/far-off areas of the country by providing quality power to people living in these areas.

M P Singh

Consultant, Water and Power Consultancy Services (India) Limited (WAPCOS)

Building innovative & sustainable technologies

T P Singh, Sales Director, Emerging Markets-Ins (India, ME, CIS, Turkey, SS Africa), FLIR shares his views on the company's vision in India, products for electrical utilities and many more in an email interaction with **Electrical India**.

Please tell us about FLIR's overall vision in India.

FLIR is a Nasdaq listed company having head office in USA. FLIR is dealing mainly in infrared imaging-based products. We did a business of around USD 1.8 billion (approximately INR 12,100 crore as per current USD/ INR rate). In 2017, our revenue growth as compared to 2016 has been 8.3 per cent. We say ourselves the World's Sixth Sense at FLIR as we provide superpower vision helping people around the world to save lives, protect the environment, and enhance productivity. We are building more than innovative technologies; we are striving to build a more sustainable, more efficient, and safer future.

Regarding India, wide range of products under instruments portfolio are available through our very strong channel partners, all of them have trained technical teams to provide the best services to our potential or existing customers. We have customers all over India that include electrical utilities, different manufacturing companies, service providers and integrators. Customers use our products effectively. Further, we have online or frequent offline training courses in India. We have service centre in Delhi.

What range of products do you offer to Electrical Utilities?

Electrical utilities are one of our main customers globally including India. We have hundreds of products for these utilities. Generation, transmission or distribution- all use and need our products. Electrical utilities face frequent problem of critical installations getting heated up. The moment this heating phenomenon starts, temperature starts rising and

FLIR Thermal Imaging cameras play a very important role there. Without touching or taking shut down, these FLIR Thermal Cameras can accurately measure the temperature of these installations. From nut or bolt on a transmission tower to transformers to many other critical installations, FLIR products meet and exceed all expectations.

We have different ranges of thermal cameras for offline (handheld) and online (fixed type) use. Under offline thermal cameras range, our starting range is with world's first pocket sized thermal camera model C3. Other products include point and shoot Ex series, Exx series for experienced users and professional T series which has unique feature of tiltable optics.

Under online offerings, we have product range under automation portfolio which has fixed type of products for 24x7 temperature monitoring. These products can be integrated with computers for real time temperature monitoring. Main applications broadly include automated inspections, process control, condition monitoring and fire prevention detection. Almost nine types of camera families (and 30 plus different products) are available under this fixed type range for different applications to suit customer needs. FLIR also has test & measurement range, which include multimeters, clamp meters, insulation testers, thermometers, and voltage detectors. Selected models have FLIR unique, infrared guided measurement through infrared detector that guides user straight to the problem, visualises the heat generated by electrical faults, and accurately measures the temperature.

Extech is also a FLIR company that provides 400 plus different products for applications like electrical, plant maintenance, health & safety, HVAC, lab and water quality are available. Extech is also ISO 9001:2015 company having 45 years of experience. In India, we cover complete range of Extech products. For electrical utilities, finding SF6 leakage is a problematic task. FLIR has a solution to visualise this harmful gas for environment. This product can also be used at safe distance. Product name is GF 306.

What is FLIR's best liked product by electrical utilities?

We have many products being accepted by Indian utilities but T series has been very successful due to its very useful design. It has rotatable optics. T6xx and T1 K has 120 Deg rotation and new T5xx has 180 Deg rotation of optical block. Since many electrical installations that need to be scanned for temperature are above eye level, this design is very useful. Benefit of this design is that operator does not get stress on wrist, shoulder, neck and eyes while using this range even if used frequently. The ease of use of this great design can be felt only with experience.

Which Electrical Utilities are FLIR's customers?

This list is very long. Few names are- PGCIL, NTPC, MSETCL, KPTCL, WBSETCL, BSES, TPDDL, UPPTCL etc.

You have vast range of products. How to choose the best suitable for application?

This is very important question. One should clearly know what's the smallest object size, they want to measure and from what distance. It may be different for generation, transmission and distribution companies. First, fundamental selection of detector is done. After this, other desired parameters should be added to specifications. Seeing the object with Thermal camera and accurate measurement are two different things. This one critical aspect can be defined as IFOV- Instantaneous Field of View. We have developed an online tool to help our customers to choose the right product, same available on our website.

What technological innovations you have incorporated in your products for making them more superior and efficient?

There are number of technological innovations. To name a few- tiltable optical block, MSX and text annotation are there. Tiltable optical design has been very well accepted by our customers as it gives less stress than straight type cameras on neck, shoulder and arm while working long hours in field. MSX is multi spectral Dynamic Imaging which helps to increase image quality multi folds and can read even text. Text annotation helps to add text comments on image in camera through touch screen, directly in field. These technical features bring good efficiency in camera use.

How would you differentiate Indian electrical test equipment markets from the global markets particularly European and American markets while offering your services and products? Do you face any competition in Indian markets?

Yes, competition is definitely there and Indian market is totally different due to bidding process which allows only lowest bidder to win.

Improving quality using system-based end-to-end tests

An end-to-end test should be an indispensable part of the commissioning of every line protection (differential and distance protection with signal comparison).

Figure 3: Distributed testing controlled centrally by a PC

The most frequent causes of protection misoperations are setting, logic and design errors, caused for the most part by the increasing complexity of modern protection systems. Line differential protection is a case in point. To date, dedicated test plans and sequences have been created for every test set and every test case, all of which had to be calculated and evaluated

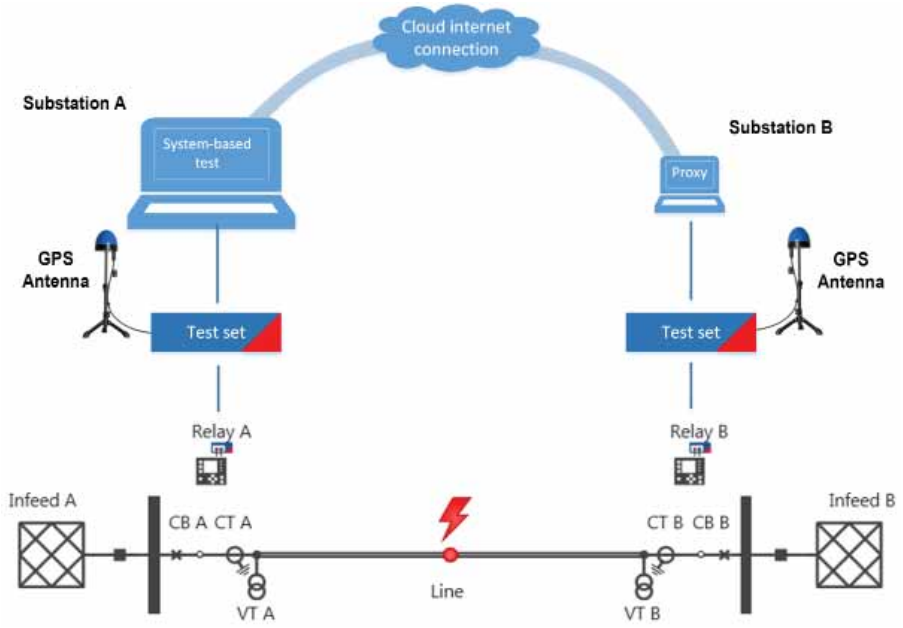


Figure 1: Setup of an end-to-end test

individually. By combining the three core functions of the test process in a software package, OMICRON electronics is raising the security and dependability of system test results to a new level.

When commissioning a protection system, utilities always endeavour to test relays in a way that reflects how they will later be used in operation. Line differential protection fulfils its function using two or more relays that communicate with each other. The relays are distributed across various substations. The testing of line differential protection under operational conditions, or as realistically as possible, requires the extremely precise time-synchronised simulation of a fault scenario at each end of the protected line, also referred to as an end-to-end test.

To date, a separate test sequence was created for each end of the line. In the facility, a phone call is made to a colleague at the opposite end so that the respective pair of test cases can be started at exactly the same instant. This methodology has stood the test of time. However, what is evident is that the costs involved and the susceptibility to errors of this approach – in its preparation, execution and troubleshooting – are very high. This has led to the scope of the test being kept to a minimum and even avoiding end-to-end testing altogether, relying instead on the self-tests carried out by the relays. But it is precisely the end-to-end test that guarantees that the protection is working securely, dependably and selectively. An innovative solution has, therefore, been developed that enables this important test to be carried out at a reasonable cost while still satisfying the testing prerequisites.

The end-to-end test as a system test

The main purpose of an end-to-end test is to validate the communications connection. However, it can also be used as a system test.

Studies such as the NERC Study have shown that most protection misoperations are caused by incorrect settings, or logic, or design errors. This is due to the complexity of the power systems and the increasing demands, resulting in an ever-growing number of protection and logic functions, not to mention relays. A system test can be a great help in detecting the faults that can occur as a result. If a threshold has already been calculated incorrectly in the design, a conventional test is only able to check if the relay picks up at the incorrect threshold. This fault can be detected by simulating the power system while calculating the end-to-end test. If we calculate the test signals by simulating a fault at 70 per cent of the line, it is possible to validate whether the settings would in fact trip a fault at 70 per cent instantaneously.

Logic errors occur most frequently when coordinating the individual components, for example, different interval times in the event of an autoreclosure (AR) at each end. Such an error is easy to identify with an end-to-end test. Coordination is not only required for differential protection. As a backup, a relay often has an additional distance protection function with a communication scheme; additionally, in transmission systems, a separate backup protection relay is fitted. Practical experience shows that faults also occur in the coordination between the primary and backup protection systems. These are not

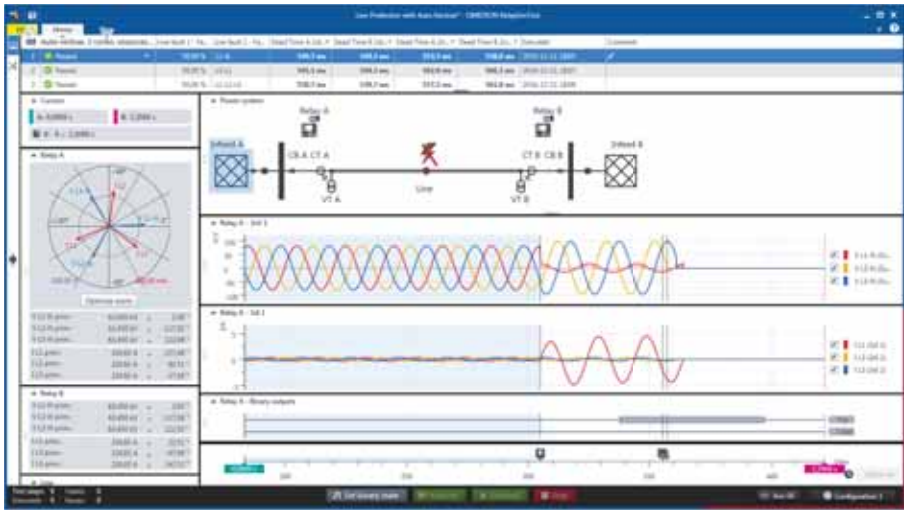


Figure 2: Integrated grid simulation

detected unless a system-based testing approach is adopted, as seen in the example of the Irish utility ESB. In this instance, the AR of the backup protection was blocked by the primary protection, resulting in unwanted three-pole tripping. The cause was a single incorrect setting in the backup protection relay. This demonstrates that the system test has to cover as much of the system as possible in order to detect interface errors.

Weaknesses of a "classic" end-to-end test

Preparing a classic end-to-end test is usually a very expensive business. If it is also going to be used as a system test, the output values have to be based on realistic fault simulations, which means that every status has to be calculated separately or exported for every test case and every test set. Then, all the test cases have to be imported into the respective test plans in the same sequence. Creating the sequence when testing the logic is even more difficult. If, for example, a state change is triggered by a circuit breaker (CB) off command at just one end, the voltage and current signals at the other end of the line must also change. The distance between the test sets means that binary triggers can only be used to a limited extent. Precise time sequences must also be known so that these sequences can be created with time triggers.

Furthermore, all the test engineers involved must be equally familiar with the testing procedure. They must all know which test is to be carried out to ensure that the correct sequence is implemented simultaneously at all ends. This is often a source of errors. To evaluate whether the system has passed the test, the results from the individual ends have to be communicated by telephone, which means a single test can take several minutes. If the system fails the test, then modifications may have to be made to the test sequence, a process that is extremely cumbersome and error-prone if done by phone.

The Right Tool Makes all the Difference

Three core functions have been combined to create innovative testing software to improve the end-to-end test process.

1. Transient power system simulation to calculate the test variables.
2. Central control of test sets from a single PC.
3. Iterative closed-loop as a patented solution for testing distributed logic.

Simulating the power system has two benefits. A system test based on power system data can pick up errors in the settings. The integrated power system simulation also saves a huge amount of time and greatly simplifies the preparation and execution of an end-to-end test. In the best-case scenario, the only data that need to be entered are the primary line impedance, the transformer ratios and, if desired, the short-circuit currents on the busbar. Then, all that needs to be done for the individual test cases is to create a fault at the required point and define its evaluation criteria. This takes no more than a couple of minutes and only needs to be done once due to the fact that the test sets are being controlled by the main application.

A "main application" in this sense refers to a PC-based application that is controlling several test sets in a time-synchronised manner (Figure 1). The integrated power system simulation correctly calculates the signals for all ends simultaneously at the moment of execution (Figure 2). The signal paths are recorded on the respective test sets and the synchronous starting time for all the sets is defined. On completion of the test, the test system fetches

the recorded binary traces (for example, the off command) from all the test sets and evaluates them. One test engineer can initiate the entire process by pressing the Start button – no different to the testing of a single relay. Not only is the test evaluated immediately, a comprehensive test report is also produced. Should the test fail, necessitating a modification, the on-site test engineer can move the fault and repeat the test immediately.

The connection between the PC and the test set can be established directly or via a simple internet connection, in which case another PC connected to the internet at the remote end will also be required. However, this will only permit access to the connected test set via a password-protected Cloud connection from the main application. All the benefits remain though. (Figure 3).

Under no circumstances should testing of the logic be neglected. The specially developed iterative closed-loop algorithm significantly reduces the complexity of the logic test, something that is exemplified in the testing sequence for an autoreclosure. As before, the user picks a fault on the line. When the fault currents are output, the relays respond after a specified time with an off command. As the test sets are distributed, it is not possible to respond quickly enough with new signals on all ends. The application therefore starts the next iteration, beginning with the same fault currents. As the same trip times are expected, a command to open the CB was added to the sequence in advance. Once the trip occurs, the relays respond with a close command. The next iteration starts. This contains the fault, the trip and also the closing of the CB. The iterative closed loop repeats the process automatically until the complete autoreclosure sequence has been tested. The test engineer does not have to define the pause times, or even whether it is a single-pole or three-pole autoreclosure. Any faulty logic or coordination is detected immediately.

Preparation and execution of system-based end-to-end tests

An end-to-end test remains logistically complex, despite the immense improvements in the tools. It is, therefore, important to make good use of valuable time. This means creating and maintaining a checklist, as shown in this example:

- Verification of the power system data: do the simulated short-circuit currents approximate to what was expected?
- Is the protection concept sufficiently familiar to ensure that the response can be correctly evaluated and tested?
- Are an adequate number of test sets available with the required licenses and firmware?
- Are enough test leads, plugs and cables available?
- Is the cable for the GPS antenna long enough? (We recommend the use of GPS antennae with RJ45 connections, as random Ethernet cable drums can be used.)
- Is the cell phone charged?
- Are the test sets connected?

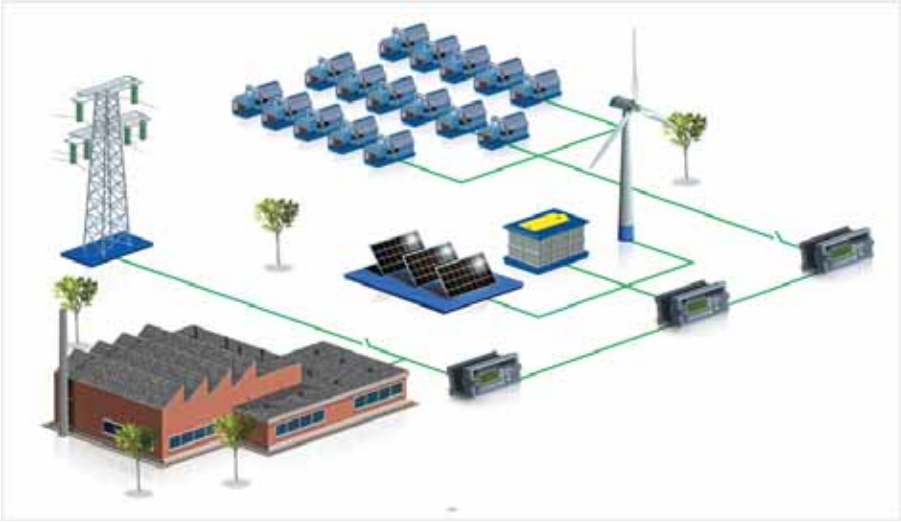
Conclusion

Over recent years, this innovative testing solution has detected many faults and saved commissioning engineers a great deal of time. An end-to-end test should, therefore, be an indispensable part of the commissioning of every line protection (differential and distance protection with signal comparison). It is also worth noting that a testing solution like this can also be used with other distributed protection systems, such as busbar differential protection, reverse interlocking, CB failure, etc., to name just a few. The transient simulation also enables transient ground fault protection, power swing blocking and other transient functions to be tested.

Christopher Pritchard

Product manager for application software in the protection testing department, OMICRON electronics

DEIF's hybrid microgrid solution



Microgrid solution

Hybrid Power – The need of the hour

Across the world, the need to make the energy portfolio environmental friendly is a pressing need. Among the renewable sources, solar and wind power are considered as a technological option for generating clean green energy. Hybrid power generation using these sources is gaining momentum backed by favourable government policies and the abundant potential in India. This increasing demand is driving down the cost of solar energy which is attracting more and more investment in the sector.

While the investment and increasing of hybrid power system share in the energy sources is fully justified, it is also equally important to have efficient controls that will enable renewable energy usage to the maximum possible extent including the possibility of exporting excess power back to the grid.

Challenge with hybrid power systems

In a contemporary system, solar power can only be utilised as long as the utility supply is available. In the absence of utility, solar power can no longer deliver the power and the diesel generators come in to deliver the backup power. The solar/battery/wind systems are not geared up to supply power along with the diesel or gas genset as the load sharing between the renewable and conventional energy groups is a challenge. This leads to burning the fuel (diesel/gas) for the genset to take the entire load for the duration for which the utility is absent, in spite of solar/wind power source being available.

DEIF's answer to the challenge

DEIF with its experience and expertise in the field of power generation control technology has

come up with an innovative solution to this challenge. DEIF introduces the Automatic Sustainable Controller (ASC-Solar, ASC-Battery and ASC-Wind), a solution that provides integrated solution for systems with utility, diesel, battery, solar and wind power sources.

The system provides an interface between the diesel/gas genset, solar, battery and wind power, with or without presence of utility supply - a solution that enables you to share the load between solar PV cell, wind power, battery bank and diesel/gas genset with maximum solar penetration, thus resulting in maximised savings even during utility failure. DEIF solution being cost-effective balances your economy and conserves the environment as it is highly efficient. It also increases the reliability of the system and reduces the dependence on one single source.

DEIF's Hybrid Microgrid

In your present off-grid setup with utility and genset power sources, a PV plant can easily be added and controlled by the ASC Solar. A solar system consists of series of PV cells connected to their respective inverters. ASC-4 Solar controller is connected to the master inverter or central control point of the group of inverters and interconnected among utility and genset controllers through CAN bus communication.

During the day time, the PV plant generates solar power which means fewer gensets need to be running. During cloudy weather the power can be supplemented by starting the necessary gensets. During the night time, the PV plant

ASC Solar edited

has no output and the gensets provide the necessary power.

An optional weather forecasting unit can easily be added. The ASC-4 controller also supports short-term weather forecasting systems to optimise the output. DEIF system is capable of withstanding a drop in PV production, for instance due to clouds casting shade on the PV panels. Using a sky image camera for cloud tracking, the solar production forecast for the coming period is delivered to the PV/diesel control system i.e. the ASC-4 Solar controller. This enables it to start up the required number of genset in due time before clouds reduce the PV production and maintain a sufficient amount of spinning reserve. DEIF's ASC solutions are compatible with the leading short-term forecasting systems of the industry from Reuniwatt and SteadySun. The forecasting is directly coupled to the existing spinning reserve routine and will generate automated start/stop of gensets accordingly.

A battery bank can easily be added and controlled by the ASC-4 Battery controller. When the power in the battery bank is low, it can be easily recharged by the system. When the battery bank is fully charged, it supplies power to the system which could mean that no gensets need to be running. During night time when the battery bank is being emptied, the system will automatically starts the correct number of gensets to compensate for the power requirement. You can easily add a wind turbine controlled by the ASC-4 Wind controller. Together with the PV plant and the battery storage system it can contribute to the green energy even at low periods such as night time. It all helps to produce as much green energy as possible.

One can easily use the solution with a grid connection controlled by the AGC Mains controller. If the grid connection is lost, the system continues on green energy for as long as possible before starting any genset. DEIF's hybrid microgrid solution (ASC) helps you to reduce your fuel consumption and maintenance intervals while at the same time cutting emissions. ASC increases safety of the system by protection against reverse power flow into the grid when running in parallel with the grid, thus avoiding tripping of the grid and penalty to the customer.

DEIF's expertise is your advantage

At DEIF, the company cares about green energy which is why they develop energy-efficient products and solutions. DEIF products have been installed and running successfully world over for over 80 years. DEIF's hybrid microgrid solution – Automatic Sustainable Controller (ASC) has been incorporated in more than 50 solar power projects of 20 MW total PV capacity with 60 MW diesel power (DG), all over India and many more projects are in the pipeline.

For more information, write at india@deif.com

Grundfos "Living Lab"

Intelligent energy monitoring with the Microsoft Azure IoT Suite and TwinCAT IoT

The energy-efficient Grundfos Kollegiet building offers students an attractive living environment in the new harbor district of Århus. State-of-the-art energy automation linked to Microsoft's Azure Cloud makes it possible to identify even the smallest energy savings potential.

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As part of a project to explore energy monitoring and smart metering technologies, Grundfos, Microsoft and Beckhoff have equipped the "Grundfos Kollegiet" student dormitory in the Danish town of Århus with intelligent PLC systems that transmit data to an energy monitoring system in Microsoft's Azure Cloud computing platform. The dormitory is near the town's port district and was built in accordance with the most

advanced energy efficiency standards and equipped with the latest building and automation technology. The energy monitoring system creates a database for optimising building operations. By including the residents of the “Living Lab” in the project itself, the building owners can increase efficiency without reducing the residents’ comfort.

The first version of the Grundfos project was implemented as early as 2012 by installing a special server infrastructure and database in the building. As the monitoring cycles grew shorter and the amount of data needed for the seamless analysis of current and historical conditions larger, administering this IT infrastructure became increasingly expensive in terms of both money and personnel. Protecting access to all this data by various groups of users also required increasingly complex systems. In order to meet these requirements in the future, the parties involved in the project decided in 2015 to redesign the project and migrate the server infrastructures to a Cloud-based system. As part of this change, Beckhoff’s highly scalable control technology demonstrated its flexibility, providing a seamless retrofit of the local building automation platform with a link to the Cloud. The PLCs and I/O subsystems now transmit the energy data to the Cloud-based system via TwinCAT IoT software, which is easy to configure and does not require programming.

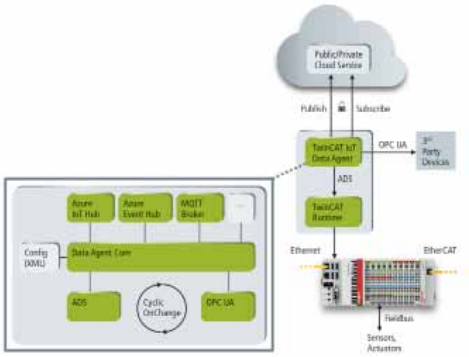
Microsoft’s Azure Cloud platform provides everything necessary to create a fast, scalable infrastructure for processing and storing the data. Access to the energy monitoring data from the “Living Lab” can be defined and enabled for a wide range of user groups. The information is made available to the building’s residents and management, as well as to the research and technology department of Grundfos. By conducting various studies in connection with the residents and the building management system, Grundfos hopes to use the data to identify new usage options for its current products, as well as for new product offerings and business models. Also involved is the University of Århus, which analyses the connection between resident behaviour and energy usage.

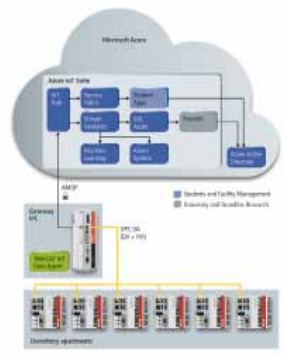
The energy monitoring system is used to store and analyse all energy consumption data, as well as for managing alarms. The 12 floors of the building house

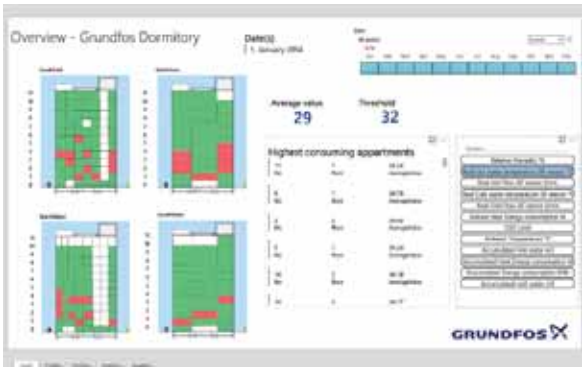
Using products that are compatible with standards like OPC-UA, Beckhoff ADS and AMQP delivered huge benefits for Grundfos. It enabled us to provide all devices and services for this project quickly and easily.

Morten Lykkegaard, Lead Enterprise Architect, Grundfos

156 residential units, with 3,000 sensors that collect energy data every three seconds and transmit them to the higher-level system. The sensors are linked to Beckhoff BC9191 Bus Couplers and CX9020 Embedded PCs. A central Beckhoff Industrial PC runs the TwinCAT IoT Data Agent software to collect sensor data via







OPC-UA and functions as the gateway to Microsoft's Azure Cloud, in particular the Azure IoT Hub. The TwinCAT IoT Data Agent effectively separates the PLC systems from the Cloud environment. Thanks to the publisher/subscriber mechanisms and communication via the Azure IoT Hub as a central message broker, there is no need for the devices and services involved in the communication process to divulge their addresses to each other. They communicate exclusively via the central broker, which handles all message addressing functions. From the perspective of the firewall placed in front of the gateway PC, the data communication provides an encrypted link for both transmitted and received messages, and the firewall makes it possible to completely block all incoming communications, thus preventing any unwanted access from the outside. This protects the residents' personal data, the companies' intellectual property and building operations from accidental or intentional manipulation.

The Data Agent's graphical user interface (GUI) makes it easy to configure the sensor data for transmission to the Azure IoT Hub. Through various parameters, the administrator can also define when the transmission will be initiated: cyclically, when certain values change or when certain actions are executed. Internal buffering mechanisms also ensure that any missing sensor data will be transmitted after a power failure. If the connection fails, the TwinCAT IoT Data Agent records a timestamp. As soon as the connection has been restored, the Data Agent retrieves the missing data from its internal memory and sends it to the Azure IoT Hub.

As a central and secure message-based connectivity service, the Azure IoT Hub is responsible for receiving and forwarding the energy data to all participating Cloud services within Microsoft Azure. Further analysis of the energy data is possible with the help of the Microsoft IoT Suite, which administers the devices and collects raw data for processing via the Azure SQL Data Warehouse and PowerBI. Azure Stream Analytics and Azure Machine Learning are used to detect anomalies. Special algorithms in these services recognise whether the values detected by the sensors over a specific period fall outside the normal range or could possibly not be recorded. If such an event occurs, the system issues an alarm via e-mail.

In addition, the various user groups such as the student residents can access the energy data via a special programming interface to develop their own apps or algorithms, as part of a project or to meet college course requirements, for example. The programming interface, which includes a function for retrieving historical energy data, is based on the Azure Service Fabric. The data is protected via Azure's Active Directory and Application Insights services, which authenticate the various user groups. As this project demonstrates in impressive detail, the Data Agent can be used to easily retrofit older, existing control systems with new technologies and connect them to the Cloud. This is all possible without having to modify the actual TwinCAT automation project, protecting the investments made in existing systems. Using Cloud-based services also makes it possible to flexibly adapt systems to changing needs without having to invest in your own hardware or software, which also significantly reduces operator costs.

Author: Sven Goldstein

Product Management TwinCAT, Connectivity & IoT
Beckhoff Automation GmbH & Co KG, Germany

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Advanced measuring solutions for electrical maintenance & safety

In these days of continuous advancements where continuity and precision have become important, one cannot afford to experience a shutdown or higher maintenance lead time as it directly infects the overall governing of the system. And if that malfunction comes in the form of an electrical breakdown, the results can be more adverse. Be it any facility or set-up, electrical maintenance is paramount.

It is often observed that the electrical maintenance engineers and facility inspectors trying their best to ensure uninterrupted service. Many a times they have to encounter problems like power losses, system failures and at worse even accidents, which are uninvited and unforeseen. Continuous inspection becomes a mandate and when your responsibilities are huge you must be well equipped to tackle such situations. That's where Testo extends its support and expertise to the industry providing a wide range of electrical equipment.

Testo Electrical Measuring Instruments is a set of equipment that enables any engineer or technician to curb down any sort of electrical disorder. Thanks to innovative technologies and simplified application, the Testo measuring instruments measure electrical parameters more reliably and precisely than ever before. The innovative electrical measuring instruments stand out due to their extraordinary elevated level of user-friendliness, setting new standards with intelligent and completely innovative technology. The status of all electrical plants and equipment (including electric motors, pumps and switching cabinets) can be tested reliably and highly efficiently. This complete set comes in a portable kit with:

Testo 745 non-contact voltage tester with a voltage range of up to 1,000 V AC is particularly well-suited to fast initial checking of any suspected fault sources. It is available with a filter and is used for high-frequency interference.

- Adjustable sensitivity
- Visual and acoustic signal
- Waterproof and dustproof according to IP 67
- Measuring point illumination.

Testo 755 voltage & current tester is the first of its kind which meet the latest standard and which can also measure current. It can determine voltage/de-energisation, for measuring current and resistance, as well as for continuity tests. In addition, the integrated torch enables dark spots to be illuminated. The measuring tips can be changed easily, so that the whole instrument does not need to be replaced in the event of damage.

- Automatic measurement parameter detection
- Certified according to voltage tester standard
- Measurement result without any switching on or selection
- Measuring point illumination
- Exchangeable measuring tips

Testo 760 multi meter is the first digital multi-meter with automatic detection of measurement parameters and selection via socket assignment. Function keys replace the traditional dial on all three instruments, which means easier operation and greater reliability.

- Easy, modern operation with function keys instead of a dial
- Measurement parameter detection and selection via the socket assignment
- Prevents incorrect settings
- True root mean square measurement - TRMS
- Large, backlit display

Testo 770 Clamp meter is ideally suited for current measurement in switching cabinets. It has a unique grab mechanism for easy and safe work and automatic measurement parameter detection also ensures reliable work. It also measures multiple parameters like, power factor, resistance, voltage etc very easily.

- Unique grab mechanism makes it easier to work at tight measuring points
- Auto AC/DC for current and voltage
- Large two-line display
- True root mean square measurement - TRMS
- With additional functions, such as starting current, power and µA measurement
- T 770-3 also works on Bluetooth and testo Smart Probes App.

Testo 750 Voltage tester comes with patented all-round LED display for visibility from all sides. They have the most essential functions for voltage testing, continuity testing and rotating magnetic field measurement.

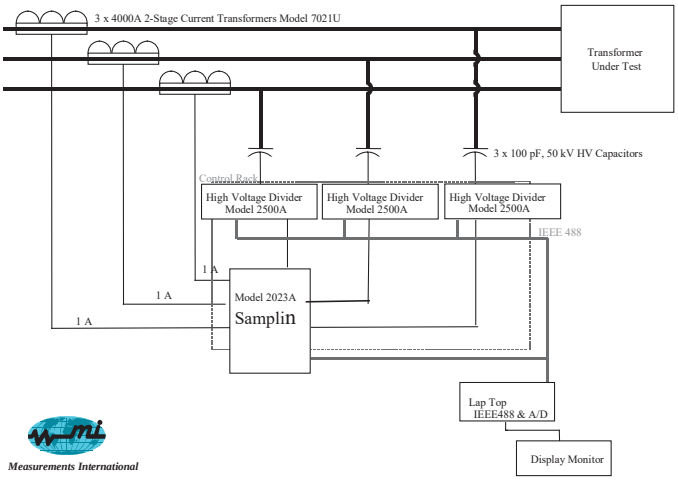
- Clear, patented all-round LED display
- Fibre-optic technology for optimum voltage indication
- Anti-slip ring for secure grip
- Ergonomic handle shape
- Measuring point illumination

It has also been proven that an efficient and healthy electrical facility can improve total performance of any industrial, residential or commercial application. Testo provides the solutions and products that not only measure the necessary parameters but also ensure longevity and minimises colossal damages.

For further details Contact: info@testo.in

AccuLoss Loss Measurement System

AccuLoss is a complete three-phase transformer measuring system designed for power frequency testing and calibration of medium and large power transformers, large motors and turbines. This measurement system follows the latest specifications dealing with the calibration of test systems to measure losses. The measurement capabilities of the various models of AccuLoss are from a few amps up to 6,000 amps and voltages from 100 V up to 300 kV (line to ground) and frequencies from 40 to 400 Hz. Using state of the art technology the AccuLoss series have the highest accuracy available on the market. AccuLoss systems have been used in the field for more than 20 years now.



The technology for the AccuLoss series of loss measurement systems is based on the two-stage-compensated current comparator technology. The current input features a two-stage-compensated current transformer with a ratio of 1000:1 or 2000:1. Current ranging is performed in the power analyser with 10 current ranges. On the voltage side a high voltage standard capacitor and an active voltage divider with 7 voltage ranges are used. The voltage divider has a built in two-stage-compensated current transformer which automatically corrects for any drifts in the electronics, there are no adjustments required and as a result both the voltage divider and current divider maintain their accuracy over several years of operation. Full Scale accuracy can be maintained over the full range of both voltage and current. Both single and 3-phase measurements can be performed.

System accuracies are better than any system available on the market today with full scale power measurements < 40 ppm in magnitude and phase and voltage and current measurements to < 0.05%. All accuracy specifications are specified as 2 sigma.

The high-voltage dividers use a current-comparator to automatically correct for any drifts or offsets in magnitude and phase. The Model 7021U Two-Stage–Current transformer is passive, and the accuracy is not affected by age. The system is completely automated and requires no manual intervention during operation. Individual or continuous measurements can be made. The components of the AccuLoss System have exceptional reliability, having years of operational experience in the rugged transformer test environment. The software provided for the system is written in LAB VIEW. Each power analyser has independent 2-volt full-scale outputs. Using these outputs with a National Instrument A/D card, harmonics are extracted up to the 25th and displayed on one of the software menu screens.

Cost Effectiveness

The AccuLoss System is a completely automated, rugged test system that maximizes throughput resulting in a short payback period in the time sensitive transformer test industry.

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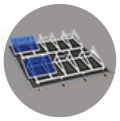

MMS Manufacturing facility in Tamilnadu -production capacity of 1 MW every 3 days

An Independent Power Producer with SPV projects developed under various national and Solar schemes

BIS certified PV modules & IMS certified company (ISO 9001:2015, ISO 14001:2015 + Cor 1:2009 & BS OHSAS 18001:2007)

Excellent after-sales service with more than 950 trained Service Engineers

MNRE Channel Partner with SP1A Rating - Manufacturer,RESCO PV & System Integrator. ESCO empanelled by BEE

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K-LITE introduces LED Landscape – Redefined

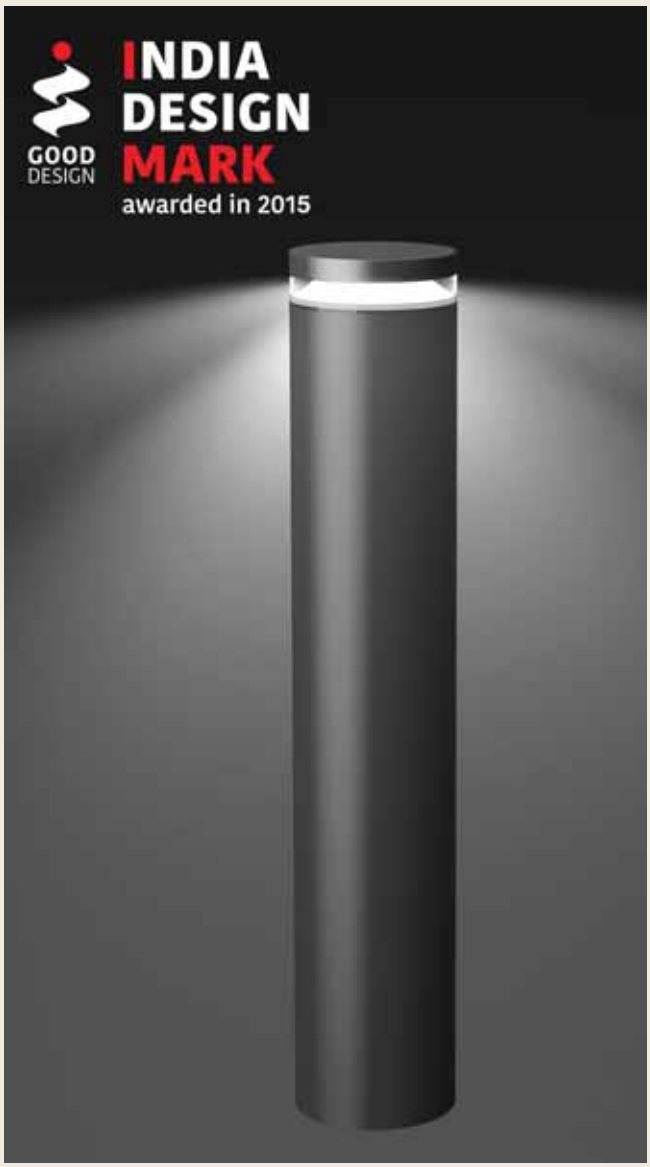
The essence of lighting is one of the most important things in our lives. Lighting manufacturer K-Lite is passionate about creating a distinctive atmosphere that improves the quality of life in the cities and towns by exploring the many potential facets of lighting that supports the well-being and safety of all.

Founded in 1977 in India, K-Lite has grown to be one of the leading manufacturers of outdoor luminaires and decorative poles. K-Lite's proven performance in the landscape segment is because of its ability to stylishly convey the identity of a space with a blend of efficiency and modularity to maximise the visual comfort that is best suited to each specific space.

Landscape range includes:

Linear wall washer, up-down lighters, LED strips/ neon flex, promenade lighting, bollards, under water lighting, post top luminaires, bulk heads, path finders, polar lighting and newly added series of facade lighting.

For more details, email: info@klite.in



KUSAM-MECO 2000A AC/DC Digital Clampmeter

KUSAM-MECO has introduced a new 2000A AC/DC digital clampmeter model KM 2775. This Clampmeter is auto-ranging and has many measuring functions. It has a display of 3¾ digit 4,000 counts. It can take conductor of diameter 55 mm maximum. The sample rate is approximately 2 times per second.

The clamp meter measure **AC/DC voltage**: 400mV /4V/40V/400V/1000V; **AC / DC Current:** 400A/2000A; **Resistance**: 400W / 4 K W / 4 0 K W / 4 0 0 K W / 4 M W / 4 0 M W ; **Capacitance:** 4nF/40nF/400nF/4mF/40mF/400mF/4mF; and **Frequency:**4KHz/40KHz/400 KHz/4MHz /40MHz.

It measures AC voltage and AC current of high frequency of 1KHz. Safety standard IEC/ EN 61010-1 EN 61010-2 CAT III 600V. With stand voltage 6000V. It has fully-automatic measurement, range change function, data hold, continuity check, diode measurement, low battery indication, and auto power off function. It operates on 9V battery. It is supplied with user's manual, carrying case, battery and test leads.

For more details, visit: www.kusam-meco.co.in

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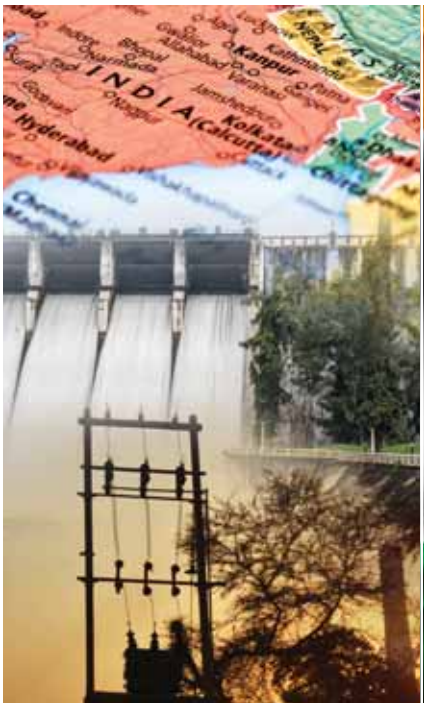

MIDEL 7131

The world-leading fire safe, biodegradable, synthetic organic transformer fluid, MIDEL 7131 has exceptionally high moisture tolerance, enabling it to extend cellulose insulation life. It is used in a wide range of transformers up to 433kV. Perfectly suited for non-breathing and free-breathing transformers (due to its excellent oxidation stability), MIDEL 7131 offers the ability to safely increase transformer loading or reduce transformer size.

MIDEL eN 1204

MIDEL eN 1204 is a natural ester liquid (rapeseed) with a high fire point that significantly increases fire safety and reduces the need for fire protection equipment. It is sustainably sourced and readily biodegradable, enabling reductions in containment measures. MIDEL eN 1204 has a pour point around 13°C lower than the soya-based natural ester, making it ideal for cooler climates.

MIDEL eN 1215

MIDEL eN 1215 is an excellent dielectric fluid because it has a high fire point, making it demonstrably safer than mineral oil. Environmentally friendly, MIDEL eN 1215 is made from renewable vegetable oil (soya), and is also non-toxic and readily biodegradable. In addition, MIDEL eN 1215 offers superior moisture tolerance and has the potential to increase the lifetime of cellulose based solid insulation, which in turn can extend transformer life.

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Net-zero carbon emissions is possible by 2060: Report

New report by the Energy Transitions Commission shows that reaching net-zero carbon emissions from heavy industry and heavy-duty transport can be done through ambitious policy, accelerated innovation, and investment, with minimal cost to the global economy.

Reaching net-zero carbon emissions from heavy industry and heavy-duty transport sectors is technically and financially possible by 2060 and earlier in developed economies and could cost less than 0.5 per cent of global GDP, according to the report published today by the Energy Transitions Commission (ETC). The report Mission Possible: Reaching net-zero carbon emissions from harder-to-abate sectors by mid-century outlines the possible routes to fully decarbonise cement, steel, plastics, trucking, shipping and aviation – which together represent 30 per cent of energy emissions today and could increase to 60 per cent by mid-century as other sectors lower their emissions.

Speaking on the occasion, Dr. Ajay Mathur, Director General, TERI said, "India is investing in new capacity in many sectors – steel, cement, petrochemicals – where low carbon technology options are not yet evident. The new Energy Transitions Commission report #MissionPossible provides strategic direction into possible technology investments to move to near-zero carbon emissions by the 2060s."

The "Mission Possible" report was developed with contributions from over 200 industry experts over a 6-month consultation process. Its findings show that full decarbonisation is technically feasible with technologies that already exist, although several still need to reach commercial readiness. The total cost to the global economy would be less than 0.5 per cent of GDP by mid-century, and could be reduced even further by improving energy efficiency, by making better use of carbon-intensive materials (through greater materials efficiency and recycling) and by limiting demand growth for carbon-intensive transport (through greater logistics efficiency and modal shift).

Speaking about the report, Adair Turner, co-chair of the ETC said, "This report sets out an optimistic but completely realistic message – we can build a zero-carbon economy with a minor cost to economic growth. We should now commit to achieving this by 2060 at the latest, and put in place the policies and investments required to deliver it."

The report also shows that this would have only a minor impact on the cost of end consumer products. For example:

- Green steel use would add approximately US$180 on the price of a car.
- Green shipping would add less than 1 per cent to the price of an imported pair of jeans.

- Low-carbon plastics would add 1 US cent on the price of a bottle of soda.

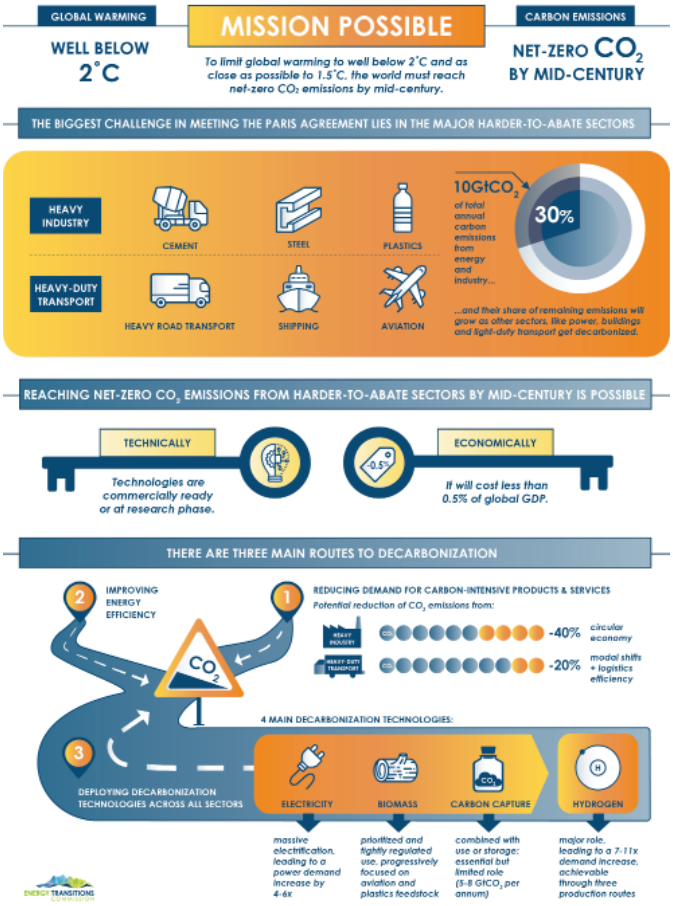
In India, the decarbonisation of heavy industry and heavy-duty transport is crucial, not only to reduce the carbon in the atmosphere, but also to improve air quality and enhance the quality of life and health of Indian citizens. The Indian industry is growing and has the opportunity to build new industrial capacity with state-of-the-art technology.

In heavy-duty transport, electric trucks and buses (either battery or hydrogen fuel cells) are likely to become cost-competitive by 2030, while, in shipping and aviation, liquid fuels are likely to remain the preferred option for long distances but can be made zero carbon by using bio or synthetic fuels. Improved energy efficiency, greater logistics efficiency and some level of modal shift for both freight and passenger transport could reduce the size of the transition challenge.

In industry, more efficient use of materials and greatly increased recycling and reuse within a more circular economy could reduce primary production and emissions by as much as 40 per cent globally – and more in developed economies – with the greatest opportunities in plastics and metals. Reaching full decarbonisation will require a portfolio of decarbonisation technologies, and the optimal route to net-zero carbon will vary across location depending on local resources.

Across all sectors of the economy:

- Direct and indirect electrification (through hydrogen) will likely play a significant role in most sectors of industry and transport, leading to a sharp increase in power demand – growing 4-6 times from today's 20,000 TWh to reach around 100,000 TWh by mid-century).
- Hydrogen use will almost certainly increase dramatically (7-11 times by mid-century), with two routes to zero-carbon hydrogen: electrolysis, which will likely dominate in the long term, and steam methane reforming plus carbon capture and storage.
- Bioenergy and bio-feedstock will be required in several sectors, but will need to be tightly regulated to avoid adverse environmental impact (such as deforestation), and its use should be focused on



priority sectors where alternatives are least available or costlier, such as aviation and plastics feedstocks.

- Carbon capture (combined with use or storage) will likely be required to capture process emissions from cement and may also be the most cost-competitive decarbonisation option for other sectors in several geographies. However, it does not need to play a major role in power generation, with the storage needs required could be less than many scenarios suggest. Tight regulation of storage is essential to ensure safety and permanence.

The "Mission Possible" report concludes that the most challenging sectors to decarbonise are plastics, due to end-of-life emissions, cement, due to process emissions, and shipping because of the high cost of decarbonisation and the fragmented structure of the industry.

The Energy Transitions Commission supports the objective of limiting global warming ideally to 1.5 C and, at the very least, well below 2 C. In the wake of the IPCC's urgent call for action, the "Mission Possible" report sends a clear signal to policymakers, investors and businesses: full decarbonisation is possible, making ambitious climate objectives achievable.

Key policy levers to accelerate the decarbonisation of harder-to-abate sectors include:

- Tightening carbon-intensity mandates on industrial processes, heavy-duty transport and the carbon content of consumer products.
- Introducing adequate carbon pricing, strongly pursuing the ideal objective of internationally agreed and comprehensive pricing systems, but recognising the potential also to use prices which are differentiated by sector, applied to downstream consumer products and defined in advance.
- Encouraging the shift from a linear to a circular economy through appropriate regulation on materials efficiency and recycling.
- Investing in the green industry, through R&D support, deployment support, and the use of public procurement to create initial demand for "green" products and services.
- Accelerating public-private collaboration to build necessary energy and transport infrastructure.

Industries and investors can anticipate the profound transformation in industry and transport they will eventually face by innovating and investing in decarbonisation technologies and low-carbon infrastructure. The ETC provides the fact base for industry groups and private companies to develop roadmaps, collaborations and projects aiming for net-zero carbon emissions in their sectors. It also encourages businesses across multiple sectors to question their procurement practices and make commitments to buying "green" products and services.

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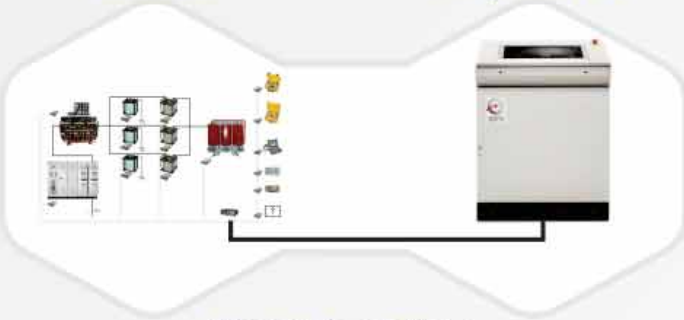
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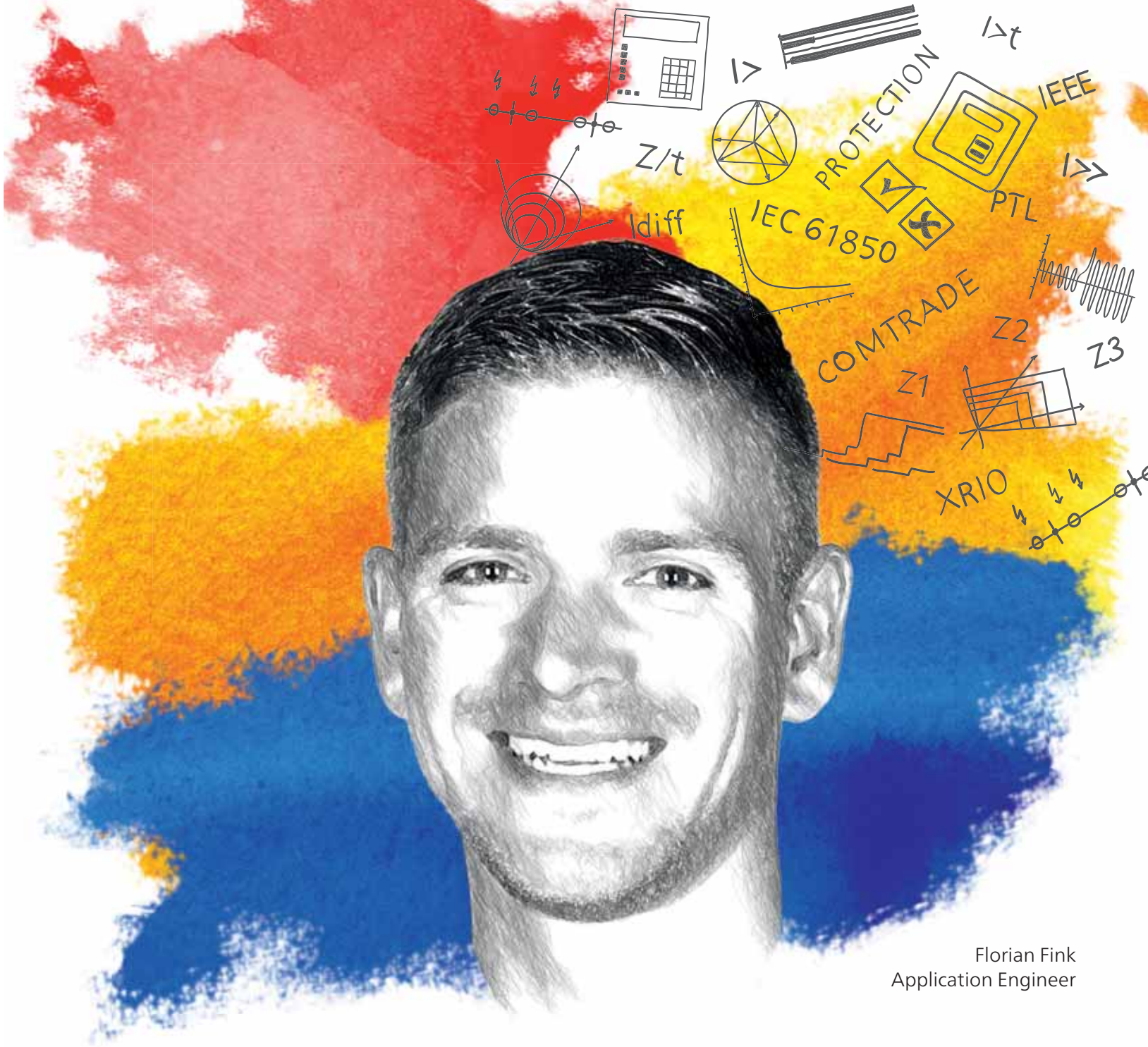

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