Vol 57 No 4 April 2017 ₹ 100

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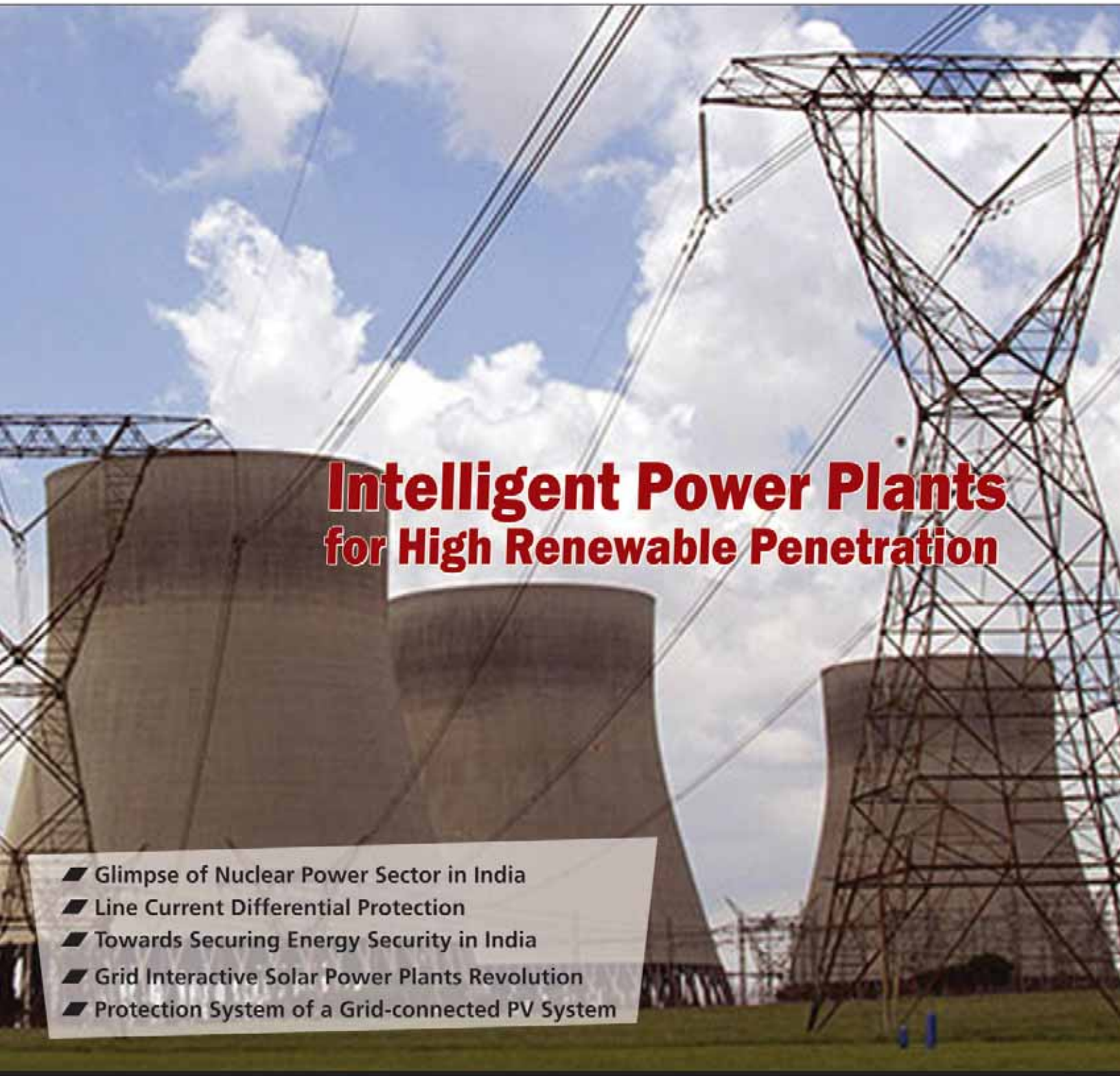

Intelligent Power Plants for High Renewable Penetration

- Glimpse of Nuclear Power Sector in India
- Line Current Differential Protection
- Towards Securing Energy Security in India
- Grid Interactive Solar Power Plants Revolution
- Protection System of a Grid-connected PV System

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Health is Wealth

Hello and welcome once again to *Electrical India*. By the time you get this issue in your hands, the celebration of World Health Day would be over, which is observed every year on the 7th of April to mark the founding of the World Health Organisation. Incidentally, just about two months from now on June 5th is the World Environment Day, which is observed to raise awareness throughout the world to take corrective environment action to save our only habitable planet, Earth. Why am I discussing about world health day and world environment day in *Electrical India*?

Last month US president Trump ordered demolishing an array of Obama's policies on global warming, which includes emissions rules for power plants. He wants to roll back the Obama's Clean Power Plan, which was aimed to cut emissions in US power plants to below 2005 levels by 2030. China, the world's biggest polluter, which had backed the former president's plan then, and wanted India too to be a part of signatory, will now retaliate with its own plan that would include setting up of more power plants run by coal. Where will this end?

Back home in Maharashtra, the government made it mandatory for all companies and real estate industry located in a radius of 300 kms from a thermal power plant to use fly ash in construction. The state produces nearly 30 lakh tones of fly ash every year, a third of which is dumped, increasing pollution. Overall, in India nearly 100 metric tonnes of fly ash is generated every year, the main cause of pollution. So the step taken by the government is in right direction. But the question is why should we allow generation of such large quantity of fly ash? The quality of coal that is used in our power plants is one reason.

But if one goes by the strictures imposed by the Comptroller and Auditor General (CAG) on the state government, which is being examined by the Public Affairs Committee, power plants run in the state generate close to 40% fly ash as against the international norm of 4%. The utilization of fly ash is still very low in India compare to some European countries. If one goes by the reports appearing in a section of press, the CAG has said in its report that people staying close to these power plants are at great risk.

Economists say if the economy of a country improves, so does the health of its citizens. But the exact opposite is also true. Only if people are healthy can a nation grow as more and more healthy people would be able to do more effective and quality work.

Do send in your comments at miyer@charypublications.in

Publisher & Editor-In-Chief

Vol 57. Issue No. 4 • April 2017

Directors
Pravita Iyer
Mahadevan Iyer

Publisher & Editor-In-Chief
Mahadevan Iyer
miyer@charypublications.in

Editorial Co-ordinator
Nafisa Kaisar
nafisa@charypublications.in

Advertising Department

Director Advertisement
Pravita Iyer
pravita@charypublications.in

Advertising Manager
Yasmeen Kazi
yasmeen@electricalindia.in

Design
Nilesh Nimkar
charydesign@charypublications.in

Sub-Editor
Dhanya Nagasundaram
edit@charypublications.in

Subscription Department
Nafisa Khan
sub@charypublications.in

Accounts
Dattakumar Barge
accounts@charypublications.in

Customer Care
Sonali Pugaonkar
mktg@*charypublications.in*

Electrical India is also available online on www.electricalindia.in. For online enquiries contact at: *dgmarketing@charypublications.in*

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Printed, Published and owned by Mahadevan Iyer from 906, The Corporate Park, Plot 14 & 15, Sector 18, Vashi, Navi Mumbai 400703 and Printed at Print Tech., C-18, Royal Indl Estate, Naigaum Cross Road, Wadala, Mumbai - 400 031. **Editor: Mahadevan Iyer**

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BHEL's first 800 MW Supercritical thermal power plant starts commercial operation

Bharat Heavy Electricals Limited (BHEL) has commenced commercial operation of its first 800 MW unit - highest-rating coal-based supercritical thermal power plant. The milestone was achieved for the first unit of the 2x800 MW Yeramarus thermal power station of Raichur Power Corporation Limited (RPCL), in Raichur district of Karnataka.

Significantly, the commercial operation of this unit also marks BHEL's foray as a developer into the field of power generation. Karnataka Power Corporation Ltd. (KPCL) and BHEL are the main equity partners of RPCL, the owner and operator of this power plant.

BHEL did complete design, engineering, manufacture, supply, erection and commissioning of this state-of-the-art supercritical project on turnkey basis. It has supplied all the critical equipment like Boiler, Turbine & Generators, Electricals, key packages of Balance of Plant, and has also carried out the associated civil works. The major equipment for the project has been manufactured by BHEL at its Haridwar, Trichy, Bhopal, Ranipet, Hyderabad, Jhansi, Thirumayam and Bengaluru plants, while the construction of the plant was undertaken by the company's Power Sector-Southern Region.

BHEL has supplied and executed 4,010 MW of coal based sets for KPCL and its joint ventures, which account for 95% of the utility's coal-based installed capacity.

BHEL is also presently executing KPCL's first gas-based combined cycle power project of 370 MW capacity involving a fuel-efficient advanced-class gas turbine at Yelahanka, Bengaluru.

IWTMA expresses the need for more policies in Rajasthan

The apex body in wind sector, Indian Wind Turbine Manufacturers Association (IWTMA) addressed the media to discuss the wind power development in Rajasthan. In the year 2015-16, Rajasthan installed 688 MW and the current total installation is 4237 MW till January 2017. The wind sector expressed confidence of growth of wind energy in the state.

There is a paradigm shift to Competitive Bidding instead of Feed In Tariff (FIT) on the recent 1 GW bid organised by SECI. The industry responded well with an interest of 2644 MW by four bidders @ Rs.3.46. The bid of Rs.3.46 need not be taken as an aggressive bid. Most of the bids are from Tamil Nadu, where the PLF is very high and is also based on interstate transaction with Power Grid Corporation of India Limited (PGCIL) network. IWTMA has requested MNRE for future bids of 5 to 6 GW so that the canvas is large and the market will grow under this process.

The apex body IWTMA also outlined the key challenges ahead in the reduction in Accelerated Depreciation (AD) from 80% to 40% and possible withdrawal of Generation Based Incentive (GBI) in April 2017 which could see some temporary slowdown in the wind industry, but not a worrying factor.

Pointing out that the States of Andhra Pradesh, Gujarat, Rajasthan and Karnataka were the major contributors in the total wind installations in 2016 with their lion share of 3718.91 MW, the IWTMA is happy to note that in the financial year ending March 31st, the wind installations are expected to cross 4000 MW and total installation beyond 30,000 MW.

The Association also highlighted some of the key challenges in Rajasthan. One of the major expectation is for the Government of Rajasthan to follow and implement the RPO trajectory as recommended by Ministry of Power. The state may also encourage new installation of turbines and encourage interstate transaction from Rajasthan to other states.

GST will be implemented in July as planned now will pose challenge to wind sector. The wind sector has requested for 'zero' rating or 'concessional rating' for wind sector without which it will impact capital cost. MNRE has also given similar recommendation and it is interesting to note that Ministry of Power has recommended to the GST Council for 'Zero' rating for Renewable Energy sector.

Cabinet approves MoU on Renewable Energy between India and Portugal

The Union Cabinet chaired by the Prime Minister Narendra Modi has given its ex-post facto approval for signing of a Memorandum of Understanding (MoU) on Renewable Energy between India and Portugal.

The MoU will help in strengthening bilateral cooperation between the two countries. Both sides aim to establish the basis for a cooperative institutional relationship to encourage and promote technical bilateral cooperation on new and renewable issues on the basis of mutual benefit equality and reciprocity. The MoU envisages constitution of a Joint Working Group which can co-opt other members from Scientific Institutions, Research Centres, Universities, or any other entity, as and when considered essential.

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57 Inter Regional Power Transmission projects has been sanctioned under PSDF scheme

Union Minister of State (I/C) for Power,Coal, New & Renewable Energy and Mines, Piyush Goyal, in a written reply in Lok Sabha informed that Inter Regional Transmission Corridors (IRTC) are planned and implemented for transfer of power from surplus states/regions to deficit states/regions on short term basis, subject to availability of margins in these lines. These lines, a part of the evacuation system from interstate generation stations, are mainly used for delivery of power from these generating stations to their beneficiaries in various states.

Goyal further informed that a number of inter-regional links have been planned which interconnect the five regional grids i.e. Northern, Western, Southern, Eastern and North Eastern regions. Presently, the total transmission capacity of such inter region all inks is 63650 MW (as on January, 2017), he said.

The Minister also informed that as of now, 57 projects have been sanctioned under the Power System Development Fund (PSDF) scheme, at the cost of Rs.7268 Crores. PSDF can be utilised, inter alia, for creating necessary transmission systems of strategic importance based on operational feedback by Load Dispatch Centres for relieving congestion in Inter-State Transmission Systems (ISTS) and intra-state system which are incidental to the ISTS. This fund can also be utilised for Renovation & Modernisation of transmission and distribution systems for relieving congestion, Goyal added.

Installed Solar Power Capacity in India crosses 10,000 MW

Union Minister of State (IC) for Power, Coal, New & Renewable Energy and Mines, Piyush Goyal, while speaking at a media event, announced that on 5th April the Ministry is holding a Quality Conference with all the coal companies and technical experts of the sector to sit down and the lay down the strategy to ensure that right quality of coal is supplied to our power plants and help them achieve higher efficiency rates. He also announced that the Cabinet has recently approved a more liberalised pricing policy on Coal-bed methane development and production, which will ensure more efficient usage of coal with evolution of technology. This will define the manner in which India uses its coal in the future, he said.

Talking about the huge strides that have been taken in the solar power sector, the Minister said that on 10th of March this year the installed solar power capacity in India has crossed 10,000 MW, four times the installed capacity 3 years back, which in next 15 months would cross 20,000 MW. He added that India could not have completely focused on 'Making in India' in the last 3 years as being in the nascent stage, its solar power sector needed technological and financial boost from abroad to rapidly expand its horizons. Now the sector has reached certain maturity level which will lead the country becoming self-reliant in meeting its Green Energy needs. The proof is the drastic reduction in costs of solar power, becoming comparable with thermal power in India, he said. The country has shown it to the world that India is a big marketplace for manufacturing in solar power sector and international investors and manufacturers have started setting up manufacturing units in the country, he noted.

Goyal also encouraged the Industry stalwarts present at the event to ramp up the silicon wafer manufacturing industry and the manufacturing of solar cells in India.

He also talked about devising strategies to combine solar power with electric vehicles, which have three times the energy efficiency on engines that run on fossil fuels. This would be a revolution in the transportation sector, he added.

13th Executive Committee Meeting of the ISGAN inaugurated

The Ministry of Power, Government of India hosted the 13th Executive Committee (ExCo) Meeting of the International Smart Grid Action Network (ISGAN) at POWERGRID Corporate Centre, Gurugram. This is the first ever Executive Committee Meeting of ISGAN being held in India. The ISGAN ExCo was opened by Michele de Nigris, Chair, ISGAN Presidium, I.S. Jha, CMD, POWERGRID and Dr. Arun Kumar Verma, Joint Secretary (Distribution), Ministry of Power by lighting the lamp. In the inaugural session Verma, shared India's training modules on Smart Grids and Model Smart Grid Regulations for guidance of the ISGAN Community.

Smart Grid implementation in India would get a boost from deliverables obtained through decisions and actions taken in 13th ISGAN ExCo Meeting as ISGAN aims to improve the understanding of smart grid technologies, practices and promote adoption of related enabling government policies. The dynamic knowledge sharing, technical assistance and project coordination and periodic ISGAN reports on progress and projects being undertaken in the field of Smart Grids across the world would also be helpful in suitable deployment of Smart Grid technologies in India.

ISGAN is an agreement under International Energy Agency (IEA) and consists of representatives from 25 countries across the globe. India is one of the founding Member of ISGAN and Joint Secretary (Distribution), Ministry of Power, is the member representative of India. ISGAN creates a mechanism for multilateral government-to-government collaboration to advance the development and deployment of smarter electric grid technologies, practices and systems.

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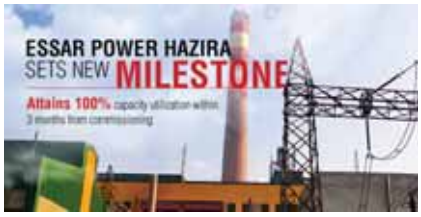
Essar Power Hazira attains 100% capacity utilisation

Essar Power Hazira Ltd, a subsidiary of Essar Power Ltd, revealed that its 2x135 MW power project in Hazira was now operating consistently at close to 100% capacity utilisation. The achievement is significant because it comes close on the heels of the commissioning of the second unit, which occurred just three months ago. It is also an indicator for the increased capacity utilisation of its captive client—Essar Steel's 10 million tonne Hazira Steel Complex.



The plant can run on multiple fuels, like coal, corex fines and corex gas, simultaneously. It can also utilise excess gases from the process units of steel making operations. Over the last few weeks, it has lived up to its green commitment by using a higher proportion of by-products from the steelmaking process, including coal fines and corex gas. The plant is also helping bring down Essar Steel's power procurement cost, while lending unmatched reliability and flexibility to the steel making process. Essar Steel has increased its capacity utilisation from 30% to 80% over the last one year.

KVB Reddy, CEO, Essar Power, said, "The year is turning out to be an important one for Essar Power. Close to 80 % of Essar Power's targeted capacity of 6,100 MW, which comprises both captive and IPP assets, have been made operational. In the last two years, increased coal availability, both from domestic and overseas suppliers, as well as the strong operational efficiencies harnessed by Essar Power's world-class technical team have helped improve our performance significantly."

Ferrero India installs Maharashtra's biggest roof top solar installation in Baramati, Pune

Ferrero, globally renowned chocolate and confectionary company revealed the installation of 1.5 MW capacity solar power project at its manufacturing facility at Baramati. This is Maharashtra's biggest roof top Solar Power installation.

Ferrero is one of the few food companies in India to install solar power at their manufacturing unit in India. The company has invested 1.2 million Euros (approx INR 8.8 crores) in this project. This project is built on an area of 22,000 square meters and covers 8.4% of the total factory load.

Solar power plant at Ferrero India manufacturing unit in Baramati

The new Solar Power plant will generate energy of 2250000 kWh per year (2250 MWh). The company will be able to cut its carbon dioxide emissions by 1.926 tonnes per year. This solar power project is enough to serve the needs of about 1500 to 2000 homes each day and could save upto Rs. 3.6 crores annually.

The company spokesperson said, "This solar power project at the Ferrero plant at Baramati is our endeavour to providing a cleaner and greener environment to the community in Baramati. In this way Ferrero is reducing its carbon footprint and protecting the natural eco system. We are committed to this project and in making the lives of people better in the community we operate."

L&T (E&A) FZE wins ` 500 crore order from Qatar rail company

L&T Electrical & Automation FZE (LTEAFZE), the competency centre for L&T Electrical & Automation (E&A)'s automation business in UAE, won a major order worth ` 500 crore from Qatar Rail Company (QRAIL) for Phase 1 of Doha Metro. The scope of the order encompasses supply, installation, testing, integration, commissioning and 5 years' maintenance of a network-wide Building Automation and Control Systems (BACS) for 37 stations.

LTEAFZE was nominated by QRAIL for network-wide implementation of BACS after a meticulous assessment of its capabilities in delivering technologically advanced solutions within stringent project timelines and with distinguished quality against global automation product manufacturers. The Frame Agreement awarded by QRAIL to LTEAFZE is through 9 contracts with design & build contractors for the stations and tunnels under multiple lines (Red line, Green line and Gold Line) and a 5-year maintenance contract directly with Qatar Rail.

S.C. Bhargava, Senior Vice President & Head of E&A Business, revealed, "LTEAFZE's core strengths for project management, domain knowledge and application engineering will enable us to offer distinctly superior and proven system integration solutions by leveraging L&T's capabilities built over four decades. Backed by a pool of experienced engineers, LTEAFZE has the competency to provide preventive and corrective maintenance services to maximise the performance and uptime of its automation systems and control equipment."

The metro system will be built in two phases: the first will see the construction of three out of the four lines (Red, Gold, and Green) and 37 stations spanning 111 km of tunnels and 8.7 km of viaducts. The Phase 1 has to be completed on a fast paced project schedule for handing over all the 37 stations by August 2018 with scheduled start on revenue period by end 2019. These lines are expected to be open to the public by 2020. When in operation, the project will provide an environmentally-friendly and sustainable mode of transport to over 600,000 commuters a day by 2021. The second phase will be completed by 2026, and will involve the expansion of the Phase 1 lines, and the construction of an additional Blue Line and another 72 stations.

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NTPC installs India's largest Floating Solar PV Plant in Kerala

A 100 kWp Floating Solar PV plant, the largest of its kind in India as on date, indigenously developed as a part of 'Make In India' initiative, was inaugurated by A. K. Jha, Director (Technical) in presence of V. B. Fadnavis, RED (SR), R. K. Srivastava, ED (NETRA) at Rajiv Gandhi Combined Cycle Power Plant (RGCCPP) Kayamkulam, Kerala.

This floating platform has been indigenously developed by NETRA (NTPC Energy Technology Research Alliance), the R&D arm of NTPC Ltd, in collaboration with Central Institute of Plastic Engineering & Technology (CIPET), Chennai and patent has been applied. The system was installed by Swelect Energy Systems Ltd, Chennai with support from NETRA & NTPC Kayamkulam station in a short span of 22 days. Such systems are fast emerging as an alternative to conventional ground mounted PV systems which are land intensive. It has various benefits like conserving water through reduction of evaporation, increased generation due to cooling effect on the panels, reduced installation time etc and could be installed on saline water environment. Installation potential of such type of systems in India is huge because of abundance of water bodies, within NTPC, the potential is approximately 800 MWp in various reservoirs in existing stations. Particularly in Kerala, due to availability of water bodies and lack of presence of enough land, this type of system has a great potential. NTPC has already started working on scaling up such type of system for MW scale installation.

OMRON expanded its reach in the energy segment at India Smart Grid Week-2017

OMRON, the front-runner in 'Sensing & Control + Think' technologies, expanded its presence in the smart energy segment in India. The company has updated its portfolio with an array of unique and innovative solutions to cater to some of the critical needs faced by utilities in the sector in the country. The solutions were displayed at the renowned exhibition India Smart Grid Week-2017 at New Delhi.

Believing in its mission of improving lives and contributing to a better society, OMRON aimed to support the utilities to manage a considerable proportion of their T&D losses caused due to power theft by providing first-of-its-kind sensing solutions which make the meters 'tamper evident' and provide remote disconnect with real-time monitoring. Another notable solution is the Line Monitoring Sensor that has the capability of detecting hooking and leakage at the distribution lines enabling the utilities further. This solutions gains immense importance considering the country has about 400,000 km stretch of distribution lines needing an efficient monitoring and management. Live demos of Flow Sensors and Seismic Sensors, utilised for gas meters, air conditioners and for managing secondary damage caused by earthquakes, has also been displayed. These solutions ensure safety and efficiency of energy usage making residences and business establishments smarter.

Vinod Raphael, Country Business Head - OMRON Electronic and Mechanical Components business division, India, said, "Tomorrow's world is going to run on sensors and data, including the power industry. OMRON has an array of solutions to help India become smarter and energy efficient. This resonates well with many key initiatives of the government like National Smart Grid Mission, deployment of 250 mn Smart Meters by 2027, Smart Cities Mission, rural electrification by 2019, etc."

Siemens to deploy state-of-the-art signalling systems for Nagpur Metro


Tilak Raj Seth, Siemens

Siemens Limited and Siemens Rail Automation Ltd. S.A.U Spain have jointly won an order worth Rs. 287 crore, out of which Siemens Limited's share is Rs. 146 crore (all inclusive). Siemens is to supply state-of-the-art signalling technology for the first two metro lines of the Nagpur Metro i.e. the North-South and the East-West Corridors. The project comprises the deployment and installation of the Siemens communications-based train control (CBTC) solution Trainguard MT for 38.2 kilometers of double track with 36 stations and two depots, as well as onboard equipment for 23 three-car trains.

The modular and future-proven Trainguard MT automatic train control system is Siemens' commitment and delivery to the comprehensive requirements of urban rail transport in India. It offers the latest standard in automation at different levels. The East-West Corridor will have 19 stations and the North-South Corridor 17 stations, and will link the Airport with the Automotive Square, at the north of the city. The CBTC solution can enable headways of 90 seconds or less with precise train detection achieved through digitalised track database; enabling increase in the frequency of trains resulting in efficient commute for passengers.

Tilak Raj Seth, Executive Vice President, Siemens Ltd. and CEO, Mobility Division in Lead Country India, said, "Nagpur Metro will play a pivotal role in enhancing quality of life and economic growth of the city and the region. We are delighted to have won the NMRCL Signalling Contract. The Nagpur metro is a prestigious infrastructure project and we will deliver state-of-the-art technology that employs CBTC to maximise the network capacity while minimising operational costs.

Siemens' future ready signalling solution will provide the basis for an attractive, safe and efficient mass transit system which will satisfy the needs of both passengers and rail operators."

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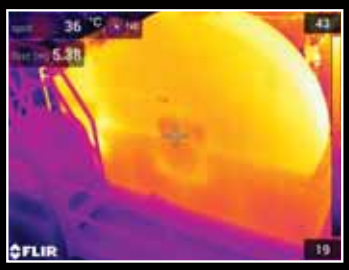

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ABB introduces digital switchgear solutions for U.S. microgrid management

ABB is launching new low-voltage solutions for microgrid management in the United States that make it easier to upgrade any facility's power network and improve control and connectivity. These new technologies will be on display for the first time at the ABB Customer World event in Houston.

The integration of Emax 2 air circuit breakers into the ABB ReliaGear line brings new embedded functions, such as automatic transfer switching and fast-load shedding logic, which enable switchgear to manage the different power sources that make up a typical microgrid. These software-based solutions enable ABB ReliaGear to offer advanced protection, programmable logic, full connectivity, easy integration and comprehensive microgrid energy management, all embedded in one space- and time-saving device.

ABB is also launching of Ekip UP at ABB Customer World 2017, a simple way to extend functionality to any kind of installation where a power circuit breaker is not suitable, or to give older facilities advanced monitoring, protection and control abilities. The plug-and-play, compact and multifunctional unit gives any low-voltage power distribution system standard and advanced microgrid technologies that are available with Emax 2 all-in-one solutions, with reduced impact on the original switchgear installation design. The ABB solution helps maximise uptime and efficiency, increases awareness of resources and process behaviours.

CSSC, Wärtsilä establish new E&A joint venture

Technology group, Wärtsilä and China State Shipbuilding Corporation (CSSC) have signed a new joint venture company agreement. The new joint venture, to be known as CSSC Wärtsilä Electrical & Automation Co Ltd (CWE&A), will focus on the growing Chinese electrical and automation (E&A) market, especially for high-tech ship applications. The joint venture company is expected to be fully operational before the middle of 2017.

China is a growing market within the high-tech ships segment, and Chinese yards are increasingly active in newbuild projects for high-tech and high-added value ships. CWE&A will supply China based customers with Wärtsilä electrical and automation systems and equipment for these ships.

The business scope will include project engineering, project management, commissioning and supply management of automation, navigation and communication systems, dynamic positioning systems, electric propulsion systems, power distribution systems, entertainment systems, architectural lighting, safety and security systems, and full systems integration. The joint venture owners are CSSC Electronics Technology Co Ltd and Wärtsilä.

Jaakko Eskola, CEO of Wärtsilä, said, "First of all, I wish to express my sincere appreciation to CSSC for their good collaboration and visionary leadership. The CWE&A joint venture enables both Wärtsilä and CSSC to serve our customers better here in the world's largest shipbuilding market. Vessels are becoming more complex, with E&A solutions being increasingly important, and as digitalisation enters the marine industry CWE&A will be well positioned to meet the needs of its customers in this field."

GE introduces Global Powering Efficiency COE

GE launches its new global Powering Efficiency Centre of Excellence (COE), which brings together cross-business experts in its energy businesses to apply a total plant hardware and software solution approach to boost the efficiency of the world's new and existing coal-fired power plants and significantly reduce their emissions. The global COE, headquartered in Baden, will create integrated solutions as well as provide vision and oversight around the world. Regional teams will focus on engineering capabilities and local execution.

Michael Rechsteiner, executive sponsor of the global COE and vice president of product lines for GE's Power Services, said, "By bringing together the combined experience of a cross-business group of experts from GE's Power Services, Steam Power Systems, Global Research Centre and Global Growth organisations, we are showing operators how they can achieve emissions compliance and increased efficiency with their new and existing coal-fired power plants."

The COE aligns with GE's recent Ecomagination study that found carbon dioxide (CO_2) emissions from the world's steam fleet can be reduced by 11% when existing hardware and software solutions are fully applied. Coal-fired power generation provides electricity for about 40 % of the world. It also accounts for nearly 75 % of the electricity sector's carbon emissions because many plants are older and inefficient.

The newest coal plants being built using GE's ultra-super critical technology can deliver up to 49 % efficiency rates—significantly higher than the global average of 33 %. Every point of efficiency reduces operating costs over the lifetime of the plant while also reducing CO_2 emissions by approximately 2 %.

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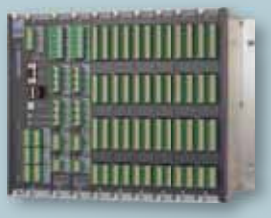

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JinkoSolar , Marubeni Corporation enter into Power Purchase Agreement

JinkoSolar Holding, a well known leader in the photovoltaic (PV) industry, revealed that a consortium consisting of JinkoSolar and Marubeni Corporation (Marubeni) have entered into a Power Purchase Agreement (PPA) with the Abu Dhabi Water and Electricity Company (ADWEC) for the Solar PV Independent Power Project (the Project) located at Sweihan, Emirate of Abu Dhabi, United Arab Emirates.

A special purpose company jointly owned by JinkoSolar, Marubeni, and the Abu Dhabi Water and Electricity Authority (ADWEA) will construct, operate and maintain the PV plant for the duration of the 25-year PPA. The project will be located in the Eastern Region of the Emirate of Abu Dhabi, approximately 120 km east of the city of Abu Dhabi in Sweihan and will have the capacity of 1,177 MW (DC). All power generated will be sold to ADWEC, a wholly owned entity of the ADWEA. The Project's financial agreements are expected to close in April 2017 with commercial operation expected to begin in 2019. Xiande Li, Chairman of JinkoSolar, said, "We are excited to be a part of the significant milestone project to co-develop with ADWEC and Marubeni. The execution of the PPA demonstrates our strong technical skills, reliable high-efficiency products and development capabilities. We are proud of making a significant contribution to the development of the solar industry in the Emirate of Abu Dhabi."

KfW signs loan agreement with EESL

KfW on behalf of the German Ministry for Economic Cooperation and Development (BMZ) has signed a loan agreement in the amount of EUR 200 million with Energy Efficiency Services Limited (EESL).

EESL will use the development funds to invest in energy efficiency measures for private households, public buildings, street lights (LED technology), water supply systems, agriculture (replacing pumps) and industry. EESL also offers its customers an array of other services to help save energy.

Dr Norbert Kloppenburg

Dr Norbert Kloppenburg, Member of the Executive Board of KfW Group, said, "The plans will lead to major reductions in CO2 emissions for the world's third largest energy consumer and producer of greenhouse gases. With this innovative business model, India is breaking new ground when it comes to promoting large-scale investments in energy efficiency, making it a global pioneer in this field."

This project follows on from the 'Energy efficiency in public buildings and infrastructure' programme, which helped to save around 600,000 tonnes of CO2 per year by successfully executing the Domestic Efficient LED Lighting Programme (DELP). This saving corresponds to emissions from approximately 70,000 Indian households.

Overall, the Federal Republic of Germany has committed EUR 600 million for energy efficiency measures in India, including the EUR 50 million for EESL in 2014.

Wärtsilä to supply 38 MW power plant to Saudi Arabia

The technology group Wärtsilä will supply a 38 MW power plant to a Saudi Arabian customer. The turn-key Engineering, Procurement and Construction (EPC) order includes four Wärtsilä 32TS engines. The order is booked in the first quarter of 2017.

The Wärtsilä 32TS engine, a two-stage turbocharged version of the Wärtsilä 32 series, is optimised for extreme ambient conditions. It is designed to deliver outstanding efficiency with reduced fuel and water consumption in high altitudes and hot temperatures while complying with the World Bank's EHS (Environment, Health and Safety) guidelines for NOx emissions. This power plant will be the first Wärtsilä 32TS installation to operate primarily on crude oil, with heavy and light fuel oils as backup fuels.

Saudi Arabia has recently launched a transformation programme related to the energy sector. Broad initiatives to improve energy efficiency, to increase the role of gas and renewables in the energy mix, and to effectively utilise the existing natural resources have been introduced throughout the country. This project is in line with the Saudi Vision 2030 programme. It demonstrates clearly that Wärtsilä's technology can deliver valuable benefits in optimising the country's power system, for instance through improving the efficiency of its customer operations.

Wärtsilä has been present in Saudi Arabia for more than 40 years. Upon completion of this project, Wärtsilä will have more than 1900 MW of installed capacity in the country. Globally, Wärtsilä's installed base is over 63 GW in 176 countries.

Qasim Latif, Business Development Manager at Wärtsilä Energy Solutions, said, "In addition to the very high efficiency, the main cornerstones of our solutions are exceptional operational flexibility, multi-fuel capability, and minimal water consumption - even in hot conditions.Together these features, along with the ability to act as a state-of-the-art enabler of renewable energy integration, make our solutions very well-suited for the Saudi Arabian market."

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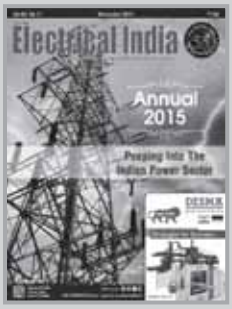

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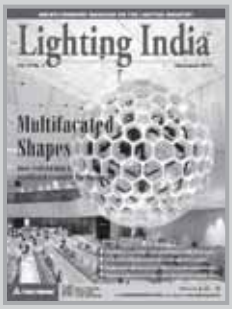

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MK Goel appointed as JERC chairperson

MK Goel took over as Chairperson, Joint Electricity Regulatory Commission (JERC) for the State of Goa and Union Territories.

Goel, an Electrical Engineer from Kanpur University has over 37 years of varied Power Sector experience. Before joining JERC, he has been heading Power Finance Corporation, a navaratna PSU and largest NBFC in the country as Chairman and Managing Director. He has close to 28 years of Power Financing experience in PFC and 9 years of Power Generation experience in NHPC before joining PFC in 1988. He has more than 9 years of Board level experience in PFC.

M K Goel

He has immensely contributed to the development of power sector and financial industry as a key member in various Committees related to policy and regulatory areas such as (1) 'Central Advisory Committee' (CAC) to advise CERC on policy issues, (2) 'Fund requirement' for National Electricity Plan constituted by CEA, (3) 'High Level Committee on Financing Infrastructure' to take up financing issues with RBI for regulatory changes etc.

GE Renewable Energy creates new roles and brings changes in its hierarchy

GE Renewable Energy recently revealed the creation of Renewable Energy Services Business, a new horizontal initiative that will work with the Onshore Wind, Offshore Wind and Hydropower businesses to provide more customer value and integrated solutions for the industry.

Anne McEntee

Pete McCabe

Anne McEntee is named Vice President (VP), Renewable Energy Services Business. In this newly created position, McEntee will be working closely with each GE Renewable Energy service organisation, as well as the Digital team, to improve GE's capabilities. The ultimate goal being to expand service agreements and explore new OEM services, while creating new value for customers and more productivity for the business. Prior to this role, McEntee led the Onshore Wind business, a role she held since 2013, and also held the role of CEO of Flow and Process Technologies and Power Services.

Pete McCabe will succeed McEntee as President and CEO of Onshore Wind. McCabe is a 22-year veteran of GE and a GE Company Officer, most recently serving as the Vice President of Global Services Organisation (GSO). GSO is a $2.2 billion unit of GE Transportation committed to improving critical customer outcomes.

Jérôme Pécresse, President and CEO GE Renewable Energy, said, "The creation of a Services offering is critical for our business to be even smarter, more efficient and faster. I am confident that under Anne's leadership our dedicated service business will continue to grow and I know that Pete, with his strategic problem-solving and willingness to embrace disruptive technology, is well suited to keep our Onshore Wind business on this positive track."

PJM board promotes Thomas O'Brien to senior VP and CIO

The PJM Board of Managers has promoted Thomas O'Brien to senior Vice President (VP) and Chief Information Officer (CIO). O'Brien previously was VP and CIO.

O'Brien is responsible for PJM's information technology services activities, including Business Solutions, Application Development Services, and Infrastructure & Operations. Additionally, he provided active leadership for implementation of the Advanced Control Centre Program including oversight of creation of a new information and application architecture for the PJM Energy Management and Market Management Systems.

Thomas O'Brien

Prior to joining PJM in 2002, he was employed by GPU Energy and First Energy. He earned his Bachelor of Arts in mathematics with a concentration in computer science from Shippensburg University and also earned a Master of Business Administration from LaSalle University. He recently completed a certificate program in Advanced Computer Security through the Stanford Centre for Professional Development.

Andrew Ott, President and CEO, said, "Now more than ever our industry needs visionary leadership around information technology. Tom's knowledge and leadership of PJM's information technology, security and resilience vision and strategy has been a real asset. His promotion clearly reflects his growth and leadership in the organisation and the industry."

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A.M. Naik conferred IMA Lifetime Outstanding Achievement Award

In appreciation of Group Executive Chairman, A.M. Naik's outstanding contribution to Indian industry and to society, Indore Management Association (IMA) has honoured him with the Lifetime Outstanding Achievement Award. The award was presented at the 26th International Management Conclave 2017 of IMA at Indore. Naik received the award from Shiv Singh Mehta, Chairman of IMA. The conclave was attended by many luminaries from industry including Deepak Parekh, Chairman, HDFC Ltd.

A.M. Naik being honoured...

IMA, an association of entrepreneurs and professional managers, was formed in 1963. It is affiliated to the All India Management Association (AIMA) as one of its constituent bodies. It has direct and indirect membership of over 3500 members including corporates, professionals, academicians and students.

Speaking on the occasion, Naik disclosed his success mantra and said, "Have an urge to do the best in what you undertake. With devotion, passion, conviction and dedication, anyone can succeed in life. Always work as a team."

Hindustan Power conferred with the 'Best Employer Branding Empowered Company' award

Hindustan Power - India's well known integrated power player – has been bestowed with the 'Best Employer Branding Empowered Company' by the Indian Brand Conventions & Branding, Advertising and Marketing (BAM) Awards 2017. The award comes in recognition of the excellent employee engagement policy of the company which has been instrumental in increasing employee productivity and ensuring higher retention especially at a time when the power sector is faced with multiple challenges due to the upward revision of the renewable target for the country.

Aman Attree

The award winning campaign enabled the company to draw upon experience and expertise from one business to solve the challenges of other business. This cross vertical approach has brought upon a culture of innovative solutions which are cost effect and time beneficial to the company.

Aman Attree, HR Head, Hindustan Power projects, said, "It gives us immense pride to be honoured with the prestigious award, since it recognises Hindustan Power's dedication to our most valuable resource, our employees. The power sector requires holistic approach for the employees to feel engaged and motivated – from being posted to remote locations to having to move from one location to another, the challenges are many for the employees but Hindustan Power has implemented a robust developmental plan ensuing in higher retention and innovative approach to solve business challenges. We were able to address the same through effective employee engagement with focus on lateral thinking resulting in growth and development. This recognition is a testimony to efforts of our great team of employees, support staff and leaders that are supporting us in realising our vision."

Today, India is a vibrant economy with businesses achieving new heights and new start-ups making their presence felt with their innovation and novelty. There is a whole generation of professionals who work hard in paving the success path of today's business ventures. Indian Brand Convention & BAM Awards aim at recognising all such professionals and offer them a platform to share their stories to inspire others.

SWECO receives AWEA Health and Safety Achievement award

Suzlon Group, a well known renewable energy solutions provider in the world, revealed that Suzlon Wind Energy Corporation (SWECO), its wholly-owned U.S.A. subsidiary, received the Gold level AWEA (American Wind Energy Association) Health and Safety Achievement Award 2017 as an operations and maintenance service provider. This is the highest level of safety recognised by AWEA.

AWEA is dedicated to cultivating the safety and health of the wind energy industry. This award recognises the organisations who have demonstrated safety as a core value and actively participated in AWEA's efforts to advance Health and Safety as a value in the industry.

Andy Cukurs, CEO, SWECO, said, "We have one of the best health and safety cultures in the North American wind industry and this award is a testament for our efforts. As a wind turbine manufacturer and service partner, we stand committed to provide top-notch health and safety measures at our wind farms. We take great pride in partnering with our clients for harnessing renewable energy solutions across the US and we are committed to support the energy transition from traditional fossil fuels to cleaner forms of energy."

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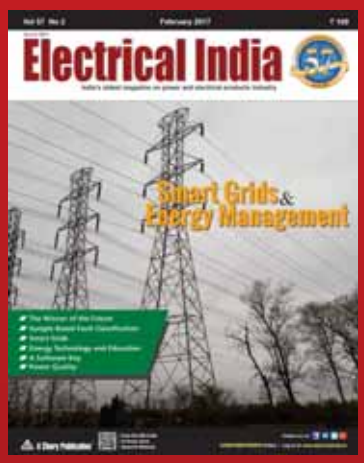

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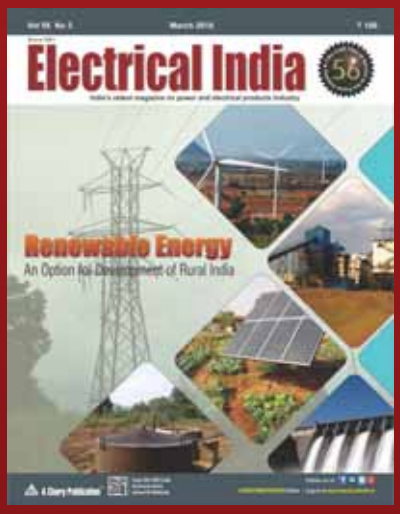

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Glimpse of Nuclear Power Sector in India

Dr Anuradha Tomar
Associate Professor
HMR Institute of Technology and Management, New Delhi

Shikhar Agrawal
Student, B Tech
HMR Institute of Technology and Management, New Delhi

Ayush Mittal
Student, B Tech
HMR Institute of Technology and Management, New Delhi

This article discusses the various economic aspects and status of nuclear power generation and transmission in context with Indian Power Sector. Details of various nuclear power plants along with Nuclear Research centers are included. Data from various sources has been collected and compiled in order to provide readers with correct information regarding the status of nuclear power generation in India.

In 1934, an Italian scientist named Fermi and his colleagues bombarded uranium with slow moving neutrons and he realized that the nucleus of uranium (235) would split down the middle in two very similar fragments and will produce much higher radioactivity than any other element. This process was to be known as nuclear fission and was the starting of an era of nuclear power/energy.Uranium is a silvery white chemical element having atomic number 92. It has numerous physical, chemical and atomic properties and as energy production and weapons design. But, its primary use is as a source of energy in nuclear reactors.

Global carbon emissions have been rising sharply since the end of 20th century, and countries have adopted various policies and switched over to alternate source of energy to minimize/reduce Greenhouse Gas Emissions in different sectors. India's Nationally Determined

Reactor No.	Project	Capacity (MWe)	Scheduled Date of commercial operation	Expected Date of commercial operation	Physical Progress
02	Kudankulam Atomic power Project	1000	Dec-2008	Mar-2017	99.92% as on FEB 2017
07	Rajasthan Atomic power Project	700	June-2016	Under Review	——
08	Rajasthan Atomic power Project	700	Dec-2016	Under Review	——
03	Kakrapar Atomic power Project	700	Jun-2015	Under Review	——
04	Kakrapar Atomic power Project	700	Dec-2015	Under Review	——

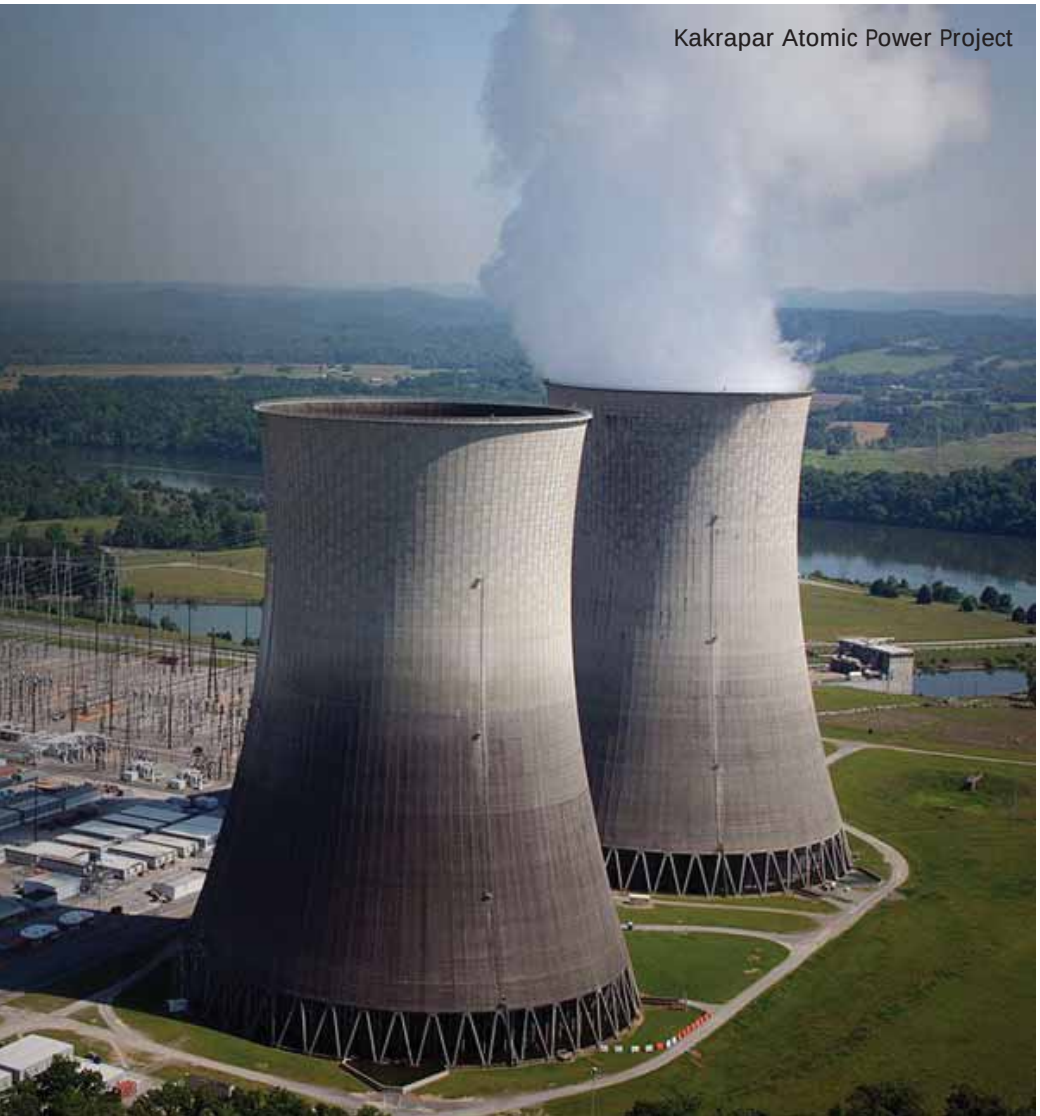
Source: Plants under Construction, National Power Corporation of India Limited (NPCIL)

Nuclear Power Reactors			
Operational	Under Construction	Long-Term Shutdown	Permanent Shutdown
22	05	00	00

Source: IAEA, Power Reactor Information Report (PRIS)

Contributions (NDC) has outlined goals to reduce the carbon emissions intensity of its economy by 33-35 percent by 2030 as well as increase the clean energy capacity to 40% of the total installed capacity in the same period. The most important source of energy for India in the coming decades is nuclear power, given its huge potential growth, emission-free nature and consistent nature of production.

India has a streamlined nuclear power program and expects to have 20,000 MW nuclear capacities on line by 2020. It aims to supply 25% of electricity from nuclear power by 2050. Since India is outside the Nuclear Non-Proliferation Treaty due to its weapons program, it had been largely excluded for 34 years from trade in nuclear plant or materials, which has hindered its development of civil nuclear energy until 2009. India's vision is to become a world leader in nuclear technology due to its expertise in fast reactors and thorium fuel cycle.



Kakrapar Atomic Power Project

Nuclear Reactors

Nuclear Reactor is an engineered design civil construction that produces and controls the release of energy from splitting the atoms of certain elements. The several components common to most type of reactors are – fuel, moderator, control rods, coolant, pressure vessels/and tubes, steam generator, containment. The reactors operational in commercial field include – Pressurized Water Reactor (PWR), Boiling Water Reactor (BWR), Pressurized Heavy Water Reactor (PHWR), Gas Cooled Reactor (AGR & Magnox), Light water Graphite Reactor (RBMK & EGP) and Fast Neutron Reactor (FBR).

According to NPCIL report, there are 21 Nuclear Reactors in operation in seven nuclear power plants with a total capacity of 5,780 MW as on January 2017. Tarapur Atomic Power Station (TAPS), Maharashtra is oldest and the largest nuclear power station in India; having four Nuclear Reactors with a capacity of 1400 MW and is in commercial operation since October 28, 1969. But, Kundakulam Atomic Power Project overtook TAPS, Maharashtra since March 2017, with a capacity of 2000 MWe only with two Nuclear Reactors. Also, according to NPCIL report, three Nuclear Reactor Projects are under construction out of which one Kudankulam Atomic Project, Tamil Nadu is under operation since March 2017.

Production and Transmission

Nuclear power plants have many features in common with traditional electrical power facilities; the main difference is that they produce energy with radioactive materials instead of convectional fuels. The same commercial power grid carries electricity from nuclear and fossil-fuel plants as well as renewable sources. A nuclear reactor produces large amounts of heat from the controlled radioactive decay of elements such as uranium and plutonium. The nuclei of these heavy elements are unstable; they emit radiation in the form of neutrons, alpha and beta particles and gamma rays, becoming more stable in the process. As they produce radiation, they also become very hot. In a nuclear reactor, the heat is used as a substitute for the burning of coal or natural gas. Both non-renewable resources (fossil fuels) and nuclear power plants use heat to boil water and make steam. Pipes carry high pressure from the nuclear reactor to a steam-powered turbine. The steam propels the turbine's blades, causing the turbine shaft to spin rapidly, turning a generator that produces electricity. The steam condenses into water, which is recycled back to the reactor to become steam again.

According to the annual report 2015-16 by the Department of Atomic Energy, India, during the calendar year 2015, NPCIL recorded highest ever generation of 38,364 Million Units (MUs), which was about 3% higher than the generation of 37,146 MUs in the last calendar year 2014.

Nuclear Power Generation (2010-11 to 2016-17)

YEAR	Gross Generation (in MUs)	Capacity Factor (%)	Availability Factor (%)
2016-17	31281	79	80
2015-16	37456	75	77
2014-15	37836	82	88
2013-14	36333	83	88
2012-13	32863	80	90
2011-12	32455	79	91
2010-11	26472	71	89

Source: Nuclear Power Generation, National Power Corporation of India Limited (NPCIL)

Also, as mentioned in the press release (Dated 25-FEB-2015) by the Department of Atomic Energy, India, Nuclear power generation increased from 14,927 MUs of electricity in 2008-09 to 35333 MUs in 2013-14 and the capacity utilization has also improved from about 50% in 2008-09 to 83% in 2013-14.

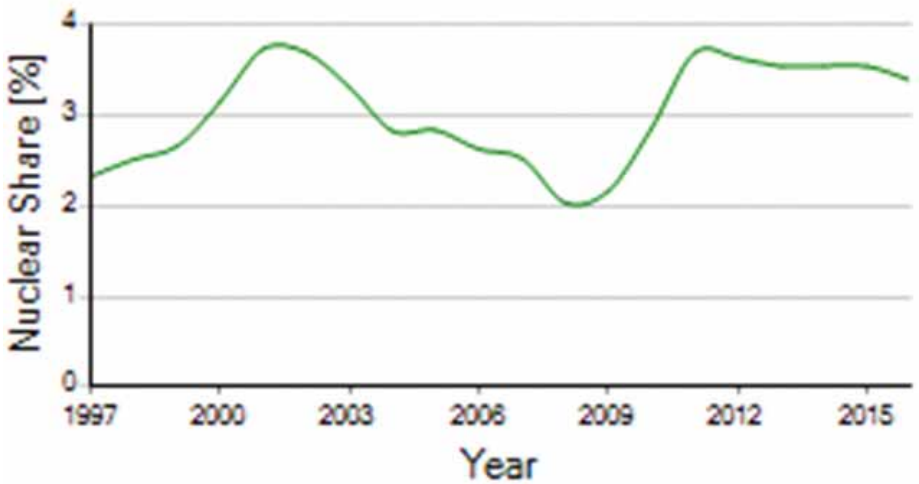
Year	Annual Target (MUs)	Achieved Target (MUs)
2012-13	31060	32863
2013-14	31708	35333
2014-15	38300	30490 (Upto JAN 2015)

Source: Press Information Bureau; Press Release (Dated 25-FEB-2015);Department Of Atomic Energy, Government of India.

Economic Times published a news article, quoting 'India has drawn up an ambitious plan to reach a nuclear power capacity of 63,000MW in 2032 by setting up of 16 Indigenous Pressurized Heavy Water Reactors (PHWR), including 10 based on reprocessed URANIUM, NPCIL Official said (08-OCT-2010). NPCIL Chairman and Managing Director, S K Jain, quoted –"Out of total target of 63,000 MW, about 40,000 MW will be generated through Light Water Reactors with international cooperation." He also said India would export 220MW, 540MW and 700 MW PHWRs by 2032.' dated 11-OCT-2010.

On the footprints of the targeted Nuclear Power Capacity of 63,000 MW, Lok Sabha was informed about the Government ambitious plan to setup nuclear plants in Bihar, Haryana and Punjab and aims to increase the capacity by three times in ten years. Also, during Question Hour in Lok Sabha, Union Minister Jitendar Singh quoted – 'If it is 4,780 MW on today, the same would go up to 13,480 MW by 2026' and the same was reported by The Times of India on 2 March 2017.

Trend of Nuclear Power Share in India (1997-2015)



Source: IAEA, Power Reactor Information Report (PRIS)

Advantages of Nuclear Power

- Energy Density: Bio-fuel or fuel from plants is one oft-cited source of renewable energy. When compared with firewood and bio-fuel, nuclear fuel has a much greater energy density, meaning the amount of energy getting from a unit mass of fuel is much greater and one needs to produce and transport much smaller quantity to get the same amount of power.
- Emissions: Nuclear power is emission free as there are no atmospheric pollutants and no greenhouse gases emitted through the operation of a nuclear power plant. Mining and transportation of nuclear fuel do have associated emissions, but the high energy density of nuclear fuel minimizes this impact.
- Land Use: All types of renewable energy take up vast areas of land. A solar power plant requires large arrays of panels or collectors spread across a wide area to capture as much sunlight as possible. Producing bio-fuels requires growing dedicated fuel crops on

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land that might otherwise have been used for agriculture. Similarly, hydroelectric dams create large lakes that flood what was previously dry land, and wind farms take up a large space for wind turbines. But, Nuclear power takes up a much smaller amount of land in comparison to the amount of power it generates, reducing the amount of habitat destruction associated with its construction.

- Reliability: Renewable energy is at the mercy of the weather. A solar power plant is going to be most efficient on days when the sun is shining brightly; wind farm works best when the wind means a drop in electricity generation. But, nuclear power continues to function just fine regardless of the weather.

Nuclear Energy Companies

- Bharat Electronics Limited (BEL)
  Expecting the nuclear deal with US to go through, India's largest defence electronics company Bharat Electronic Ltd (BEL) is looking at tapping the lucrative business potential in the atomic energy sector.
- Larsen & Toubro
  Global nuclear power companies are moving in fast into India. Large power majors with a strong presence in nuclear energy such as General Electric, Westinghouse and Areva are in negotiations with Larsen & Toubro (L&T) for a possible joint venture in nuclear power equipment and nuclear power generation.

Nuclear Power Research Centres

- Indira Gandhi Centre for Atomic Research
  IGCAR was established in the year 1971, under the Department of Atomic Energy, Government of India. The centre is engaged in broad based multidisciplinary programme of scientific research and advanced engineering directed towards the development of "Fast Breeder Reactor technology". Fast Breeder Test Reactor is based on unique mixed Plutonium Uranium Carbide fuel, first of its kind in the world and KAMINI Reactor, the only operating reactor in the world using U233 fuel are successfully operated. The design of 500 MWe Prototype Fast Breeder Reactor is completed and the construction is in progress.
- Baba Atomic Research Centre
  BARC provides a broad spectrum of scientific and technological activities extending from basic laboratory bench scale research to scale up plant level operations and its functional domain covers all walks of science and technology – stretching from classical school of thoughts to the emerging novel fields of interest. The core mandate of this institution is to provide research and development support required to sustain one of the major peaceful applications of nuclear energy viz. power generation. This includes conceptualization of the programme, finalisation of the design of the reactor and the peripheral components, preparation of computer generated working models and their evaluation studies under simulated reactor running conditions, identification, and selection and testing of materials and components for their risk analysis under extreme conditions of reactor operating environments, development and testing of new reactor fuel materials etc.
- The Tata Institute of Fundamental Research
  The Tata Institute of Fundamental Research is an autonomous institute under the umbrella of the Department of Atomic Energy of the Government of India. TIFR does basic research in physics, chemistry, biology, and mathematics and computer science. They have campuses in Mumbai, Pune and Bangalore and research facilities in various other places in India.

Rajasthan Atomic Power Station

Nuclear waste Disposal

Nuclear power is the only large-scale energy-producing technology which takes full responsibility for all its wastes and fully costs this into the product. The amount of radioactive wastes is very small relative to wastes produced by fossil fuel electricity generation. Used nuclear fuel may be treated as a resource or simply as a waste. It is neither particularly hazardous, nor hard to manage relative to other toxic industrial wastes. Safe methods for the final disposal of high-level radioactive waste are technically proven; the international consensus is that this should be geological disposal.

Economic Aspects

Globally

The only accurate measure of economic competitiveness is the cost of electricity produced by a particular project compared to alternative sources of electricity and to the market price of electricity when plant starts commercial operation. Economics of nuclear power involves consideration of various parameters/aspects such as- capital costs, plant operating costs,

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external cost to society and environmental degradation cost. Assessing the relative costs of new generating plants utilising different technologies is a complex matter and designing and construction of the reactors/plants are expensive but relatively cheaper to run. Nuclear energy/power is an economic source of electricity generation, combining the advantages, such as – security, reliability, virtually zero greenhouse gas emissions and cost competitiveness. Existing plants function well with a high degree of predictability with a low risk of significant operating cost inflation.The International Energy Agency (IEA) sees the global demand for electricity growing at 1.9% per year in the period to 2040.

Apart from considerations of cost of electricity and the perspective of an investor/ operator, there are studies on the economics of particular generating plants in their local context. Some of the published reports are – Economic Impacts of Thr R.E. Ginna Nuclear Power Plant (2015), Economic Impacts of The Indian Point Energy Center (June 2015) and Brattle Group Report (September 2015).

Indian

After studying various survey reports, in 2004 Department of Atomic Energy (DAE), Govt of India estimated that India would need 8 trillion kWh of electricity per year by 2050. The DAE has made some very ambitious projections for increasing the nuclear energy but was unable to meet the targets even over the very short run due to non-standard reactors. These reactors have the advantage that they can work with naturally occurring uranium without the need for enrichment. While this saves some expense, these reactors use heavy-water, which is expensive.

Moreover, the economics of nuclear power in India is particularly complicated by two factors. First, it is hard to obtain an accurate estimate of the subsidies that go into various aspects of nuclear power, including heavy-water production. Second, the DAE uses a so-called "closed cycle," where the spent fuel is reprocessed. This reprocessing is very expensive, but is not included in the official estimation of the cost of power. The reasoning behind this is that the reprocessed fuel will eventually be useful in the second stage of the nuclear programme; since this second stage has not yet become operational, this is rather specious. It is sometimes argued that nuclear power is cost-competitive with coal. Under reasonable assumptions for the subsidy that goes into heavy-water production, nuclear power is not cost-competitive with coal even for (real) discount rates as low as 3 per cent. This conclusion holds even if the costs involved in reprocessing are completely neglected.

Specific Factors in Indian Context

The first factor has to do with the poor uranium resources of the country. Uranium deposits in India are not only rare, but they are of poor quality. The report of the Kirit Parikh- led expert committee on energy policy, pointed out that "India is poorly endowed with Uranium. Available Uranium supply can fuel only 10,000 MW of the Pressurised Heavy-Water Reactors (PHWR). Further, India is extracting Uranium from extremely low grade ores (as low as 0.1% Uranium) compared to ores with up to 12-14% Uranium in certain resources abroad. This makes Indian nuclear fuel 2–3 times costlier than international supplies". It is evident then that a large nuclear programme can only be sustained on the basis of imported fuel. Of course, this makes nuclear energy more expensive. However, more seriously, importing fuel will make India dependent on imperialist countries for fuel supplies."

The second important issue in India is the lack of a strong regulatory framework. In 1948, Bhabha wrote to Nehru stating that "the development of atomic energy should be entrusted to a very small and high-powered body, composed of say three people with executive power, and answerable directly to the Prime Minister without any intervening link. This body may be referred to as the Atomic Energy Commission". The AEC was set up in 1954 and 55 years later; this small opaque clique of bureaucrats continues to oversee all aspects of atomic energy in the country but, for decades, the atomic energy establishment did not even see the need to have an independent regulatory body. The DAE was in charge of both the construction and regulation of nuclear power plants. It was only after the serious nuclear accident at Three Mile Island (Pennsylvania, US) in 1979 that the DAE started the process of setting up a separate Atomic Energy Regulatory Board (AERB). However, the AERB, which was set up in 1983 with the mission of ensuring the safety of atomic energy, reports directly to the AEC, which is chaired by the head of the DAE. In 1995, the AERB, under a proactive chairperson, A Gopalakrishnan, compiled a report citing 130 safety issues in Indian nuclear installations, with about 95 being top priority. It is unclear what, if any, action was taken on the AERB Report.

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Intelligent Coal Fired Thermal Power Plants

Next generation automation to accommodate high renewable penetration into the grid

M. Siddhartha Bhatt
Director
Central Power Research Institute, Bangalore

N. Rajkumar
Engineering Officer
Central Power Research Institute, Bangalore

The requirement for making coal fired stations intelligent arises from the beed for highly efficient plant operation and asset management on one hand and wide scale penetration of renewable energy (solar photovoltaic and wind) into the grid which results in rapid cycling of the thermal plants, on the other hand. Ramping up or down of thermal plants hitherto was through manual load setting or through the free governor mode of operation. With the entrance of rapidly varying renewable generation, the need for automatic load setting on the thermal plants through intelligent features arises.

Figure 1: View of a coal fired thermal power plant

The requirement for making coal fired stations intelligent arises from the wide scale penetration of renewable energy (solar photovoltaic and wind) into the grid which results in rapid response cycling of the thermal plants. Ramping up or down of thermal plants hitherto was through manual load setting or through the free governor mode of operation. With the entrance of rapidly varying renewable generation, the need arises for automatic load setting on the thermal plants through intelligent features to respond to variations in renewable generation. Manual load setting or free governor mode has limitations of response time. Also the ramping rate is also to be automatically set. When the load on the thermal plants goes below its technical minimum load, coal cannot be fired into the plant because of flame separation but fuel oil has to be fired to maintain the load. The other issue with cycling plants is that the plant machinery especially of the power block are designed for a specific number of cyclic operations.

When the rate of ramping and cycling goes up, the plant component life will be reduced due to figure and creep mechanism of degradation. The power plant assets (boiler, turbine, generators, major auxiliaries, etc.) are designed for an operational life of 3,00,000 (3 lakh) operating hours or around 35 years of service under normal operating regime. The factors which affect the operational life are both the

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Figure 2: View of a Solar PV Power Plant based on Crystalline Silicon Modules

Figure 3: View of a Solar PV Power Plant based on Thin Film (Amorphous Silicon) Technology.

physical running hours as well as cyclic (on/off) operations. Each on/off or start/stop operation can be taken as an expenditure of 20 h of steady operational life. The allowable starts of base load units are 10 hot starts/year, 5 warm starts/year and 3 cold starts/year. For peaking units the starts are much higher. For all units, starts and stops are factored into the life expenditure @ 20 h/start on an average.

Typical (normal) number of starts in the life of a unit over 200 MW unit are as 5000 hot starts, 1000 warm starts and 500 cold starts. The design step load change is + 15% /min and the ramping rate is + 5%/min.

The plants are designed for continuous operation at near full load with annual PLF of around 80 %. Under high renewable injection, the thermal plant loading will have to be ramped up and down resulting in cycling transient operations with low load factors. When the rate of cycling goes up, the plant component life will be reduced due to degradation mechanisms of fatigue and creep rupture initiation.

Power plant operation involving intelligence features through IT applications involves automation of manual operations, control of systems, data acquisition and logging of information to fulfil requirements of versatility, user friendliness and cost competitive.

Intelligent Power Plants

Intelligent power plant automation is defined as a composite system of components which enables the operation, monitoring, control, co-ordination, security in real time mode from remote locations to fulfill the objectives of load management, energy efficiency, environmental control and resource conservation. Intelligent power plants help to save resources of primary energy (coal and solar photovoltaic power) by avoiding shut downs to balance the system.

The components of a coal fired station which respond dynamically are:

- Boiler
- Steam turbine
- Generator
- Condenser
- Feed water heaters
- Lube oil coolers
- Heat recovery devices: gland steam condenser, stack steam condenser, vent steam condenser
- Auxiliaries: Pumps, Fans, Mills

To handle this dynamic behavior, power plant automation started with supervisory control and data acquisition (SCADA), Energy management systems (EMS), distributed control systems (DCS) and field control stations (FCS) with controls to maintain the operating safety band.

Later controls for performance optimization were also included. Presently power plant automation encompasses control and monitoring systems for meeting the requirements of load control, fluctuating grid conditions, system security, communication, safety and operational energy efficiency.

The starting point of intelligent power plant designs is the digitization of the existing instrumentation and control loops which open the floodgates of vast array of technologies hitherto inaccessible: Soft instrumentation, Expert systems, Logic based systems, Intelligent instruments & devices, Optimization based on regression data, Optimization based on deterministic calculations of 3-d profiles, Fuzzy logic models, Computational models, ANN models, Multimedia systems, Web interactions, Telemetry based gateways and Diverse external connectivity through communication technologies.

In a digital environment, information from all sources can be freely exchanged and utilized in any form creating a uniform digital currency which enable intelligent features. Some of the expected functions of an intelligent distributed control power plant automation system are:

- **Data acquisition**: Logging of data, Event report, report generation
- **MMI**: Graphical User Interface and Cross Platform Portability
- **Computation**: Computation of gross performance parameters and indices, computation of 3-d system profiles, neuro computing, computation for pattern recognition.
- **Decisions**: Logical operations, fuzzy logic based decisions, neuro-fuzzy decisions, pattern recognition decisions, expert system based decisions
- **Monitoring**: System operating point data, Component specification, Customization, Alarm generation (audio / video)
- **Control**: Switching, interlocking, modulation
- **System Information**: System variables and status (CB, LBS, isolator, auto trip, etc.) Component health,
- **Security**: authentication , intruder alarm, access control, surveillance
- **Watchdog**: diagnostic and rectification tool, CCTV

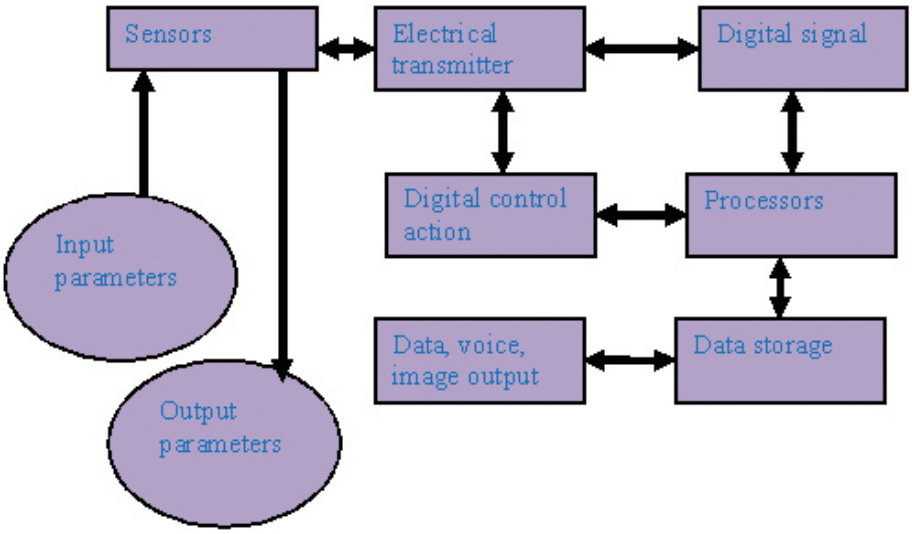

Figure 4: Typical view of a power plant automation system

- **Network Generation**: Topological information, Graphical representation, Editing, validation, printing

Intelligent Automation

Intelligent automation is achieved by a network of the following elements:

- Primary sensors and their associates transmitters which acquire data and control components
- Control elements such as actuators for valves
- Analog to digital (A/D) and (D/A) converters
- Processors of digital data
- Software & drivers

A view of a coal fired thermal power plant is shown in Figure 1. Views of solar pv power plants are given in Figure 2 & 3. A detailed list of components are given in Annexure 1.

Automation is based on the principle of converting all inputs and outputs into digital forms. Figure 4 gives the basic configuration of a power plant automation system.

The automation system can be designed and developed using information technology/ embedded systems and integrating the same into the existing power plant systems. Components such as computers, Remote Terminal Units (RTUs), actuator control of motorized valves, breakers, switched capacitor banks, on-load tap changing transformers, load break/ make switches, auto re-closures, sectionalizers, and communication systems can be integrated into the automation system. Integration with Automated Mapping (AM) and Geographical Information System (GIS) Software packages is widely used at present.

An intelligent integrated distributed control, automation system enables power plants to have real time on-line control of energy efficiency, system security, safety systems at an improved ENERGY efficiency which ultimately results in lower costs, better reliability, planned control & optimum resource utilization.

The power plant automation systems aims at achieving:

- Intelligent operations and control of the plant
- Reactive power control through switched capacitors banks
- Fault detection and isolation
- Control of DTRs, pumps, fans, mills, heaters and their motors
- Control of air conditioning systems, water heating systems, lighting systems
- Operation of auto re-closures, lines sectionalizers, motorized actuators,
- Data acquisition from load end CTs and PTs
- Operation of CBs
- Issue, control and receiving back of line clears, introduce interlock and safety algorithm, password protected operating environment.
- Real time logging of data / archived records.
- Equipment data base
- Interactive voice based security systems

The major components are described below:

Sensors

Some of the sensors are:

- Fibre optic photoelectric sensors: thru-beam, retro-reflex, diffuse -reflective and definite-reflective types
- Photoelectric sensors: self contained, focused beam, transparent target and one touch calibration types
- Proximity sensors
- Displacement sensors
- Pressure sensors
- Area sensors: Laser thru-beam and retro-reflex
- Electromagnetic sensors
- Chemical sensors: zirconia, electrochemical
- Temperature sensors: RTDs, thermistors and IR sensors
- Optical CTs & PTs.
- IR, UV & optical sensors
- Accoustic sensors

The sensor technology is moving into the area of non-interactive and non-intrusive measurement systems.

MEMS is the integration of mechanical elements, sensors, actuators and electronics on a common silicon substrate through micro-fabrication technology. While electronics are fabricated using IC process (CMOS, bipolar, BICMOS processes), micromechanical components are fabricated by micro-machining by etching silicon wafer or adding new materials to form mechanical and electromechanical devices.

Smart and Intelligent Sensors

Sensors are primary sensing elements in the distributed control automation system.

Smart sensors are those that have additional secondary sensors which measure secondary variables and then use them to correct the calibration of the main sensor. A smart pressure transducer is one where the deviation in calibration due to changes in atmospheric temperature and pressure are sensed (as secondary variables). These are used as inputs to calibrate the pressure transducer.

An intelligent sensor is one which has a logic based internal control system which performs certain programming operations for optimizing the required tasks. Fuzzy logic and neural network based controls are most popular.

Remotely Operable Devices

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AV ATS The Advance Automatic Transfer Switch

Automatic Transfer Switch AV ATS

Motor Operated Changeover Switch

AV ATS range of True 4 pole Auto Changeover Switches with Positive Break Indication. They enable the On Load transfer of Two, Three-Phase supplies via Remote Volt-Free Contacts, from either external Automatic Controllers, using Pulse Logic or Push Button Station.

They are intended for use in LV Power Systems where interruption of the load supply is acceptable during transfer though have the solution for Uninterrupted Power Supply Systems also.

AV Onload Changeover Switch

AV Load Break Switch

AV By Pass Switch

AV Switch Fuse Changeover

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These include Air break type Load Break Switch (LBS) for 6.6 kV-11 kV operation (operating time: 80 ms); Moulded Case Circuit Breaker (MCCB) unit for 415 V operation (operating time: 80 ms); Load change over switches for 6.6 kV-11 kV operation (operating time: 80 ms) or Motorized control valves for flow quantity control, flow isolation, flow bypass, etc. (operating time:4-5s)

Closed Circuit TVs

CCTVs play a role in digitization of process operations as well as surveillance. Typically CCTVs help in flame monitoring, fire ball monitoring, leak detection in coal and water piping prone to leakage.

Static Electronic Devices

Some of the new trends in power plants is the constant and continuous movement from mechanical and electro mechanical components to static electronic digitally controlled systems such as the following:

- Numerical control relays
- Turbine governing
- Turbine start-up
- Generator excitation
- ESP control
- STATCONS
- Generator synchronization with the grid

Remote Terminal Units

Remote Terminal Units (RTU) designed through standard off-the-shelf cards are used for acquisition of data parameters in the field and transmitting these to the control centre along with capability to exchange the data with IEDs, microcontrollers and DCS/FCS/SCADA. The RTU are designed to be flexibile and expandable, modular at signal conditioning and communication interface level, low cost, rugged, intelligent microprocessor based with bi-directional data communication with 24/48/54 analog and 24/48/96 digital I/O channels.

Processors

The processor is the heart of the automation technology. Power plant automation is generally build around one of the following core technologies:

- Multi-medial technology
- Transputer based instrumentation and control systems.

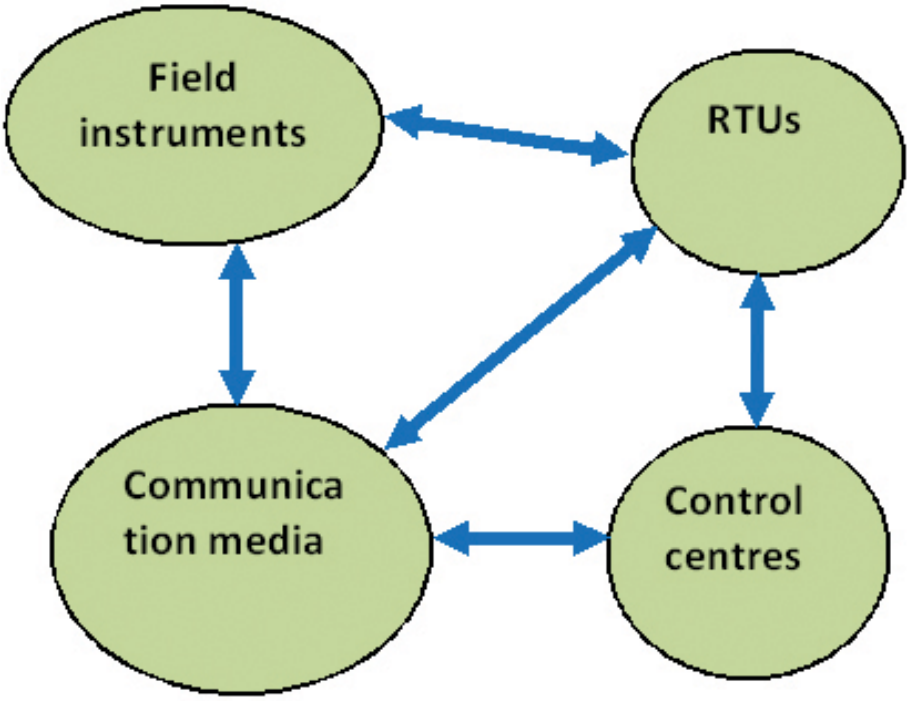

Figure 5: Components of an automation system

- SCADA (Supervisory control and data acquisition) systems.
- EMS (Energy management systems)
- Field control stations (FCS)
- Distributed control system (DCS)

Distributed Control Systems (DCS)

Distributed control system (DCS) is a system whereby all control processing is decentralized, built up of stand-alone controllers and independent of a central computer to avoid damage to system due to controller failure.

Remotely Operable Micro Controllers & Field Control Stations

Microcontrollers operate as per microprocessor based control logic, derives control logic operate on current and voltage sensors, samples the data on continuous basis, conditions the signals and converts to digital form for processing, decision making and logging.

Intelligent Electronic Devices (IEDs)

Intelligent Electronic Devices (IEDs) (such as Intelligent transformer) have inbuilt intelligence into them depending on their functions. IEDs available at the site such as relays, electronic energy meters, flow controllers, motor controllers directly communicate the data with the DCS. Analog quantities and digital information, which are not available directly from the IEDs, are extracted through the I/O interfaces of the RTUs. RTUs have provision to send the control command to the actuator of a switching element through the IED relay (if available). Few analog and digital signals, which are not handled by any of the IEDs, are directly connected with the RTU that communicates with DCS.

PC based Intelligent Power Plant Automation Systems

The various components (software and hardware) needed for PC based power plant automation consist of Industrial work stations, server-slave configurations, Signal conditioning, Modular industrial controllers, Industrial communications and Application software.

Communication Options

Unlike traditional communication solutions, the approach in power plant automation is to have a core communication controller at the control centre, which can support diverse choices of communication media options such as the following radio, satellite, hardwire, wireless Ethernet, etc.

One-way VHF radio can be used for load

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PSPC TRAPPED KEY INTERLOCKS

PSPC
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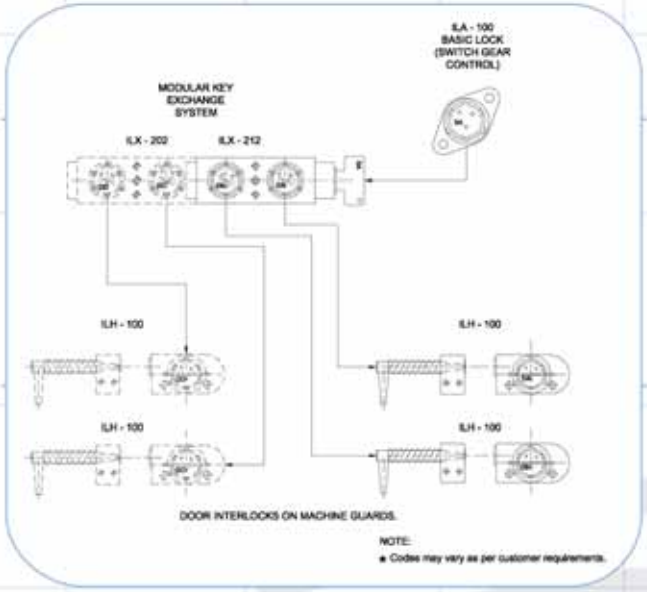
MACHINE GUARD INTERLOCKING

While designing safety systems for machines, movable guards like doors, panels, gates or other physical barriers are frequently used. Each and every one of these guards should be interlocked with the machine control system so that the hazards covered by the guards will be effectively controlled even when the guard is opened.



This Scheme shows a single control, Multiple Access System. Options of Multiple control systems are also available.

The drawing shows Door interlock suitable for Hinged doors. Contact **PSPC** for suitable locks for sliding and bolted doors.

The **Unique Modular** key exchange system from PSPC allows addition of more guard interlocks to the system at will. For more complex systems use PSPC Rotary switch interlocks, Time Delay interlocks and Remote controlled interlocks with Solenoids, for controlling isolation.

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control because low cost load control switches are available for this technology. VHF radio switches can also be used for such applications as capacitor control instead of more expensive RTUs.

The components of an automation system are indicated in Figure 3 below.

Protocols

The present techniques of data communication among the IEDs supplied by different vendors involve adherence to standard protocols such as IEC-60870-5 (International Electro-technical Commission).

Integration of Components & Networking

Integration is the ability of control system components from independent manufacturers to inter-connect and facilitate coordinated real-time data exchange and control through common communication data exchange protocol and man machine interface or integrator interfaces.

Network is the linking of a system of distributed control units on a communication highway. A network enables central monitoring and control of the entire system from any distributed control unit location and permits sharing of point information between all control units. First tier networks provide "Peer-to-Peer" communications while Second tier networks provide "Peer-to-Peer", Master-Slave or Supervised Token Passing communications.

Intelligence Features

Intelligence features can be incorporated in the most of the components. Building a digital utility by development of intelligent IT architecture of the power plant suitable for seamless interface for automatic process control and e-business and Web based interactions is gaining importance.

Some of the areas of intelligent automation in power plants are :

Boiler and its associated system

- Coordinated boiler-turbine control
- Boiler stress level monitoring in certain areas
- Fatigue cycling monitoring
- Residual stress monitoring
- Boiler tube cleanliness monitoring and intelligent soot blowing
- On-line combustion diagnostics
- Oil gun operation
- Furnace safeguard supervisory system (FSSS) and burner management system (BMS).
- Soot blower operation
- Operation of continuous/intermittent blow down (CBD/IBD)
- Burner tilt operations
- Combined O2/CO based control strategy for combustion control
- Fireball centering controls
- Flame scanning through CCTV and control and fireball
- Condition monitoring of failure prone tubing
- Tube leak monitoring
- Monitoring of corrosion prone boiler components
- Slag monitoring
- Noise monitoring inside boiler

Turbine, Condenser and its Associated System

- Turbine stress level monitoring
- Turbine supervisory instrumentation for:
  - Shaft eccentricity
  - Relative shaft vibration
  - Absolute vibration in the bearing pedestals (horizontal and vertical)
  - Axial shift
  - Differential expansion of rotor and cylinders
  - Overall expansion
  - Turbine speed
  - Positions of emergency stop valve and control valve
  - Steam parameters
  - Turbine metal temperatures
  - Bearing metal temperatures
  - Drain oil temperatures
- Fatigue cycling monitoring
- Electronic governing and synchronization
- Heat rate and heat balance monitoring
- Process optimization
- Maintenance management
- Condition monitoring
- Noise monitoring
- Endoscopes for examination of blading without opening of the casing.
- Expert system for signature analysis and fault diagnosis
- Expert system for heat rate and efficiency monitoring.

Generator System

- Generator remaining life monitoring
- Stress level monitoring
- Fatigue cycling monitoring
- Electronic synchronization.
- Numerically controlled generator excitation.
- Numerically controlled generator protection.
- Bearing vibration, eccentricity, axial shift monitoring
- Speed monitoring

Auxiliaries- in-house and out-lying

- Bus transfer schemes for change over from station transformer to auxiliary transformer.
- Variable pressure operation of BFP
- Operation of FDFs, IDFs & PAFs at optimal efficiency point
- Operation of CEPs, CWPs at optimal efficiency point
- Operation of mills at optimal loading
- Operation of conveyors in coal handling plant
- Logic based operation of cooling towers based on ambient conditions and cooling requirements.
- Operation of crushers
- Fuel management system
- Operation of water treatment plant
- Logic based operation of river water pumps
- Logic based operation of ash handling pumps

Many of the manual controls, semi-automated open loop controls can be converted into closed loop controls by the integration of some of the following with the DCS:

Plant Outages Analysis

Power plants have basically five types of outages:

- Forced outages
- Pre-arranged outages
- Planned annual overhauls
- Planned capital overhauls
- Planned outages associated with renovation/ modernization/up gradation/ revamping/ retrofitting/life extension programs.

Outage management involves a combination of modern technology, econometric techniques and data management. The ITs find application in minimization of deployment time, event management, knowledge application, use of public information to achieving reduction in cost and improvement in efficiency. The present

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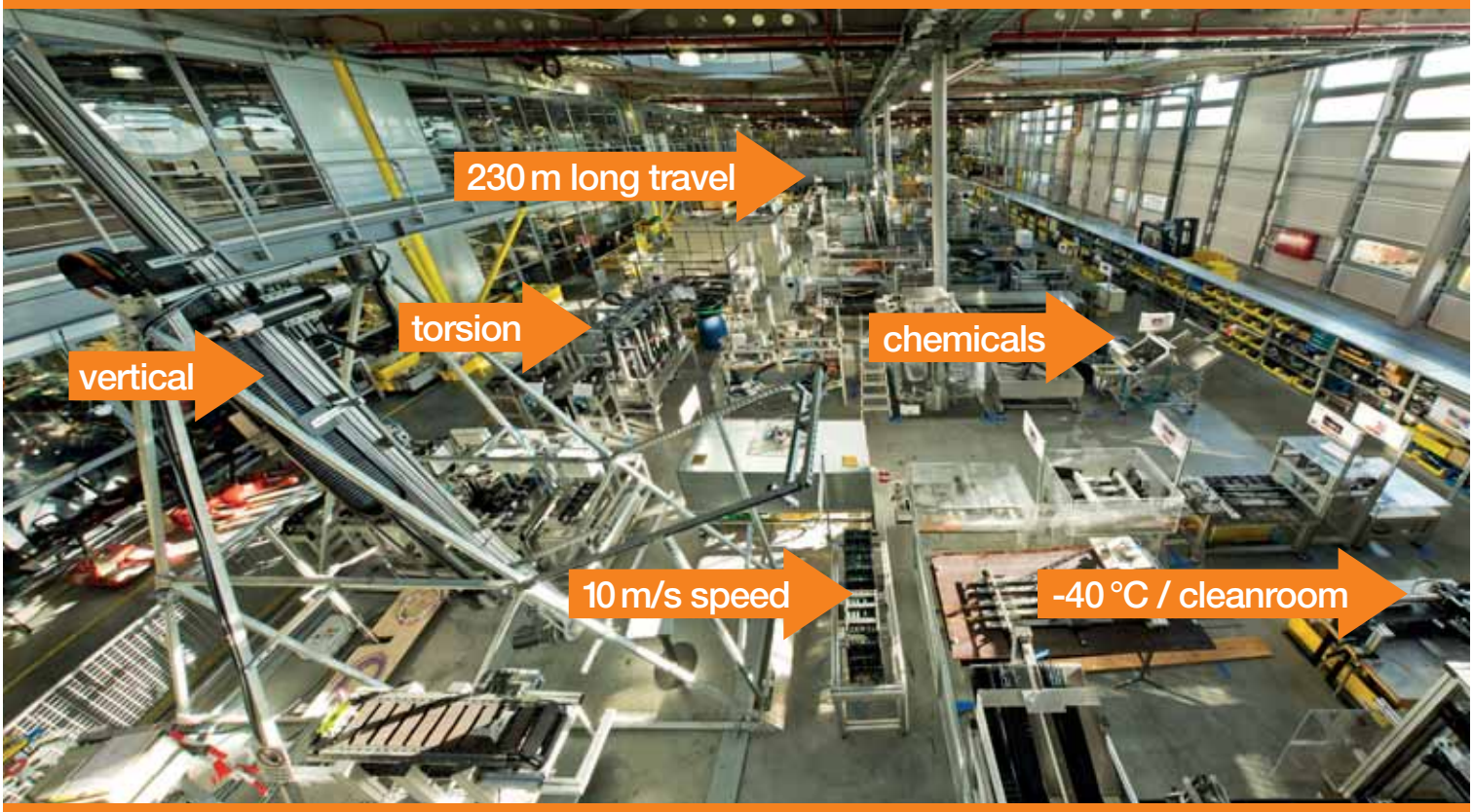

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Annex 1: Details of components of a power plant automation system

Sl. No.		Particulars of distribution automation systems
01		DCS/FCS/SCADA with open architecture and modular construction, migration features for all control loops and auto loops
02		Additional microprocessor/microcontroller/Intelligent electronic device/ based features (with alarm, trip facility, digital indicators and recorders) (wherever applicable) to be compatible and integral with DCS/FCS/SCADA:
	2.1	Sequence of event recording
	2.2	Eccentricity, vibrations, axial shift measurements
	2.3	Coal feeder speeds and coal flow
	2.4	Turbine loading controller
	2.5	Lux level
	2.6	Water flow, steam flow, steam level, hydrastep, attemperation, DM water, make-up water, blow down flow measurement
	2.7	Electrical power in generator output and auxiliaries
	2.8	Opacity/Oxygen/CO measurement
	2.9	Air, water temperature measurement
	2.10	Multimedia
	2.11	Coal weighment to PC & RC bunker
	2.12	Conveyor control
	2.13	CCTVs for surveillance & control
03		C & I system:
	3.1	Primary elements: CTs, PTs, CVTs, Flow nozzles, orifices, thermocouples, RTDs, etc..
	3.2	Transmitters: Smart 2 wire transmitters.
	3.3	Sensors: Additional sensors along with primary elements for on-line measurement (e.g.: flow, pH, electrical conductivity in water etc.) for providing redundancy of critical parameters.
	3.4	Unit protection and interlocks: Protection for all unit related equipment and interlock schemes.
	3.5	Recorders: digital display, digital recorders or paperless recorders.
	3.6	Scanners: Duplex type scanners.
	3.7	Cables: Screened, insulated, armoured, fire retardant, low smoke cables. Cables for analog signals to be overall and power shielded. Cables for digital signals to be overall shielded.
	3.8	Power supply: Provision for parallel, redundant, uninterrupted power supply with bypass, battery bank/ diesel back-up, charger.
	3.9	Field junction boxes: Ingress proof against water and dust.
	3.10	Splitters & isolators: Splitters for important measurement parameters and auto controls.
	3.11	Control panel/desk: PC based
	3.12	Indicating lamps: LEDs
	3.13	Alarms and annunciation: Stand-alone microprocessor based window alarm and annunciation system
	3.14	Communication: Intercommunication through Walkie-talkie/WLL system.
	3.15	Impulse lines: For high pressure lines
	3.16	Local gauges: Installation of pressure, temperature, flow at local areas
	3.17	Maintenance spares: Essential spares for the above hardware
04		Control valves and actuators: Actuators for vanes and dampers (including control valves).
05		DAS: Data acquisition system, data storage with PCs and lap top computers for data processing, computation.
06		Electrical protection: MCCBs/Switchgear (thermal relay, contactors, switches, breakers, protection system of MCS) of all electrical actuators
07		Drives: VSD/VFD/eddy current drives/soft starters
08		Controllers: PLCs, PID controllers, Microcontrollers, Logic based controllers
09		Miscellaneous valves:
	08.1	Shut off valves
	08.2	Solenoid valves
	08.3	High pressure root valves and isolating valves

technology of authentication, confidentiality, integrity and non-repudiation is suitable for e-business during outages.

Intelligent operation of thermal power stations involves:

- Cold start
- Warm start / hot start
- Black start (grid has failed)
- Absolute cold start

Start-up

Intelligent start-up of a thermal power plant unit consisting of:

- Water filling
- Fuel oil support
- Steam generation
- Turbine rolling as per the heating ramps
- Steam ejectors-condenser vacuum
- Turbine synchronization with the grid
- Turbine loading as per the heating ramps

Overall System

Dynamics of a power plant involves:

- Load setting on the unit and associated control of Mill throughput, Coal flow, Steam flow, Turbine output, Generator output
- Predictive emission monitoring
- Performance monitoring
- Process optimization
- Maintenance management
- Compliance reporting
- Coordinated boiler-turbine control

By and large the most important feature expected out of an intelligent power plant is the load fixing based on intelligent features in the event of a transient from the paralleled renewable generation in the grid.

CONCLUSION

The main conclusions are as follows:

i. Intelligent power plants help to save resources of primary energy. Intelligent features can be integrated into the plant DCS based on 3-d computations, logic learning algorithms, neural computing, pattern recognitions, expert systems, etc., for accommodating variation arising from integration of sizeable renewable power.

ii. Present concepts of intelligent power plant automation involve operation and control based on optimal performance or optimum decisions emanating from on-line computation.

iii. New developments in non-interactive sensor technology and MEMS now enable very sophisticated solutions at reasonable costs to meet the objectives of optimal operation of the power plant through intelligent systems.

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'Elektrolites' embarked on its journey in 1966 with trading in power station equipment. Elektrolites have in-house R&D facilities approved by DSIR, Govt of India for MV and HV Switchgears products says **Anil Saboo, Managing Director, Elektrolites (Power) Pvt Ltd** in an e-mail interaction with **Electrical India**.

Please give us a brief account of products offered by Elektrolites in India?

We design, type test, manufacture and export various Switchgears i.e. Isolators (11kv-420kV), Lightning Arrester (9kV-198kV), Drop out Fuse (11kV-33kV) and smart grid equipments viz. Load Break Switch (11kV-33kV), VCB Sectionalizer (11kV) and Fault Passage Indicator (11kV-66kV) and Sensors.

What makes Elektrolites products different from those of its competitors?

"**Where innovation is life and to remain in business keep on innovating solutions for customer**" has been the mantra of success which became part of DNA of every employee at Elektrolites, this gave traction for profitable growth for the company enabling global vision for the future.

We have developed unique eco-friendly technology in Switchgears & SCADA based products which suits Indian conditions for distribution like cost effective Air Break technology instead of SF6 & oil based Sectionalizer which were being imported.

In 2012, the company started focus on development of smart grid products like LBS, FPI, Sectionalizer etc. & developed eco friendly Air Break LBS instead of imported SF-6 type products. The company successfully introduced and exported smart grid products to various private customers & utilities.

Can you tell us about the testing facility available in-house?

The company got recognition from DSIR, Govt of India in November 2012 for switchgear based on past innovations done & latest R&D lab development. The R&D lab has unique equipments up to 1200kV for testing of LA & switchgear which helps to judge the equipment as per field conditions.

Elektrolites design unique Disconnectors & Surge Arresters from 11kV to 400kV & have inhouse R&D facilities approved by DSIR, Govt of India for these products. We have also developed various SCADA operatable smart grid products i.e. 11kV LBS, Pole mounted VCB, FPI etc. at our world class newly built factory alongwith R&D facility to develop Switchgears as per the requirement of overseas client.

Can you tell us about your 'In-House R&D Centre' and its contribution to your business?

R&D team studied application of LA and found that these products

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were not connected in circuit due to frequent failures. The root cause of failure was specification of LA's for 9kV, 5kA which does not have capability to withstand Switching Impulse. The R & D team designed and developed new 12kV, 10kA LA and educated customers to use them to optimize use/purpose.

As per company's policy for innovation, the company incorporated Surge Arrester and DO Fuse along with the Switch Isolator as single product (SFU) which saved the one third cost with better performance in field.

The newly developed eco-friendly 11kV / 33kV Load Break Switches are unique in achieving smart grid requirements.

Can you share the Corporate Social Responsibility (CSR) activities carried out by the company?

Company is also engaged in CSR activity with NGO – JAGRITI, Jaipur for providing free quality education to 2,500 slum children in 12 schools in Jaipur since 2010.

Our initiative has been well recognized by Govt of Rajasthan and our target till 2018 is 5,000 children with 20 schools.

Please visit the website www.jagritijaipur.org.

What kind of services do you offer to customers?

After supply of equipment we provide after sales service to all customers. We have a trained team to look after the installation or guidance required by customers.

Who are your major customers in India as well as abroad?

All power utilities both Govt or private sectors are our customers. We are approved by PGCIL, NTPC, Railway etc and also foreign utilities like NIPP Nigeria, PHCN Nigeria, and KPLC Kenya etc.

Many African countries are approaching us for design and development of new smart equipment for their distribution network.

What are your new plans in 2017?

We keep on developing new products and services for smart grid or SCADA based distribution systems. In 2017 we shall increase our supply for these new products.

We have also plans for introducing more efficient and trouble free design of ISOLATORS from 11kV to 400kV.

<< Appointment

Stuart Henderson to Lead US DOE's Jefferson Lab as Director

Jefferson Science Associates, LLC has appointed Stuart Henderson. He will become the new Director of the US Department of Energy's (DOE's) Thomas Jefferson National Accelerator Facility in Newport News, Virginia. Currently, he is serving as the Director of the Advanced Photon Source Upgrade Project at DOE's Argonne National Laboratory. Henderson will assume his responsibilities at Jefferson Lab on April 3, 2017.

In his role as the Director of Jefferson Lab, Henderson will be responsible for leading and managing all lab initiatives and activities in support of a world-class research facility, including its strategic and long-range planning processes as well as building a comprehensive relations program to serve and promote the interests of the lab and its users.

He is an internationally recognised particle accelerator scientist. Prior to joining Argonne, he was the Associate Laboratory Director f or Accelerators at Fermilab, responsible for its accelerator research, development, construction, and operations activities centred on accelerator-based particle physics. Prior to joining Fermilab, he spent nearly a decade at Oak Ridge National Laboratory's Spallation Neutron Source (SNS), a billion-dollar U. S. Department of Energy Project to construct the world's most powerful accelerator-based neutron science user facility. Serving as the Director of the Research Accelerator Division, Henderson was responsible for leading the SNS beam commissioning campaign and transition to successful user operations at megawatt beam power levels.

Before joining the DOE National Laboratory System, Henderson served as Senior Research Associate at Cornell University working on the performance and upgrades to the NSF- funded Cornell Electron Storage Ring and a Research Associate in particle physics at Harvard University. After receiving his B.S. in Chemistry from Vanderbilt University, Henderson earned a Ph.D. in Physics from Yale University.

Henderson said, "I'm thrilled to be taking the helm of Jefferson Lab, particularly at this time of tremendous opportunity and potential. Jefferson Lab plays a very special role in furthering the DOE mission both through its operation of a world-class nuclear physics research facility, and through its world - renowned technology capabilities. I'm looking forward to working with the laboratory staff and the Jefferson Science Associates Thomas Jefferson National Accelerator Facility scientific community to make the most of Jefferson Lab's capabilities today while capitalising on those capabilities as we chart a course for the future."

DEIF's Hydro Turbine Control Solutions

Conventional hydro turbine control systems are generally complex and fragmented setups that include a general purpose PLC, separate generator protection relays, synchronisers, governors, water level controls and other auxiliary control systems. These old generation hydro turbine control and protection systems may no longer be up to the task of meeting today's requirements for cost-effective and reliable operation of the hydro power plant. These systems may also be vulnerable to failures due to their complex nature. The suppliers/manufacturers of these systems being diverse and small & medium enterprise, which implies that you as a customer may not get the support when required, which could result in decreasing availability and deteriorating operational reliability of your power plant that can land in loss of revenue.

DEIF, a company of Danish origin with global presence, is one of the world leaders in control solution for the power generation systems on land and marine segments. DEIF with its eight decade of experience has developed control solutions for hydro power, the largest and most economical source of renewable energy on Earth. In order to guarantee optimised power plant operations, increase safety and simplify maintenance; DEIF has developed integrated solutions that are capable of performing large number of functions compared to standard systems. Due to our integrated products and solutions we can reduce the maintenance costs to a minimum. DEIF India Pvt. Ltd., a subsidiary of DEIF A/S, Denmark, is the Centre of Excellence for Hydro Power applications. DEIF India develops and provides innovative solutions for power management and control of micro, mini and small hydro power generating sets for the whole world. Our systems have been installed successfully in large number of hydro power plants countrywide over a very short time span. Our product Delomatic, is used by numerous renowned OEMs and end users including Himachal Pradesh State Electricity Board Ltd. and Uttarakhand Jal Vidyut Nigam Ltd., the states with maximum hydro power potential in India.

Delomatic 4 Hydro

Globally local existence

Our "glocal" approach combines leveraging global experience with strong local presence and expertise. Our local experts work hand-in-hand with you to meet your exact needs at every stage of the project. Working as a part of your team, DEIF's process helps to define problems, identify solutions and develop ideas in a manner which will provide the most successful and appropriate end results. DEIF HYDRO is supported by global sales and service setup which gives us a global reach and the ability to serve our customers in any corner of the world. After completion of the project, DEIF offers an extensive local support network in order to ensure high availability of maintenance and other services. By doing so, we offer a highest degree of operational safety and efficiency.

Technology through innovative solutions

DEIF invests heavily in research and development globally, to provide state-of-the-art technology that meets customers' needs and stay at the forefront of technological innovation. The expertise and vision of our designers and their partnership with different fields of power control equipment such as marine, steam, gas and diesel; allows us to consistently offer cutting-edge technology to our customers in Hydroelectricity generation sector as well.

Tailor-made solutions for specific requirements

Every project is different in terms of challenges and requirements. Local conditions or budget limitations are also determining factors for hydropower projects. DEIF offers integrated and cost-efficient solutions of different scope according to customer-specific requirements and capabilities. In the development process our goal is to maximize efficiency by customising our solutions to reach the best possible solution for each client, thus gearing up the customer's profit to a higher level.

Hydro Turbine Generator Control

A customised solution, DEIF's integrated hydro turbine generator control solutions economizes installation costs significantly by using fewer components and lesser wiring compared to systems that require multiple units to provide synchronisation, protection and PLC functionality.

Delomatic 4 (DM-4) Hydro-controlled plants offer fully automated

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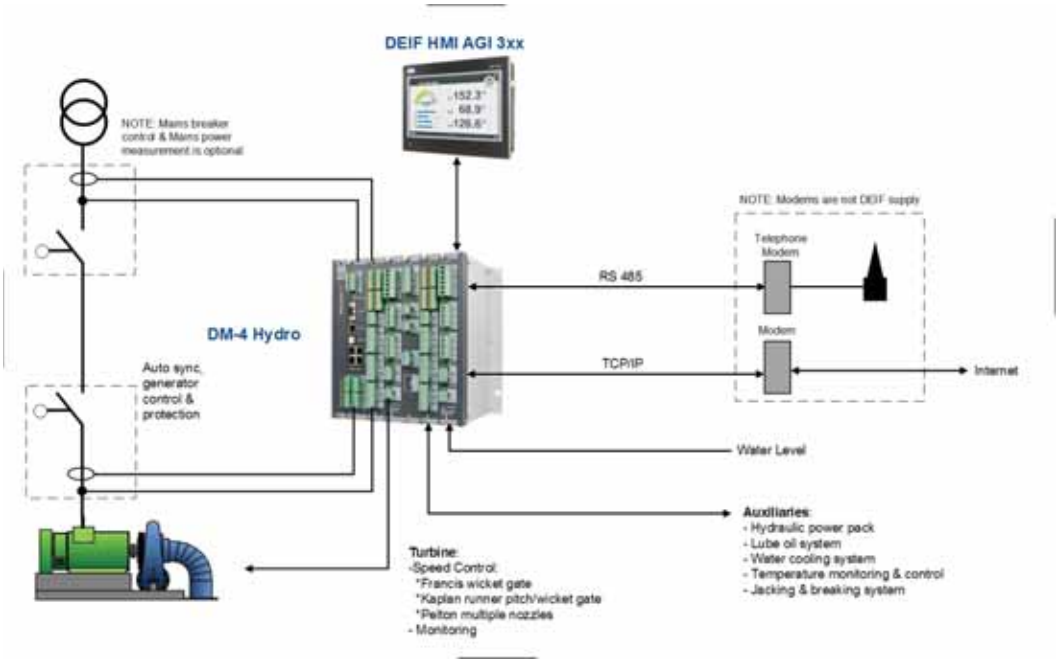
control for stable optimised operation and require less maintenance and fewer man hours. The Delomatic 4 Hydro is compatible with all types of turbines and flexible and easy to adapt with simple parameter settings. Critical functions such as speed governing, generator protections and synchronising are fully integrated with password-protected features for maximum security.



The controller's Human Machine Interface (HMI) is easy to operate. Based on the graphic screens embedded in the DM-4 Hydro unit itself, the screens are uploaded to a PC like any other interactive webpage graphics using USB or TCP/IP communication, enabling simple password-protected remote control and monitoring.

The advantages to DEIF's Delomatic solution go beyond savings, wiring, construction, engineering and maintenance. It is also a flexible solution equally suited for new installations and retrofits, designed to control hydro turbine generators ranging from 2 kW to 20MW along with its auxiliary equipment.

Features of Delomatic 4 Hydro	Types of hydro turbines		
	Francis	Kaplan	Pelton
Automatic Start-Stop control	✓	✓	✓
Sequencing Control (Auxiliaries Controls)	✓	✓	✓
Speed & Load Control	✓	✓	✓
Over speed protection with Redundant speed sensor input	✓	✓	✓
HMI with Mini SCADA	✓	✓	✓
Future proof communication (TCP/IP)	✓	✓	✓
Protection – Turbine & Generator	✓	✓	✓
Synchronisation – Auto & Manual	✓	✓	✓
Voltage & Power Factor control	✓	✓	✓
Site selectable CT & PT inputs	✓	✓	✓
Standalone (island) control	✓	✓	✓
Parallel with grid control	✓	✓	✓
Load sharing	✓	✓	✓
Water level control	✓	✓	✓

Delomatic Hydro Features

- Hydro Turbine Controller for Parallel with Mains or Stand-alone Generator
- Speed and Load Control
- Valve Controls (main/drain/fill)
- Water Level Control
- Turbine control, auxiliary control, protection and supervision
- Generator control, Auto synchronisation protection and supervision
- Dedicated HMI touch screen operator panel

DEIF's hydro control systems are not only suitable for new installations but also can be used to upgrade existing plants that can give you following key benefits.

Key benefits

- Product dedicated to hydro turbines, for new and retrofitted plants
- Modular design
- Extremely reliable and robust
- Can sustain the harshest conditions
- Short commissioning time, easy installation and operation
- Increased plant availability, operational flexibility, reliability, and safety
- Amplified power generation
- Boosted revenues
- Optimized plant operating life
- Reduced service and maintenance costs

References

DEIF India has supplied control systems for hydro projects with total 150 MW of capacity all over the world for various types of hydro installations.

Badrinarayanan Suresh
Managing Director
DEIF India Pvt. Ltd.

Line Current Differential Protection Unique Applications At Hindalco

Raman Bajpai
Manager
Renusagar Power Division
Hindalco Industries Limited

Kaushik Tarafdar
Assistant General Manager
Hindalco Industries Limited

Sthitaprajnyan Sharma
Lead Application Engineer
Schweitzer Engineering Laboratories

This paper describes the use of advanced line current differential protection, to address conditions like CT saturation at only one-end during through fault conditions. It also describes an industry-unique three-terminal application of line current differential protection within Hindalco Industries Limited.

Importance of Line Differential Protection

Protection philosophy of high-voltage transmission lines traditionally calls for distance protection relays, which are basically impedance operated relays. Distance relays and their time of operations are dependent on voltage, Source-Impedance-Ratios and length of line. For short lines, or lines connecting power-plant to industry like in the case of Hindalco, Line Current Differential relays are deemed crucial, owing to their independence from loss or absence of voltage or SIR, and their faster operation times. There are a total of 10 numbers 132kV transmission lines of which 6 are double circuit and 4 nos. are multi-circuit (4 Circuits on same tower) between Hindalco CPP at Renusagar and Hindalco Smelter Plant at Renukoot. Because of strong zero sequence coupling between the parallel circuits, distance protection tends to over-reach or under-reach, even after including compensation factor. This was specially observed during lightning faults, thereby propagating the disturbance further. Additionally there were 3 short lines only protected by conventional relays. Numerical Line differential relays can also have back-up distance protection, to work in tandem with an alternate distance protection relay on the line. Figure 1 below shows a typical line current differential-cum-distance backup protection using Schweitzer Engineering Laboratories make SEL 311L relays, applied to a line having two-terminals.

Challenge involved with the Line Differential application at Hindalco

There a total of 10 numbers 132kV transmission lines between Hindalco CPP at Renusagar and Hindalco Smelter Plant at Renukoot. Each of these lines were protected with separate distance relays with Power Line Carrier Communication, linking both ends of the line. Single-mode Optical Ground-wire laid over transmission line exists between the two stations of approximate length 35kilometers. The remarkable factors for line differential protection

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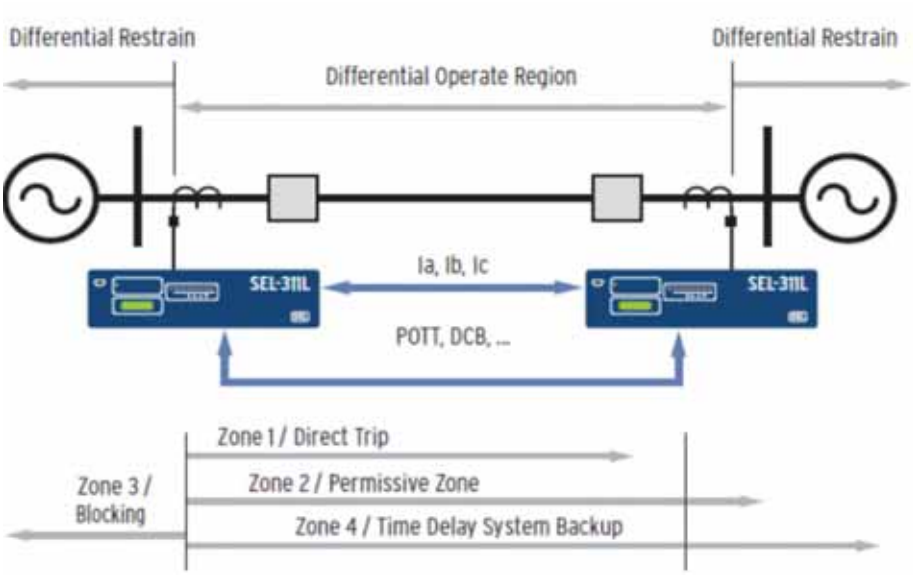

Figure 1: Typical Line Differential Relays on a transmission line

of some of these lines (Implemented in 6 lines) were as follows:-

- Non-identical CT ratios at each end of line
- Non-identical CT Class at each end of line(Class PS at one end, Class 5Px at other end)
- A Relay operation time of 17-22 ms in Test Bed as well as in Actual operation, was recorded by HIL independent DFR.

The line differential relays were required to operate correctly with existing system parameters and remain immune to external faults. The challenges owing to the above factors were prominent during external faults when CTs at one end of a line saturate, whereas the CTs at the other end did not. False differential currents arise during such conditions, which may cause the line differential relays to operate incorrectly. Since, such faults are external to the line, the line differential relays were required to remain stable during such disturbances. Figure 2 below shows one such case where CTs at only end were found to be saturated.

Line Differential solution with Backup Distance element provided by SEL

SEL 311L line differential relays employ the Alpha Plane Differential principle and provide the advantage of restraining differential operation for such through fault conditions where only one set of CTs has saturated on a line. SEL conducted simulated tests with the disturbance records received from Hindalco and based on the reports by SEL, one pair of SEL 311L relays were installed as a trial installation on 132kV Line #8 having CT Ratio 2000/1A, Class PS at Renukoot End and 1200/1A, Class 5P20 at Renusagar End. The simulated test waveform and the results plotted on the restraining region on alpha plane graph of the SEL 311L, for the above disturbance is shown in Figure 3.

The application architecture was as shown in Figure 1 earlier. The line differential element is dependent on the communication channel between the two stations. The SEL 311L relays monitor the communication channel status and were configured such that distance protection element takes over as the primary protection, to compensate for communication channel fail conditions. In case of communication channel being restored line differential element is automatically restored, again as the primary protection element.

Theory of the Generalized Alpha Plane Differential in the SEL 311L

Traditional current differential relays use a percentage bias-restraint characteristic. SEL introduced the concept of a digital 87L principle that used a restraint characteristic implemented on the Alpha Plane. The α-plane is a current-ratio plane, illustrated in Figure 4 below. The ratio of the remote terminal current to local current is plotted on the α-plane. Ratios that lie within the restraint region prevent the differential element from operating. This characteristic responds well, to phase alignment errors by explicitly looking at the angle difference between the local and remote currents. Sensitivity is controlled, by a separate comparison of operate current versus a minimum sensitivity setting and further enhanced by the presence of zero-sequence and negative-sequence elements, in addition to segregated phase elements.

The generalized α-plane develops two equivalent currents, $IL_{(EQ)}$ and $IR_{(EQ)}$, that produce the same operate and restraint as any number of original terminal current phasors. The ratio of smaller current to larger current is always plotted; thus, the ratio on the generalized α-plane always has a magnitude of one or less. Because the α-plane is symmetrical, all ratios are reflected to positive angles in the first and second quadrant. $IL_{(EQ)}$ and $IR_{(EQ)}$ themselves are composite signals, made up of operate and restraint values, as

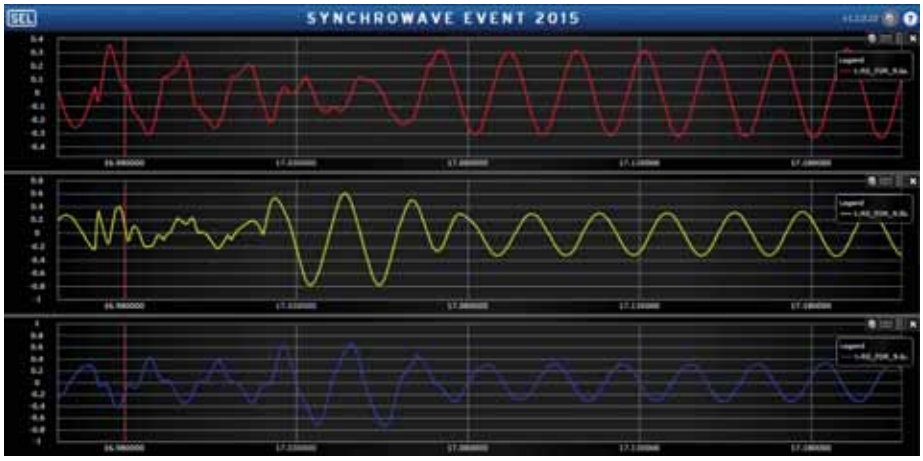

Figure 2: Disturbance record showing saturated waveform collected from only at one end of the line

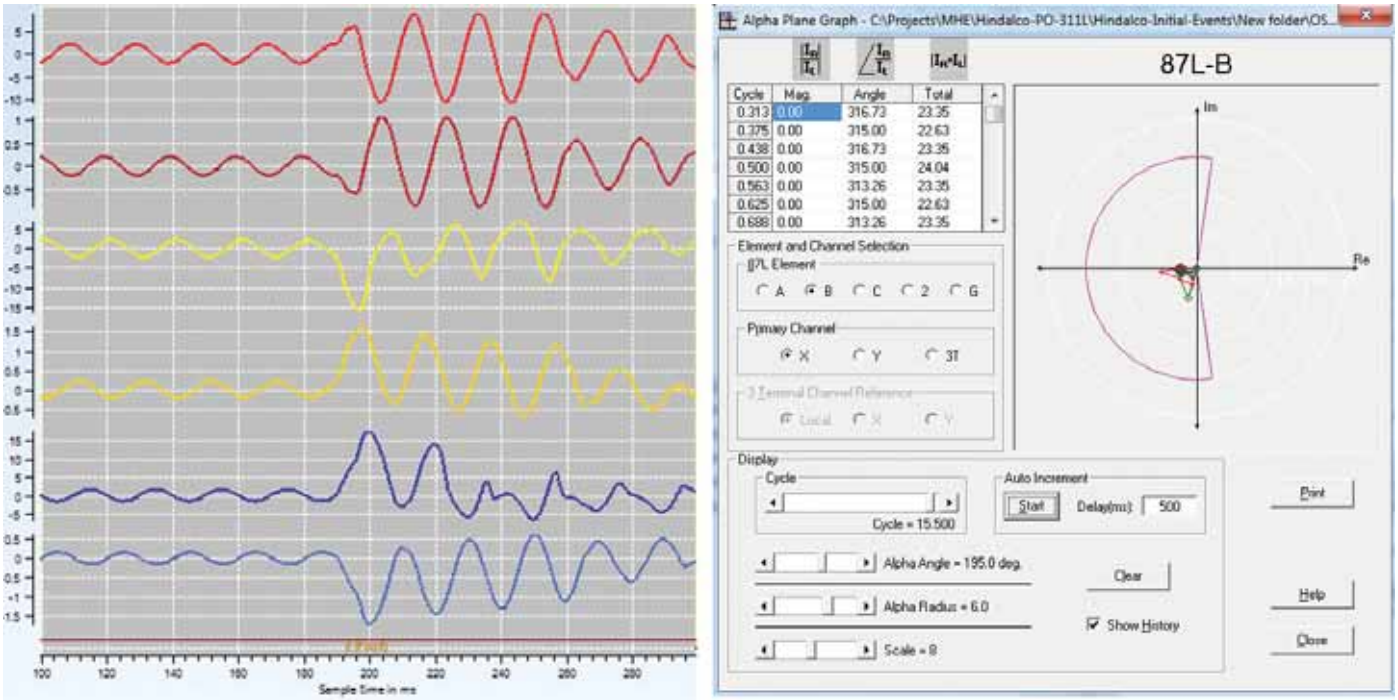

Figure 3: Simulation test run in lab tests with combined COMTRADE records from both ends and the results in Alpha Plane Graph of SEL 311L showing the fault plotting in restraining region

shown in below equation. To accommodate CTs with different nominal ratings, the generalized α-plane relay automatically calculates taps and performs difference calculations in per unit. The generalized α-plane relay also employs an external fault detector that uses raw samples to determine if a fault is external to the zone of protection within one-quarter of a cycle. Once an external fault is detected, the relay switches automatically from normal to more secure settings, improving security in case a CT saturates during the external fault. The plot on the complex plane, is obtained by calculating the fundamental phasor values of currents I_L and I_R, using the output signals of the 16 samples-per-cycle cosine filters and then determining the phasor I_R / I_L ratio. Further, for data alignment, a traditional ping - pong method is used for symmetrical channels.

Industry Unique Three-terminal Application at Hindalco

Hindalco has a 132kV Line between Co-generation Switchyard and Rectifier Plant 2, with a tapping which connects the Extrusion Press, as shown in Figure 5. Lengths of all the three lines are very short(less than 5Kms), which makes Line Current Differential the ideal choice for Line Protection. The communication channel is conventional Fiber Optic cable between each of these terminals. For an internal fault on the line, fault feeding may happen from either of Co-generation End and/or Rectifier Plant 2 End. Three-terminal lines with sources at more than one end are always challenging to protect. Dual communication channels connect each of the three-ends, for these kind of applications. In a three-terminal application, the α-plane is plotted by vector-addition of the two-remote end currents, to determine I_R, the local current is noted as I_L and the phasor ratio of I_R / I_L is derived. Simply put, the SEL 311L converts the three-terminal line to its electrically equivalent two-terminal line and runs the two-terminal protection algorithm.

For internal faults with outflow, external faults with CT saturation, and terminal(s) with open breaker or low current, all three alpha calculations do not make the same trip/restrain decision. During such events, the relay executes special CT Saturation Security Logic to provide both security and dependability to the differential elements. This logic differentiates between an internal and an external fault. If the traditional restraint region is not enabled, the CT

$$I_{L(EQ)} = \left(\frac{Im(I_x)^2 - \left[I_{RST} - Re(I_x)\right]^2}{2 \cdot \left[I_{RST} - Re(I_x)\right]} + j \cdot Im(I_x) \right) \cdot 1\angle\beta$$

$$I_{R(EQ)} = \left(I_{RST} - \left|I_{L(EQ)}\right|\right) \cdot 1\angle\beta$$

Here -
I_{RST} = Restraint Current
I_x = Differential Current

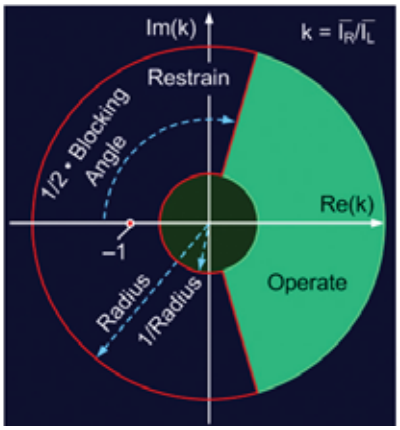

Figure 4: Concept of the Generalized Alpha Plane

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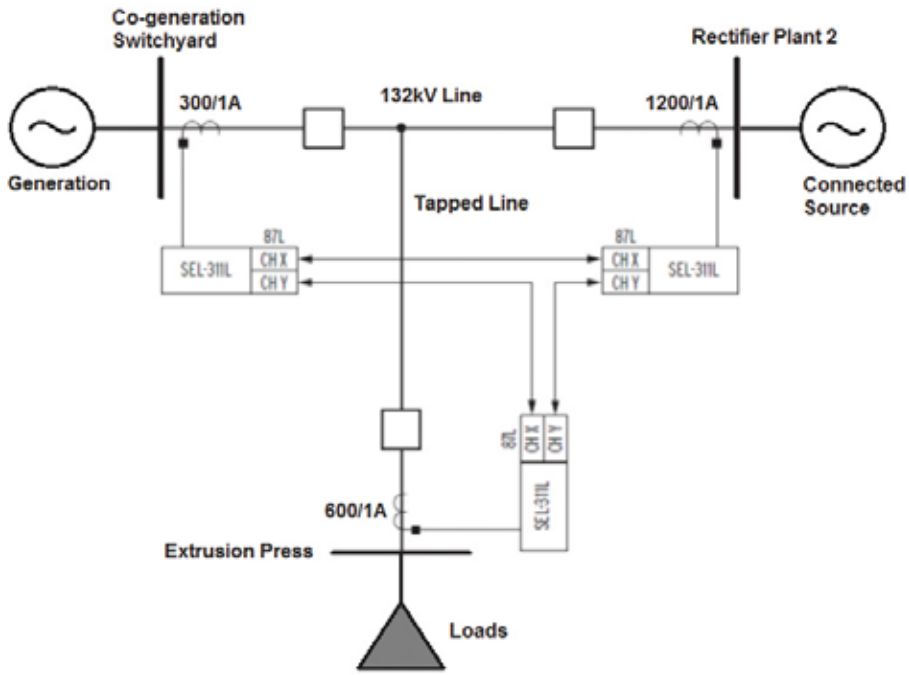


Figure 5: System Configuration for the three-terminal line at Hindalco

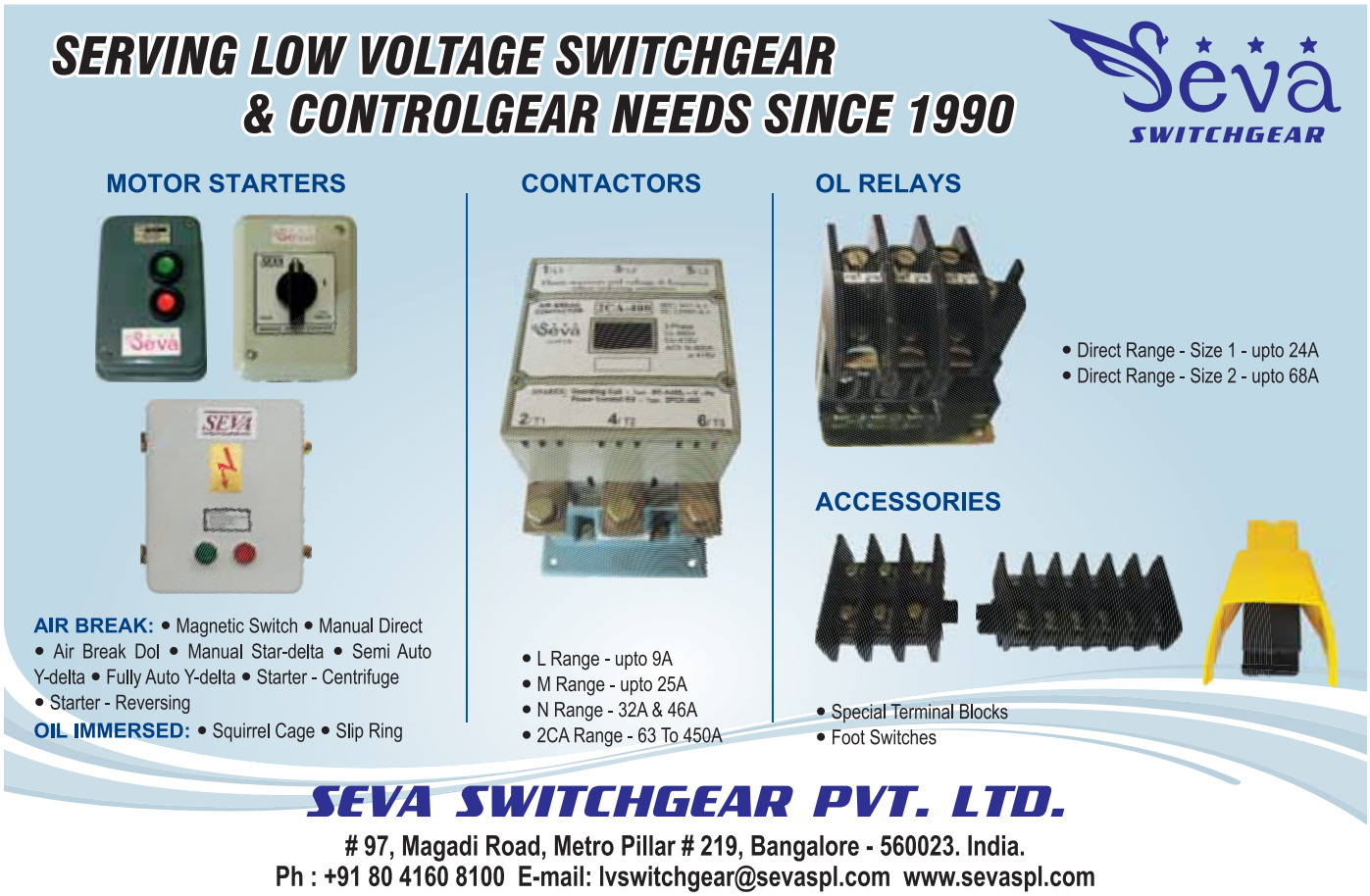
Saturation Security Logic sets the restraint region angle at 180 degrees. The CT Saturation Security Logic is only enabled when the relay is used in a three-terminal application.

This application is also designed with two-setting groups. Line differential is primary protection in Group 1 with backup directional over-current and earth-fault elements, having separate inverse and definite-time delays. Group 2 is enabled for a communication fail condition and backup directional elements take-over as the primary protection. The first group is have higher time delays and the second group has lesser time delays.

For naming convention, we consider Co-generation Switchyard as Station S, Rectifier Plant 2 as Station L and Extrusion Press as Station R. The SEL-311L uses all three possible combinations of remote current to process all 87L elements, as shown in Table 1.

	1	2	3
I_{Remote}	$I_L + I_S$	$I_R + I_S$	$I_L + I_R$
I_{Local}	I_R	I_L	I_S

Table 1: Three Possible combinations of Remote and Local Currents at each of the three terminals



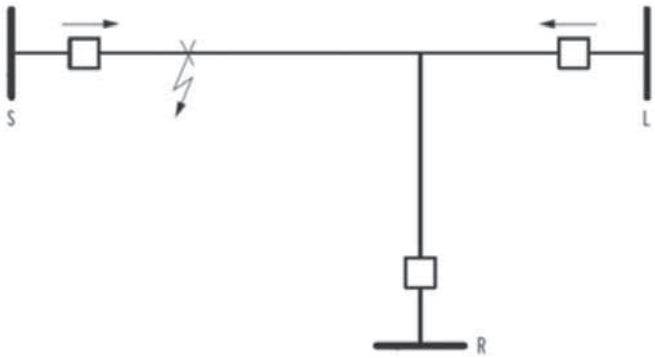


Figure 6: Study of an internal fault on the line, with fault-feeding from the Co-generation End.

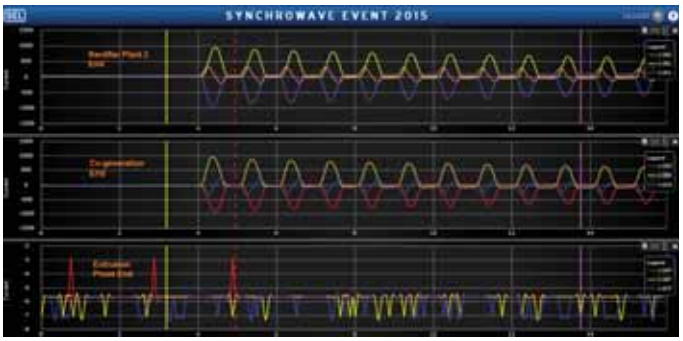


Figure 7: Disturbance Record showing a B-G fault record showing currents at each of the three terminals

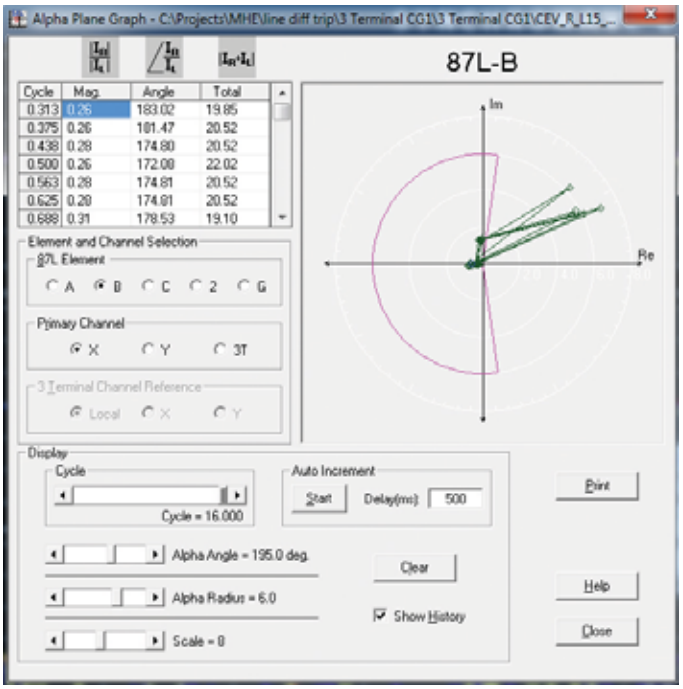


Figure 8: Alpha Plane plot of the B-G fault seen in Figure 7

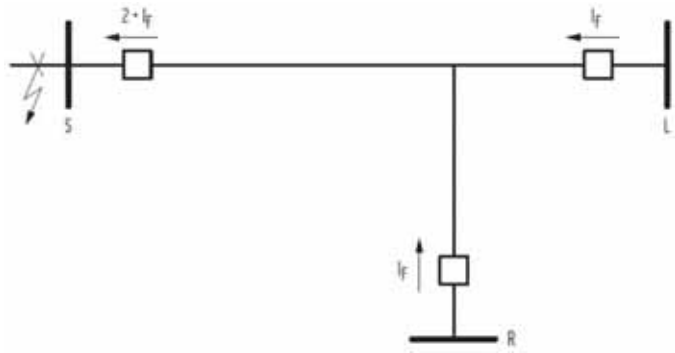


Figure 9: An external fault on the three-terminal line

Analysing faults on the three-terminal line

To help further understanding of the application, we have analysed performance with actual faults and explained with actual disturbance records. Considering a single-phase to ground (B-G) fault on the main line, we have observed fault feeding from Co-generation End and Rectifier Plant 2 End, as seen in Figure 6. The disturbance record capture from Rectifier Plant 2 End shows the details of fault currents from all three-sides in Figure 7 and the α-plane plot in Figure 8. All three relays process the 87LG elements, using three possible combinations of remote ground current, from Table 1. The scheme then selects the trip/restrain decision produced by the processing method that used the largest ground current as the local current.

In effect, the relay with the largest local current makes the proper trip/restrain decision, and the other two relays make the same trip/restrain decision as the relay with the largest local current. The same processing occurs in all three relays. This method works in all cases where the out feed current is the smallest terminal current.

Continuing with the algorithms explained earlier, the fault contribution from the remote ends, vector additions and α-plane plotting , the scheme brings the security of the α-plane and calculation of differential quantities at each end, to provide stability against CT saturation or external fault conditions. An example of a through fault is shown in Figure 9.

Conclusion

Current-only differential schemes must balance security challenges from CT saturation and channel asymmetry with sensitivity: the more secure the scheme, the less fault coverage. When we consider the cumulative errors of CT saturation and channel asymmetry, the α-plane element provides better sensitivity and security, as compared to percentage differential relays using a slope setting. The α-plane element is very tolerant of CT saturation while maintaining a maximum degree of fault resistance coverage. Restricting phase differential elements to detecting three-phase faults, while using a negative-sequence differential element to detect all other fault types, maximises sensitivity while maintaining security. The α-plane analysis helps to visualise how various power system and protection system phenomena affect unit-type protective relay element security, dependability, and sensitivity.

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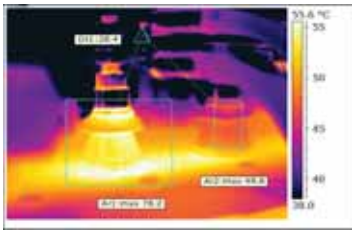
FLIR Thermal Imaging Cameras Help Prevent Power Failures at Utilities

'Detecting maintenance issues before failures occur is crucial to E.ON Bayern'

In Western Europe electricity is usually taken for granted. Due to thorough maintenance programs power failures are a thing of the past in most European countries. To ensure continuous power supply regular inspections of the network's components are really a must. FLIR thermal imaging cameras can play an important role in determining the state of operation of these components, so utility companies can more accurately maintain and repair their network.



With temperatures approaching 80°C this transformer requires further inspection.

One of the first European utility companies that realised the potential of thermal imaging technology for the maintenance of their electricity network was E.ON Bayern. "In our maintenance program thermal imaging plays a pivotal role in ensuring that components are replaced in time, before any failures occur," explains Ronald Hintzsche, head of the measurement department of E.ON Bayern.

E.ON is a power and gas utility company of German origin. It is the main power supplier in central Europe and combined with its subsidiaries it is also one of the world's largest investor-owned power suppliers. One of E.ON's subsidiaries is E.ON Bayern, headquartered near Regensburg, Bavaria. With a network area stretching over 41,000 sq.km. E.ON Bayern is one of the largest regional energy service providers in Germany.

Most electronic components heat up before they break down. "Detecting this rise in temperature in an early stage allows us to plan our maintenance accordingly and to prevent costly failures," continues Hintzsche. "The thermal imaging cameras from FLIR Systems play a crucial part in our preventive maintenance program."

All components are checked periodically

The predictive maintenance program contains an exact planning of

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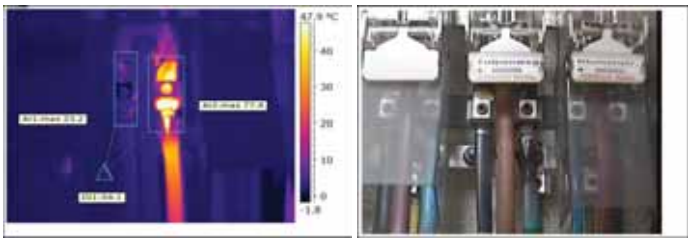
when each part of the systems needs to be inspected, depending on the importance of that part for the operation of the entire system and on how prone its components are to failure. "Each component of the existing network is checked at least once in every 12 years," explains Hintzsche. "Due to our long-standing experience we define a separate maintenance cycle for particular network components. But crucial parts will be inspected in cycles of 4 to 5 years and some installations near busy traffic intersections or in difficult industrial environments where the components can be affected by pollution, such as salt, dust, smoke or soot, are inspected once a year."



This connector has become resistive due to loosening and corrosion. This can be easily remedied by opening, cleaning and reassembling the connector.

The thermography team reacts immediately to the slightest deviations within the network processes. "An inspector or technician might hear a strange sound in the transformer of a substation, for instance," explains Otto Heigl, one of the thermographic inspectors that use the thermal imaging cameras. "In such a case we have to find out whether there is a problem and if there is a problem we have to find out very quickly what is causing it. Our FLIR thermal imaging cameras help us to do that."

Excellent thermal image quality

The cameras used by E.ON Bayern's inspectors are one FLIR P65 thermal imaging camera and three FLIR P60 thermal imaging cameras. Both of these models incorporate an uncooled microbolometer detector that produces thermal images at a resolution of 320 x 240 pixels and a thermal sensitivity of below 80 mK. "One of the reasons why we chose these models, apart from the excellent image quality and accurate temperature readings, was the visual imaging camera," Heigl explains. "It helps us to exactly locate which component is showing up as being hot on the thermal image."

Interchangeable lenses

Another advantage is the fact that these thermal imaging cameras from FLIR have interchangeable optics. "We use a 45-degree wide angle lens for close up inspections of transformer stations or substations and for long distance observations of power lines or high voltage transformation substations we enhance the lens by a 7-degree telephoto lens. This flexibility is very important for us," Heigl said.

Word compatible software speeds up reporting

To enable better maintenance predictions the thermal data gathered in the field is combined into a report, using FLIR Reporter software. "Because the software is fully compatible with Microsoft Office we can easily and swiftly compile reports with the most commonly used text editor: Microsoft Word," Heigl explains. "Everybody can immediately start using the software, since most people know Word already."

The models currently being used at E.ON Bayern – the FLIR P60 and P65 – that were bought in 2004 and 2005 are not currently marketed by FLIR Systems. In the current product range these models have been replaced with the FLIR P660 thermal imaging camera. It mostly has the same important features, such as a visual imaging camera and interchangable lenses, but its uncooled microbolometer detector produces better thermal images with a resolution of 640 x 480 pixels and a thermal sensitivity of below 30 mK.

The older FLIR models used by E.ON Bayern still function perfectly, however. "And if there is a problem with one of our cameras the service we get from FLIR is very good," adds Hintzsche. "The camera is repaired and sent back very swiftly."

Good training is crucial

The operation of thermal imaging cameras from FLIR Systems is relatively easy, but that doesn't mean that it's just a matter of pointing the camera at a network component and pressing a button, explains the head of the measurement department Hintzsche. "It's very important that the operator knows at least the basics of thermographic theory. Without that knowledge it is very easy to draw the wrong conclusions.

Luckily, FLIR offers thermography courses in co-operation with the Infrared Training Center (ITC). We therefore make sure that all of the inspectors at E.ON Bayern have at least followed a three-day thermography training course at the ITC."

FLIR: a reliable long term partner

As the old FLIR P60 and P65 models are still functioning properly, the purchase of a new thermal imaging camera is not yet an issue at E-ON Bayern, according to Hintzsche. "But when the time comes to look for new thermal imaging cameras, FLIR will be our first choice. FLIR simply delivers the best combination of thermal imaging camera quality, very good repair service, excellent customer support and top of the line training options. And as the global market leader FLIR has also proven to be a reliable long term partner, so why change our thermal imaging camera supplier? When buying a new thermal imaging camera becomes an option again our choice is clear: it will be a FLIR."

For more details, contact: **flirindia@flir.com.hk**

"Growth in renewable energy is further expected to multiply"

India has significant expertise and manufacturing operations strengthening it as a potential hub for renewable energy, hopes **Amit Kumar, Partner, Energy & Utilities, PwC** while giving a glimpse of Indian Renewable Energy Sector during an e-mail interaction with **Electrical India**.

Following climate commitments made at the Paris Summit, the Indian government gears up to achieve 175 giga watts (GW) of clean energy by 2022. According to you, what kind of potential will it generate for Indian renewable energy sector?

India's nationally determined contributions released at the COP21 Paris summit commit that 40% of India's generation will be met by non-fossil fuel based sources by the year 2030, which as per our estimates will translate to an installed capacity of non-fossil sources exceeding 350 GW. This clubbed with India's 2022 targets of 175 GW installed capacity of renewable energy and the increasing interest shown by sectoral players and investors promises that this sector is bound to grow at an immense pace.

India has already completed wind power installations of over 28.9 GW against the 2022 targets of 60 GW. SECI recently received bids of 2.6 GW against a capacity of 1 GW for the first reverse bidding auction for the wind energy sector. Likewise, India's current solar capacity has exceeded 10 GW with an additional 13-14 GW projects currently in the pipeline and over 5 GW projects in the tendering phase. The auction for the Rewa project in MP concluded in February this year, that saw India's lowest ever levelised tariffs for solar @ INR 3.29/kWh, had initially seen bids of 7.5 GW being made by 20 players as against the total project capacity of 0.75 GW and the reverse bidding process lasting over 30 hours.

This increased interest of players is essentially because they see a massive market size for renewable in India. Our total installed capacity of 50.7 GW is targeted to increase by almost 125 GW for the attainment of these targets. This translates to an investment potential of around USD 50 billion in the solar sector alone and an investment potential of over USD 70 billion in total by 2022. These figures are only for the development of projects. Enhancement of the grid and adoption of storage technologies can take these figures to well over USD 100 billion.

What are the initiatives taken by the government for generating the momentum in the sector?

The Government has put in place a mixture of initiatives in the

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form of subsidies, innovative project implementation mechanisms, enabling policies involving simpler clearances, access to cheaper finance and a mixture of tax concessions. Accelerated depreciation of 40% for solar projects, subsidies of 30% on the capital cost of several categories of solar rooftops, the establishment of a sugar development fund for financing cogeneration projects and excise and customs exemptions for various components of renewable energy projects have been some of the notable initiatives.

Considering India's renewable energy sector has fairly advanced, amongst the most impactful initiatives at this stage has been the initiation of a real time reverse auction process for tendering both solar and wind projects. This process has resulted in substantial declines in the electricity tariffs and as a result all NTPC, SECI and state government solar bids are now conducted under this mechanism. Its success resulted in this mechanism being tried on wind projects as well, wherein a record low tariff of INR 3.46/kWh was witnessed in February 2017 in the first ever such bid, breaking the previous low of INR 3.82/kWh.

The concept of solar parks particularly has been very successful and witnessed India's lowest levelised solar tariff of INR 3.29/kWh. Solar parks have led to significant declines in the tariffs of solar energy in the past two years, particularly, because investors perceive reduced risks in the implementation and operation of projects. Obtaining clearances and approvals is more streamlined and are usually in place for majority components. The first phase of the solar park policy saw MNRE finalizing all 20 GW solar parks within seven months from the release of the policy and the subsequent developments have resulted in MNRE recently announcing another phase of 20 GW through solar parks.

The nation has also progressed in terms of releasing a policy for offshore wind projects, 1000 MW Inter State Transmission System Guidelines and a repowering policy for turbines of sizes 1 MW and below. Another recent notable initiative taken was the release of the national tariff policy in 2016 that details 8% solar RPO by 2022 and a renewable generation obligation for new coal and thermal plants.

The main and planned outcome of the various initiatives taken by the Government has been to foster advancements and economies of scale in renewable energy technologies to bring about significant reductions in cost of generation from such sources, making these competitive and in cases cheaper than conventional sources.

Can India become a renewable energy hub with these initiatives? Please elaborate.

India has definitely witnessed significant growth in the renewable energy sector, which is further expected to multiply in the coming years. Attainment of the 2022 and NDC targets will imply that India will figure amongst the leaders, most probably one of the top three countries in terms of the installed renewable energy capacity. This would imply that India has significant expertise and manufacturing operations strengthening it as a potential hub for renewable energy.

However, attainment of these targets will require overcoming multiple barriers, some of which may not be foreseen at this stage. A mixture of additional initiatives tailored as per market requirements will hence be of great importance to propel the sector forward. Prominent challenges such as grid integration, energy storage and ensuring compliance of RPO targets will have to be addressed through these.

India has definitely witnessed significant growth in the renewable energy sector, which is further expected to multiply in the coming years. Attainment of the 2022 and NDC targets will imply that India will figure amongst the leaders, most probably one of the top three countries in terms of the installed renewable energy capacity.

The International Solar Alliance (ISA) of over 120 prospective countries is a defining step that has the potential to make India a solar energy hub in the near future and probably increase its chances of becoming a renewable energy hub. All countries of the alliance do not have a highly developed RE market and require support in the form of expertise or equipment to foster growth of the sector. This provides a huge market potential for Indian players.

What are stumbling blocks in achievement of this target by 2022? According to you, what are the solutions for tackling these hurdles?

Despite huge growth in the renewable energy sector in the past few years, there are still some bottlenecks, particularly, related to implementation of policies. These are mainly because the roles of stakeholders are not properly defined or due to lack of infrastructure or resources to achieve what we plan out to do.

India lacks proper green energy infrastructure, as a result of which intermittent renewable energy may result in transmission, grid balancing and stability issues in the grid. The green energy corridor that was being planned is a viable solution to this problem but will

require significant investment and time to take shape. Recently, solar tenders involving storage have been released by SECI, which is a commendable step in this direction.

Secondly, Discoms may have power purchase constraints in view of the significant increase in power generation capacity on the whole and implementation of energy efficiency measures. Delays in multiple tenders such as in the Cudappa solar park happen because Discoms currently have no substantial requirement for additional power. Further, with an increase in the supply of energy to the grid, appropriate measures will have to be taken to ensure that renewable energy projects are not asked to back down. There have been multiple cases where wind power developers have been asked to back down their generation, which in turn lends a bad name to the industry and will definitely hamper the addition of new capacities and the investments that are expected to be made in this sector.

Thirdly, a major issue is in the promotion of solar rooftops as rooftop owners face a significant number of issues in obtaining the requisite permissions and clearances from local departments such as obtaining grid connectivity and net metering permissions. Additionally, there are frequent delays in the disbursal of subsidies and an insignificant percentage of the installations currently have been implemented in the RESCO mode. Owing to these factors, only around 1 GW of solar rooftops against the target of 40 GW has been implemented till date.

Another stumbling block is the non-compliance of RPOs and of the REC mechanisms by obligated entities. As of March 2017, a total of 18.3 million RECs were lying unsold in the power exchanges across India.

Which is the best source of energy considering the economics and cost of electricity?

Since the past couple of years, solar energy has gained tremendous growth momentum as a result of significant attention from both Government and investors alike. This has resulted in a significant quantum of policy enablers and increased investments resulting in a 230% increase in India's cumulative commissioned capacity from 3,062 MW to over 10,000 MW over in just a span of two years. This does not include the over 18,000 MW of projects that are currently in the tendering or implementation phase. Amazingly, the World's largest project of 648 MW was also commissioned in Tamil Nadu covering an area of 10 square kilo meters.

The economies of scale, improvements in technology and increased access to finance have resulted in the project development costs for utility scale projects dropping to INR 5.3 crore/MW as per the latest CERC benchmarks. However, the actual costs as per our discussions with project developers, have further dropped since these benchmarks were released and are now much lower, somewhere around INR 4.5 crore/MW in some cases. These developments have resulted in the tariffs for solar project falling to as low as INR 3.29/kWh in the most recent Rewa bid in February 2017. The previous low was INR 4.34/kWh for project in Rajasthan achieved in January 2016. For majority of projects being established tariffs of below INR 4.5/kWh has now become common. Even in the case of solar rooftop bids received by SECI, developers have bid project development costs as low as INR 45,100/kW and tariffs under the ESCO mode as low as INR 3/kWh after subsidy for rooftop projects.

The global installed capacity for solar power has crossed 300 GW as per latest figure. China is the leader accounting for 77 GW of the total capacity and India figures around the 6th position with over 10 GW of installed capacity.

In terms of the current installed capacity, wind has the maximum capacity amounting to more than 57% of the total renewable energy capacity of the nation. Although solar has seen significant growth in the recent past, still wind energy is in todays date giving solar a run for its money. Project development costs of wind energy are higher than solar projects on a per MW basis, but this is more or less balanced by the generation of these projects.

Where does India stand on the global scale in terms of generation of renewable energy?

The global installed capacity for solar power has crossed 300 GW as per latest figure. China is the leader accounting for 77 GW of the total capacity and India figures around the 6th position with over 10 GW of installed capacity. In the wind energy sector as per figures released by GWEC, the total global installed capacity stands at 486.7 GW as of the end of 2016, of which China accounts for 168.7 GW and India comes in fourth at 28.7 GW after USA and Germany.

In other technologies, India featured as the third country in terms of installed capacity of CSP projects as per the latest statistics released by REN21. In the Biomass and Cogeneration sector, India has an installed capacity of 8.1 GW and in the Small Hydro Power sector a capacity of 4.3 GW.

Based on the current pipeline of projects, India is expected to

figure amongst the top three countries in terms of both solar and wind installations in the coming 2-3 years.

How can India learn from the experience of other countries and rapidly scale up renewable without any wastage or curtailment?

Countries leading in particular technologies have considerable and varied experience of how to promote growth and resolve any issue that may accompany respective technologies. Their success stories along with examples of various innovative mechanisms that they have implemented have been guiding Indian stakeholders as is evident from the introduction and success of the solar park concept in India.

The main role of Indian stakeholders is to identify based on international experiences, which mechanisms are required in India and subsequently innovate on those mechanisms to tailor them to local requirements. It is not necessary that mechanisms that have been successful elsewhere may be successful in India, hence the above two steps are of significant importance.

Just as an example – in the year 2015, Indian Government was planning to introduce dollar denominated tariffs for solar bids in an attempt to increase the participation of foreign investors by reducing their risks. This mechanism has been successful in various countries and recently saw the lowest ever tariff for concentrated solar power projects of 6.3 US dollar cents being bid in Chile this month for round-the-clock solar power.

However, after much due-diligence this mechanism was rightly not implemented in India owing to the risks associated with currency fluctuations. Instead, other enablers such as reverse auction, solar parks and 100% FDI led to tremendous growth without the associated risks.

Countries such as Germany and Japan have excellent experience of solar rooftops; Demark and Scotland have excellent experience of grid balancing and can provide invaluable expertise to Indian players. It may be suitable to adopt a global approach and partner with these nations to formulate initiatives that propel our sector forward.

What is your outlook for the renewable energy sector for 2017-18 fiscal?

It has been almost two years since India's scale up targets were put into place and the progress specifically in solar and wind energy segments has been commendable. We can be confident that the renewable energy sector has gained significant momentum and attention at a level from which it is very unlikely that its growth will slow down in the near future. Innovation in terms of storage technologies and advancements in grid integration will pave the way for increase in renewable energy deployment. Increased deployment and innovation will even further drive down costs and promote greater installations.

The current pipeline of 13-14 GW of solar projects and additional implementation of solar rooftops implies that India's installed capacity by March 2018 will exceed 20 GW.

This will bring in significant equity infusion in the sector and in all likelihood an increasing number of foreign players participating in the sector. This will also create significant demand for manufacturing of solar components and hence the manufacturing capacities will definitely witness an increase.

The most interesting trends in this financial year will be observed in the energy storage sector. Owing to the increasing likelihood of evacuation, grid integration and balancing issues this sector will face and to ensure stable, round the clock supply from renewable energy sources this aspect is likely to get a lot of attention.

With the number of players that have entered the Indian RE market, the investments that are being made and are forecasted, one can safely infer that the sector is promising in both the medium and long term - subject only to appropriate measures and efforts being put in by both internal and external stakeholders.

Towards Securing Energy Security in India

Dr. Naveen Kumar Sharma
Lecturer
Electrical Engineering Department, National Institute of Technology, Hamirpur HP

Anuj Banshwar
Pursuing Ph.D in the Department of Electrical Engineering, National Institute of Technology Hamirpur (HP)

Dr. Yog Raj Sood
Professor
Electrical Engineering Department & Dean (Research & Consultancy), National Institute of Technology, Hamirpur (HP)

Renewable energy sources and technologies have potential to provide solutions to the energy problems faced by the developing countries like India. These technologies have long been recognized as an important part of the solution to address energy security concerns.

Power industry is moving rapidly from regulated conventional setup to a deregulated environment. In the deregulation environment, generation, transmission, and distribution are independent activities. India has a vast supply of renewable energy resources, and it has one of the largest programs in the world for deploying renewable energy based products and systems. India is a developing and fast-growing large economy and faces a great challenge to meet its energy needs in a responsible and sustainable manner. There is a competition among generators for managing different customers. Main benefits from the deregulation include cheaper electricity, efficient capacity expansion planning, cost minimization, more choice, and better service. During the nineties decade, many electric utilities throughout the world have forced to change their way of operation and business, from vertically integrated mechanism to open market system. India is on the path of rapid economic growth along with speedy overall development; simultaneously it has to face the global threat of climate change. India has unique renewable energy resources (RES) and development of country depends to a great extent on harnessing these sources. India has unique RES and development of country depends to a great extent on harnessing these sources. Since conventional sources of energy pose significant threats to our current and future global security, environmental quality, health and society. So, there is urgent need to promote renewable energy in present Indian restructured power sector in sustainable and eco-friendly manner. Restructuring in Indian power sector started with the unbundling of Orissa state power utility, and soon followed by many other states throughout India.

Power is one of the most critical components of infrastructure crucial for the economic growth and welfare of nations. The existence and development of adequate infrastructure is essential for sustained growth of the Indian economy. In the recent past, India has been growing at an average rate of 8.5%. Growth of economy is reciprocally linked to energy usage, and consequently the energy requirements of the country have increased phenomenally in the last couple of years. Over the years, Indian power sector has experienced approximate six-time increase in its installed capacity - it jumps from 30 GW in 1981 to over 306 GW by 30 September 2016, but still there is a huge gap between generation and demand in India. Hence, it needs to be establishing more generation plants preferably to come from renewable sources by governmental as well as various private sectors. Restructuring has changed the traditional mission and mandates of utilities in complex ways, and had large impacts on environmental, social, and political conditions for any particular country. So, there is a great need to promote the renewable energy source in Indian power sector to meet

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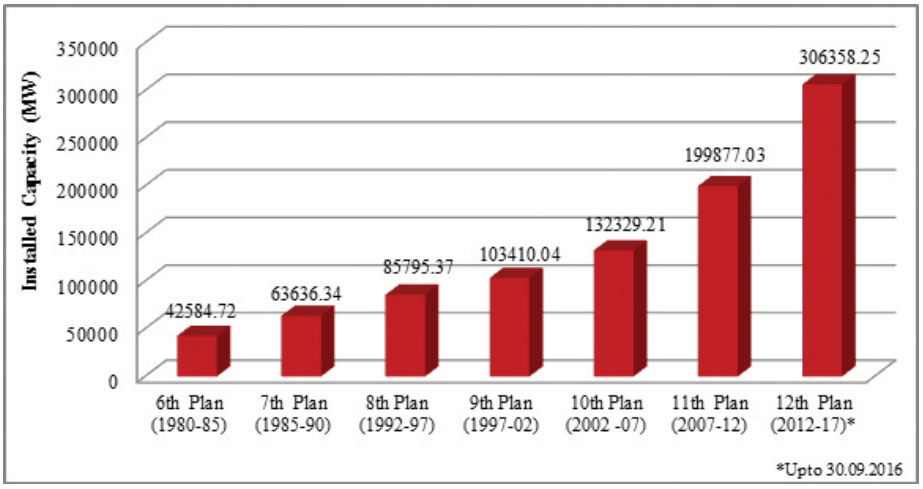

Figure 1: Plan wise growth of Indian power sector

future energy demand and remove GHG emission for environment protection. Deregulation encouraged the growth of new independent power producers whose business requirements transformed the power plant industry.

Plan wise growth of Indian power sector is shown in Figure 1.

The functions of Central Electricity Authority (CEA) are to advise the Ministry of Power (MoP) on national power policy, national power planning and regulatory matters on the national level where as State Electricity Regulatory Commissions (SERCs) does the same function at state level. Indian power sector is organized into five Regional Electricity Boards such as Northern Regional Electricity Board (NREB), Southern Regional Electricity Board (SREB), Western Regional Electricity Board (WREB), Eastern Regional Electricity Board (EREB) and North Eastern Regional Electricity Board (NEREB). As shown in Figure 2, each regional electricity board covers many states electricity boards in India as on 30 September 2016. With the establishment of various inter-regional links, inter-regional power exchange has grown manifold. Growth of inter-regional power exchange has helped in meeting more demand in energy deficit regions besides achieving overall economy.

Current Status of RES in India

Renewable energy has been an important component of India's energy planning process. The importance of renewable energy sources in the transition to a sustainable energy base was recognized in the early 1970s.

a. Grid Connected

India, total grid-connected renewable power generation capacity of 45,916.94 MW has been achieved till 30 September 2016, which is about 15% of the total installed power generating capacity in the country. It includes wind power of 28 GW, small hydropower of 4.3 GW, biomass power of around 4.8 GW, and around 8.5 GW Solar Power as shown in Table 1.

A capacity addition of 24,000 MW is targeted during the 12th Plan period that would take the renewable power generating capacity to nearly 50,000 MW by 2017. This momentum is likely to be sustained and it is envisaged that the renewable power capacity in the country will cross 87,000 MW by 2022. The MNES (Ministry of New and Renewable Energy Sources), Government of India (GOI), has undertaken measures to facilitate the growth of both grid and off-grid RE power through specific programs. Major programs in India for power generation from renewable include wind, biomass (cogeneration and gasifiers), small hydro, solar, and energy from wastes. The contribution of renewable to the total installed capacity of electricity generation has been rising after private participation into generation and distribution due implementation of restricting of power sector. The total potential of renewable in India for power generation is estimated to be 84777 MW with the major contribution coming from wind energy.

(b) Off-Grid Renewable Power

It needs to be underlined that for two major reasons Indian renewable energy priorities are different from that of the developed countries. Most important, it provides energy access to large rural populations including those in inaccessible areas and meeting unmet demand in many other areas. Perhaps the remote areas can get electricity only through renewable sources. Table 2 presents a summary of the achievements in off-grid/ distributed renewable power and decentralized renewable energy systems. While these achievements are evidently impressive, there is great need for potential and deployment of such off-grid/ distributed/ decentralized systems.

Environmental, Social and Economic Benefits by RES

Renewable energy is central to climate change mitigation efforts. Broad estimates indicate that mitigation from existing renewable energy portfolio is equivalent to around 4-5 % of total energy related emissions in the country. India is already providing competitive green investment loans, tariff subsidies and tax breaks for the renewable industry. These are some of its

Figure 2. Regional electricity board of India and RES share of region wise installed capacity.

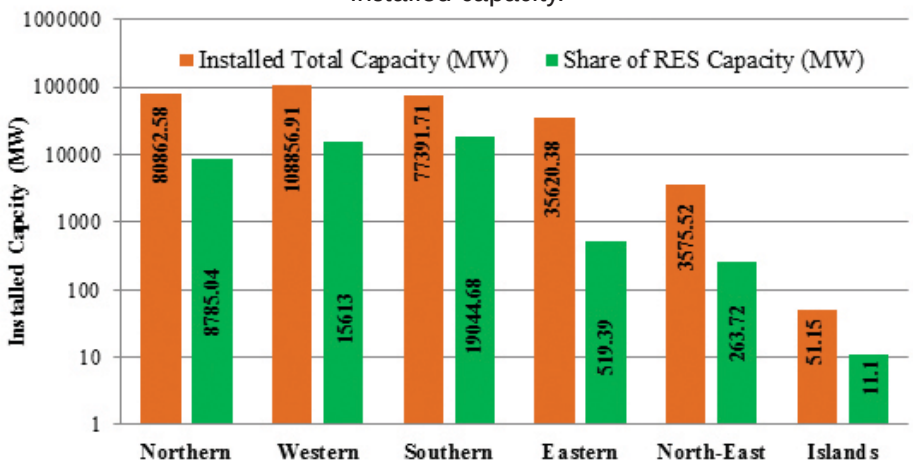

Table 1. Estimated Target and cumulative achievements of RES connected Indian grid

Grid- connected RES Power (in MW)		
RES Sources	**Target through 2016-17**	**Cumulative Achievements**
Wind Power	4000.00	28082.95
Solar Power	12000.00	8513.23
Small Hydro Power	250.00	4323.35
BioPower	400.00	4882.33
Waste to Power	10.00	115.08
Total	16660.00	45916.94

measures to encourage the economy to transform into a low-carbon economy. A sustainable energy economy offers not just ecological benefits, but social and economic benefits too. Solar energy in India has the potential to offset a huge volume of GHG emissions as demonstrated and help realize a low carbon economy at a faster rate. India's climate modeling studies show that its per capita emissions will be around 2-2.5 tones of carbon-dioxide equivalent by 2020 and around 3-3.5 tones of carbon-dioxide equivalent by 2030, compared to around 1-1.2 tones presently.

RES is in direct contravention to the huge social, economic and environmental externalities created by conventional power projects. The foremost benefit of deployment of RE technologies is employment generation. The renewable energy industry offers a variety of highly skilled and semi-skilled jobs and the sector is highly employment intensive. In India, if we sincerely implement the 15% RE target set by National Action Plan on Climate Change (NAPCC), we would have to add 90,000 MW of additional renewable power up to 2020. At an average of 20 jobs per MW (both direct and indirect) addition of 90,000 MW of renewable capacity can create 1.8 million jobs. Energy security and autonomy would be the major economic benefit due to freedom from fossil fuels. Import dependency exposes us to major price risks since fossil fuels are globally traded commodities.

Future perspectives for RES in India

The Government of India is taking a number of steps and initiatives like 10-year tax exemption for solar energy projects, etc., in order to achieve India's ambitious renewable energy targets of adding 175 GW of renewable energy, including addition of 100 GW of solar power, by the year 2022. The government has also sought to restart the stalled hydro power projects and increase the wind energy production target to 60 GW by 2022 from the current 20 GW. Most of the investments in renewable energy come from private sector. Total estimated investment in renewable energy power projects during last three years is around Rs 86,000 crore. As per inputs provided by Central Electricity Authority (CEA), around 15,400 MU has been generated through solar energy during the last three years and it has met the energy requirement to that extent in the country. A capacity addition of 14.30 GW of renewable energy has been added during the last three years under Grid Connected Renewable Power, which include 5.8 GW from Solar Power, 7.04 GW from Wind Power, 0.53 from Small Hydro Power and 0.93 from Bio-power.

In the present Indian power sector with maturing technologies, promotion policies in renewable energy business, and suitability of various new renewable projects is likely to improve resulting in higher utilization of available government funds and faster market growth. India has experience with many technologies and their implementation. Worldwide India ranks fifth in installed wind energy installed capacity, fourth in annual PV production capacity and second with biogas plants. India possesses a very large solar energy resource which is seen as having the highest potential for the future. The

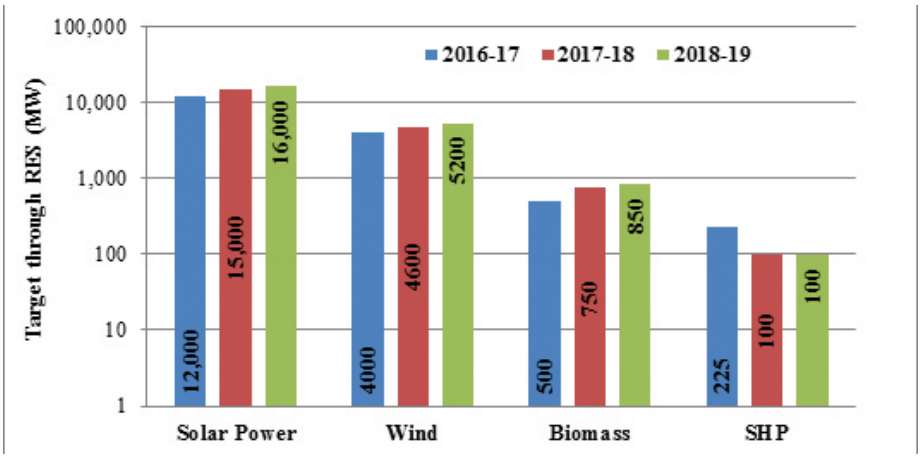

Figure 3: Target through RES in Indian grid connected power (in MW)

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Table 2. Off-grid Renewable Power (up to 30.09.2016)

S. No.	Resources/ Systems	Cumulative Achievements (up to 30.09.2016)
Off-Grid/Distributed Renewable Power (including Captive/Cogeneration Plants)		
1.	Biomass Power / Cogen.(non-bagasse)	651.91 MW
2.	Biomass Gasifier	184.79 MWeq
3.	Waste-to- Energy	162.4 MWeq
4.	Solar PV Power Plants	361.98 MWp
5.	Aero-Generators/Hybrid Systems	2.79 MW
6.	Water mills/micro hydel	8.81 MW
	Total	1382.68 MWeq
MWeq. = Megawatt equivalent, MW = Megawatt		

first, recently announced, the very ambitious Jawaharlal Nehru National Solar Mission (JNNSM) with a target of 20,000 MW grid solar powers, 2,000 MW of off-grid capacity including 20 million solar lighting systems and 20 million square meters. Solar thermal collector area by 2022 is under implementation. The main objectives of the mission are to help reach grid parity by 2022 and help set up indigenous manufacturing capacity. By addition of RE capacity via creation of the National Clean Energy Fund; India is contributing more renewable power through grid. In India, many states recognizing by renewable energy as a grid-connected option and entry of major corporate groups into manufacturing of RE devices.

Only renewable are eligible for support from within their country of origin and count towards that Government's renewable and carbon targets. Renewable energy is experiencing new enthusiasm and vibrancy all across, and the foundation of a new economy is being laid that is inclusive, sustainable and aspires for de-carbonization of energy in a definite timeframe. Increased recognition of the contribution of renewable energy makes to rural development, lowers health costs (linked to air pollution), energy independence, and climate change mitigation is shifting renewable energy from the fringe to the mainstream of sustainable development. For renewable development in India, the renewable energy program has been in existence for more than three decades, but a market for renewable energy technologies still need to be existed. Renewable energy strategy needs to be integrated with liberalization of energy markets and withdrawal of direct government interventions in energy sector. Need to construct market-based energy policies that provide a competitive market framework, and may internalize externalities in terms of energy security, environmental protection and economic efficiency for effective promotion of renewable. India's rural areas and in reducing consumption of fossil fuels which is essential for future energy security of the country. It outlines the policies that have been followed to foster the growth of this sector and also indicates the targets and the future pathway.

Grid Interactive
Solar Power Plants Revolution

Jaydip Bankar
BE, Electrical engineering
Baramati, Maharashtra

The solar has potential to produce clean energy to meet the need of present without compromising the ability of future. The solar grid interactive power plants have great potentials to make India energy secure and make India energy independent...

Economic growth and development is desirable for developing countries like India and energy is essential input for economical growth. However, the relationship between economical growth and the energy demand is not always consistent. Eg- Under present conditions, 6% increase in India's GDP would impose an increased demand of 9% on its energy sector. India's overall generation capacity as of November 2016 stands at 308.83 GW, of which approximately 262.165 GW comes from conventional energy sources and 46,665 MW from renewable energy sources. According to India's existing power demand the power infrastructure is not capable to meet the need of load. Still Indian villages are in dark.

Table 1: India's Overall Generation Capacity (November 2016)

Source	Installed Capacity (MW)	Share
Coal	187,252.88	61.12%
RES MNRE	44,236.92	14.44%
Large Hydro	43,112.43	14.07%
Gas	25,057.13	8.18%
Diesel	918.89	0.30%
Nuclear	5,780.00	1.89%
Total	302,833.20	100.00%

The Indian energy scenario shows either resources or technology used for energy sector is imported from other countries. India is dependent on other countries for energy sector. Compared with developed the power infrastructure and energy practices are developing now a days. The resources India is using have adverse impacts on climate and biodiversity. The consistent use of those resources will make adverse impact on human life. There is a need to go for resource capable of meeting India's today's energy demand without compromising the ability of future. The resources should be clean, sustainable and efficient. The solar energy can be option as sun's energy is free and vast. Solar cells made of silicon can convert the solar radiation into electrical energy i.e photovoltaic, another is solar thermal. The solar photovoltaic has very good outputs and can be implemented anywhere. The solar PV panels can be used in as off grid and grid interactive systems.

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Table 2: Installed Grid Interactive Renewable Power Capacity in India as of April 30, 2016 (Resource: MNRE)

Source	Total Installed Capacity (MW)	2022 target (MW)
Biomass Power (Biomass & Gasification and Bagasse Cogeneration)	4,932.33	*10,000.00
Small Hydro Power	4,324.85	5,000.00
Solar Power	8,874.87	100,000.00
Waste-to-Power	114.08	*10,000.00
Wind Power	2,8419.40	60,000.00
Total	46,665.53	175,000.00

Grid Interactive Solar Power Plants

Solar photovoltaic power plant is connected to grid with the gross metering system or net metering systems in India. The grid interactive system has great potential and very popular in India. Ministry of New and Renewable Energy is promoting the solar grid interactive system at large scale. The grid tie system has great potential to make the power infrastructure more strong and sustainable. The grid tie solar system has the ability to meet the need of present without compromising the ability of future. The grid tie systems may lead India to better energy security. The system can be installed by industrial, domestic purpose, commercial purpose,etc.

Table 3: Grid Connected Solar PV plants in India

Regions	MWs
Northern Region	2,097.72
Western Region	2,464.91
Southern Region	3,766.46
Eastern Region	184.98
North Eastern Region	5.37
Islands and others	106.77
Total	8,874.18

The total installed solar roof top power plants in India is 500 MW out of 8874.87MW. India's target is to install 22 GW solar roof top power plants by 2022. This target can be revised as the energy need is growing with time.

The main blocks include in solar power plants

- SOLAR (DC): Module mounting structure, DC cable, Solar modules
- Power Conditioning Unit: Solar Inverter
- Power Evacuation: AJB (Array Junction Box), ACDB (AC Distribution Box), AC CABLES
- Measuring Instruments and Data Logging System: Whether monitoring system, Energy Meter, SCADA

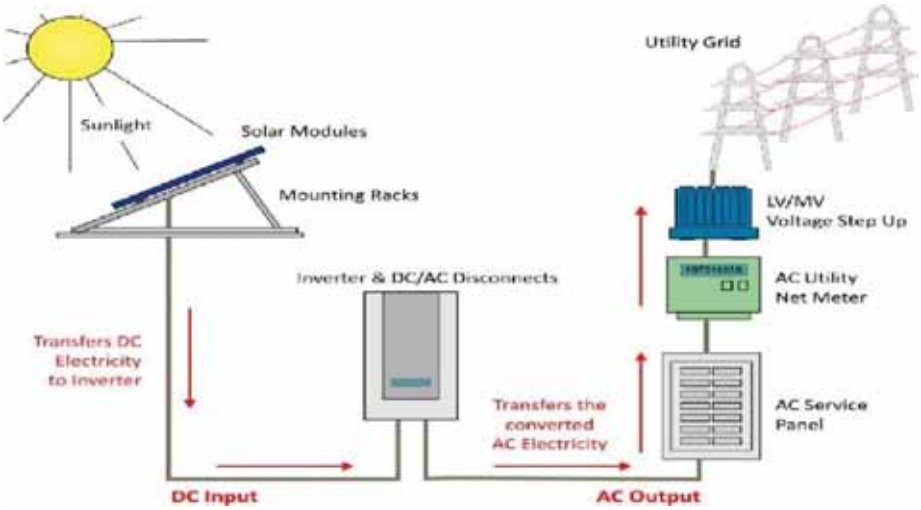

Figure 1: Overview of GRID CONNECTED SOLAR power plant

Practices to improve performance of grid tie solar power plants in India

The performance of solar power plants is dependent on the weather conditions such as irradiance, wind speed, temperature; various performance loss factors. The output of solar power plant can be maximized by certain standard practices while designing and the installation. The sun irradiations availability in India is very good. The modules should be mounted in order to optimize the output. The modules should be mounted with facing to the south as India is in the northern hemisphere of earth. There are four seasons in India the sun path varies in every season according to the sun path tilt of modules should be given.

Table 3: Optimised Tilt for Solar Module in India

Spring	21st March to 21st June	Tilt= Latitude
Summer	21st June to 21st September	Tilt= Decrease 10 To 15 Degrees
Autumn	21st September to 21st December	Tilt= Latitude
Winter	21st December to 21st March	Tilt= Increase 10 To 15 Degrees

Sun's irradiations are very important as output mainly depends on it. Irradiations are of two different types like diffused irradiation and directed irradiations. As the irradiation changes, the output current changes and the power of the solar plant changes. As the irradiation increases, the output power also increases and the performance of the solar power plant increases. There should be minimum shadow on the

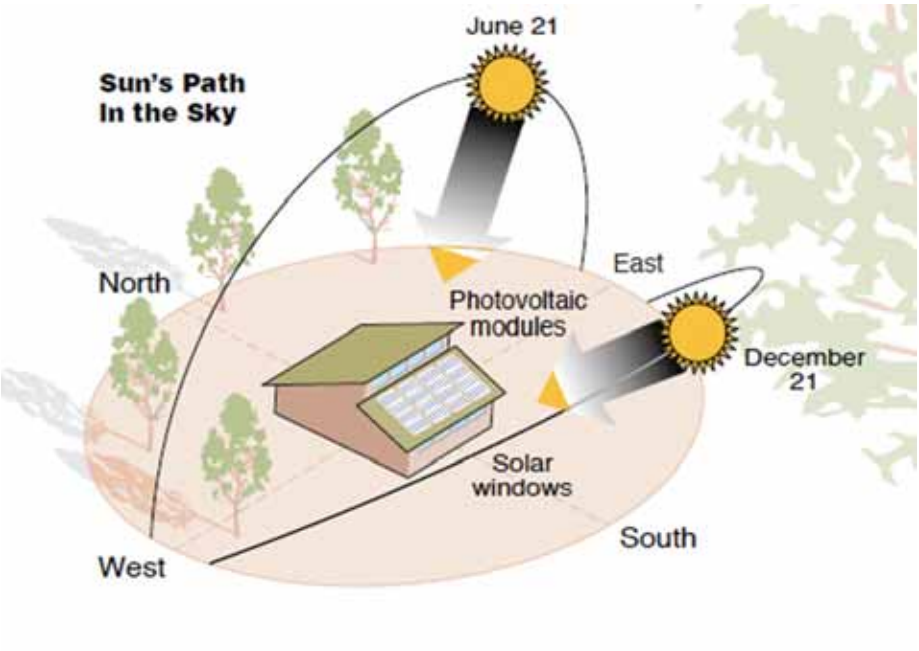

Figure 2: Sun path diagram.

modules to maximize the output. The solar modules give good performance for first 25 years with some degradation every year the performance of modules decreases. The modules should be selected with NOCT45 (Nominal Operating Cell Temperature) as ambient temperature in India is high compared to European countries. Power conditioning is very important in the grid tie system, the inverter converts the DC into AC. Inverters used are probably transformer less and based on a power electronics. The inverter with maximum number of MPPT (Maximum Power Point Tracking) should be preferred. The modules with different orientations should be connected to the separate MPPT in order to maximize the outputs.

Conclusion

According to MNRE'S resources India is having 8874.87 MW Solar PV grid connected capacity which can produce 13279941MW per year. The solar has potential to produce clean energy to meet the need of present without compromising the ability of future. The solar grid interactive power plants have great potentials to make India energy secure and make India energy independent.

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- Build: While most companies have employees who know a lot, it is unlikely that they have time to write it all down for posterity. A more effective solution is to build a library and have your in-house experts curate the collection. Annotating key materials as they relate specifically to the company is another invaluable service these employees can provide – and most of them will be glad to do it as they are passionate about their profession!
- Grow: Materials are all around but they need to be sourced, thoughtfully selected and catalogued, so make sure you have someone who is knowledgeable enough to do that for the library.
- Maintain: While some material may be timeless, the most recent understanding of a subject must also be housed within the library. Electrical testing, for example, has advanced – if you have material on this topic,
when was the last time you updated it?

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- Demagnetizing procedures – different approaches

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Megger invites you to download a new TLM bulletin each month – absolutely free of charge. You can also register to receive an alert as soon as the latest bulletin becomes available. Visit megger.com/TLMBulletin to learn more and start reclaiming the potential of your library today!

Protection System of a Grid-connected PV System

Dr (Smt) Sasmita Behera
Assistant Professor
Dept. of Electrical & Electronics Engg., Veer Surendra Sai University of Technology, Burla, Odisha

Dr Bibhuti Pati
Professor, Dept. of Electrical Engg.
Veer Surendra Sai University of Technology, Burla, Odisha

Photovoltaic (PV) generation is growing very fast to meet load demand, as its installation takes short time. In this paper, a case study of protection system of a Grid-connected PV power plant has been presented. The function and the ANSI codes for different relays have been discussed for a Line- In- Line- Out (LILO) arrangement and the protection standards in Indian scenario has been briefed.

Unobstructed sunlight throughout the day can add to generation capacity to mitigate power crisis through Photovoltaic (PV) system. India has high solar insolation, hence it has high potential of utilising solar power. Jawaharlal Nehru National Solar Mission (JNNSM) has targeted to add a capacity of 20,000 MW by 2022. A grid-connected PV system feeds to the grid. But when sun is unavailable or solar insolation is insufficient to generate power, it draws power from grid. Grid interconnection raises various issues out of which significant ones are interconnection voltage level, feeder reliability, protection and power quality issues. Central Electricity Authority (CEA) has formulated regulations regarding technical standards of connectivity to grid.

PV panel produces DC power. It may be fixed or tracking the sun to extract maximum power [3-4]. In a grid- tied system, AC power from inverter is fed to grid after synchronisation. Generally systems below 100 kW are connected to 400 V at low voltage distribution line, where as beyond this up to 3 MW at 11 KV and 5 MW and above at 33 KV. Evacuation of power demands reliability of distribution system to be 99.5 %. So, power systems with low penetration of distributed generation demands:

- Ensure that the generation unit operates safely

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- Ensure that the grid is not disturbed

Protective relaying is concerned with the redundancy and reliability of the system. The multi-function relays provide a high level of protection at a very attractive cost. The multi-function digital relay can protect a generator from voltage, frequency, reverse power, over current, loss-of-field, and over-excitation (V/Hz) disturbances, while also providing breaker failure/flashover protection. If a multi-function relay is out of service, the consequences can be more severe since many protective functions may be incorporated into the unit. So, a second multi-function digital relay could provide voltage, frequency, over current, directional power, and directional over-current protection as a backup.

PV Generation Protection

Due to cost as well as space of individual relay, systems designed in the past had reduced level of protection. With the use of multi-function digital relays, less no of relays reduce panel space, wiring and other costs. Therefore, a very high level of protection becomes affordable; however the reliability issue demands back up for important functions.

With the advent of multi-function relays, the trade-off of protection coverage versus cost has taken a marked turn toward more protection. In order to put the PV generator protection problem in perspective, a short discussion on protection schemes is discussed herewith. The "IEEE Guide for AC Generator Protection" ANSI C37.102 is one of the premier documents available to the protection engineer for guidance in generator protection system design.

A sample one-line protection scheme for the first commissioned PV generator located at Sadeipali, Bolangir, Odisha with capacity of 1 MW is shown in Figure 1. The PV module delivers AC power at 270V after inverter which is stepped up to 11 KV by transformer. In this paper, discussions are limited to faults or abnormal conditions that are primarily related to grid-interconnection of such PV system at 11 KV level. The generation started in June 2011 and initially fed to a 11 KV rural feeder. OERC has fixed Rs.15/KWh for first 15 years and Rs 7.5/KWh for 13th to 25 years. As the feeder was supplied from 33/11 KV Laltikra as well as 1 MW PV system installed by Rajratan Energy Holdings Pvt. Limited(REHPL), effective protection system became important. As in single line diagram (SLD), the PV system has two bays. It has Line-In-Line-Out (LILO) arrangement for 11 KV Chandanvati Feeder. The connected load of 11 KV feeder is more that 1 MW. The PV generation is metered and fed to this feeder at an intermediate location of Sadeipali. During night when there is no generation of PV it is bypassed and after off-grid closing I-5 shifts the total load of the feeder to grid. The station auxiliary supply of PV power plant is also drawn from grid. The main fault types and disturbance conditions are classified as:

- Phase Faults
- Ground Faults
- Abnormal voltage
- Unbalanced Currents
- Abnormal Frequencies
- Breaker Failures
- System Faults

In addition to the above faults and disturbance conditions, loss of synchronism is also protected. This paper is focussed on important points in grid interconnection protection.

The numbers used in Figure 1 represent a shorthand notation defined by the ANSI/IEEE Standard C37.2-1979 to identify specific relaying functions. The guide to the use of these numbers and their definitions is found in reference. The protection system falls under two categories discussed below: Primary Protection and Secondary Protection.

The primary protection trips the appropriate breakers to clear faults in the protected zone only. The primary protection is typically the fastest protective function for detecting the designated fault type.

The backup protection operates independently of the primary protective function only if the primary protection fails or is temporarily out of service. It may be slower to operate than the primary protection so that the primary protection has the first chance to operate.

Phase Fault Protection of Feeder

Phase faults in a incoming feeder can be detected and protected by a pack of 3 nos Over Current relay (50) and 1 no IDMT earth fault relay (51N). One IDMT non-directional over current relay (51) is also provided.

Phase Fault Protection of

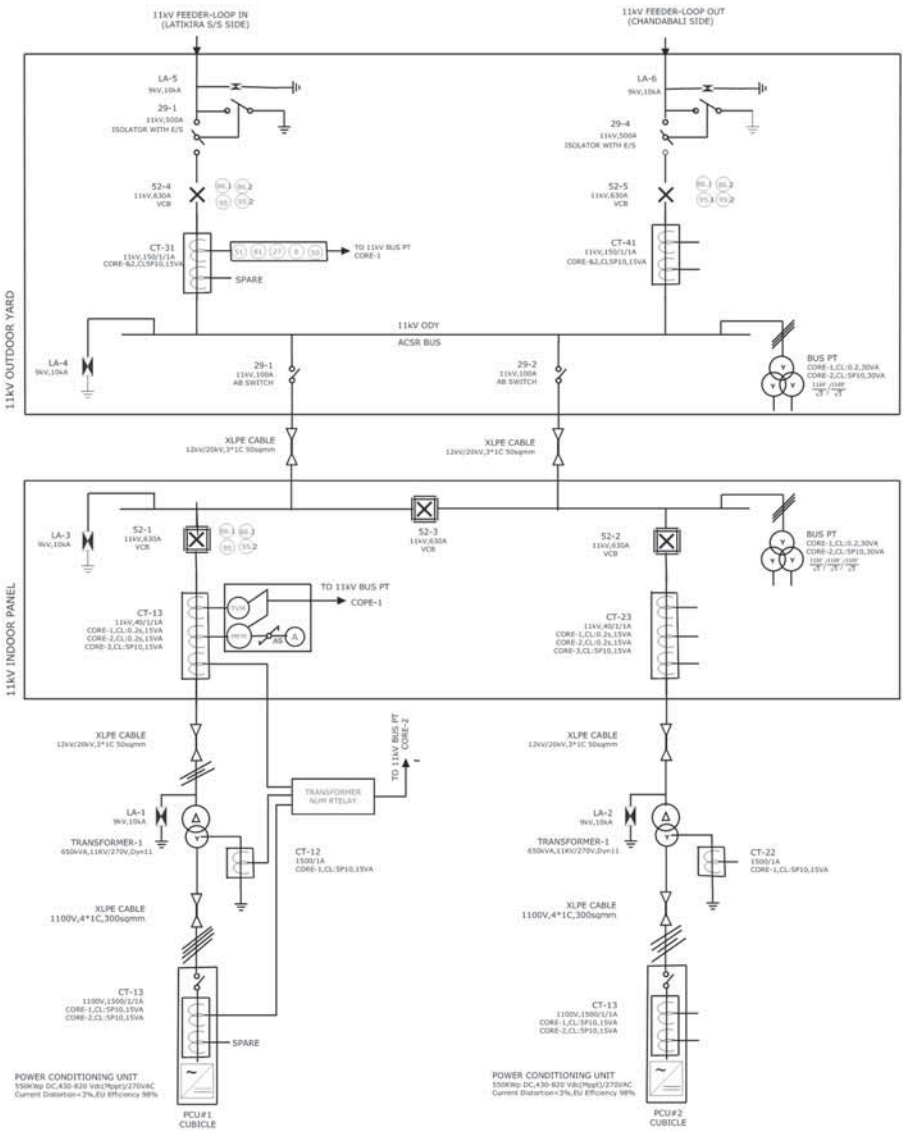

Figure 1: Single line diagram of first 1 MW PV power plant at Sadeipali, Bolangir, Odisha evacuating power at 11 KV

Transformer

Phase faults in a transformer stator winding can cause thermal damage to insulation, windings and the core. Primary protection for transformer phase-to-phase faults is best provided by a differential relay (87T) used for unit protection. Differential relaying will detect phase-to-phase faults, three-phase faults, and double-phase-to-ground faults.

Ground-Fault Protection

One of the main causes of ground faults is insulation failure. Depending on the location of the fault, separate ground-fault protection is usually provided by instantaneous over current relay (50N).

Backup protection for ground faults can be provided by an Inverse Definite Time Over-current relay (device 51N) in conjunction with an Instantaneous Over current relay (device 50N) applied at the generator neutral to detect zero sequence unbalance current which flows during ground faults.

Abnormal Voltage Protection

Overvoltage may occur during a load rejection. The overvoltage relay (59) is used to protect the PV generator from this condition. Three limits can be set which are in the range of 110-135% with time range 0.05 to 2 sec. Similarly, under voltage may occur due to sudden reactive power demand which can be taken care of by under voltage relay (27). Under voltage range is 50-90%.

Abnormal Frequency Protection

Frequency variation in the grid requires a response from the PV system for safety of the equipments at point of common coupling (PCC). The PV system should operate in synchronism with the grid with ±1% and for exceeding range must trip with in 0.2 sec. Again on restoration of frequency with in this range needs resynchronisation.

Over Frequency Protection

The multifunction relays provide a two-set point over frequency relay (810) that can be set to alarm or trip on an over frequency condition.

Under Frequency Protection

Overloading of a generator, perhaps due to loss of system generation and insufficient load shedding, can lead to prolonged operation of the generator at reduced frequencies. While load-shedding is the primary protection against generator overloading, under frequency relays (81U) should be used to provide additional protection. In addition to relays fuses are provided and fuse failure is also protected by fuse failure protection (97).

Breaker Failure Protection

Backup protection must be provided for the case where a breaker fails to operate when required to trip. This protection consists of a current detector, in conjunction with a timer initiated by any of the protective relays in the generator zone. The breaker failure relay (95) in association with trip coil supervision will initiate tripping of the backup breakers.

Anti-Islanding Control and Protection

In Grid-tied mode of operation, when the output power of the inverter matches with the total load on the grid, the failure of grid does not create any change in voltage or frequency. The inverter continues to support the load. This condition is not safe. It is mandatory for power exporting inverters to detect grid failure and stop exporting power to the grid within 2 seconds.

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  Sound-intermittent sound 50dB apart 3m
- **Overall length:**
  Retracted: 893±50mm(230HD)
  Retracted: 1370±50mm(290HD)
  Extracted: 1520±50mm(230HD)
  Extracted: 2450±50mm(290HD)
- **Measuring Voltage:** 3kV~36.5kV(230HD)
  6kV~81.5kV(290HD)
- **Leakage Current:** 100mA/<100mA at withstand voltage test .
- **Insulation Resistance :** 2000MΩ min by 1kV

24KV AC Non-Contact High Voltage Detector Model 276HD

FEATURES :

- **Frequency :** 50/60Hz
- **Dielectric Strength**
- **Leakage Current Test**
- **High Voltage detection in high tension circuits (3.3kV, 6.6kV & 24kV)**
- **Low Voltage detection in low tension circuits (80V ~ 600V)**
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Table 1: Protection system of 1 MW PV Power plant at Sadeipali, Balangir, Odisha, India

ANSI No.	Type of Protection	Relay Make	Model
50+51N	30/C+1 E/F Relay	CSPC	1RI1-PRD
64R	Restricted Earth Fault Relay	CSPC	IRI-1ER
87T	Transformer Differential	CSPC	IRD1-T2-WG
94-1,3	Auxiliary Relay	CSPC	
59	Over voltage	Woodward	MFR-13
27	Under voltage	Woodward	
810	Over frequency	Woodward	
81U	Under frequency	Woodward	
48	Voltage Asymmetry	Woodward	
	Zero voltage	Woodward	
33	Over load	Woodward	MFR-13
32F/38	Reduced Power	Woodward	
32R	Reverse Power	Woodward	
47	Unbalanced load	Woodward	
	Reactive power	Woodward	
40Q	Loss of excitation	Woodward	
50/52	Time-over current	Woodward	
51V	Voltage restraint time-0/C	Woodward	
50GS/51GS	Ground fault, calculated	Woodward	
26	Synchronisation check	Woodward	
86	Master trip relay	CSPC	
95	Trip circuit supervision Relay	CSPC	MRA-PRO-V2
89	DC Supply Monitoring Relay	CSPC	

System Fault Backup

Phase Faults

The voltage-restrained/controlled over current function (51V) can also be used for this backup function. The voltage-restrained/controlled over current relay will restrain operation under emergency overload conditions and still provide adequate sensitivity for fault detection.

Ground Faults

Backup for system ground faults can be accomplished with a time over current (51) relay connected in the neutral of the step-up transformer primary.

A master trip relay (86) connects to all the relays and connects to the tripping devices such that its command is used for tripping the Circuit Breaker.

The inverter switches automatically to off-grid in case of grid failure. But if it fails to do so, to prevent accident due to back feeding of power manual Air break (AB) switches are provided.

Earthing inside the yard is also important for safe operation of operators. The next section discusses the actual relays used in the case studied and importance of power quality requirements.

A protection philosophy should cover the various fault types.

Table 1 contains a functional list for the important relays used including two multifunction protection relays that are used in the installed PV system.

The important functions have been discussed in earlier section. The relays incorporate six or ten protective functions in one package.

Power Quality Requirements

Harmonics on AC side

i. Harmonic distortion is caused principally by non-linear load such as rectifiers and arc furnaces and can affect the operation of a supply system and can cause overloading of equipments such as capacitors, or even resonance with the system leading to overstressing (excessive voltage & current). Other effects are interference with telephone circuits, metering errors, overheating of rotating machines due to increased iron losses (eddy current effects), overheating of delta connected winding of transformer due to excessive third harmonics or excessive exciting current.

ii. The limits for harmonics shall be as stipulated in the CEA Regulations on grid connectivity which are as follows:
   a. Total Voltage harmonic Distortion = 5%
   b. Individual Voltage harmonics Distortion = 3%
   c. Total Current harmonic Distortion = 8%

Voltage Unbalance

The Voltage Unbalance at 33 kV and above shall not exceed 3.0%.

Voltage Fluctuations

i. The permissible limit of voltage fluctuation that may occur repetitively is 1.5%.

ii. For occasional fluctuations the maximum permissible limits is 3%.

DC Injection into the grid

Improper design of inverter may cause DC injection into the grid. It causes saturation of transformer; reduce its efficiency and life. It is proposed by BIS to limit DC injection within 1% of the rated current of the inverter as per IEC 61727. The power conditioning unit (PCU) takes care of the following limits of power quality requirement.

Conclusion

In this paper a detailed case study of protection system of a PV power plant has been presented. The function and the ANSI codes for different relays have been given. The primary and back up protection system have been discussed for a LILO arrangement. The multifunctional relays used with their advantages have been discussed. But it can be seen that with such interconnection at distribution level successful utilisation of capacity is possible only when reliability of feeder is high and synchronisation is maintained. Further, there is requirement of manual operation after sun set to bypass it. However, with such an arrangement, the consumers at tail end of the feeder will have quality of power better than with only supply from grid.

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Standardisation can help millions access electricity

LVDC is a disruptive technology that fundamentally changes and accelerates energy access. Over the last twenty years several mega-trends have created a groundswell of demand for LVDC...

The International Electrotechnical Commission (IEC) is stepping up efforts to bring electrical energy to the 1. 3 billion people who have no access to electricity, via a disruptive technology – Low Voltage Direct Current (LVDC). The IEC is hosting the inaugural LVDC Conference on Sustainable Electricity Access, in Nairobi, Kenya, on 22 and 23 May 2017, in partnership with the Kenya Bureau of Standards (KEBS).

Frans Vreeswijk, General Secretary & CEO of the IEC, said, "Combined with some form of energy storage, LVDC has the potential to bring millions of people out of the dark. The IEC is driving the development of LVDC, making this technology safe and broadly accessible. Holding this conference in Africa will provide a real understanding of electricity access needs to IEC experts and stakeholders.

Energy, and especially electricity, is the golden thread that impacts the majority of the 17 Sustainable Development Goals (SDGs), and furthermore, the development of every nation and economy. The work of the IEC directly impacts 12 of the 17 SDGs – it provides the technical foundation for the whole energy chain and all equipment that is driven by electricity.

The UN recognises that electricity access helps to reduce poverty and hunger, improves educational opportunities and enables higher quality healthcare. In developing economies, LVDC helps governments and policy makers to rapidly improve the living conditions, livelihoods and leisure time of millions of citizens as they gain access to affordable and clean electricity. Against this backdrop, the LVDC Conference on Sustainable Electricity Access will bring together a diverse group of stakeholders including policy makers, power utilities, equipment manufacturers, NGOs, technology gurus, industry experts, systems engineers, funding agencies and insurers.

Charles Ongwae, Managing Director, Kenya Bureau of Standards, said, "I urge all stakeholders to register and attend the conference, which will be a thought leadership platform to effectively engage with policymakers and regulators. This event will help us to gain the technological and economic information needed to evolve LVDC standards and drive the technology's commercialisation."

Vimal Mahendru, Chair of the IEC Systems Committee (SyC) on LVDC, and IEC Ambassador said, "For areas where grid connection is too expensive, LVDC is the only economic way to provide electricity access to everyone: it is clean, safe and affordable. The applications for LVDC are wide, varied and apply in every country in the world. This conference is your opportunity to input your local needs and requirements? to hear about economic benefits linked to LVDC? and to contribute to the development of key performance and risk assessment indicators to allow regulators and systems administrators to benchmark LVDC solutions."

The recent evolution of LVDC

LVDC is a disruptive technology that fundamentally changes and accelerates energy access. Over the last twenty years several mega-trends have created a groundswell of demand for LVDC. The need to mitigate the effects of climate change has seen a renewed focus on Energy Efficiency and sustainability, taking power generation increasingly towards renewable sources and away from fossil fuels. In addition, the cost of energy generation from solar photovoltaics (PV) has become more accessible, while LED lighting has made the conventional incandescent lamp a thing of the past.

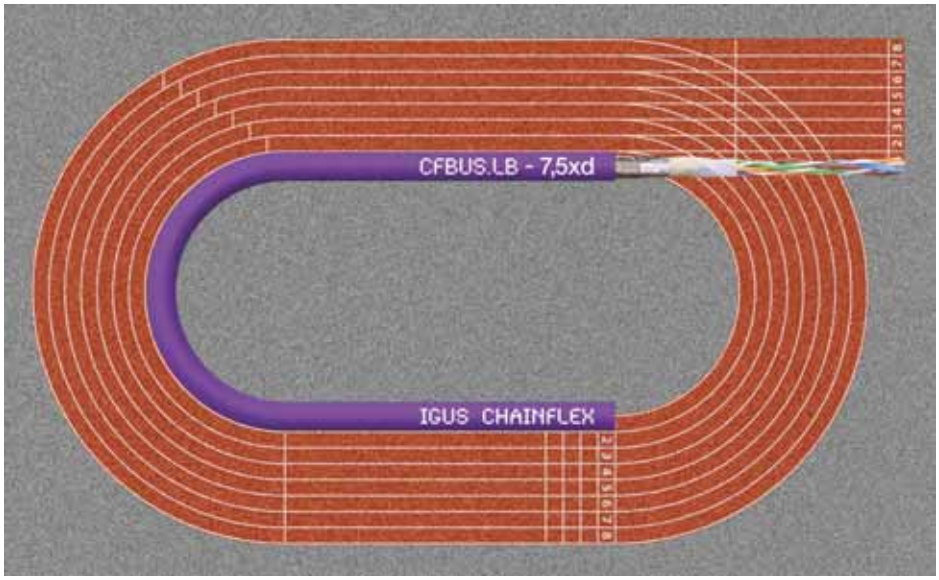
Without realising it, today we live in a 'direct current' world, with most of our electronic devices already being able to use current that is produced by renewable sources directly, without conversion. As a result, LVDC is seeing a growth in uses like data centres, e-mobility and related infrastructure, urban homes and buildings for lighting and other applications, public distribution, DC micro-grids, and storage etc.

igus Cables Set New Standards for Continuous Movement in Energy Chains

Extended range of chainflex Ethernet/Bus cables for extreme mechanical stress and bend radii of 7.5xd

At SPS IPC Drives 2016, the motion plastics specialist igus presents the CFBUS.LB Bus cable - one of several new high-end cable families for continuous movement in e-chains, with an outer jacket made of halogen-free TPE. With these cables, igus completes its range for demanding energy and data supply applications, for example with very limited installation space, very long travel distances or extremely low temperatures.

While igus has significantly extended its cable range in the lower and middle price segment over the past years, at this year's SPS IPC Drives igus is presenting new high-end cables with an outer jacket made of halogen-free TPE. High-end cables from the chainflex range are the right solution when the properties of other cable series are no longer sufficient. The motion plastics specialist igus has now included a new Bus cable series in its product range for the smallest bend radii for Bus cables, down to 7.5xd or even for temperatures down to -35°C.



Technical benefits thanks to the smallest bend radii. The new cable family CFBUS.LB is suitable for the highest mechanical stress and bend radii of 7.5xd. (Source: igus GmbH)

Specially developed and tested for movement in e-chains

The core structure of the CFBUS.LB cable is optimised for movement, combined with an inner jacket and the highly flexible, abrasion-optimised igus TPE outer jacket, offering a unique solution when it comes to Bus cables for Ethernet. "The customer will already find several cable series with an outer jacket made of this material in our range, which has proven itself for many years in numerous moving applications," explains Rainer Rössel, head of the chainflex cables division at igus. "To offer them a better choice, we are now offering a Bus cable family for the highest mechanical stress with the new CFBUS.LB." This can be used for all common Bus systems such as Ethernet CAT5, CAT5e, CAT6, Ethercat, Profinet or even the standard fieldbuses such as Profibus. The "LB" in the product name stands for "low bending", i.e. a very low bend radius, in which the cable can be moved in energy chains. In addition to the CFBUS.LB, igus now also offers a control cable and a servo cable with the same outer jacket material. Due to the extension of the range, it has now become even easier for customers to choose exactly the cable that works reliably in their application - without having to pay too much.

Tested under real conditions - guaranteed to last

Whether for very cost-effective ones for applications with very moderate movements or for the highest dynamics and the most complicated movements, igus guarantees a service life of 36 months on all cables. This is onlyt possible through continuous tests under real conditions in the igus test laboratory. The results make it possible to reliably predict the service life and the specific temperatures and bend radii in which the cable can be safely used.

For more details, visit: **www.igus.in**

www.electricalindia.in

Good Response to CWST Expo 2017

Tribhuvan Kabra, Chairman, RR Global, P K Pattanaik, Assistant General Manager, OPTCL, B V Raghavaiah, Ex-Director, CPRI, Dr S V Kulkarni, Associate Dean, IIT Mumbai inaugurated the exhibition

The 2nd edition of CWST-Expo2017 evolved as a solution for various coil winding, motor, magnetic material, transformer manufacturers to interact and boost their presence in the category. Over and above the fact that a range of cutting-edge concepts and products were displayed here, major attraction was the knowledge oriented concurrent conference on Power Transformer Industry. The synergy between the show and conference ensure interaction ensure interaction with a broader set of audience from a wide cross-section of industries.

The exhibition was inaugurated by Tribhuvan Kabra, Chairman, RR Global, P K Pattanaik, Assistant General Manager, OPTCL, B V Raghavaiah, Ex-Director, CPRI, Dr S V Kulkarni, Associate Dean, IIT Mumbai. The exhibition saw the major participation from companies like RR Global, Elantas Beck India Ltd, Bharat Insulation Company, G K Winding Wires Ltd, Specific Mechatronics and many more. The exhibition was spread over 5,000 sq metre area and attracted 2800 quality visitors from round the globe.

Transtech India 2017- Life Cycle Management of Power Transformers in association with Brandscope Exhibitions conducted an international conference cum workshop on power transformers.

The conference covered the total life cycle of the power transformers with the involvement of utilities, manufacturers, service providers and other stake holders. Each session started with a presentation by a senior expert highlighting the relevance and state-of-the-art status of the topic of the particular session.

The floor was then opened for panel discussion followed by question and answer round. The topics of the conference covered the whole lifecycle of power transformer starting from "inception and planning for giving birth of power transformer" to "Testing & Post Mortem Analysis". The paper presentations were made on the topics from companies like CG, International Copper Association India, Cargill Inc., Dupont and many more.

Delegates at Transtech India 2017 conference

Visitors at Electrical India's stall

Tentative State-wise break-up of Renewable Power target to be achieved by the year 2022 So that cumulative achievement is 1,75,000 MW

State/UTs	Solar Power (MW)	Wind (MW)	SHP (MW)	Biomass Power (MW)
Delhi	2762			
Haryana	4142		25	209
Himachal Pradesh	776		1500	
Jammu & Kashmir	1155		150	
Punjab	4772		50	244
Rajasthan	5762	8600		
Uttar Pradesh	10697		25	3499
Uttrakhand	900		700	197
Chandigarh	153			
Northern Region	31120	8600	2450	4149
Goa	358			
Gujarat	8020	8800	25	288
Chhattisgarh	1783		25	
Madhya Pradesh	5675	6200	25	118
Maharashtra	11926	7600	50	2469
D. & N. Haveli	449			
Daman & Diu	199			
Western Region	28410	22600	125	2875
Andhra Pradesh	9834	8100		543
Telangana		2000		
Karnataka	5697	6200	1500	1420
Kerala	1870		100	
Tamil Nadu	8884	11900	75	649
Puducherry	246			
Southern Region	26531	28200	1675	2612
Bihar	2493		25	244
Jharkhand	1995		10	
Orissa	2377			
West Bengal	5336		50	
Sikkim	36		50	
Eastern Region	12237		135	244
Assam	663		25	
Manipur	105			
Meghalaya	161		50	
Nagaland	61		15	
Tripura	105			
Arunachal Pradesh	39		500	
Mizoram	72		25	
North Eastern Region	1205		615	
Andaman & Nicobar Islands	27			
Lakshadweep	4			
Other (New States)		600		120
All India	99533	60000	5000	10000

www.electricalindia.in

Forward Reverse Starter with Enclosure

Seva Switchgear have been in the low voltage switchgear field for over 4 decades now. Started in 1970 as a proprietory firm in Matunga, Bombay, Seva were founded as a private limited company in 1990.

About 80% of the company's revenues comes from exports to Europe and the US.

SEVA have 3 lines of business –

- Motor control and motor protection equipment – contactors and motor starters – sold in the Indian market
- Crane control stations – for overhead cranes, port cranes and material handling machines – sold in the Indian market
- Custom switchgear for exports – selector, rotary, cam switches, plastic injection moulded parts, machined parts

SEVA developed and put together a range of control gear products for Indian industries – Urban and Rural. Our motor starters and contactors are better suited to Indian conditions than most competition. SevaSPL specializes in making rugged, custom starters that are built to specifications.

We manufacture a wide range of air break contactors up to 450A rating , thermal overload relays and motor starters for LV AC squirrel cage induction and slip ring motors.

In starters, we offer greater variety than the majority of manufacturers in the field.

SEVA offers eight varieties of Direct On Line and nine varieties of Star-delta starters with many special features.

SEVA starters are maintenance-friendly and long lasting.

Our customers are very satisfied with our products performance under tough field conditions and our service.

Website: www.sevaspl.com

Forthcoming Events At A Glance

National

Intec 2017
Venue: CODISSIA Trade Fair Complex, Coimbatore, India
Date: 1-5 June, 2017
Website: www.intec.codissia.com

Automation 2017
Venue: Bombay Convention & Exhibition Centre, Mumbai
Date: 09-12 August, 2017
Website: www.automationindiaexpo.com

Renewable Energy India Expo 2017
Venue: India Expo Centre, Greater Noida
Date: 20-22 September, 2017
Website: www.renewableenergyindiaexpo.com

Intersolar India 2017
Venue: Bombay Exhibition Centre, Mumbai
Date: 5-7 December, 2017
Website: www.intersolar.in

International

Wire & Cable Guangzhou
Venue: China Import and Export Fair Complex, Guangzhou, China
Date: 9-11 June, 2017
Website: www.wire-cable-china.com

18th POWER Sri Lanka 2017
Venue: Sri Lanka Exhibition & Convention Centre (SLECC)
Date: 14-16 July 2017
Website: http://cems-powerseries.com/powersri/

Vietnam ETE 2017
Venue: SECC, Ho Chi Minh City
Date: 19-22 July, 2017
Website: www.vietnam-ete.com

12th International Wire & Cable Trade Fair for Southeast Asia
Venue: BITEC Bangkok, Thailand
Date: 19-21 September 2017
Website: http://www.wire-southeastasia.com/

KUSAM-MECO unveils High Voltage Detector

KUSAM-MECO has introduced the advanced High Voltage Detector Model 230 HD, which detects high and extra high voltage in AC lines. An extendable insulation rod permits checking of high tension circuits at safe distance for voltage.

Also it is telescopic, compact, light, weight, easy to use and handy. The intermittent lighting in red of a high intensity light emitting diode and intermittent audible sound of an electronic buzzer greater than 50 dB are easy recognisable at full daylight and noisy locations, from 3 m apart. The detecting head, being tightly enclosed, is free from any trouble due to dust and water. The retracted overall length is 893 mm and extracted

length is 1520 mm. The 485gm weighing model can be operated in - 10°C to 50°C temp. The electrical specifications are as follows.

Measuring Voltage range : 3KV to 36.5KV, Operating Start Voltage (to ground) - 1.35 KV, Freq - 50/60Hz , With Stand Voltage - 100kV / 300mm, Insulation Resistance - 2000MΩ, Leakage Current - less than 100µ A. It is most suitable for use in switch yards of Electricity Beards and also H.T. Corporate Customers. Model 230HD is suitable for use upto 36.5KV. & Model 290HD is suitable for use upto 81.5KV.

For further information: www.kusam-meco.co.in

NEW Testo 770 - the first clamp meter with revolutionary clamp mechanism

The three instruments in the testo 770 clamp meter family are ideally suited for current measurement in switching cabinets. One of the two pincer arms can be fully retracted into the instrument. This unique grab mechanism means that cables in tight switching cabinets can be easily grabbed. The automatic measurement parameter detection also ensures reliable work: in the current and voltage area, all three instruments detect direct and alternating current and select other parameters such as resistance, continuity, diode and capacitance automatically. The testo 770-1 model is the standard version for daily measuring tasks, including starting current measurement.

In addition, the testo 770-2 contains both a µA area as well as a temperature measurement by means of an optional thermocouple adapter type K. The testo 770-3 also calculates all output ratings, has a Bluetooth interface and the possibility of connecting to the testo Smart Probes App to show the measuring profile as a graph or to document it directly in a report.

- 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
- Bluetooth and testo Smart Probes App

For further information: www.testo.com

Hanson UK unveil a new high-performance concrete ideal for use by the power sector

Powercrete, developed by Hanson's parent company HeidelbergCement in Europe, is a heat conducting concrete. It helps to dissipate the heat generated by high-voltage and ultra high-voltage electrical cables with the same ease of placement as normal concrete.

The product's high thermal conductivity means it can be used as a bedding and infill material for underground high-voltage and ultra high-voltage cabling, helping to minimise transmission loss.

Powercrete is the only product of its type available in the UK and its first application has been at Iver, Buckinghamshire, where 217 cubic metres was used to encase the 175 kilovolt cables which send power to Heathrow airport.

Jasen Gauld, Concrete technical sales manager, said, "Power cables are increasingly being run underground, generating energy savings and reducing the visual and environmental impact created by pylons. However, heat generation can be an issue with underground cable runs: as the cable temperature rises, so does the resistance, increasing transmission loss."

"Using Powercrete allows you to increase power capacity, reduce conductor cross sectioning or switch to aluminium conductors. It also serves to reduce magnetic field strength for alternating current and mitigate hotspots," he further added.

Powercrete is a sustainable and long lasting solution and mixes can incorporate Regen GGBS (ground granulated blastfurnace slag), a by-product of the iron-making industry, used as a cement substitute to further improve the concrete's sustainability credentials.

The consistency of Powercrete can be adjusted to suit the application and Hanson's cement and concrete specialists will work with clients and specifiers to maximise the performance of the mix – an approach currently being taken at Hornsea Project One, the world's first gigawatt offshore windfarm.

For further information: www. hanson.co.uk

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Leviton unveils Decora Smart In-Wall Dimmers and Switches with Apple HomeKit Support

Leviton at the 2017 Consumer Electronics Show revealed the development of new Decora Smart Apple HomeKit–enabled lighting control accessories for use with your iPhone or iPad, including in-wall dimmers and switches. Apple HomeKit technology provides an easy, secure way to control HomeKit–enabled accessories using Siri voice control on one's iPhone or iPad or Apple's Home app. The simple app-based setup and control allows professionals and end-users alike to easily install a Leviton HomeKit–enabled accessory and begin controlling lighting and loads from Apple's Home app or the free Decora Smart Home iOS app – no hubs or bridges required. Three new lighting and load control accessories from Leviton will include:

- 1000W Universal Dimmer (up to 450W LED)
- 600W Universal Dimmer (up to 300W LED)
- 15A Universal Rocker Switch (up to 600W LED)

The new lighting control accessories are engineered with advanced technology to function with extremely sensitive, low-wattage light sources, such as a single LED bulb in a hallway or a strand of holiday lights. The in-wall dimmer and rocker switches leverage the Decora form-factor pioneered by Leviton with true rocker paddles, making usage easy for guests and family members alike, even in the dark. The dimmers feature embedded LEDs to display the illumination level, but the LEDs vanish to afford a clean appearance. Leveraging the Decora wiring device platform, there is support for multi-way applications, such as hallways or staircases, in which one fixture is controlled by two devices. Common colour change kits and screwless wallplates round out the smart offering.

For further information: www.leviton.com

Dynapower, Samsung SDI launch Integrated Storage Solution

Dynapower Company and Samsung SDI introduce an integrated behind-the-meter energy storage system built on their respective proven technologies. The initial release of the system will be a 250 kW/550 kWh offering, with a 100 kW two-hour system to follow.

The integrated energy storage offering provides energy storage system vendors, project developers, and utilities with a fully engineered solution that reduces costs for commercial and industrial end users in the deployment of energy storage. This line of systems will incorporate Dynapower's recently released Generation 2 MPS product line of behind-the-meter energy storage inverters and Samsung SDI's recently released E2 battery solution.

The two companies share a wealth of field proven integration experience of their technologies across a wide range of ESS projects, sizes and applications including the Electrical Training Institue Net Zero Plus building microgrid and Duke Energy Notrees 36MW/14MWh ESS repower.

Dynapower and Samsung SDI are launching their integrated behind-the-meter ESS offering with an immediate first deployment at the University of Minnesota, and are already working with several behind-the-meter ESS developers to deploy their unique integrated solution across the nation throughout 2017.

For further information: www.dynapowerenergy.com

Eaton launches its state-of-the-art rack Power Distribution Units

Power management company Eaton has introduced its new advanced range of rack Power Distribution Units (PDUs), ePDU G3, in India. Featuring the company's third-generation (G3) technology, the ePDU G3 platform combines best-in-class efficiency and reliability with innovative technologies such as the new Eaton patented grip feature for International Electrotechnical Commission (IEC) connectors that make operations safer. Offering a variety of capabilities to fulfill IT requirements, the range of ePDU G3 models support a wide-array of applications ranging from small/medium businesses to enterprise data centres.

In India, Eaton's ePDU G3 range will initially be available in three different models.

The Basic model provides reliable and cost effective power distribution, enabling load balancing with colour-coded outlet sections that match the corresponding circuit breakers. The Metered model helps conserve energy by additionally monitoring and measuring critical factors such as voltage, current and power consumption at the branch breaker and outlets, and delivers true IEC ±1 percent billing-grade metering accuracy. The third variant is the Managed model, which combines both outlet switching and metering functionality, offers advanced power management and precision control, enabling administrators to operate remotely with lights-out control, including remote re-booting, scheduled shut downs and restarts.

For further information: www.eaton.in

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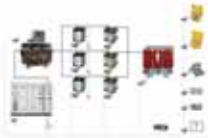

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Powerbox's COTS/MOTS power supplies

Powerbox, one of Europe's largest power supply companies and a leading force for four decades in optimising power solutions for demanding applications, has made known the release of its new Defense Line of ruggedised power solutions for highly demanding environments. The launch includes seven series of new power supplies, comprising three DC/DC (DAA-DAB-DAC), four AC/DC (DBA-DBB-DBC-DBD) and embracing a power range from 50W up to 1,200W. In metal chassis format with a baseplate for conduction cooling, the DAx and DBx series can be used with a baseplate operating temperature range of -40 up to +100 degrees C. For extremely demanding applications they can be configured with a conformal coating and mechanically ruggedised as well as electrically ruggedising to withstand harsh transients and demanding EMC performance requirements as required with most common defense, marine, avionics, rugged industrial and railway standards. Designed for high availability, short time-to-market and to meet commercial and military off-the-shelf (COTS/MOTS) business models, the modular build style of the DAx and DBx series allows up to six outputs which can be connected in serial, parallel or used as a standalone output – very versatile products.

For further information: www.prbx.com

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- Manufacturing of Transposition coils and remaking the same.
- Commissioning of all electrical equipments.
- Dynamic balancing of Rotors, Fans & Impellers.
- Generators Redesigning & uprating of capacity of existing machines without disturbing the rotor winding.
- Redesigning of cooling systems like air cooled to water cooled and vice versa.
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