Vol 54 No 5 May 2014 ₹ 100

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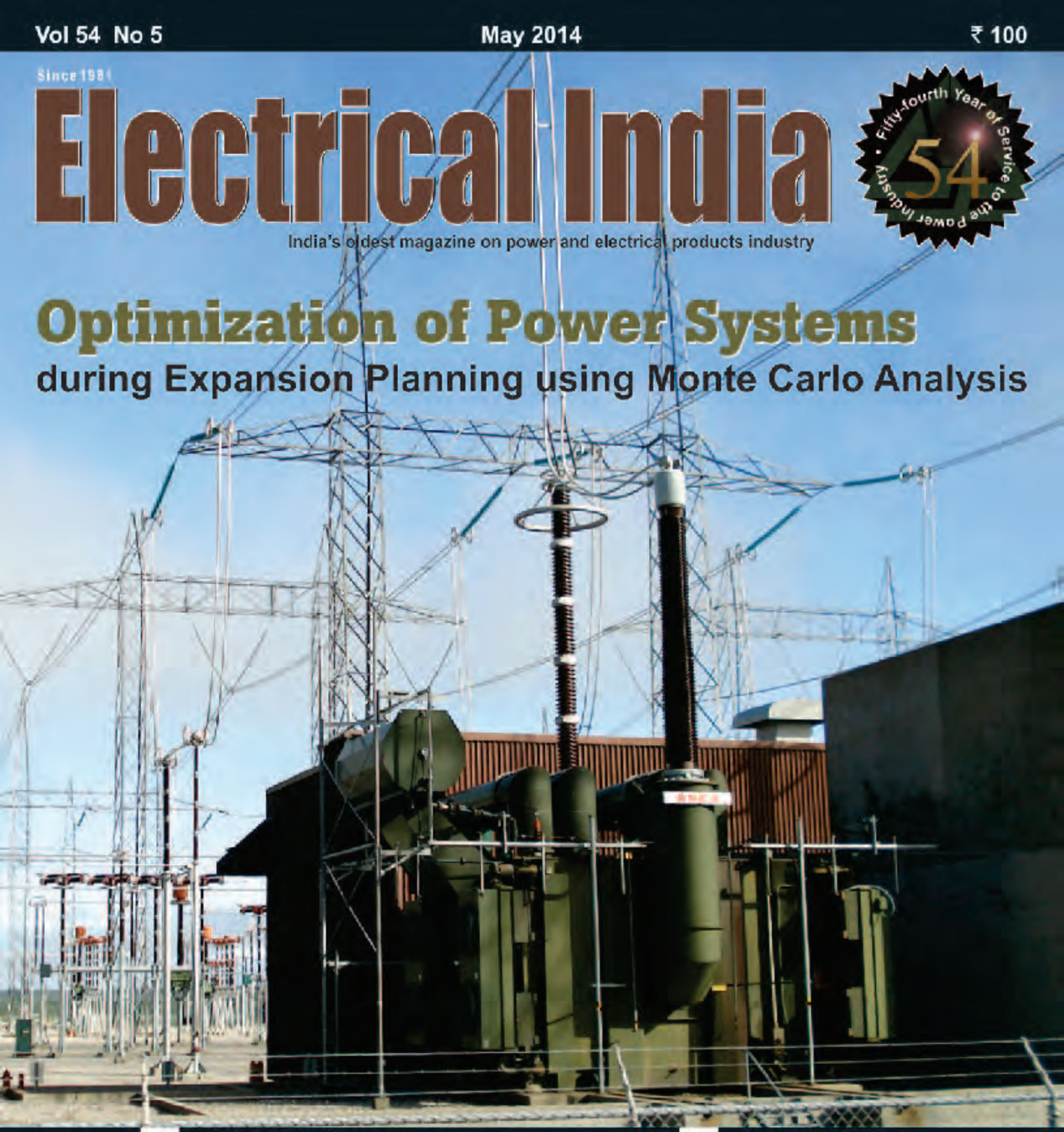
Fifty-fourth Year of Service to the Power Industry 54

Optimization of Power Systems during Expansion Planning using Monte Carlo Analysis



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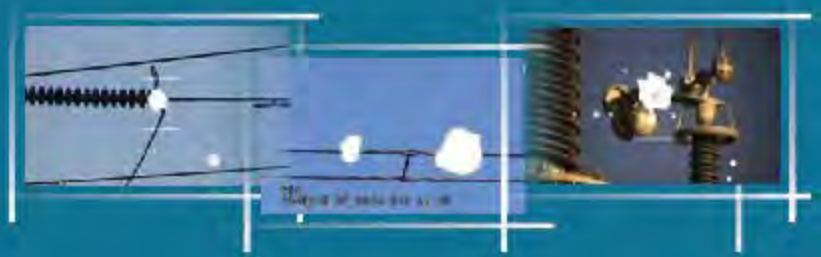

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Nuclear scientists estimate, country could produce 500 GWe for at least four centuries

According to a report issued by the IAEA, India has limited uranium reserves. Although India has only around 1-2% of the global uranium reserves, thorium reserves are bigger. According to plan, 30% of the Indian electricity in 2050 will be generated from thorium based reactors. Indian nuclear scientists estimate, country could produce 500 GWe for at least four centuries using just the country's economically extractable thorium reserves is discussed in-depth in an article 'India's Three-Stage Nuclear Power Programme'.

Microgrid is promising alternative to the traditional power distribution systems as it offers the consumers the reliability of power, energy savings and economic benefits. According to a write-up 'Power Quality Issues in Microgrids', with increasing number of renewable energy resources it is necessary to develop new control strategies for proper operation and management of the grid embedded with DG and other microgrid units in order to maintain or to improve the overall reliability and quality.

All energy sources have an impact on the environment. Thermal energy refers to the energy created after the potential and kinetic energy of an object in motion is put together. When this energy is applied to a specific substance, the velocity of the particles that make up the substance rises making it warmer. The article 'Thermal Energy: Reliable Source of Energy' details various sources of thermal power energy.

All the more, we present a new layout for you and would like feedback from our patrons, readers, advertisers and subscribers.

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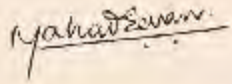

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Growth in Transmission Technology & Efficient Energy Source

A stable and reliable electric system is a key priority in every developing country and it is the responsibility of its government to develop electricity resources, which is vital for economic growth. Indian power system is one of the largest operating synchronous grids in the world, with about 243 GW of installed power generation capacity currently. Furthermore, the growth of power sector is contingent to the development of transmission network. Transmission lines carry electric energy from one place to another in an electric power system; operate at high voltages; transmit large quantities of power and over large distances. PGCIL, the central transmission utility, engaged in power transmission business, is augmenting a vast network of transmission system that feeds the power generated at one station to grid system for distribution to number of states. A distribution system at substation includes the lines and transformers etc to deliver electric power to the customer at the required voltages, that creates opportunities, market and options for generating energy, new sources of energy, and site selection for thermal generating stations.

"243 GW of installed power generation capacity currently"

For managing demand and stability of electricity grid, we need an energy policy and approach that establishes balance not only for reliable and alternative sources of energy but also towards environmental regulations and affordability of electricity. Several state-level corporations account for about 41% of overall generation and intra-state distribution of electricity. Our country has been facing power shortages in spite of the manifold growth over the years. Other than PSUs and state level corporations, private sector enterprises also play a major role in generation, transmission and distribution. About 29% of total installed capacity is generated by private sector. India's transmission grid is in urgent need of expansion and improvement. Level of innovation and technology in the industry must be upgraded, thereby upgrading quality, speed and safety standards.

According to industry sources, India Smart Grid spending is to touch about Rs 9,500 crore by 2015 from current level of Rs 5,500 crore. The utilities worldwide will spend US$ 378 billion in Smart Grid technologies by 2030 and India, the third largest smart grid investment market, is set to install 130 million smart meters by 2021. According to the International Energy Agency, India, China and the Middle East will account for 60% of worldwide growth in energy demand by 2035. Hence, fast moving technological change including modern information system practices and the need to improvise and integrate system designs, such as demand side management, is a must in the transmission and distribution sector of the country to enhance the installed capacity with emphasis on the renewable energy sector, which is must as add-on increasing the proportion in electricity generation mix.

Gopal Krishna Anand

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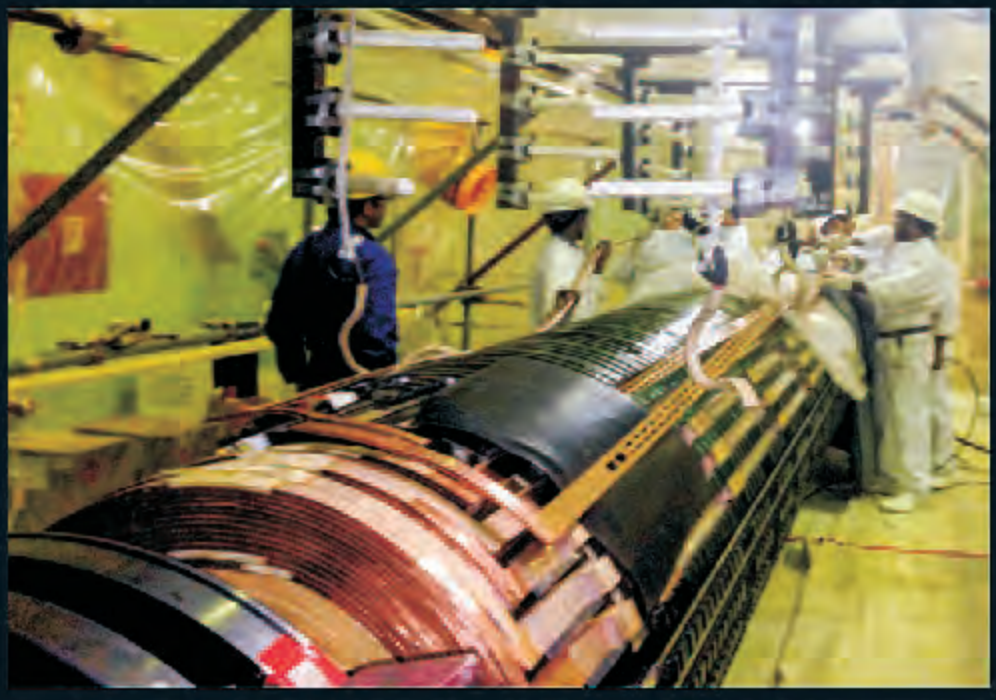

- **IN THE ABOVE PICTURE WE RKEWW WERE CARRYING OUT COMPLETE REWINDING OF 168MW 15 KV 3000 RPM TOSHIBA MAKE STEAM TURBINE GENERATOR ROTOR AT KUWAIT AND THE WORK IS UNDER PROGRESS.**

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- Redesigning of cooling systems like air cooled to water cooled and vice versa.
- Redesigning with change in voltage like 415V to 660 volts or 3.3KV to 6.6KV or 11KV to 15KV & vice versa.

Profile

- RKEW is one of the premier and experienced service outfit in the field of electrical motors, generators and transformer repair in India.
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Alstom gets contract by BHEL for 2x660 MW Banharpalli coal power plant

Alstom has been awarded a contract by BHEL worth close to Euro 30 million to supply components and services for the 2x660 MW Banharpalli Super Thermal Power Project (STPP) located in Jharsaguda, Orissa. Alstom will co-operate with BHEL in designing the boilers and supply identified pressure parts of the 660 MW supercritical boilers, along with windboxes. It will also assist BHEL with technical advisors during the erection and commissioning of the units. Key components will be manufactured in Alstom's manufacturing facilities in Concordia (USA), and in Durgapur (India). The units I & II are expected to be commissioned by 2018. Patrick Ledermann, VP, Alstom Thermal Power & Renewable Power in India, remarked, Alstom's supercritical boilers satisfy the most stringent environmental requirements and stand out for their robustness and high reliability. It also helps in achieving about 3-4% higher plant efficiency compared to conventional subcritical design.

Emerson Network Power appoints neoteric infomatique ltd as Distributor

Emerson Network Power, a business of Emerson, and a global leader in maximizing availability, capacity and efficiency of critical infrastructure, appointed neoteric infomatique ltd as a national distributor for its range of small and medium uninterruptible power supply (UPS) products in India. With this partnership, the company plans to address the growing demand from enterprises for innovative and technologically superior back-up power solutions devised for modern day IT requirements. Sanjay Zadoo, country manager, channel business, Emerson Network Power in India said, "We are pleased to announce neoteric infomatique ltd as a distributor for India. neoteric has a successful history and robust distribution presence with a network of 10,000 partners spread across 500+ cities. We are confident that neoteric will help us extend our nationwide footprint and support us in inducting more valued partners for a varied range of products. Through Neoteric, IT resellers in India will now have access to Emerson's reliable and highly effective UPS solutions which can thrive in India's power infrastructure." Rakesh Kaul, national head-sales, neoteric infomatique ltd., said, "Signing up with Emerson Network Power has enhanced our offerings in the UPS segment. Emerson's back-up power solutions enable enterprises to have reliable back-up power and thereby, protect their IT infrastructure. We will focus on on-boarding and enabling partners to provide Emerson's state-of-the art UPS solutions that facilitate real-time infrastructure optimization."

Gamesa India: 1000 MW of Wind Power Projects In India

Gamesa India, global technological leader in the wind industry, announced commissioning of 1000 MW in India in four years. Ramesh Kymal, Chairman & Managing Director, Gamesa India said, "This 1000 MW have been remarkable for Gamesa India and we would like to take this opportunity to thank our customers, stakeholders and employees for their continuous support which has helped us emerge as a leading player in the Indian wind industry". Speaking about Gamesa India's future plan, Kymal said, "Celebrating the success of commissioning 1000 MW, we will focus on the next phase of accelerated growth through innovative technology, expansion, larger market share and sustainable partnerships". Gamesa India has recently commissioned its second state-of-the-art manufacturing unit at Mamandur, near Chennai and plans to develop a vendor park near the location. Gamesa believes health and safety is the backbone of their sustainable growth and they have registered an impressive safety track record of over 1700 days of accident free operations in its manufacturing facilities. Gamesa as a socially responsible organization has been constantly engaging with the communities around their wind farms spread across 7 states in the county, through their various community engagement initiatives in the areas of education and environment.

GAIL's New Jubilee tower

GAIL (India) Limited's iconic new office building GAIL Jubilee Tower, one of the tallest buildings in the National Capital Region, was inaugurated by Saurabh Chandra, IAS, Secretary, Ministry of Petroleum and Natural Gas. The 22-storey Tower has a height of 118 metres and designed as per LEED Platinum Green Building norms. The building has its own captive power generation plant using gas engine generators and the waste heat recovered is used to run the airconditioning system. A 30 KW solar power plant has been installed for area lighting. Its electricity load will be 40% less than other similar high-rises. The building houses the National Gas Management Centre which is linked to all the major pipeline centres of GAIL.

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India and Sudan Agree to Promote Cooperation in Renewable Energy

Union Minister of New and Renewable Energy, held a bilateral meeting for promoting cooperation in renewable energy with a delegation from Sudan. The Sudanese delegaton was led by Al Simah Al Siddiq Al Nour, Minister of Industry. He along with other members including Magdi Hassan Yasin, State Minister of Finance and National Economy from Republic of Sudan met MNRE Minister Dr. Farooq Abdullah to discuss ways of enhancing cooperation in promoting renewable energy between the two countries. He acknowledged that India and Sudan have good potential for enhancing cooperation in promoting renewable energy and offered to provide Indian assistance for developing renewable energy resources in Sudan. The talks focused on the areas of possible cooperation especially in the development of wind energy, solar energy, biomass and small hydro resources. It was also agreed that Ministry of New & Renewable Energy would provide support for resource assessment and training in the areas of wind and solar energy through its technical institutions viz. Centre for Wind Energy Technology, Chennai and the National Institute of Solar Energy, Gurgaon. Indian Renewable Energy Development Agency (IREDA), the Indian green energy financial institution would provide knowledge and technical appraisal assistance in developing renewable energy projects on commercial basis. A team comprising officials from Ministry of New & Renewable Energy, IREDA, CWET and NISE would soon visit Sudan to discuss a framework for further cooperation between the two countries.

Smart Automation: First 'SE' Experience Centre in Punjab

An amazing smart facility can now be experienced at Smart Automation Experience centre which has been launched by Anil Chaudhry, Country President & Managing Director Schneider Electric (SE), India who was Chief Guest at the Smart Automation, Experience Centre, Mohali. Inaugurating the Experience Centre at Mohali, Anil Chaudhry said, "We are really proud to be able to announce launch of first fully featured home automation experience centre in North India. This is the first time that Lighting, Audio-video, AC, Security automation has been demonstrated as a complete solution. Smart Automation has come up with unique facility which helps people what they can do in their home to make life simple." Chaudhry emphasized on the need of bringing in new technology to the developing and prospering lives in India. Adding onto the facts Chaudhry said, "Schneider Electric, in the last one year has done a significant amount of business in automation space. And with lot of attractions in the North Indian markets we expect to improve business prospects year on year. Talking about the special features of the Smart Home, CP Singh, Founder Smart group said, we are planning to launch multiple experience Centre's across India for Indians to experience home automation & ideate about their new home.

Mailhem Ikos Environment to Tap Waste for Energy in India

Mailhem Engineers, a leading Indian waste management and renewable energy company, and Lhotellier Ikos, a French-based 200 m Euro group specialising in infrastructure and renewable energy & in water management and treatment, announced joint venture to provide waste to energy solutions for India - Mailhem Ikos Environment Private Limited. With the growing concerns of energy and waste management in India, Mailhem Ikos will be able to provide centralized solutions for waste management. The solutions will enable close to 85% of the waste to be reused in form of energy or recycled. JV will be able to establish large scale, upto 500 tonnes, waste management bio gas plants in India. The new joint venture will specialize in energy production from organic as well as household waste, turnkey bio gas plant and recycling solutions including design, construction, & operations, and landfill restoration & degassing. Colonel Suresh Rege, Founder, Mailhem Engineers said, working for over 250 bio gas projects Ikos will help us to cater to this growing market.

Lapp Group presents multi-cable entry system with gel insert

Lapp Group from Stuttgart presented a new model of its proven multi-cable bushing system, the SKINTOP® CUBE MULTI at the Hannover Messe trade fair. With the new multi-cable entry system, a particularly high packing density and optimum strain relief on the whole cable bundle are achieved. In addition, very secure assembly is also made possible. These benefits are due to the use of a high-strength gel that has previously been used in sporting equipment or medical engineering. The cable is simply routed through the gel membrane. The static friction between the gel and the cable ensures a secure grip and also provides a reliable seal. The elastic gel technology used for the sealing element enables large, variable clamping ranges. This means it is not necessary to remove individual inserts to install the cables, thus eliminating several work steps from the installation process - a clear gain in efficiency. Finally, the material also makes it possible to route more cables through the system than conventional methods.

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Top awards for OMICRON products at 2014 key exhibitions

The quality and innovation of three of OMICRON's latest products was recognized with prestigious awards at two major 2014 exhibitions; ELECRAMA in Bangalore and Middle East Electricity in Dubai.

"Best Product" Award at ELECRAMA 2014 took place in January at the Bangalore International Exhibition Centre (BIEC) in India. The 11th edition of IEEMA's premier flagship event was the world's largest exposition of electrical transmission and distribution equipment hosting 806 exhibitors from India and 166 from 25 other countries. OMICRON was delighted to be named as the winner of the 'Best Product' category with its combined entry of the new circuit breaker test system CIBANO 500 and the portable partial discharge (PD) monitoring system OMS 605. "Best Innovation of the Year" at Middle East Electricity. The Middle East Electricity Exhibition, Dubai took place in February. With over 19,000 prospective buyers from 115 countries around the world,it is the most important fair of its kind in the Middle East. After reviewing a record number of nominations, the expert panel of judges announced the winners of the Middle East Electricity Awards 2014. OMICRON was very proud to win the award for the 'Best Innovation or

Technology of the Year' with its new voltage transformer testing system VOTANO 100. Its innovative approach allows for comprehensive testing of the parameters of voltage transformers regardless of rating. This, combined with high level of accuracy and mobility,makes VOTANO an extremely valuable testing asset.

Ferrite cores: Modular stackable U-cores for flexible large designs

TDK Corporation has developed a new kind of ferrite core: EPCOS stackable U-cores feature a unique modular ferrite design that offers flexibility and economy for high-voltage transformer and HF filter applications. The new U-cores are tooled by and available exclusively from Dexter Magnetic Technologies as Dexter StackPack™ U-Cores. US-based Dexter Magnetic Technologies is a provider of optimized magnetic solutions and distributor of TDK and EPCOS products. The new modular EPCOS stackable U-cores provide standard options that can fit any application. This is a major advantage in applications that require large ferrite cores but are limited by manufacturing constraints and high tooling costs. As a result, designers have been cutting and gluing large U and I cores together to make them bigger – an approach that is not only imprecise but also expensive. The standardized design of the StackPack U-Cores, which were developed together with Dexter Magnetic Technologies, enables multiple configurations as well as lower costs than custom tooling or machining.With short lead times, Dexter Magnetic Technologies can provide customers with standard modular cores that allow rapid prototyping. Moreover, the modular StackPack U-Cores enable further mounting flexibility. "Customers can expand the ferrite with just three parts – a corner piece, legs, and spacers," explains Chris Spadafora, Marketing Manager for EPCOS Ferrite Products. "Holes allow an engineer to insert a threaded rod and screw assembly together. It's an attractive, inexpensive solution." Chuck Wild, Business Manager at Dexter Magnetic Technologies, agrees, "The new StackPack U-Cores deliver the flexibility to grow designs based on a standard platform. Engineers can increase ferrite height or width, whichever way they need to go."

Cooper launches new Genset - 200 KVA Diesel Generator

Cooper Corporation Pvt Ltd, an Engine Major unveils 200 KVA eco-friendly diesel generators at the MEE Expo in Dubai. The Low fuel consumption generator is lighter in weight, smaller in size and engine meets with US & European Emission norms. Years of in-house research and the technical collaboration with Ricardo, UK, have culminated in the launch of the Cooper ECOPACK gensets, are available in power ranging from 10KVA - 200 KVA.. Cooper has come out with breakthrough technology in collaboration with Ricardo, an international design engineering company. The entire range goes up to 200 KVA powered by 2, 3, 4 and 6 Cylinder Cooper engines. Commenting on the launch of Cooper Corp's 200 KVA ECOPACK generators, Farrokh N. Cooper, Chairman and Managing Director says, "The ECOPACK series will set a global platform for Cooper Corporation as this genset claims a unique position among other diesel power generators in India. It owes this distinction to several outstanding features and benefits like 25% lower fuel consumption, 25% smaller in size, 40% lighter in weight, 42% saving in maintenance cost and several times quieter. Cooper Corp's Eco Pack could be used for homes, farm houses, bungalows, hotels and retail outlets,offices, telecom towers and many more." Cooper Corp's ECOPACK series is India's first Euro IV, US EPA Tier IV Interim and CPCB 2 compliant set of generators. The Engine has an advanced control module which monitors all critical parameters of the engine.

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Suzlon Group wins OMS contract extension with Exelon for 231 WTG's

Exelon extended their service agreements with Suzlon Wind Energy Corporation's service group to continue servicing 231 Suzlon S88 and S64 wind turbine generators adding upto 408.5 MWs. "Exelon is one of Suzlon Groups largest and long standing customers and sets very high standards for wind turbine operations, maintenance, and safety, and we strive to be their easiest OEM to do business with." said Duncan Koerbel, Suzlon Wind Energy Corporation's CEO, Suzlon Energy Limited's Chief Technology Officer and Head of Global Operations. "We look 1378 wind turbine generators, totalling 2,716 MW. Suzlon maintains its strong presence in the North American market largely due to its working philosophy of being easy to do business and transparent with its customers and maintaining one the highest safety ratings in the wind industry.forward to continuing our partnership with Exelon. Suzlon has a strong safety track record in the industry, and we are proud of the many men and women on the group who make this possible," added Koerbel. Suzlon Wind Energy Corporation, which focuses on the North American market, is a subsidiary of Suzlon Energy Limited, of Pune. The sales and service headquarters for North America is located in Chicago, IL, where the service group monitors and oversees the maintenance of retained its 5th place among global wind turbine makers in 2013, according to MAKE Consulting. In its annual Global Wind Turbine OEM Market Share report, MAKE said Suzlon had a global market share of 6.3%, as measured by newly installed generating capacity. Suzlon continues to be a formidable Global Wind Energy player.

World Record for Solar Thermoacoustic Power Generation

Qnergy, a world leader in the development and manufacture of Stirling-based engines and systems, announced a major breakthrough in solar thermoacoustic power generation. The company recently set a new world record, using acoustic waves created by solar heat to produce 1 kW of electrical power during a field test completed this month at its test facility in Ogden, Utah. "This is a milestone achievement for Qnergy," said Erez Harel, Qnergy CEO, "and it marks a significant step forward in the global quest for reliable, cost effective and highly efficient engine technologies that will power our future." Added Harel, "This successful demonstration solidifies Qnergy's position as a world leader of innovative power solutions designed to meet the world's commercial, industrial and residential energy needs."For the record-breaking test demonstration, Qnergy fitted its third-generation traveling-wave thermoacoustic Stirling engine, the TASE-3, to a solar concentrator at the company's test facility in Ogden, Utah. Lead Physicist Eran Gonen, TASE-3 Project Director, explains, "The TASE-3 employs the physical interaction between heat and sound to produce acoustic power. As pressurized helium inside the engine is heated above the critical temperature gradient, intense sound waves travelling through the gas are amplified by means of novel heat exchangers set within an acoustical network. The resulting acoustic power is then quietly and reliably converted into grid quality electricity using linear alternators to eliminate any hot moving parts."

Luminous announces Zelio, Home UPS - shows power back-up time in hours and minutes

Luminous Power Technologies, the leading power back-up solution provider in India, introduces Zelio - a pure sine wave, state-of-the-art Home UPS, designed to work with the most sensitive home appliances that the consumers in India are using in their households today. Zelio has a unique feature that shows Power Back-up display in Hours & Minutes, which will allow the consumers to plan their day without any hassle and manage their appliances accordingly when there is a power outage. Apart from this, Zelio is the most stylish and good looking Home UPS in the industry. Zelio packs multiple advanced features and has one of the most simple and intuitive user-interfaces in the industry yet. This product can be used to provide power back up for all domestic appliances and is equipped with various in-built protection features. This next generation architecture by Luminous comprises of a Digital Signal Processing core that yields high performance. It has a learning software that adapts to the different types of batteries and their current discharge status to predict the remaining back up time. It is backed up by the promise of Luminous' quality and reliability. Announcing Zelio, Manish Pant, Managing Director, Luminous Power Technologies, said, "Year 2014 will be a year full of new opportunities and challenges and we are aiming high to establish the Brand as the leading integrated power backup and electrical solutions provider in India and across the globe. This new product offering – Zelio, from Luminous, is the outcome of our robust research and development focused on customer-centric innovation. The Price of the UPS is Rs 5500. It is an example of the cutting edge technology that we are bringing in the market and it will be a unique product for the consumers and will help them to manage the power outages more efficiently and comfortably."

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£1 billion could be saved from electrcity costs if UK doubles interconnector capacity by 2020

New analysis prepared for National Grid's Interconnector business points to benefits for the economy, the consumer and the environment if the UK could double its interconnector capacity by 2020. At the moment the UK has 4 interconnectors with 4GW capacity – the equivalent of about 5 large power stations. If interconnector capacity could double to 8-9 GW there are potential savings of £1bn a year. This would also take GB closer to the European benchmark of having interconnectors making up 10% of generation capacity. It is estimated that each 1GW of interconnection could reduce Britain's wholesale power prices by 1-2%. These benefits would be a result of British wholesale prices remaining higher than those in neighbouring countries, which experts think will be the case until the early 2020s. Peter Boreham, National Grid's Director of European Business Development said "This analysis makes a compelling case for the UK to press ahead with more interconnection with benefits for the economy, consumers and the environment. There's broad support from the UK Government, European institutions and energy regulators, and a willingness from developers like us to make the necessary investment". Ed Davey, Secretary of State, Department for Energy and Climate Change said "Today's report from National Grid is welcome. Increasing the number of interconnectors to Europe is one of my priorities, as it will help reduce consumer bills and add to Britain's energy security. These power links to Europe will make an energy single market a reality, which is something successive British Governments have pushed for but with only limited success to date." The report points out that if the savings on wholesale prices were passed on, this could result in lower energy bills for domestic consumers and industry thus helping with their competitiveness.

Changes Within PV Market Leads to Lowered Prices in 2Q14

Recent changes in the PV market have led to China's waning demands at the end of March 2014, while further observations are required for orders in April this year. These have led to lowered price quotes for relevant products. In other words, although there were few changes in April and May orders, price quotes have fallen. Thus, manufacturers are still conservative about price trends in Q2, analyzed EnergyTrend, a research division of TrendForce. Polysilicon contract prices continued to decline in April 2014. In fact, contract prices dropped to US$ 21-22/kg after hitting US$23/kg in March. "Due to growing mono-si wafer demands, manufacturers have started to focus on high-quality polysilicon in April, which led to decreased demands for normal-grade polysilicon that was previously in high demands," said Arthur Hsu, research manager of EnergyTrend. "Meanwhile, auxiliary material demand has declined leading to improved supply and demands situation since manufacturers now focus on high-efficiency products and mono-si products. Based on current prices, the price difference between auxiliary material and normal products is about 15%." In addition, polysilicon contract price declined for two consecutive months, which also affected spot price trend. "Certain price quotes have dipped around 0.5%-1%. Looking into the price trend in Q2, polysilicon spot price will be further lowered and contract price will continue to decline slightly. Furthermore, policy changes and increased market uncertainties might cause wafer, cell, and module prices to decline as well," added Hsu. Recent Price Quotes are- Polysilicon price slightly declined 0.3% to US$20.392/kg. Due to Chinese manufacturers lowered price quotes, multi-si wafer price dropped 0.49% to US$1.021/piece, but mono-si wafer prices remained flat.

EverPower acquires 240 MW Big Sky Wind Farm

EverPower Wind Holdings, Inc., a portfolio company of Terra Firma, a leading European-based private equity firm, has announced that it has signed a definitive agreement to acquire the 240 MW Big Sky Wind Farm located in Bureau & Lee Counties, Illinois, about 95 miles west of Chicago, from Suzlon Energy. This acquisition of Big Sky by EverPower makes it the nation's 18th largest wind generator, with a combined capacity of 752 MW in the US in winder power generation. "We are very pleased to welcome EverPower to the Suzlon family of customers," said Duncan Koerbel, CEO of Suzlon Wind Energy Corporation and CTO of the Suzlon Group. "The SWECO OMS team looks forward to partnering with EverPower to maintain the high standards of availability and reliability at Big Sky that we have seen since operations started at Big Sky four years ago." "We are pleased to add this project to our portfolio," said James Spencer, President and Chief Executive Officer of EverPower. "It fits into both our overall growth strategy and our strategy of building ourportfolio in liquid markets like PJM." "This sale of Big Sky Wind Farm to a sound long term investor like EverPower is an important part of our dis-investment strategy to hive off non-core assets, and the net proceeds of the sale will be used to fuel our business growth," said Kirti Vagadia, Group Head – Finance at Suzlon. The Big Sky Project utilizes 114 Suzlon 2.1MW S88 turbines to generate enough electricity per annum for nearly 50,000 homes while also offsetting over 225,000 tons of CO_2 emissions.

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Honeywell to help China meet Growing Energy Demand

Honeywell announced that PetroChina Company Limited will expand its use of Honeywell advanced information management and process modeling software tools to 17 additional refining and petrochemical sites across China, to helpmeet the country's growing demand for chemicals and transportation fuels. PetroChina currently uses Honeywell's information solutions at 13 locations. Honeywell's Refining and Petrochemical Modeling System (RPMS) and its Intuition® Executive advanced information management software will give PetroChina plant operators the ability to monitor operations across its entire organization to help provide the real-time information they need to better improve the profitability and efficiency of their plants. "Refiners and chemical plant operators must make complex business decisions quickly to take advantage of rapidly changing market conditions – from prices for feed stocks such as crude oil and natural gas, to rising demand for finished products," said Aldous Wong, vice president and general manager, Honeywell Process Solutions, China. "Implementing these Honeywell solutions across more of their locations will help PetroChina maximize profitability through better visibility and efficiency of their overall operations, and help them meet the growing demand for energy." China is the world's largest consumer of energy and the second largest consumer of crude oil, slightly behind the United States, according to the U.S. Energy Information Administration. Many analysts expect China to become the world's largest importer of crude oil within the year, putting pressure on its refining and petrochemical facilities to improve their efficiency. PetroChina expects to complete the project within two years.

Eaton opens Asia Pacific Vehicle Technical Center in Shanghai

Eaton announced opening of its Vehicle Group Asia Pacific Technical Center in Shanghai. The new technical center will drive the development and product localization strategy of energy-efficient vehicle power management solutions for the Chinese and regional markets. Eaton Chairman and CEO Alexander M. Cutler were in Shanghai to preside over the opening of the new technical center. The occasion also marks the issuing of Eaton's China Sustainability Report for 2013. "The opening of the new technical center enables Eaton to better serve the high-growth Asia Pacific markets by bringing the innovative and energy-saving solutions closer to our customers," Cutler said. With a $3.3million investment, the new technical center occupies 1,200square meters with seven major labs. This facility will further strengthen the local testing and development resources of Eaton's Vehicle Group, and significantly upgrade its ability to work with the customers in the development of new engine platforms and efficient solutions in support of the largest passenger and commercial vehicle market in the world. "We are well positioned to participate in China's massive urbanization and will continue to expand our engineering and manufacturing presence in this important market," Cutler said. "Protecting and improving the environment through innovation are among Eaton's highest priorities. We are confident that we can help our customers here address the great energy challenges as China promotes a new model of sustainable urbanization."

CG installs ZIV Substation Automation System at Latin America's largest PV Power Plant

CG's Automation Business Unit (BU), through the Spanish contractor Isastur, has installed, in the Llanos de LLampo substation, in Chile, a complete 61850 SAS based on ZIV protection IEDs and a SAS gateway, providing also the associated engineering, system integration, commissioning, and training services. The size of the order is 500.000 Euros. SunEdison's 100 Megawatt Llano de Llampos substation is located in the Atacama Desert in Chile. It distributes the energy generated by the largest Solar Photovoltaic Plant in Latin America (100 MW). The Substation's PV modules transform sunlight radiation into DC electric power after converting it to AC by means of an inverter. This power is then distributed through Sistema Interconectado Central High Voltage power lines. After acquiring ZIV, CG is a key provider and a player in the global smart grid market where it offers ZIV meters, protections, communication and automation solutions. CG offers innovative Substation Automation Systems (SAS) and Distribution Automation Solutions (DAS) commercialized under the ZIV® brand. ZIV has been working in Latin America supplying its IEDs and Systems to the main Utilities in the Region. Avantha Group Company CG's CEO & MD, Laurent Demortier said, "As a global pioneering leader in the management and application of electrical energy, this installation reaffirms our strengths in several areas - our expertise in automation technology, our expertise in transmission and distribution of power from renewable energy sources such as photovoltaic power plants, and our expertise and presence in Latin America. It is another milestone in our global expansion and a vital component of our plans to gain expertise in technologies that cover the entire power spectrum – from generation, to automated transmission and distribution, to final consumption."

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Thermal Energy

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Energy creates the power to drive tools and machines, to process materials into manufactured products and to create structures. Power is generated from nonrenewable energy sources such as coal, oil, and gas, or can be generated from natural resources such as geothermal, solar and gravitational energies.

Dr. Deepali & Dr. KK Gangwar

Thermal energy has been used by man from earliest times, to keep warm in cold weather and to cook food. Nowadays we also use it in many industries particularly the chemical industry including oil refining, and also in power stations to produce electricity. It is good alternative source of energy and also called energy for the future. Thermal energy is a term which refers to the energy created after the potential and kinetic energy of an object in motion is put together. When this energy is applied to a specific substance, the velocity of the particles that make up the substance rises making it warmer. Because "thermal" means heat, and heat is used in thermal energy. Still, thermal energy is not the same as heat.

Heat is energy transferred between substances or systems due to a temperature difference between them. So it is correct to say that a system contains thermal energy, but not

that it "contains" heat, since heat means energy that is transferred from one thing to another. The amount of heat transferred by a substance depends on the speed and number of atoms or molecules in motion. The faster the atoms or molecules move, the higher the temperature, and the more atoms or molecules that are in motion, the greater the quantity of heat they transfer.

Fossil fuels are non-renewable energy sources that formed more than 300 million years ago during the Carboniferous Period - long before dinosaurs roamed the Earth. Fossil fuels are made up of plant and animal matter. When plants and animals died, their bodies decomposed and were buried under layers of earth. Millions of years later we have the three forms of fossil fuels. Large amount of fossil fuels are burnt everyday in power stations to heat up water, to produce steam which further runs the turbines to generate electricity. Fossil fuels provide more than 40 % of all the energy consumed in the world, nearly two-thirds of the electricity, and virtually all of the transportation fuels. Moreover, it is likely that the nation's reliance on fossil fuels to power an expanding economy will actually increase over at least the next two decades even with aggressive development and deployment of new renewable and nuclear technologies.

Sources of thermal power energy

There are various sources of thermal power energy that comes from different types of fossil fuels like coal, petroleum and natural gas.

Petroleum products

Petroleum is a thick, dark, liquid. It is composed mostly of compounds called hydrocarbons that contain carbon and hydrogen. It's found way down in the ground, usually between layers of rock. The oil is then pumped out of the ground. Oil is carried in pipelines and large tanker ships. A refinery changes the oil into products like gasoline, jet fuel and diesel fuel. It's also burned in factories and power plants to make electricity. The oil is burned, which produces gases that turn a turbine to create electricity. Saudi Arabia is the leading in having oil resources i.e. 262.73 billions of barrels and accounting 22.3% of world resources. It is followed by Iran (132.46 bbs), Iraq (115.00 bbs), Kuwait (99.00 bbs), United Arab Emirates (97.80 bbs) and so on. United states consumes more than 20,000,000 barrels of oil every year but has less than 2 % of the world's remaining oil (BP statistical Review year-end 2004 & Energy Information administration). India has total prognosticated hydrocarbon reserves of 30 billion tonnes, spread across 26 sedimentary basins. Only 18 per cent of this estimated bounty has been explored so far. The remaining 82 per cent is up for grabs for those who will bid to explore (India today, Feb 25, 2005).

Natural Gas

Natural gas is lighter than air. Natural gas is made out of methane, which is a simple chemical compound made up of carbon and hydrogen atoms, but it also contains significant amounts of ethane, propane and butane. This gas is smell less and highly flammable. Natural gas is found near oil in the ground. It's pumped, just like oil, from wells that tap into the source and send it to large pipelines. Due to its colorless and smell less nature a stinky chemical is added before sending through pipelines. Natural gas is burned to produce heat, which boils water, creating steam, which passes through a turbine to generate electricity.

Natural gas is expected to be the fastest growing energy source until 2035, according to the latest BP Energy Outlook 2035. Between 2012 and 2035, natural gas demand is expected to grow by an average 1.9 percent per year, outpacing all other energy sources (Arab News, March 16, 2014).

According to BP report forecasts, global energy consumption will grow by 41 percent from 2012 to 2035. Over 95 percent of this demand growth is projected to come from emerging markets, including China and India, with the share of total of these countries accounting for about a quarter by 2035.

Fossil Fuel Energy - Coal

Coal comes in several different forms from hard black rocks. Some forms burn hotter and cleaner than others. Coal is one of the true measures of the energy strength of the world. Coal is also called as the workhorse of the nation's electric power industry. Coal extracted from coal mines and from there it is transported by trains to power plants where it's burned to make steam. The steam turns turbines, which produce electricity. China firmly holds the first place among coal producing countries. The United States remains the second largest coal producer, followed by India and Australia. Coal production increased significantly in Indonesia (15.8%), Colombia (12.7%), Ukraine (12.1%) and China (10.6%). Over three quarters of global coal consumption was accounted for by five countries: China, the United States, India, Russia and Japan. China alone accounted for over 48% of total global coal consumption. It is estimated that Coal will remain the primary source of energy growth, with consumption growing 48 percent over the next 20 years. Global coal use will grow 39 percent over the next decade, tops for all electricity-generating fuels. On the other hand, nuclear, hydro and other renewables combined will only match coal's share of the global energy mix in the next 10 years (www.businessinsider.com). Growth in power generation has been depicted in Fig. 1.

How Thermal Power is Generated

In a conventional thermal power station, a fuel is used to heat water, which gives off steam at high pressure. This in turn drives turbines to create electricity. At the heart of a power stations is a generator, a rotating machine that converts mechanical energy into electrical energy by creating relative motion between a magnetic field and a conductor. The energy source harnessed to turn the generator varies widely. It depends chiefly on which fuels are easily available and on the types of technology used. When coal is used for electricity generation, it is usually pulverised and then burned in a furnace with a boiler. The furnace heat

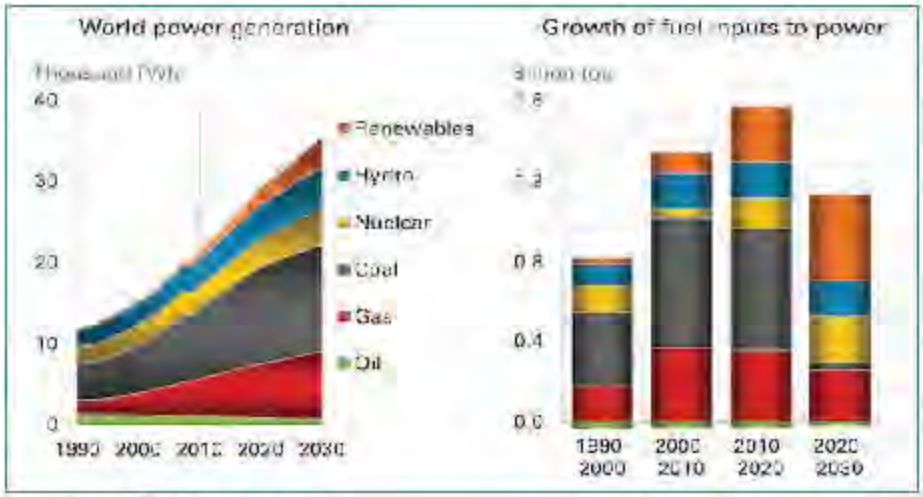

Fig. 1: Growth in Power Generation *Source: Energy Outlook 2030*

converts boiler water to steam, which is then used to spin turbines which turn generators and create electricity. The thermodynamic efficiency of this process has been improved over time. 'Standard' steam turbines have topped out with some of the most advanced reaching about 35% thermodynamic efficiency for the entire process, which means 65% of the coal energy is waste heat released into the surrounding environment. Old coal power plants, especially 'grand-fathered' plants, are significantly less efficient and produce higher levels of waste heat. About 40% of the world's electricity comes from coal.

Advantages of Thermal Energy

- The main advantage of the use of thermal energy as it provide continuous, reliable energy that is not dependent on the weather.
- Coal is in plentiful supply worldwide which generally makes its price and availability reliable.
- Natural gas produces more electricity and creates less pollution in comparison to coal it also produces less CO_2.

Disadvantages of Thermal energy

- All thermal power stations produce steam which once used to drive the turbine is still too hot to discharge directly. Resource consents stipulate how waste steam must be cooled before it can be discharged to the environment.
- Burning coal creates carbon dioxide emissions which contribute to greenhouse gases.
- Natural gas once burnt also creates carbon dioxide emissions.

Thermal Power Plant

A thermal power station is a plant where water is heated, until it turns into steam which drives the steam engine. When it runs through the system it is condensed and turned to water state again and is re-heated. It goes through the same system as are cycling process. Super Thermal Power Stations (STPS) are a series of power projects planned by the Government of India in 1990s by the end of the eleventh plan. The capacity of thermal power is 1000 MW and above. The Ultra Mega Power Projects, each with a capacity of 4000 megawatts or above, are being developed with the aim of bridging this gap. The Ministry of Power, in association with the Central Electricity Authority and Power Finance Corporation Ltd., has launched an initiative for the development of coal-based STPS's in India. Ramagundam Super Thermal Power Station, one of the biggest thermal power stations in India, is a coal based power station situated at Jyothinagar in Karimnagar District. Raichur Thermal Plant in Karnataka, Korba Thermal Plant in Madhya Pradesh, Farraka Thermal Plant in West Bengal are a few of the thermal power plants located in India. There are several by-product of power plant operation that need to be considered in both the design and operation. Waste heat due to the finite efficiency of the power cycle must be released to the atmosphere, often using a cooling tower, or river or lake water as a cooling medium. The fuel gas from combustion of the fossil fuels is discharged to the air; contains carbon dioxide and water vapour, as well as other substances such as nitrogen, nitrous oxides, sulfur oxides, and in the case of coal-fired plants- fly ash and mercury. Ash generated can be re-used for building materials.

Conclusion

All energy sources have an impact on the environment. Concerns about the greenhouse effect and global warming, air pollution, and energy security have led to increasing interest and more development in renewable energy sources such as solar, wind, geothermal, wave power and hydrogen. But we'll need to continue to use fossil fuels and nuclear energy until new, cleaner technologies can replace them.

Profile

Dr. Deepali

is PhD and post doctoral fellow at Uttarakhand. She has published 1 book, 21 research papers & 6 book chapters & 5 technical reports etc. She is a fellow of Indian Academy of Environmental Sciences, Haridwar.

Dr KK Gangwar

PhD is Senior Consultant. He is MoEF approved EIA Sector Co-ordinator. He published more than 60 research papers, authored three books. He is fellow of IAES, Haridwar & editorial secretary of Journal of Environment & Biosciences, published by IAES.

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POWER AUTOMATION INDUSTRIAL CONSUMER

Drying of Hydro Generator Windings

Before first commissioning and after a long shut down of the machine, the generator windings are dried out.

Mayadhar Swain

During manufacture, storage and transport, it is possible for the insulation of stator and rotor windings to absorb moisture. Also in a standstill condition for a long time, the windings may absorb moisture. Moisture diminishes the insulation resistance (IR) of the windings. Hence, it is required to remove the moisture by drying out the generator.

Requirement of Drying

Due to the compact, extensively enclosed design of modern generator, the windings may absorb very little moisture during standstill. Further, absorption of moisture depends on the atmospheric conditions at the site. In hot and dry climate, the windings may not absorb much moisture. Hence, the windings should first be tested before deciding the dry out.

Polarization Index Test

Polarization Index (PI) is the ratio of insulation resistance measured at 10 minutes to that of measured at 1 minute.

$$P.I. = \frac{IR_{10}\ Min}{IR_{1}\ Min}$$

The following table shows the winding condition on the basis of PI and necessity of drying.

P.I.	Insulation Condition	Necessity of drying
<1 1 – 1.5	Hazardous Bad	Drying is must
1.5 – 2	Doubtful	Drying is recommended
2 – 3 3 – 4 ≥4	Satisfactory Good Excellent	Drying is not required.

As per IEEE recommendations the minimum value for P.I. for class A insulation is 1.5 and that for class B and E is 2.

Methods of Drying

Drying of the hydro generator windings can be done indirectly or directly in the following methods.

Drying with Heaters

This is indirect heating and is done with the generator at standstill. Clean, dust free air with low absolute moisture content is warmed by heaters and guided diagonally through the generator by hose pipes through openings in the end-shields. The temperature of the inlet air should not exceed 80°C and the temperature of the discharged air from the generator should be at least 10°C above the ambient temperature so that water is not precipitated at the discharge side of the generator.

Drying with DC Current

The windings of all the three phases are generally connected in series and DC current is passed through it. Temperature rise should be gradual and temperature should not be more than 90°C. This method is used for small generator because the DC current used for drying should be at least 50% of stator rated current. Generally welding set is used for providing D.C. current.

Drying in Short Circuit Operation

This is the most common method for drying the generator. The three phases are short circuited at generator terminals. The machine is run at rated speed by opening the guide vanes of the turbine. Excitation is kept in manual mode. Excitation voltage is regulated so that 40% of rated current flows for the first two hours and then the full load current flows. The current is controlled so that winding temperature increases gradually and it must not exceed 90°C. Temperature of the windings can be measured by resistance thermometers.

IR value of the windings should be taken every hour with a 2500 V or 5000 V motorised megger. While measuring IR, the generator may be de-excited temporarily.

Completion of Drying

In the beginning of the drying process, IR decreases quickly until it attains a certain minimum value where it remains for a longer time. Then it starts slowly increasing since the humidity in the winding decreases and sometime later attains a constant value.

Drying can be stopped when three consecutive hourly readings of IR measurements remain same. After that the generator is cooled gradually to ambient temperature. To prevent winding temperature from dropping too quickly water flow to the air coolers may be regulated.

Minimum value of IR

IR is one of the main factors indicating the conditions of winding insulation. Minimum value of IR can be calculated from the following formula.

$$IR = \frac{V}{S/100 + 1000}$$

Where,

IR = Insulation resistance of the winding in MΩ at temperature of 75°C

V = Rated generator voltage in volts

S = Rated apparent power of the machine in kVA

Here, the operational voltage of the generator takes the insulation strength into account and the machine power takes the machine size into account (this parameter is significantly proportional to machine speed).

The minimum value of IR at cold condition is about five times the value calculated from the above formula. It may be noted that IR is largely dependent on the temperature. At higher temperature, IR is less. As a rule of thumb, for every temperature increase of 10°C, the IR decreases by half. Hence, while taking IR measurement, temperature of the windings must be measured.

The above formula is for stator winding.

The minimum value of IR for rotor winding is 1 MΩ at a temperature of 75°C. IR of rotor winding can be measured with a 250 V or 500 V megger.

Conclusion

Drying of generator is an important activity during first commissioning. The whole process of heating and cooling may take three days. Now some generators have been designed such that short circuiting is not required for drying. Simply by rotating the machine at rated speed and without applying excitation, the winding is heated and dried due to friction and windage loss.

Profile

Mayadhar Swain

BSc Engg. (Elect.) and ME in Water Resources Development from IIT Roorkee, is now working as Deputy General Manager in MECON Limited, Ranchi. Throughout his service period he has worked in Design, Erection, Commissioning, Operation and Maintenance of Thermal and Hydro Power Plants. At present he is working in consultancy jobs for Thermal and Hydro Power Plants. He has published 50 papers in different journals including Electrical India.

India's Three-Stage Nuclear Power Programme

India's three-stage nuclear power programme was formulated by Dr. Homi Bhabha in the 1950s to secure the country's long term energy independence, through the use of uranium and thorium reserves found in the monazite sands of coastal regions of South India. The ultimate focus of the programme is on enabling the thorium reserves of India to be utilised in meeting the country's energy requirements. Thorium is particularly attractive for India, as it has only around 1–2% of the global uranium reserves, but one of the largest shares of global thorium reserves at about 25% of the world's known thorium reserves.

Dr. P K Vasudeva

As of 2012, the first stage consisting of the pressurised heavy water reactors (PHWR) is near completion of its planned goals, the second stage consisting of fast breeder reactors (FBR) is poised to go into operation within one year, and the third stage consisting of advanced heavy water reactors (AHWR), as one among several technology options, is slated to begin construction so that its commissioning can be done by 2020. The recent Indo-US Nuclear Deal and the NSG waiver, which ended more than three decades of international isolation of the Indian civil nuclear programme, have created many hitherto unexplored alternatives for the success of the three-stage nuclear power programme.

Dr. Homi Bhabha conceived of the three-stage nuclear programme as a way to develop nuclear energy by working around India's limited uranium resources. Thorium itself is not a fissile material, and thus cannot undergo fission to produce energy. Instead, it must first be converted into the fissile isotope uranium-233 by teransmutation in a reactor fuelled by other fissile materials.

The first two stages, natural uranium-fuelled heavy water reactors and plutonium-fuelled fast breeder reactors, are intended to generate sufficient fissile material from India's limited uranium resources, so that all its vast thorium reserves can be fully utilised in the third stage of thermal breeder reactors.

In November 1954, Bhabha presented the three-stage plan for national development, at the conference on "Development of Atomic Energy for Peaceful Purposes" which was also attended by India's first Prime Minister Jawahar Lal Nehru. Four years later in 1958, the Indian government formally adopted the three-stage plan.

Indian energy resource base was estimated to be capable of yielding a total electric power output of the order shown in the table below Indian government recognised that thorium was a source that could provide power to the Indian people for the long term.

Energy resource type	Amount (tonnes)	Power potential (TWe-year)
Coal	54 billion	11
Hydrocarbons	12 billion	6
Uranium (in PHWR)	61,000	0.3–0.42
Uranium (in FBR)	61,000	16–54
Thorium	~300,000	155–168 or 358

Fuel reserves & research capability

According to a report issued by the IAEA, India has limited uranium reserves, consisting of approximately 54,636 tonnes of "reasonably assured resources", 25,245 tonnes of "estimated additional resources", 15,488 tonnes of "undiscovered conventional resources, and 17,000 tonnes of "speculative resources". According to NPCIL, these reserves are only sufficient to generate about 10 GWe for about 40 years. In July 2011, it was reported that a four-year-long mining survey done at Tummalapalle mine in Kadapa district near Hyderabad had yielded confirmed reserve figure of 49,000 tonnes with a potential that it could rise to 150,000 tonnes. This was a rise from an earlier estimate of 15,000 tonnes for that area.

Although India has only around 1–2% of the global uranium reserves, thorium reserves are bigger; around 12–33% of global reserves, according to IAEA and US Geological Survey. Several in-depth independent studies put Indian thorium reserves at 30% of the total world thorium reserves.

As per official estimates shared in the country's Parliament in August 2011, the country can obtain 846,477 tonnes of thorium from 963,000 tonnes of ThO_2, which in turn can be obtained from 10.7 million tonnes of monazite occurring in beaches and river sands in association with other heavy metals. Indian monazite contains about 9–10% ThO_2. The 846,477 tonne figure compares with the earlier estimates for India, made by IAEA and US Geological Survey of 319,000 tonnes and 290,000 to 650,000 tonnes respectively. The 800,000 tonne figure is given by other sources as well.

It was further clarified in the country's Parliament on 21 March 2012 that, "Out of nearly 100 deposits of the heavy minerals, at present only 17 deposits containing about 4 million tonnes of monazite have been identified as exploitable. Mineable reserves are ~70% of identified exploitable resources. Therefore, about 225,000 tonnes of thorium metal is available for nuclear power programme."

India is generally considered as the leader of thorium based research in the world. It is also by far the most committed nation as far as the use of thorium fuel is concerned, and no other country has done as much neutron physics work on thorium. Bhabha Atomic Energy Research Centre (BARC) had the highest number of publications in the thorium area, across all research institutions in the world during the period 1982-2004. During this same period, India ranks an overall second behind the United States in the research output on Thorium. Analysis shows that majority of the authors involved in thorium research publications appear to be from India. According to Siegfried Hecker, a former director (1986–1997) of the Los Alamos National Laboratory in the US, "India has the most technically ambitious and innovative nuclear energy programme in the world. The extent and functionality of its nuclear experimental facilities are matched only by those in Russia and are far ahead of what is left in the US."

Stage I – pressurised heavy water reactor

In the first stage of the programme, natural uranium fuelled pressurised heavy water reactors (PHWR) produce electricity while generating plutonium-239 as by-product. PHWRs was a natural choice for implementing the first stage because it

had the most efficient reactor design in terms of uranium utilisation, and the existing Indian infrastructure in the 1960s allowed for quick adoption of the PHWR technology. India correctly calculated that it would be easier to create heavy water production facilities (required for PHWRs) than uranium enrichment facilities (required for LWRs). Natural uranium contains only 0.7% of the fissile isotope uranium-235. Most of the remaining 99.3% is uranium-238 which is not fissile but can be converted in a reactor to the fissile isotope plutonium-239. Heavy water deuterium oxide (D_2O) is used as moderator and coolent.

Indian uranium reserves are capable of generating a total power capacity of 420 GWe-years, but in order to ensure that existing plants get a lifetime supply of uranium, it becomes necessary to limit the number of PHWRs fuelled exclusively by indigenous uranium reserves. US analysts calculate this limit as being slightly over 13 GW in capacity.

Several other sources estimate that the known reserves of natural uranium in the country permit only about 10 GW of capacity to be built through indigenously fuelled PHWRs. The three-stage programme explicitly incorporates this limit as the upper cut off of the first stage, beyond which PHWRs are not planned to be built.

Almost the entire existing base of Indian nuclear power (4780 MW) is composed of first stage PHWRs, with the exception of the two Boiling Water Reactor (BWR) units at Tarapur. The installed capacity of Kaiga station is now 880 MW, making it the third largest after Tarapur (1400 MW) and Rawatbhata (1180 MW). The remaining three power stations at Kakrapar, Kalpakkam and Narora all have 2 units of 220 MW, thus contributing 440 MW each to the grid. The 2 units of 700 MWe each (PHWRs) that are under construction at both Kakrapar and Rawatbhata and the one planned for Banswara would also come under the first stage of the programme, totalling a further addition of 4200 MW.

Stage II – fast breeder reactor

In the second stage, fast breeder reactors (FBRs) would use a mixed oxide (MOX) fuel made from plutonium-239, recovered by reprocessing spent fuel from the first stage, and natural uranium. In FBRs, plutonium-239 undergoes fission to produce energy, while the uranium-238 present in the mixed oxide fuel transmutes to additional plutonium-239. Thus, the Stage II FBRs are designed to "breed" more fuel than they consume. Once the inventory of plutonium-239 is built up thorium can be introduced as a blanket material in the reactor and transmuted to uranium-233 for use in the third stage.

The design of the country's first fast breeder, called Prototype Fast Breeder Reactor (PFBR), was done by Indira gandhi Centre for Atomic Research (IGCAR). Bharastiya Nabhikiya Vidyut Nigam Ltd (Bhavini), a public sector company under the Department of Atomic Energy (DAE), has been given the responsibility to build the fast breeder reactors in India. The construction of this PFBR at Kalpakkam was due to be completed in 2012. It is not yet complete. A start date in 2015 has been suggested.

In addition, the country proposes to undertake the construction of four FBRs as part of the 12th Five Year Plan spanning 2012–17, thus targeting 2500 MW from the five reactors. One of these five reactors is planned to be operated with metallic fuel instead of oxide fuel, since the design will have the flexibility to accept metallic fuel, although the reference design is for oxide fuel. Indian government has already allotted Rs 250 crore for pre-project activities for two more 500 MW units, although the location is yet to be finalised.

Doubling time

Doubling time refers to the time required to extract as output, double the amount of fissile fuel, which was fed as input into the breeder reactors. In Bhabha's 1958 papers on role of thorium, he pictured a doubling time of 5–6 years for breeding U-233 in the Th–U233 cycle. This estimate has now been revised to 70 years due to technical difficulties that were unforeseen at the time. Despite such setbacks, according to publications done by DAE scientists, the doubling time of fissile material in the fast breeder reactors can be brought down to about 10 years by choosing appropriate technologies with short doubling time.

Type	U238–Pu cycle	Th–U233 cycle
oxide	17.8	108
carbide-Lee	10	50
metal	8.6	75.1
carbide	10.2	70

Another report prepared for US Department of Energy suggests a doubling time of 22 years for oxide fuel, 13 years for carbide fuel and 10 years for metal fuel.

Stage III – thorium based reactors

A Stage III reactor or an Advanced nuclear power system involves a self-sustaining series of thorium-232-uranium-233 fuelled reactors. This would be a thermal breeder reactor, which in principle can be refuelled – after its initial fuel charge – using only naturally occurring thorium. According to the three-stage programme, Indian nuclear energy could grow to about 10 GW through PHWRs fuelled by domestic uranium, and the growth above that would have to come from FBRs till about 50GW. The third stage is to be deployed only after this capacity has been achieved.

According to replies given in Q&A in the Indian Parliament on two separate occasions, 19 August 2010 and 21 March 2012, large scale thorium deployment is only to be expected "3 – 4 decades after the commercial operation of fast breeder reactors with short doubling time". Full exploitation of India's domestic thorium reserves will likely not occur until after the year 2050.

Advanced Heavy Water Reactor (AHWR)

Of the options, the design for AHWR is

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AHWR design that will be taken up for construction is to be fuelled with 20% low enriched uranium (LEU) and 80% thorium. The low enriched uranium (LEU) for this AHWR design is readily available on the world market.

ready for deployment. AHWR is a 300 MWe vertical pressure tube type, boiling light water cooled and heavy water moderated reactor, using uranium233–thorium MOX and plutonium–thorium MOX.

It is expected to generate 65% of its power from thorium and can also be configured to accept other fuel types in full core including enriched uranium and uranium–plutonium MOX. There was a plan for constructing such an AHWR with a plutonium–thorium core combination in 2007.

This AHWR design was sent for an independent pre-licensing design safety review by the Atomic Energy Regulatory Board (AERB), the results of which were deemed satisfactory. AHWR would offer very little growth for the fuel build up that is essential for wide deployment of the third stage, and perhaps the impact on the accumulated fissile material could even be negative.

The AHWR design that will be taken up for construction is to be fuelled with 20% low enriched uranium (LEU) and 80% thorium. The low enriched uranium (LEU) for this AHWR design is readily available on the world market.

As of November 2011, construction will start after the site is identified in 6 months time. It will take another 18 months to get clearances on regulatory and environmental grounds. Construction is estimated to take six years. If everything goes according to plan, AHWR could be operational in India by the end of this decade.

Linkages with the Indo-US nuclear deal

In spite of the overall adequacy of its uranium reserves, Indian power plants could not get the necessary amount of uranium to function at full capacity in the late 2000s, primarily due to inadequate investments made in the uranium mining and milling capacity resulting from fiscal austerity in the early 1990s. One study done for U.S. Congress in that time period reaches the conclusion, "India's current fuel situation means that New Delhi cannot produce sufficient fuel for both its nuclear weapons programme and its projected civil nuclear programme." An independent study arrives at roughly the same conclusion, "India's current uranium production of less than 300 tons/year can meet at most, two-thirds of its needs for civil and military nuclear fuel." This uranium shortfall during the deal negotiations was understood by both players to be a temporary aberration that was poised to be resolved with requisite investments in India's uranium milling infrastructure.

Drivers for the deal from the Indian side

It was estimated that after attaining 21 GW from nuclear power by 2020, further growth might require imported uranium. This is problematic because deployment of third stage requires that 50 GW be already established through the first and second stages. If imported uranium was made available, Department of Atomic Energy (DAE) estimated that India could reach 70 GW by 2032 and 275 GW by 2052. In such a scenario, the third stage could be made operational following the fast breeder implementation, and nuclear power capacity could grow to 530 GW. The estimated stagnation of the nuclear power at about 21 GW by 2020 is likely due to the fact that even the short "doubling time" of the breeder reactors is quite slow, on the order of 10–15 years.

Maintaining nuclear power growth at a rate commensurate with the economic growth requires imported uranium. As per research data, the U238–Pu cycle has the shortest doubling time by a large margin, and that technology's compounded yearly fissile material growth rate has been calculated as follows, after making some basic assumptions about the operating features of the fast breeder reactors.

Type	Fissile Material Growth %
oxide	1.73%
carbide-Lee	2.31%
metal	4.08%
carbide	3.15%

Indian power generation capacity has grown at 5.9% per annum in the 25 year period prior to 2006. If Indian economy is to grow at 8–9% for the next 25 year period of 2006 to 2032, total power generation capacity has to increase at 6–7% per annum. As the fissile material growth rate does not meet this objective, it becomes necessary to look at alternative approaches for obtaining the fissile material.

Creating more options for India U.S. analyst Ashley J. Tellis argues that the Indo-US nuclear deal is attractive to India because it gives it access to far more options on its civil nuclear programme than would otherwise be the case, primarily by ending its isolation from the international nuclear community. These options include access to latest technologies, access to higher unit output reactors which are more economical, access to global finance for building reactors, ability to export its indigenous small reactor size PHWRs, better information flow for its research community, etc.

Finally, the deal also gives India two options that are relatively independent from the three-stage programme, at least in terms of their dependencies on success or failure. The first option is that, India can

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opt to stay with the first stage reactors as long as the global supply of uranium lasts.

The second option, and perhaps the more interesting one, is that India can choose to access the third stage of thorium reactors by skipping the more difficult second stage of the plan through some appropriately selected parallel approach such as the high-temperature gas-cooled reactor, the molten salt reactor, or the various accelerator driven systems.

According to one foreign analyst, the deal could "over time... result in India being weaned away from its... three-phase nuclear program involving FBRs and advanced PHWRs. This would occur should India become confident that it would have assured supplies of relatively cheap natural uranium, including from Australia. Of course, nobody in the Indian nuclear establishment would yet admit to that possibility."

According to one view within the Indian defence establishment, the deal "has for all practical purposes capped Indian ability to field test and proof high yield nuclear weapons till some time in future (about 20 years) when Indian three-stage nuclear fuel cycle based on Thorium fuel matures into mainstream power production, thus eliminating Indian dependence on imported nuclear fuel from NSG countries or if there is a breakout in global nuclear test moratorium."

Bhabha announced that there would be 8,000 MW of nuclear power in the country by 1980. As the years progressed, these predictions were to increase. By 1962, the prediction was that nuclear energy would generate 20–25,000 MW by 1987, and by 1969, the AEC predicted that by 2000 there would be 43,500 MW of nuclear generating capacity. All of this was before a single unit of nuclear electricity was produced in the country. Reality was quite different.

A study by the DAE, estimates that the nuclear energy share will be about 8.6% by the year 2032 and 16.6% by the year 2052. The possible nuclear power capacity beyond the year 2020 has been estimated by DAE.

Anil Kakodkar, then Chairman of the Atomic Energy Commission, went to the extent of making public, the milder position of keeping the country's indigenous fast breeder programme out of the ambit of international safeguards, saying "in the long run, the energy that will come out from the nuclear fuel resources available in India (from domestic uranium and thorium mines) should always form the larger share of the nuclear energy programme.." and "our strategy should be such that the integrity and autonomy of our being able to develop the three-stage nuclear power programme, be maintained, we cannot compromise that." The full demand of the Indian scientists, to have the ability to reprocess plutonium from spent fuel of the imported reactors (goes beyond the defensive position of Kakodkar), appears to have been met in the final deal.

Installed capacity in 1979–80 was about 600 MW, about 950 MW in 1987, and 2720 MW in 2000.

In 2007, after five decades of sustained and generous government financial support, nuclear power's capacity was just 3,310 MW, less than 3% of India's total power generation capacity.

The Integrated Energy Policy of India estimates the share of nuclear power in the total primary energy mix to be between 4% to 6.4% in various scenarios by the year 2031-32. A study by the DAE, estimates that the nuclear energy share will be about 8.6% by the year 2032 and 16.6% by the year 2052. The possible nuclear power capacity beyond the year 2020 has been estimated by DAE is shown in the table. The 63 GW expected by 2032 will be achieved by setting up 16 indigenous Pressurised Heavy Water Reactors (PHWR), of which ten is to be based on reprocessed uranium. Out of the 63 GW, about 40 GW will be generated through the imported Light Water Reactors (LWR), made possible after the NSG waiver.

Year	Pessimistic (GWe)	Optimistic (GWe)
2030	48	63
2040	104	131
2050	208	275

Indian Prime Minister Dr. Manmohan Singh stated in 2009 that the nation could generate up to 470 GW of power by 2050 if it managed the three-stage programme well. "This will sharply reduce our dependence on fossil fuels and will be a major contribution to global efforts to combat climate change", he reportedly said.

According to plan, 30% of the Indian electricity in 2050 will be generated from thorium based reactors. Indian nuclear scientists estimate that the country could produce 500 GWe for at least four centuries using just the country's economically extractable thorium reserves.

Profile

Dr. P K Vasudeva

Professor P K Vasudeva was Colonel, turned Economist , is PhD in 'World Trade Organization'. He had been Founder Director: Atmanand Jain Institute of Management and Technology (KU), Past President: Chandigarh Management Association, Principal-Director: College of Communication and Management, Bharatiya Vidya Bhavan, and Senior Professor: ICFAI Business School, Chandigarh. He regularly writes for Business and Financial papers - Indian and Foreign Journals and Columnist, American Chronicle.

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Nuclear Wave

Growth in Power Sectors

In the times we live, energy and its abundance is certainly an asset for every nation. Which is why it makes it all the more important that we develop new and imaginative ways to harness this energy and find cheap and easily accessible resources or 'fuels' for better times ahead.

Shailaja Mahara, Jyotsana Verma & Dr. Anuradha Tomar

Achieving energy security is of fundamental importance not only to India's economic growth but also for the human development objectives that aim at alleviation of poverty, unemployment and meeting the development goals. With 754,612,000,000 KWH of total power consumed in India per day, we find ourselves dealing with different forms of power generation in different parts of the country and have tried to cover some of these power generation techniques.

The primary part of energy consumption is the process of energy generation. The most widely used power generation technique in India is by Hydro Power plants. The electricity produced through the use of the gravitational force of falling or flowing water. Providing 114,000 GW hours of energy production, India is the 7th largest

consumer of electricity by hydro power. Another popular method for electricity generation in India is via Thermal Power Plants. This plant works by converting the energy rich fuels into electricity and heat where the possible fuels include coal, natural gas, petroleum products, agricultural waste and domestic waste and is usually economical in areas of high industrial density.

In the midst of the currently economical forms of energy generation, we must be at par with the future of these methods as well as they are all conventional forms of energy sources. With the global boom in technologies that offer better forms of such, the most promising one we know is Nuclear energy. Nuclear energy is a method of generating electrical energy by releasing the energy from atoms of a molecule. This can be achieved in two ways: nuclear fusion and nuclear fission.

The types of nuclear reactor used throughout the world today for electric power generation obtain most of its energy from slow-neutron fission of the scarce isotope of Uranium 235. It is a non renewable element and although it is a common metal found in rocks all over the world, the fuel for a nuclear reaction is not abundant on the surface of the earth. The nuclear plants use a certain kind of uranium, U-235, as a fuel because its atoms are easily split apart. During nuclear fission, a small particle called a neutron hits the uranium atom and splits it, releasing a great amount of energy as heat and radiation. More neutrons are also released. These neutrons go on to bombard other uranium atoms, and the process repeats itself over and over again. Hence starts the chain reaction, phenomenon, which on triggering starts a sequence of reactions which can self amplifies and get very hard to control. This is one of the foremost disadvantages of power generation by nuclear power plant. Some other disadvantages to fission are that the radioactive wastes which take a very long time to degrade.

The equation to a nuclear reaction of Uranium^{236} is -

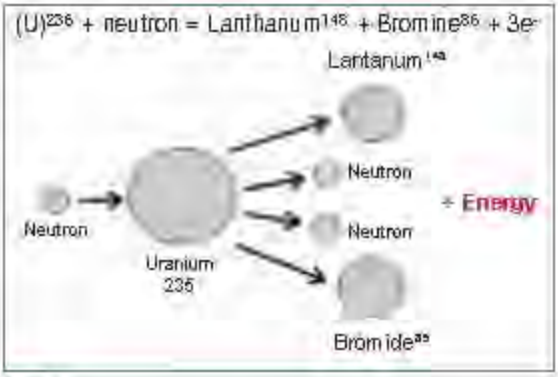

Fig. 1

One fusion of U^{236} causes a release of 200 MeV of energy. If all atoms of 1KG of pure U^{236} were fissioned, the energy released would be equivalent to that contained in 3x10^{6} Kg of coal, enough for consumption of a house for over 300 years!

Unfortunately, there is a dark side to this carefree lifestyle; it is said that all good things have a price, and the price of dependence upon fuels is no exception to this rule. And even though the uranium ore is sufficient to fuel the deployment of 1,000 reactors over the next half century, it will eventually die out like the other conventional resources we have been trying to replace. And thus begins the search of other resources, possibly non conventional, which can replace the U235 isotope for a limitless and possibly cleaner supply of energy.

Which renewable resource can produce the same amount of electricity as nuclear fission?

Can a water molecule be the answer we are looking for?

Although nuclear fusion is unlikely to be ready for commercial power generation in the coming decades, it remains nevertheless an attractive energy solution and arguably, the only truly sustainable option for large-scale base load supply in the long-term. Nuclear fusion occurs when the nuclei of atoms collide with one another and bind together, releasing large amounts of energy, which can be converted to heat and used to generate electricity as with other thermal power plants. The most efficient fusion reaction to use on earth is that between the hydrogen isotopes, deuterium (D) and tritium (T), which produces the highest energy at a lower temperature of the reacting fuels. For the fusion reaction to occur, the nuclei need to be brought very close together. If the atoms of a gas are heated, the motion of the electrons and the nuclei will increase until the (negatively charged) electrons have separated from the (positively charged) nuclei. This state, where nuclei and electrons are no longer bound together, is called plasma. Heating the plasma further to temperatures in the range of 100-200 million C, results in collisions between the nuclei being sufficiently energetic to overcome the repulsive force between them and to fuse.

This fusion energy differs from all other low-carbon energy technologies and will not make any viable and commercial contribution into the electricity grid until after 2050. Of course it is premature to speculate about the situation in 2050, but the current planning foresees fusion starting to be rolled out on a large-scale around the middle of the century. There do not appear to be any resource issues that would prevent fusion being deployed at least as rapidly as fission was deployed after the mid-20th century, given the will and the funding to do so.

But nuclear power is currently being used by many countries, some even as their primary source of energy. A on its practical utility reveals the operation of this technology.

Some reactor in France and Slovakia today operate in the load-following mode with large daily power variation of about 50% of rated power. In these countries Nuclear Power Plant participates in frequency control grid.

In the world, France, Belgium and Slovakia depend on more than 75% of their domestic electricity to Nuclear Power Plant and many Asian countries such as India, Russia and South Korea have a considerable amount of nuclear power reactors being built currently.

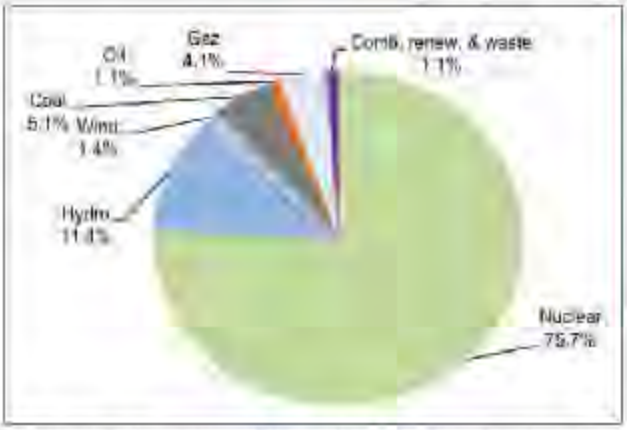

Fig. 2: Electricity generation in 2009 in France by source [5]

The two main types of reactors used in NPP are Pressurised water reactor and Boiling Water Reactor. In case of Pressurised Water Reactor (PWR) the change of reactor power level could be performed by control rods movements and by changing the concentration of Boric acid (Neutron absorber) in the primary coolant. Where as in the case of boiling water reactor (BWR), the power regulation is performed by changing the coolant flow rate (using the recirculation pumps) and/or the control rods. No boron regulation is used in BWRs. In general, there are three operating modes currently used by the Nuclear power plants:

Base-load generation mode

Almost a whole cycle operates at constant power at the Nuclear Power Plants. Today, a significant part of nuclear power operates in the base load mode.

Primary and Secondary frequency control

Another mode for the nuclear cycle is frequency regulation. There is a certain random variation of demand resulting in frequency fluctuations as the power demand can never be exactly evaluated in advance. The power plants have to monitor the frequency grid and immediately adapt their level of generation in order to keep the frequency stable at the desired value but it's a short term adjustment.

Another type of frequency regulation as secondary control acts over longer timeframes & restores the exact frequency by calculating an average deviation period of time. It has its importance in the interconnection of the European grids.

Load following

The third operating mode is by the load following method. The Nuclear Power Plants operating in the load following mode follow a variable load programme with one or other power changes per period of 24hr.

With a different form of power generation, we have to make changes with its transmission and distribution system as well

Nuclear Power plant usually has large distribution network and there are numerous electrical components that must be considered during the establishment of system limitations.

Distance to the components and connecting equipment (cables and transformers and associated voltage drops) must be taken into account as it is one of the most important element which affects the minimum allowable busbar voltage. Main issue that occur during transmission is regarding transformers whether there is TAP changer installed or not. American based NPP's normally do not have TAP changer installed and voltage on safety related busbars is directly proportional to voltage on grid. Since it is normal for voltage to sway during day so will voltage on safety related busbars change. On the other hand in the Europe transformers usually have TAP changer installed and voltages on safety related busbars are thus stable and do not change or sway.

Ideally, the best electrical supply would be a constant magnitude and frequency sinusoidal voltage waveform and a practical system that resembles ideal supply system is known as Power Quality of a system. And if the power quality of the network is good, then any loads carbon footprint will be minimal. Hence, as we can attain a stable voltage, we can conclude that nuclear power reactor has good power quality. The problem in transmission system depends upon many factors from which harmonics are one of the factor that cannot be ignored. Harmonics voltages in the electrical system are generated by non linear electric load. And with the increase of such loads at every consumer end, there is observed a large presence of harmonics and an even larger need to control them. Some of harmonics within the power system are:

- A reduction in the efficiency of the generation, transmission and utilization of electric energy.
- Malfunction of system or plant components.

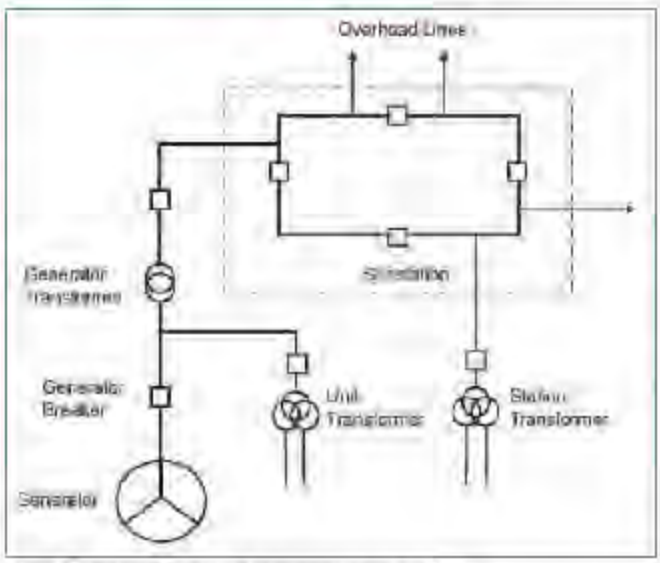

Fig. 3: Typical Electrical connection of a NPP

Eliminating harmonics at their source has been shown to be the most effective method to reduce harmonic losses.

There are special filters specifically designed to reduce the unwanted frequencies in the signal and enhance the wanted ones for a better power supply. And if the harmonics

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are due to the change in frequency then special measures such as frequency protection relays installed in electrical distribution system for protection against such events.

To enhance the power quality and to reduce the losses during transmission and distribution of nuclear power plant and for taking all its benefits economically and environment friendly we can also use power electronics.

The invention of new semiconductor materials such as band gap semi conductors are expected to reduce power consumption up to a whopping 75%, handle 10 times higher voltages and eliminate 90% of the power losses. Similar technologies in the future are expected to provide a cleaner and smarter form of energy supply, which drastically reduces the cost and increases efficiency of the already installed power transmission system.

What are we looking at the future with the nuclear power plants?

The nuclear power generation seems to be a very promising solution for the future ahead. But currently we are faced with its major cons and the limited prospects of nuclear power today are attributable, ultimately, by four unsolved problems in the future.

Cost: the nuclear power plant has a higher overall lifetime cost as compared to other forms of power generation(thermal and hydro power generation) and further advancement of this feature will reduce the cost of power generation.

Safety: Nuclear power plants are not the safest option for power generation as history has proved that many times. There is also a growing concern about the safe and secure transportation of nuclear material and security of nuclear facilities from terrorist attack.

Proliferation: it entails a potential security risk and possible misuse of nuclear factories. The fuel cycle that prevent the possible use of spent fuel to separate the weapon use of Uranium and plutonium enrichment technologies are of special concern.

Waste: The problem of radioactive wastes is no news to the drawbacks of this system. The danger of toxic waste to the streams and rest of the environment is not to be ignored and constant research in the future will hopefully provide an alternative to this situation as well.

Another Glance at the Future prospects of Nuclear Reactor by NASA

Usage of Nuclear reactor in Space application

Nuclear reactor power systems can support human exploration at surface outposts as well as onboard spacecraft. A nuclear reactor on the surface of the Moon or Mars can be a source of reliable power to provide life support, to replenish fuel cells for mobile systems, and to supply the large power demands of facilities processing materials.

Low Energy Nuclear Reaction Aircraft

The purpose of this research is to investigate the potential vehicle performance impact of applying the emergent Low Energy Nuclear Reaction (LENR) technology to aircraft propulsion systems. This technology could enable the use of an abundance of inexpensive energy to remove active design constraints, leading to new aircraft designs with very low fuel consumption, low noise, and no emissions.

A Nuclear Reactor to Replace Your Water Heater

A low-energy nuclear reactor (LENR) uses common, stable elements like nickel, carbon, and hydrogen to produce stable products like copper or nitrogen, along with heat and electricity.

The LENR offers a slow-moving neutron to an element - NASA researchers are working with nickel. The nickel absorbs the extra neutron, rendering the nickel unstable. To regain stability, the acquired neutron splits into an electron and a proton. This process releases high energy which, hypothetically, can be used to generate electricity.

Conclusion

As electricity, considered by most to be energy, is actually an energy currency. Hence, we can come to the conclusion that despite long standing technical and political challenges associated with it, Nuclear Power is the only future that lies in womb of time. Though the days of full integration are still many years away, the future is now, embracing in the innovation today.

Profile

Shailaja Mahara

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BE with "Honours" from Institute of Engineering & Technology, is MTech from National Institute of Technology, Hamirpur (H.P.) with honours and PhD. Currently she is working as Assistant Professor in Northern India Engineering College, New Delhi. She is Member of IEEE, ISTE, IEI, IETE and also associated with "Prabha Electronics Automation", Ajmer. Her areas of interest are Photovoltaic Systems.

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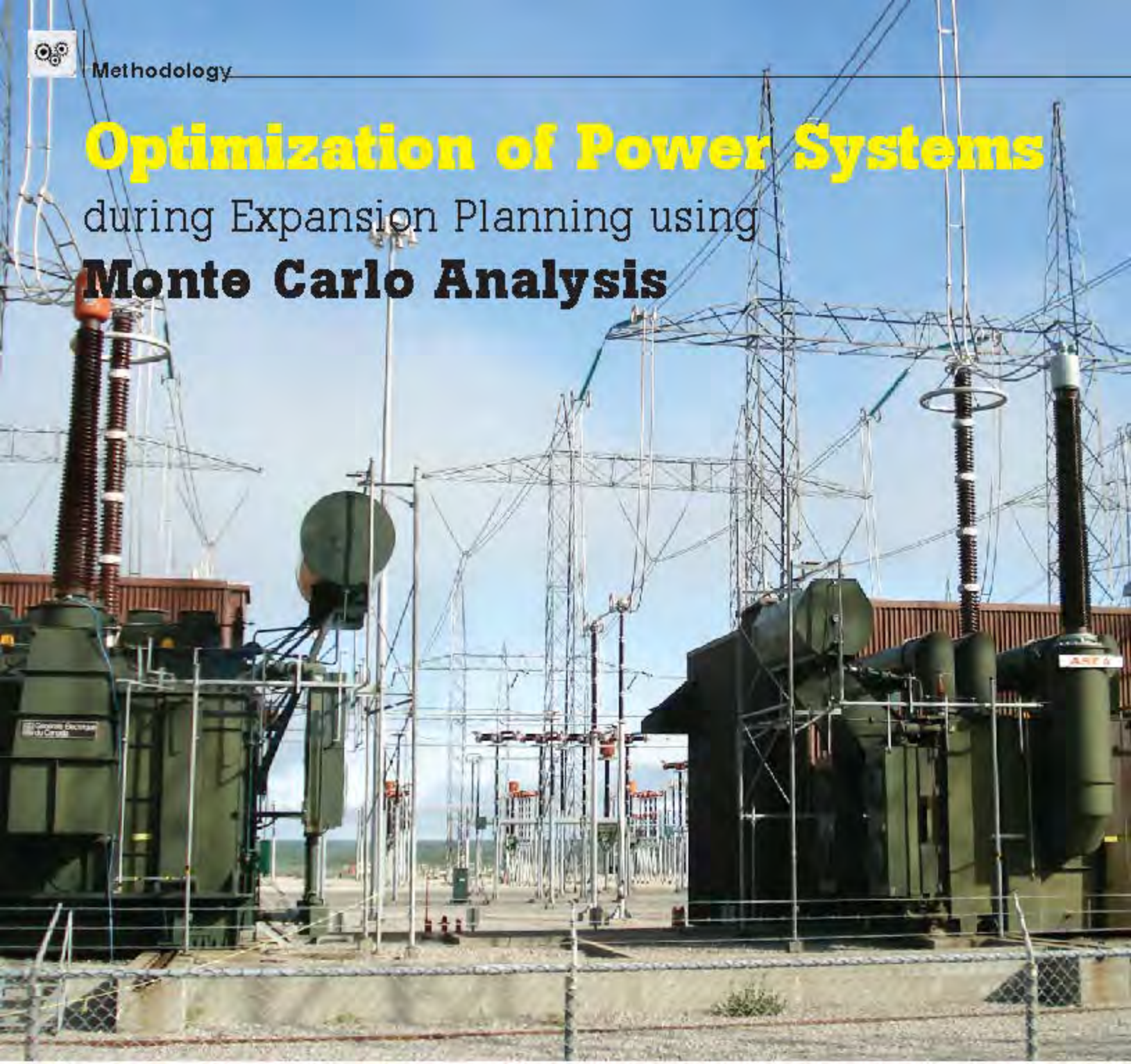
Optimization of Power Systems during Expansion Planning using Monte Carlo Analysis



In this article, the Monte Carlo method is described for optimisation of power systems during expansion planning, and its use is discussed by taking three examples to optimize the power systems during expansion planning by minimizing the cost functions subject to power and/or energy constraints.

C S Indulkar

The optimization of expansion planning for the electric power system is directly related to the country's pan-energy system (fuel and energy supplies) at both the national and regional levels. This relation is mainly one of the quantity, forms, and rates of power generation and utilization, during the various seasons of the year and in the various regions of the country. It is to be noted that this relation can be evaluated to a varying degree of accuracy; depending upon how detailed the various studies are made. The scope and degree of detail in the various tasks vary with time and from area to area. In the study of a power system as a whole, it is assumed in advance that one must give at least an approximate consideration, over the same time span to its constituent elements, namely, interconnected and regional power systems and individual installations. Subsequent studies to refine the approximate solutions are made which account for the feedback received from the respective entities. This is usually done, both in a centralized way and locally, by many organizations. To do this properly, these organisations need a system of quantitative criteria leading to solutions that would be optimal for at least the system and, ideally for the national economy as a whole, even if the solutions are sought locally. The basic design data whose credibility differs markedly at the various time levels of problem–solving are: the rate of technological advance in the power and allied industries, demand for energy, the load curves at the system nodes, the power resources available, and the likely rate of expansion in their utilization, the technical, economic and performance characteristics of the power stations, transmission lines, and the lead time needed for the construction of power stations. The fact that these data lack in credibility or essential detail inevitably makes the tasks involved probabilistic in character and necessitates a choice from a multitude of alternative solutions. Many mathematical programming methods are available to carry out the techno–economic optimization of the power systems during expansion planning. (Refer books: A. Venikov, Cybernetics in Electric Power Systems, Mir Publishers, Moscow; R. L. Sullivan, Power System Planning, McGraw-Hill, USA, and B. E. Gillett, Introduction to Operations Research-A Computer-oriented Algorithmic Approach', Tata-McGraw-Hill, New Delhi).

In this article, we describe the Monte Carlo simulation method (Refer book: A. M. Breipohl, Probabilistic systems Analysis-An Introduction to Probabilistic Models, Decisions, and Applications of Random Processes, John Wiley, New York) and then apply it for the first time to optimize the power systems during expansion planning taking three simple problems.

Monte Carlo Simulation

In Monte Carlo simulation, the variation of several parameters reveals the interaction between them. The computer carries out Monte Carlo simulation efficiently thus providing more information on the overall performance of the power system for given simultaneous parameter variations. If the cost of expansion planning, K is a function of the random variables X1, X2, X3, etc; and if the sample value of each random variable were known (say X1= x11, X2 = x12, X3 = x13, etc.), then a sample value of K (say K1) could be computed. Then if another set of sample values were chosen for the random variables (say X1= x21, X2= x22, X3 = x23, etc.), then another sample value of K (say K2) could be computed. If one had the time one could compute many such sample values of K. The computer actually supplies the speed that makes many such calculations possible. The computer selects the different values of X1, X2, X3, etc as follows.

If each of the random variables X1, X2, X3, etc had a normal or uniform distribution within a given range, values for each random variable X1, X2, X3, etc could be chosen from tables of random values. In actual practice, computer routines generate these random value tables, which may be used, and the cost of expansion planning K determined for various sets of random values.

Monte Carlo simulation is easy to implement on the available computer programs such as Pspice, TK-Solver, MATLAB, Excel, and many others that have built-in random number generators. In this paper, the Excel program that has a built-in random number generator is used. The power system model is simulated on the computer for 100 trials, where for each trial, new parameter and operating variable values are chosen randomly from within the given range, assuming uniform distribution for variations in parameter and operating variables. In the Office 97 suite of programs,

the Excel spreadsheet provides a random number generator in the data analysis option of the drop-down Tools menu, and allows the user to specify nominal (mean) parameter values as well as their standard deviations while using normal distribution, and the ranges of parameter and operating variables while using uniform distribution.. Other statistical distributions can also be easily implemented, since Bernoulli, Binomial and Poisson distributions are also available on the Excel spreadsheet.

Determination of hours of operation of power stations with constraint on energy

Considering three power stations, the specific costs c_1, c_2 and c_3 for each power station in Rs/MWh are known. The number of operating hours for each station, subject to a maximum of Tmax hours, which would minimize the operating cost of the three stations, is to be determined. Two cases are to be considered, where in case 1, $c_3 > c_1$, $c_2 > c_1$, and in case 2, $c_3 < c_1$,$c_3 > c_2$.

Case 1

The power system has three power stations with installed capacities: P_1=50 MW, P_2= 100 MW and P_3 =150 MW and the corresponding specific costs c_1=3000, c_2= 4000 and c_3=5000 in Rs/MWh. For simplicity, we assume the power stations to be independent of the operating state of the system. The total output E in MWh of the three stations has been specified in advance. That is,

$$P_1h_1+P_2h_2+P_3h_3= E \quad (1)$$

It is required to determine the hours of operation of the three stations, h_1, h_2, and h_3 that would minimize the cost:

$$z = P_1h_1c_1 +P_2h_2c_2+P_3h_3c_3. \quad (2)$$

The unknown hours of operation are subject to the following constraints:

$$h_1 \ T_{max}, \ h_2 \ T_{max}, \ h_3 \ T_{max}. \quad (3)$$

The data for the three power stations is given in Table 1. T_{max} is restricted to 7000 hours. In Monte Carlo analysis, the hours of operation for each power station are chosen randomly in the range 0-7000 h using uniform distribution. This is simulated on the computer for 100 trials, where for each trial, new hours of operation for each power station are chosen randomly from within the given range. For each trial the corresponding energies P_1h_1, P_2h_2, and P_3h_3 =E- P_1h_1-P_2h_2 in MWh and the corresponding costs, $P_1h_1c_1$, $P_2h_2c_2$, $P_3h_3c_3$ in Rs, for each station, and the total cost ,z, for the three stations are evaluated. The total costs obtained for each trial are arranged by sorting the total cost z for each trial in an ascending order from the lowest to the highest cost. The operating hours for the three stations which give the minimum, maximum and average total cost of operation, z, for case 1 are picked up from the 100 trials and are shown in Table 2. The results for three lower values of z which are close to the minimum value are also picked up and shown in Table 2. The minimum (optimum) value and the three lower (sub-optimal) values of z give flexibility to the station operators in selecting a particular set of operating hours for the stations depending upon other factors, such as maintenance etc. The optimal and the suboptimal values of z indicate that the 50 MW station, with the lowest specific cost, is loaded the most with its hours of operation reaching nearer to the limiting value of 7000.

The study for case 1 has shown that if the specific cost of station 3 exceeds that of stations 1 and 2, the latter (stations 1 and 2) should be loaded to capacity which

	Power station 1	Power station 2	Power station 3
Pi, MW	50	100	150
Total output, E, MWh	2100000		
T_{max}, h	7000		
Specific costs of operation, ci, Rs/MWh	3000	4000	5000

Table 1: Data for three power stations with constraint on energy

Case 1					
Specific costs, Rs/MWh	c1=3000, c2= 4000, c3=5000				
Total output, E, MWh	h_1(hours)	h_2(hours)	h_3(hours)	Z(Rs,Crores)	
	6084	6947	2674	921	Minimum value
	5911	6818	705	923	Lower values
	6793	5828	4176	924	Lower values
	5844	6542	6294	926	Lower values
	3437	3288	702	982	Average value
	649	12	2101	1043	Maximum value
Case 2					
Specific costs, Rs/MWh	c1=5000, c2=3000, c3=4000				
	h1(hours)	h2(hours)	h3(hours)	Z(Rs,Crores)	
	609	6806	2248	775	Minimum value
	731	6600	6260	778	Lower values
	78	6229	537	778	Lower values
	672	6342	1548	780	Lower values
	2215	1099	936	840	Average value
	6410	687	317	865	Maximum value

Table 2: Hours of operation of power stations with constraint on energy

is nearer to the limiting value of 7000 hours; and station 3 should be assigned utilization hours necessary to give the specified total output equal to E, i.e. $P_1h_1+P_2h_2+P_3h_3=E$.

Case 2

The same three-station power system, with P_1=50 MW, P_2= 100 MW and P_3 =150 MW, is considered, but for case 2, we assume that $c_3 < c_1$, $c_3 > c_2$. That is, the corresponding specific costs are c_1= 5000 Rs/ MWh, c_2 = 3000 Rs/MWh, and c_3= 4000 Rs/MWh. The total output E in MWh of the three stations as in Case 1 is equal to 2100000, and the hours of operation of the three stations,h_1, h_2, and h_3 are to be determined that would minimize the total cost, z. The maximum hours of operation for each station are restricted to 7000h. The results for this case are also shown in Table 2. In this case, if c3 <c1, c3 >c2, it is necessary to reduce load on station 1 (as being less economical than station3), that is, to load station 3 to capacity. Here, the optimal and the suboptimal values of z indicate that the 100 MW station, with the lowest specific cost, is loaded the most with its hours of operation reaching nearer to the limiting value of 7000.

Determination of hours of operation of power stations with constraints on both power and energy

It is planned to build three power stations. There maximum capacities are set at $P_{1, lim}$ $P_{2, lim}$ and $P_{3, lim}$. The operating hours, h_i, of the stations are constrained to lie between h_i^{min} to h_i^{max} hours. Further, there are constraints on both power and energy i.e.

$$\sum_{i=1}^{3} P = P_{max} \quad (4)$$

and

$$\sum_{i=1}^{3} P h_i = E_{max} \quad (5)$$

The objective function to be minimized is

$$z=\sum_{i=1}^{3}(a_i+b_i h_i)P \quad (6)$$

where

a_i = discounted investment cost including renovation and repair, Rs/kW

b_i = discounted fuel costs per MWh for each station

h_i – operating hours of each station.

We assume that the investment costs and the costs bi are linear functions of h_i. Thus

$$b_i = b_i^{min} + (b_i^{max}-b_i^{min})\,(h_i^{max}-h_i)/(h_i^{max}-h_i^{min}) \quad (7)$$

The data for the three power stations is given in Table 3. Here again, the hours of operation for each power station are chosen randomly in the range 3000-7000 h using uniform distribution. The powers for each station are also selected randomly within the range of zero to their individual capacities. This is simulated on the

	Power station 1	Power station 2	Power station 3
$P_{i\,min}$, MW	900	1200	1200
h_i min, h	3000	3000	3000
himax,h	7000	7000	7000
Pmax, MW	2600		
Emax, TWh	15.6		
ai, Rs (Crores)/MW	8	10	10
bi min, Rs/MWh	4000	3000	3000
bimax, Rs/MWh	8000	6000	6000

Table 3: Data for three power stations with constraints on both power and energy

MW				Hours			Total TWh	Rs, Crores			
P_1	P_2	P_3	$P_1+P_2+P_3$	h_1	h_2	h_3		z_1	z_2	z_3	Total z
847	900	824	2572	4630	3320	5986	11.8	1570	897	4620	7086
727	984	914	2625	4706	4456	3865	11.3	1369	1316	3044	5729
737	1085	806	2627	4487	5949	5822	14.4	1323	1936	4590	7848
789	914	1085	2788	4429	3426	4610	11.6	1399	940	3857	6196
871	907	1040	2818	3340	5841	5809	14.3	1164	1590	4913	7667
752	1169	1184	3105	6467	4304	6742	17.9	1945	1510	6282	9737

Table 4: Hours of operation of power stations with constraint on both power and energy

computer for 100 trials. For each trial, $(P_1+P_2+P_3)$ and $(P_1h_1+P_2h_2+P_3h_3)$ are calculated. These should be less than the specified values of P_{max} and E_{max} respectively. The total cost, z, for the three stations are evaluated from equation (6), using b_i's of equation (7) and the specified data of Table 3.

The 100 values of $(P_1+P_2+P_3)$ are than arranged to appear in an ascending order from the lowest to the highest value. The optimal and the suboptimal sets of P_1,P_2, and P_3 and the corresponding operating hours h_1,h_2,and h_3 are then picked up (from the 100 trials) which require minimum or near-minimum costs, and also satisfy the constraints of both P_{max} and E_{max}. The results are given in Table 4. In this Table, only those trials are taken where the values of P_{max} and E_{max} satisfy the given criterion.

There are six rows of results in this Table. The first row satisfies both the criterion of P_{max} and E_{max}, hence the total cost of Rs 7086 crores corresponding to this row may be taken as the optimal cost. The second row exceeds the P_{max} criterion by a small amount but the total cost of operation which is Rs 5729 crores decreases by a large amount showing that the operating hours and the MW capacity at which the stations are operated are interlinked and affect the overall cost of operation. The third row also exceeds the Pmax criterion by a small amount, but it gives a high total cost of operation which is greater than the optimal value of Rs 7086 crores in the first row of the Table. Rows 4 and 5 may not be considered, since the total MW value of the three stations is much larger than the specified value of P_{max} (2600MW). In Table 4, therefore, row 1 gives the near optimum value, because although the total power is close to 2600 MW, the total energy is much lower than the constraint of 15.6TWh. Hence, in order to get much better optimum values for P_1,P_2,P_3 and h_1,h_2,h_3 it is suggested that further 100 trials of the Monte Carlo method may be carried out in which while applying the uniform distribution (which selects the values of P_1,P_2, and P_3) P_1,P_2,P_3 may be selected as ranges 800-900,800-1200 and 800-1200 in MW instead of the starting MW values which were selected for getting the result of the first row of Table 4. This would give a more accurate result.

Conclusions

Three simple examples are used to demonstrate the application of the Monte Carlo method for optimising electric power systems by minimising specific cost functions with constraints from an economics point of view. Normally, the methods of analysis used in the examples considered in this paper are based on the simplex algorithm which is applicable to the optimization of many variables related by linear constraint equalities on the condition that the constraint equations and the objective function are in their canonical form. In this article, the Monte Carlo analysis is used for the first time to optimize electric power systems during expansion planning, and it is shown that the method is quite simple using the Excel spreadsheet, and no specific software is required to solve the problems.

Profile

C S Indulkar

BTech (Hons),IIT Kharagpur, MSc Tech (research) and PhD from University of Manchester, retired as Head of Electrical Engineering Department, IIT Delhi. He has been a reviewer for several international and national journals.

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Power Quality Issues in Microgrids

Microgrid is promising alternative to the traditional power distribution systems as it offers consumers the reliability of power, energy savings and economic benefits. As the microgrid operates in Islanded mode (i.e. disconnected from main grid), power quality issues crop up that are different as compared to traditional centralised grid. This article presents an overview of various power quality issues which arises in microgrid and possible solutions to mitigate the same.

Jayesh G Priolkar

Microgrid is defined as cluster of the distributed generation sources (DG), distributed storage devices and distributed loads that operates in synchronism or isolated from main power grid. With increasing number of renewable energy resources it is necessary to develop new control strategies for proper operation and management of the grid embedded with DG and other microgrid units in order to maintain or to improve the overall reliability and quality.

Large-scale integration of renewable energy is fundamentally changing the characteristics of the power grid. The coexistence of multiple DG sources which have versatile dynamic properties and electrical characteristics have impact on safety, efficiency, control and stability of microgrid. High penetration of DGs, alongwith different types of loads is cause of concern for coordinated control and power quality issues in microgrid operation.

As the renewable DG sources are highly dependable on environment, variability of the resource introduces power quality problems.

The impact of the DG on power quality of a distribution network depends on different factors like-

- Type of DG
- Type of interface with the utility system
- Size of the DG unit
- Mode of operation
- Expected output fluctuation
- Total capacity of the DG relative to the system
- Size of generation relative to the load at the interconnection point
- Feeder voltage regulation

The issue of power quality is important as it directly affects the characteristics of microgrid operation. Power quality problem can be defined as the occurrence of short to long periods of inadequate or unstable power outputs from the microgrid. The increased infiltration of non linear loads, unbalanced loads and power electronic interface for integration of DG creates power quality issues in microgrid.

In the islanded mode the system voltage and frequency must be established by the microgrid otherwise the system will collapse due to versatile dynamic properties and electrical characteristics of microgrid components. The harmonic distortion problem also arises due to high speed operation of the converter switches which are used as power electronic interfacing of DG with the grid. In order to address various power quality issues it is necessary to adopt various mitigation techniques.

Power quality problem can be defined as the occurrence of short to long periods of inadequate or unstable power outputs from the microgrid.

Power Quality Issues

Voltage Regulation

The voltage regulation problem may arise as a result of introduction of DG into the distribution network due to various reasons like intermittent nature of the wind turbine, Photovoltaic cells (PV), geothermal energy sources, interference of the synchronous generators (capable of supplying active and reactive power) with the utility voltage regulating equipment, due to use of induction generators and inverters (for grid connection) that are not suited for voltage regulation as they lack the ability to produce reactive power, use of a small DG unit (which lacks the ability to regulate the voltage), breakdown of a large DG unit (responsible for voltage regulation) in case of a fault on the feeder; lack of coordination between multiple DG units, frequent connection and disconnection of a large number of small DG units.

Voltage Flicker

Voltage flicker is caused by fluctuation of energy which results from intermittent generation from wind turbines and photovoltaic sources, or connection and disconnection of induction generators from the network.

Voltage Sag

A voltage sag is a reduction in the RMS voltage in the range of 0.1 to 0.9 p.u. (retained) for duration greater than half a mains cycle and less than 1 minute and a voltage swell is an increase in the RMS voltage in the range of 1.1 to 1.8 p.u. for a duration greater than half a main cycle and less than 1 minute. Voltage dips can occur during start up of induction generators (as reactive power is consumed during magnetization), switching off generator from synchronous speed or due to short circuits.

Voltage sags are also caused by faults, increased load demand and also due to large motor starting. And voltage swell is caused by system faults, load switching and capacitor switching. A voltage interruption is the complete loss of electric voltage. Interruptions can be short duration (lasting less than 2 minutes) or long duration.

Sustained Interruptions

A voltage interruption is the complete loss of electric voltage. Interruptions can be short duration (lasting less than 2 minutes) or long duration.

All the DG technologies are not able to provide backup generation in case of interruptions or breakdown of the main system. DG based on an induction generator, or with an uncontrollable inverter, or lacking proper storage might be unable to operate in island (standalone) mode to cater the load.

Harmonics

The power quality assessment is mainly based on harmonics. Harmonics are a phenomenon associated with the distortion of the voltage and current waveforms (periodic voltage or current disturbances with frequencies multiple of the fundamental frequency). Some forms of DG, i.e., photovoltaic and fuel cells, are connected to the power network through power electronic converters.

The modern converters based on insulated gate bipolar transistors use pulse width modulation technique and thus produce fewer harmonics than the old generation of thyristor based line commutated inverters.

DG based on induction and synchronous generators change the response of the network to the other harmonic sources by changing harmonic impedance of the network. Capacitors used for excitation and reactive power support for induction generators can cause resonance in the network.

Voltage Unbalance

Voltage unbalance can occur as a result of integration of a single phase DG, i.e., DG based on PV units, in distributed networks. This unbalance becomes noticeable as more and more single phase DG units are introduced into distributed network.

When critical loads are connected to a microgrid, severe unbalanced voltages

are not generally acceptable and the microgrid should be disconnected from the utility grid.

If the voltage unbalance is not so serious or the local load is not very sensitive to it, the microgrid and load can remain connected.

Power quality problems due to Renewable energy sources

Renewable Energy is influenced by some environmental input parameters, and hence energy produced from renewable energy sources is inherently variable. Numbers of challenges are faced in operation of microgrid due to intermittency and randomness of renewable energy sources.

Due to variable and unpredictable power output from Solar photovoltaic, wind and other renewable energy resources, special consideration and analysis is required to address voltage regulation, harmonic distortion and reactive power compensation on the power system.

Renewable energy sources are mostly integrated into the grid through Pulse Width Modulation inverters that are controlled to behave as current sources, that is, to inject into grid active currents that depend on the amount of energy available from the renewable sources.

As the penetration level of DG with power electronic interfacing and the number of grid-tied micro-grids are increasing the reactive power compensation and power quality problems have become vital issues in the control of distribution systems. Various power quality problems in renewable energy sources are highlighted in Table I.

Mitigation Techniques

To enhance the power quality of the microgrid system various methods like optimization techniques, filters, controllers, FACTS devices, Custom power devices, compensators and battery storage can be adopted.

- Droop control technique provide an effective method to enhance the power quality parameters like active and reactive power control in autonomous as well as grid connected operation.
- In order to meet power quality requirement use of particle swarm optimization algorithm based control strategy for real time self tuning of control parameters is reported in literature. Optimization process used in power controllers helps to evaluate steady state, dynamic response and also harmonic distortion in addition to regulate voltage and frequency.
- Use of load compensators for reduction of current harmonics in distributed microgrid.
- Use of active power conditioner for power quality improvement. Power quality conditioner is the integration of series and shunt active power filters across the grid with renewable energy resources. Control strategy uses compensation technique that forces current from microgrid to become balanced and sinusoidal by making conditioner to compensate nonlinear load current. The shunt component is responsible for mitigating the current quality problems caused by the consumer: poor power factor, load harmonic currents, load unbalance etc. It injects currents in the AC system such that the source currents become balanced sinusoids and in phase with the source voltages. Series conditioner uses PWM voltage controller to minimize the voltage disturbances.
- Use of FACTS devices like DSTATCOM (Static Compensator) for mitigation of voltage variations.
- Storage batteries can enhance the dynamic behavior of microgrid. During process of islanding, it results in voltage drop and frequency deviation which are reduced in presence of storage batteries.

Conclusion

Integration of renewable energy resources, alongwith different types of loads into the grid is cause of concern for coordinated control and power quality issues in microgrid operation. Various power quality issues with suitable mitigation techniques are highlighted in the article. Use of mitigation techniques helps to enhance power quality, reliability and stability of microgrids.

Power Quality Problems	Wind Energy	Solar Energy	Micro/Small hydro
Voltage Sag/Swell	√		√
Over/Under voltage	√		
Voltage unbalance		√	
Voltage Transient	√		
Voltage Harmonics	√	√	√
Flicker	√	√	
Current Harmonics	√	√	√
Interruption	√	√	

Table I: Power quality problems in Renewable Energy sources

Profile

Jayesh G Priolkar

is working as Assistant professor in E&E department in Goa College of engineering. He is MTech in Energy systems and engineering from Indian Institute of Technology, Bombay. He has eight years of teaching and five years of Industrial experience. His research interests are in microgrids, power system protection and energy management.

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Problem with Power system Harmonic Resonance

- a methodology for trouble-shooting and removing barriers to energy efficiency and increasing productivity

Fig. 1: 6.5T, 6mva, 3Ph, EAF at its normal operation

An Electrical Arc Furnace in the vicinity of a hyperactive railway traction line was facing an unusual power quality harmonic distortion problem. The Gigantic 22kA copper bus-bar used to overheat visibly red-hot, vibrate audibly loosening nuts and bolts and wear out affected plates. In-addition it frequently encountered usual harmonic problems namely, detuned capacitor bulging and blasting, motor overheating and failures, HPMV lighting ballast failures, 33kv fuse failures as well as overheating of the main EAF transformer.

Kanai Banerjee

An onsite power quality harmonic analysis revealed an unstable grid supply zone supplying to the plant, tending towards a series resonance condition. A solution was designed, installed and performance monitored for over a year. The passive tuned harmonic filter sustainably resoled all power quality harmonic disturbances, power system resonance and tripping and failures of plant equipment. Furthermore, the improved operative power system conditions, facilitated increased productivity substantially with congruous reduction in the SEC, the specific energy consumption, in terms of kWh/Tons.

The factory manufactures Pig Iron which is an intermediate product of smelting iron with high-carbon-fuel such as coke usually with limestone as flux. As seen in Fig. 2, ingots are produced from many a branching structures formed in sand, at right angle to the central channel, called the runner, wherein the liquid metal is poured directly from the bottom of an EAF. Such a configuration resembles in appearance to a litter of piglets suckling on a sow. And as the metal cools and hardens, the branching ingots (the Pigs) are simply broken from the much thinner runner (the Sow), hence the name Pig Iron. The high carbon content 3.5%-4.5% makes it brittle. And being an intermediate product it is intended for re-melting, the uneven ingots size and inclusion of small amounts of sand is insignificant compared to the ease of casting and of handling. Pig

Fig. 2: The Pig Iron is being tapped into casting bed

Iron is used traditionally and primarily in foundry industry and to some extent in induction furnace for producing specific grade iron billets.

The EAF is powered from a 3ph, 6.0mva, 33kv/160v, 50Hz, TRF as shown in Fig.5, through a 3ph, 22kA, 160v, copper bus-bar connecting to the electrodes of the EAF. The electrodes inside the EAF are submerged into the charge of iron ore and coke, get short circuited causing enormous current of 22kA to flow through the charge, the effect of which melts the charge as shown in Fig. 1.

The Heat control into the charge is done by electrode positioning, lowering it increase, and raising it decrease the heat and also the power demand. A Semiautomatic control system continuously positions the electrodes, at an appropriate depth into the charge, for the optimum heat and the power demand. The charge is continuously fed into the EAF from top hopper. The liquid metal is however tapped from the bottom of the EAF in a batch process at every interval of about 3-1/2hrs as shown in Fig. 2, producing 6.5Tons per batch and summing up to 45tons per day in seven batches. There however, is a problem to overcome for using EAF for iron ore melting. Iron ore fines in particular from Indian mines, have about 56% Fe content, not enough conductivity to create the effective short circuit between the electrodes which require minimum 66% Fe content.

The problem is solved by pre-processing the iron ore and increasing its Fe content; wherein it is mixed with few percentage of mill scales and sintered in a hydro cyclone. Sintering is a process of welding together smaller particles of metal by applying heat below its melting point. It is a simple process which requires no direct electricity. The initial heat is started using some waste materials like packaging waste, rice husk etc., and then the flame is carried through by oxygen lancing, which is done by drawing ambient air through the sintered mixture by ID Fan.

Mill Scale is hardened oxidized surface that gets developed on steel surface when hot processed. It contains 98% Fe in the forms of iron and oxidized iron namely Fe, FeO, Fe_2O_3 and Fe_3O_4. It is a bye-product of hot rolled mill, wherein heated steel ingots are rolled into hot rolled coils, high pressure water jets at about 70 bar are used to descale the mill scales formed on the steel surface. It is a scale, thus it peels off as flake off the hot rolled steel surface. Mill scale is a waste generated by large integrated steel plants.

Case Study

Problem Statement

Firstly, low fault level, thanks to its remote location near a forest land. Secondly, high power quality harmonic disturbances, a hyperactive Howrah-Mumbai railway traction line passes beside it and receives 25kv supply from the same, nearby, 132/33kv Ghatsila Substation as shown in Fig.3.

Furthermore, conventional engineering design practice is limited, in installing power factor compensation capacitors for linear loads, and capacitors with detuned reactors for NLL. The same design practice is also followed here considering the EAF as the NLL.

The factory receives power form a 50mva, 132/33kv, TRF at Ghatsila S/S that also supplies to several other surrounding industries namely; 2x Pig Iron plants, 1x Induction Furnace plant, 6x Public Distribution substations through 33/11kv sub-distributions, 7x Rice Mills through 33/11kv sub distributions and 2x Induction Furnace plants through 33/11kv sub-distribution.

If NLL are present in the power system, connecting PF capacitors with current-limiting or detuned reactors without having

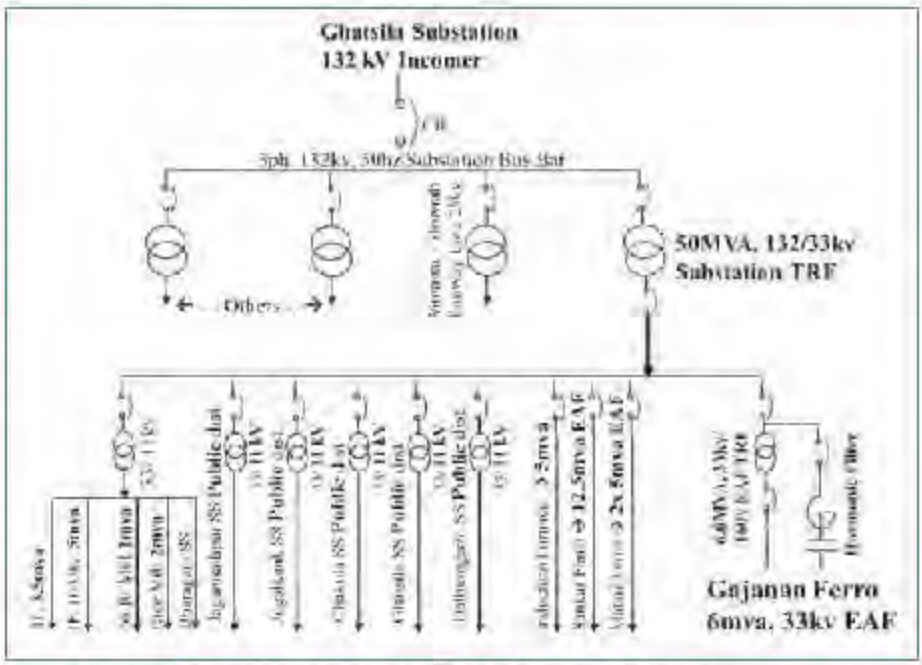

Fig. 3: Single Line Diagram of the 132/33kv Grid at Ghatsila Substation

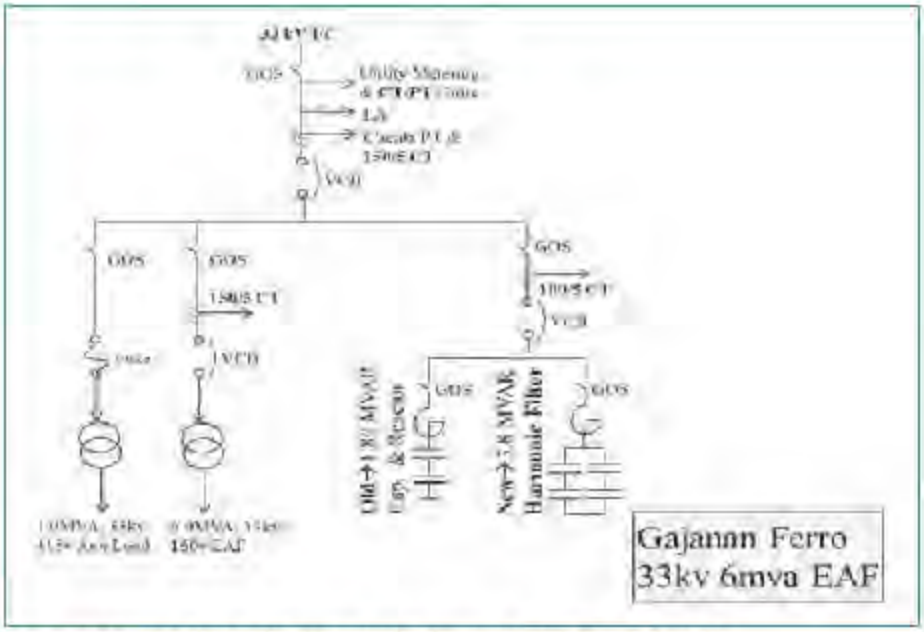

Fig. 4: Simplified SLD of the factory with 6mva EAF, Old Cap & New HF

Fig. 5: EAF Transformer, 3ph, 6mva, 50Hz, 33kv/160v

the least check on its resonance condition, is a recipe of a potential harmonic resonance, which is one of the major causes that defines a stable grid. The resulting power surge which mainly manifest as voltage sag as a consequence of power quality harmonics, is the single most major cause that inflicts billions of dollar damages, in terms of industrial equipment failures and productivity losses, every year, worldwide. Electrical harmonics are unpredictable and under favorable power system impedance trigger harmonic resonance that magnifies both the harmonic and the power fluctuations in the grid supply. The factory was then barely 6-months from its commissioning, reported extensive power quality disturbances and equipment failures during our onsite harmonic study.

- 33kv capacitor failure: It had installed 1800+1200kvar capacitor banks with detuned reactors from a MNC company for maintaining PF, at near UNITY level. The capacitors bulged from all sides, reduced effective kVAr and PF and eventually started failing with blast. We observed smaller bank had failed completely and 1800kvar bank partially.
- HPMV ballast failure: Lighting ballasts burnt regularly.
- 33kv HT Fuse failure: The auxiliary loads, 415v, of the EAF is powered from a 1.0mva, 33/0.415kv, 50Hz TRF, which at upstream is connected through a 33kv, HT, fuse as shown in Fig. 4. The fuse failed frequently tripping the whole plant.
- AC Motor overheating & failure: The auxiliary loads include, several constant speed squirrel case induction motors for applications like in EOT cranes, cooling tower fans, condenser water pumps, air compressors as well as other utilities. Almost all 415v motors used to overheat frequently, leading to stator insulation failures.
- The Gigantic 22kA copper bus-bar overheat & vibrate: The 22kA copper bus-bar that connects to the electrodes of the EAF, used to overheat visibly red-hot, vibrate audibly loosening nuts & bolts. It used to happen in about once a month. The problem persisted even after ensuring firstly, all nuts & bolts were tight and secondly, after replacing those by brazing the affected plates. The continued vibrations and rubbing between the plates wore out the affected bus bar section and those plates were replaced; till the problem continued. The 22KA bus-bar terminating at the 160v, TRF secondary side is shown in Fig. 5.
- 6mva EAF TRF high winding temperature: Its winding temperature reached as high as 90oC even though it could not be loaded beyond 5mva due to the existed problems. The prevailed conditions were ideal enough for the potential failure of the TRF itself. Transformers are susceptible to current harmonic distortion that can melt open HV winding, creating a single or multiple phase fault usually an open circuit with or without earth fault. The metal industry and in particular the EAF transformer has history of such high voltage winding failures.

Harmonic Study and Root Cause analysis

The Power Quality harmonic measurements were carried out during Apr. 2012, using a high quality 3phase power quality harmonic analyzer of type PowerPro which measures at a sampling rate of 256/cycle and calculates RMS value of all measured parameters at every cycle basis. It measures all steady state power parameters, power quality including

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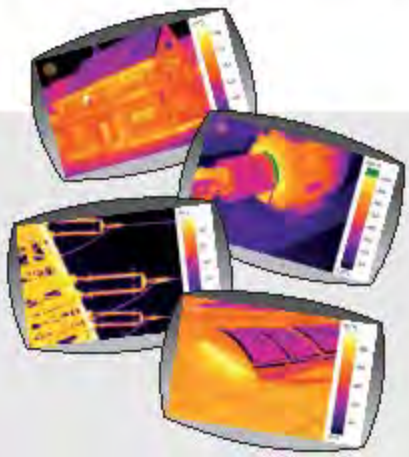

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It was observed that the power system of the incoming grid was tending towards the higher harmonic resonance which was the primary reason for the about once a month overheat and vibration of the gigantic 22kA copper bus-bar. The measured harmonics both voltage and current and waveforms are as shown in Fig. 6 and 7.

The current waveform at the 33kv incoming grid PCC was highly distorted with 14.8% THDi, at 125A-peak load current and I11 and I17 as major current harmonics as shown in Fig. 6.

The voltage waveform at the 33kv incoming grid PCC was only moderately distorted but within IEEE 519 norms with 3.9% THDv at 47kv-peak load voltage (RMS value of rated line voltage is 33kv) and V11 and V5 as major voltage harmonics as shown in Fig. 7.

It was evident from those measured harmonic bar charts and waveforms that a part of the grid which was supplied from the 50mva TRF of Ghatsila S/S was under electrical harmonic resonance condition. The 11th harmonic is not a natural harmonic that an EAF generates. Its real cause was the capacitors with detuned reactors installed by the factory and may be by others within the same electrical power system. And a combination of those was tending towards a series harmonic resonance in interaction with the grid power supply. Once an electrical power system gets subjected to a harmonic resonance condition, it magnifies both the current and the voltage harmonics, the extent of which depends upon the conditions which exist then within the effective zone of the electrical power system and its loads, which itself is variable continually and so is the harmonic magnifications.

The root-cause diagnosis derived from the onsite harmonic analysis was further cross checked with the failure records as detailed under problem statement. The nature of electrical failures and the ways those happened were in consonance with the fact of existence of a harmonic resonance condition.

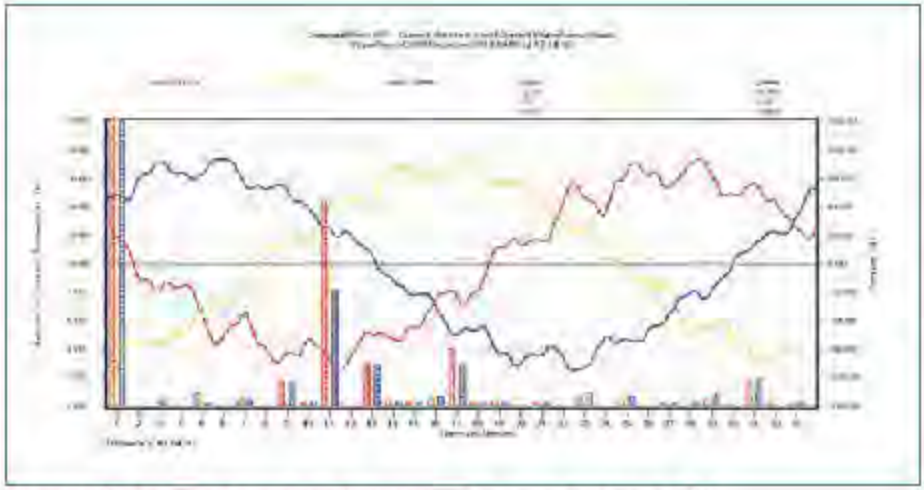

Fig. 6: Grid Current harmonics with 1800kvar Capacitor & Reactor ON

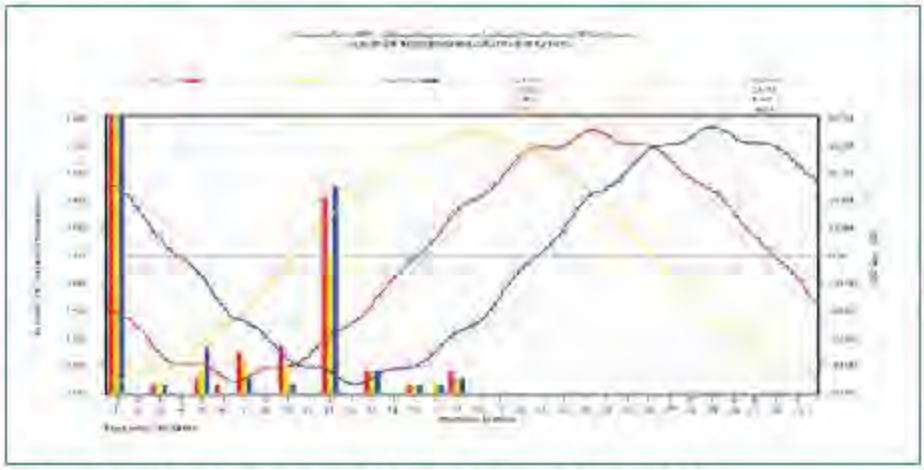

Fig. 7: Grid Voltage harmonics with 1800kvar Capacitor & Reactor ON

The Solution, Passive Tuned Harmonic Filter (HF)

The best possible solution for tackling harmonic resonance problem is to install passive tuned harmonic filter closer to the load, which for this case study was at 3ph, 160v, 22kA, EAF TRF secondary supply bus. An isolation transformer in between the grid and the factory, it was relatively easier to tackle the potential series harmonic resonance with lesser design complexities, than designing it without the advantage of the TRF that greatly had isolated the factory load from other loads within the same effective grid supply zone. However 160v is too low a voltage and 22kA is too high a load current that would have rendered the LT harmonic filter project commercially unviable, even after considering higher energy efficiency and productivity those usually accrue when installed closer to the load end compared to the upstream at a higher bus voltage.

Practically the solution got limited to tuning and realigning the incoming grid's power system impedance at 33kv PCC, starting from the 50mva grid TRF supply at Ghatsila S/S. It required installing the harmonic filter at the 33kv PCC which also happened to be the grid as shown in Fig. 3. The installed harmonic filter would not only cater to the factory's own NLL, but also to a

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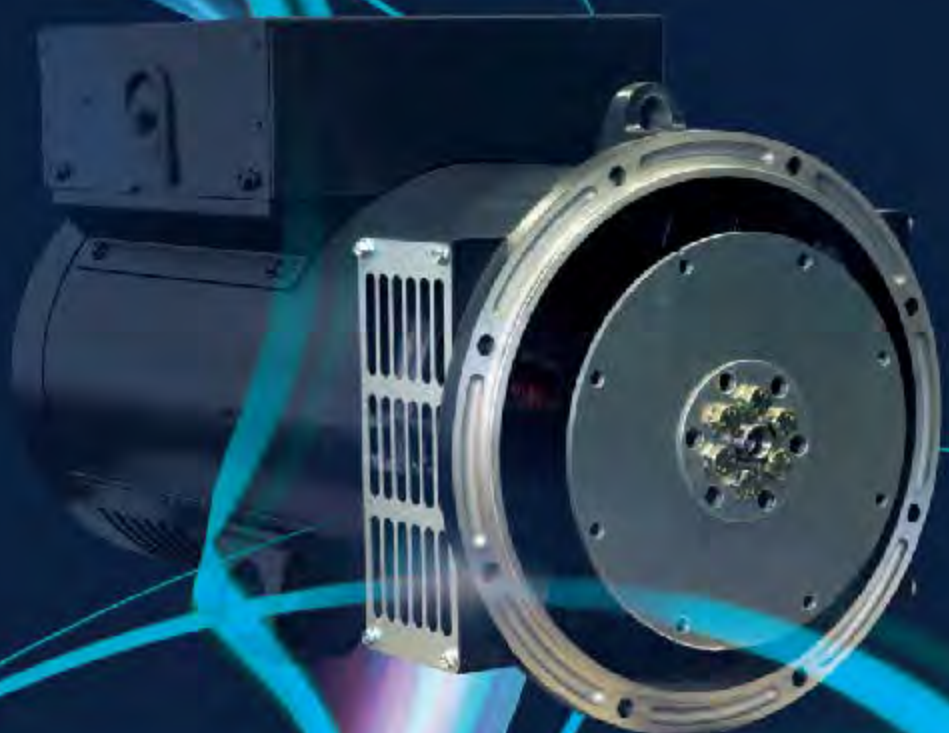

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Fig. 8: 6mva, 33kv EAF substation with Harmonic Filter (view from front)

Fig. 9: 6mva, 33kv EAF substation with Harmonic Filter (view from rear)

larger grid supply zone to the extent connected with the same 50mva grid TRF. In-addition harmonics are called NLL for all the good reasons, it does not like to contain itself within a transformer isolated zone and transgressions within an effective and larger grid zones are very common, the extent of which is again continually variable in line with the associated electrical power system and its load conditions.

We had past experiences of trouble from such installations, which further gets compounded due to the lack of motivation for harmonic suppression among the other factories. Given the nonlinear nature of harmonic resonance, it is very much likely that some factories get affected very hard and some may not be as hard to have taken a note of it. The THDv at the affected 33kV grid supply zone could reach intermittently, as high as 40% plus, under resonance with a favorable power system impedance condition and combined with NLL and capacitor switching by neighboring factories.

The resultant resonance causes vibration, noise, overheat and occasional TRF HV winding failures. Recorded details of similar 33kv grid supply under harmonic resonance condition could be obtained from Error! Hyperlink reference not valid. under home page under "Rare Event Case Studies". The harmonic filter was installed at the 33kv PCC of the factory at its outdoor substation as shown in Fig. 8, a view from the front and Fig. 9, a view from the rear.

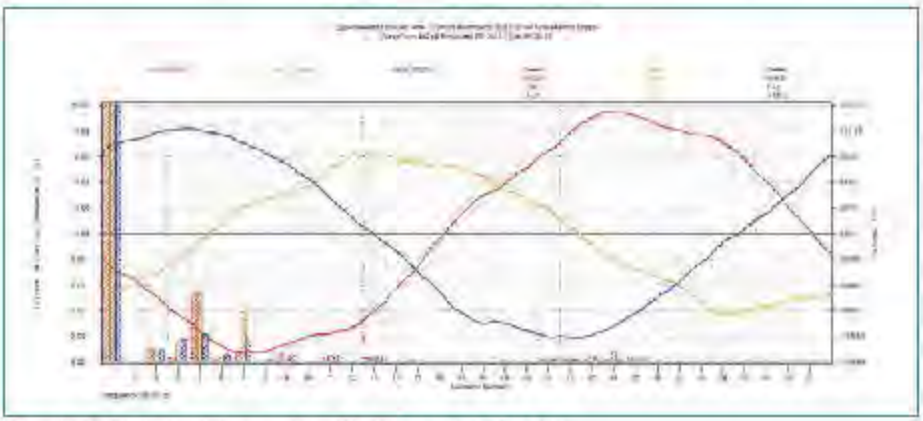

Fig. 10: Grid Current harmonics with Harmonic Filter ON

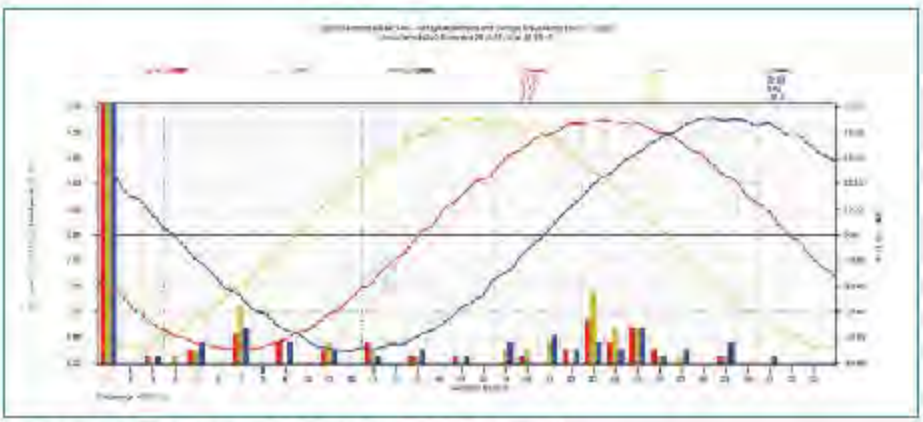

Fig. 11: Grid Voltage harmonics with Harmonic Filter ON

Results Achieved

After the installation of the harmonic filter about a year ago, a repeat harmonic study was carried out.

The current waveform at the 33kv incoming grid PCC was controlled within 6% THDi, at 152A-peak load current and I5 and I7 as major current harmonics as shown in Fig. 10. The unbalance in the 3ph waveforms in current magnitudes is due to the unequal arcing among the three electrodes of the EAF.

The voltage waveform at 33kv incoming grid PCC was controlled well within IEEE 519 norm at 2% THDv at 45.6kv-peak load voltage (RMS value of rated line voltage is 33kv) and V7 and V23 as major voltage harmonics as shown in Fig. 11.

Thereafter performance is observed for over a year. And all power quality harmonic disturbances and equipment failure issues are all resolved and the unusual resonance problem with the gigantic 22kA bus bar overheating and vibration did not occur,

indicating that the chances of resonance is greatly eliminated. However looking at the THDv waveform in Fig. 11, on the post solution scenario, there still remain some chances for resonance and that's why it is said resonance can't be eliminated it can only be shifted away from a working bandwidth.

The problem arose in this plant were not due to the ordinary power quality harmonic issues, the current harmonics were not high enough to cause such an unusual harmonic problem and the voltage harmonics were well within IEEE 519 norms, as found during those days of the measurement.

A portion of the grid supply zone starting from the 50mva, 132/33 TRF at Ghatsila S/S, was on the boundary lines of the power system stability.

Conclusion

The enumerated case study and its yearlong performance verification report, clearly establish all round improvement of major power system parameters, not only inside the plant but also within the effective grid supply zone.

Doing the power quality engineering at the downstream at the plant with NLL, mirrors the optimum grid condition, an engineering effort that will greatly prevent electrical pollution from entering into the electrical power systems of the grid.

In-addition, it reduces carbon emissions by enhancing productivity, removing barriers to energy efficiency and promoting efficient use of energy all alone, from the downstream plants, the users, up to the upstream the power plants, the suppliers.

The cost saving when looked narrowly in comparison with the electricity bill alone might seem moderate, but when compared holistically with substantially reduced investment cost, lower carbon footprint, uninterrupted production, MTBF, inventory cost of components and workforce motivation coupled with ever rising cost of energy, the economic benefits would far outweigh the cost of the solution.

Kanai Banerjee

graduated in Electrical Engineering. His special fields of interest include power quality engineering, harmonic solutions and manufacturing passive tuned harmonic filters of almost any size, LT or HT, troubleshooting failures, energy conservation, electrical consultancy and HVAC engineering setting up truly green buildings or retrofitting centralized HVAC projects. He is energy auditor certified by the BEE under the ministry of power, a member and chartered professional engineer with the institute of engineers, India, a member of ISHRAE and a member of the Canadian and American EMTP-ATP group.

Interview

Specialization in tracker systems for solar products

Vijay Karia, Chairman & Managing Director
Ravin Group

Ravin Group Ravin Group, in the domestic and global market as Power Experts, comprises of companies which are involved in diverse businesses such as manufacture of Energy Cables, EHV Cables and Installation, Solar Energy Systems, Retail Energy Products etc. The company's products always adhere to internationally safety standards. Ravin is involved in the manufacture of technology-driven energy cables. They offer a complete range of cabling solutions for LV, MV, HV, EHV cables from 1.1 kV to 220 kV from state-of-the-art manufacturing units in India and U.A.E. In an exclusive interview to **Electrical India, Vijay Karia,** states, Ravin has moved on from pure cable manufacturing into five clear verticals.

➢ **What is the scenario of power cable industry in India? And how would you overcome the challenges?**

The power cable industry in India over the last few years has been struggling to sustain itself, and I think this is the general status of the entire industry, more particularly the electrical industry which is staggering under a regime of very little capital investment and very little growth. This of course has been compounded by the fact that on the generation side there have been various problems which somehow or the other have not got addressed. One has to understand that the power cable industry in India has a weightage of almost 30% in the overall electrical industry, and in order for the electrical industry to grow, the cable industry in India has to grow. Overall, there is a problem of lower number of projects, high costs of both raw materials as well as of manufacturing due to continuously increasing prices of fuels, increasing labour costs and increasing interest costs.

In order to overcome the challenges a clear way out would be

- to increase the demand and increase the size of the industry with infrastructure developments in the country which is the prime need of the hour.
- Bring in policy changes which are an impetus for a long term and not a short term injection of demand, which in any case does not help much in any industry.
- Encourage R&D spent and encourage the growth of the local industry so that the latest technological developments are

available in the country

- Discourage 100% FDI into this sector, as this sector is highly stressed out and foreign companies coming in would lead to an acceleration of closure of local industry and would further on lead to price rise and price cartelization by the foreign manufacturers.
- Encourage growth in the renewable segment, which would make electricity available across the country without the high transmission and distribution costs and so we can rapidly industrialize or at least electrify the country without a long gestation period. I do see that change in policies and an impetus to the industry especially after the general elections would spur the industry after 2015.

What are the Product range catered to by Ravin for the Indian market?

It has to be understood that Ravin has moved on from pure cable manufacturing into five clear verticals. Energy cables is one of them. EHV projects and services is another vertical. The renewable energy segment is the third one which not only consists of Fixed installations of solar panels but also consists of single axis and dual axis solar tracker systems which change their orientation according to the direction of the sun thereby leading to higher efficiency. Fourth is various power products and power equipments manufactured by Ravin and the fifth is the retail energy products. We are specializing on the EHV side of the business , and with our stellar expertise we install pre-moulded joints and terminations for all voltages from 11kV to 400kV. We have catered to various projects in India, which have been appreciated by various utilities both public sector and private sector , and we are proud of our position in the market. Basically we have made our mark in the B2B arena and our now expanding our horizon into the B2C market. We see a huge potential for new products not just in the cable segment, but in all electrical segments.

Are you planning to extend the collaborations with any other company?

Our joint venture with Prysmian unfortunately has not worked out in the way we wanted to, and we have other joint ventures with other foreign companies for manufacture of various electrical products. We are on the lookout for good technical collaborations so as to bring technology in the company and in the country, and we are looking for new products and solutions to fit into the Indian market, with the motto of availability, affordability and accessibility is our driving force. India is a price sensitive market and we have to understand that we will have to develop products to suit our pockets, rather than being given products which would drive foreign companies. We have to insist on technology coming into the country, rather than just importing products into the country, because I believe that our attitude and policies of allowing free import of all kinds of products is actually harming the local industry and therefore we need to import technology and not just mere products.

Would you tell us about the major products in the cables that you have done so far.

Ravin cables has been one of the companies in the Ravin group and Ravin group was established in the year 1950 so we are more than 64 years old into this field. Ravin cables started its cable manufacturing in the year 1996 at Pune, and soon was catering to all the projects across the country, notable amongst which were the Reliance refinery at Jamnagar, various Infosys complexes, various steel plants, cement plants, airports and infrastructure projects all over the country. From year 2000 we started our exports, when people felt it was impossible to export cables from India. For more than a decade we have won the Highest Exporter of Power Cables Award, and have been catering to more than 50 countries across the globe. After the Ravin cables joint venture with Prysmian, our exports have been stunted, and we might relook to enter the export market. We have a manufacturing unit in the UAE, which caters to the Middle East market, which is a joint venture with the government of Fujairah. On the cable front, we see little scope for price improvements and margins, because of huge overcapacity so what we are looking to do is to grow into other technology areas which are currently absent from the country . So we have executed EHV projects for major public utilities across the country, as well as undertaken various renewable energy projects for various customers around the country. We now specialize in tracker systems for Solar projects, and this we feel is an exciting area of growth, because it requires technology and intrinsic skill and knowledge of the market which is available with only very large players. We are happy to have acquired that skill.

Can you share with us about the latest technology that you have equipped your facility?

As explained above we have grown in a big way in the EHV projects and services and have done various projects right from 66KV to 400KV. We have specialization in tracker systems for solar products, and have also set up manufacturing facility to produce moisture removal systems for transformers which is in collaboration with a company from UK. Apart from this we are also into the retail energy products, which are today doing pretty well in the local markets. We do hope that over the next year's time we will be able to launch more high technology products, and will be able to cater to the Indian markets at affordable prices.

What products did you display at Elecrama 2014? Could you share details about the colour changing wire?

We displayed various products at Elecrama 2014, including the tracker system, our capability for EHV projects and services, the full range of cables that we manufacture, as well as our retail energy products and the power products equipments that we manufacture. One of our newly launched products is colour changing wire or cable which is formulated from R&D purely made in-house. When a wire or cable is subjected to stress i.e. it is either overloaded or it is subjected to physical stresses by way of bending or by excessive temperature outside etc. it mimics the human body i.e. the conductor starts getting heated, and the cable starts performing poorly. The human body also when is unwell or is subjected to stress or has fever, starts exhibiting signs of illness. Eyes become red, nose starts running, and there is a general lethargy and lack of energy. These signs are visible when one looks at that person suffering from fever. Taking reference to this natural phenomenon, our R&D team designed and produced a colour changing wire which changes colour when subjected to excessive temperatures. The best thing is that this wire regains its original colour once the temperature is back to normal, this product is the first of this kind in the world as far as we know and it is absolutely homegrown and home invented and was designed internally without any external assistance.

What was the experience and what did you anticipate from Elecrama 2014?

As you know we won the Best stall award in our category at Elecrama 2014 and we were a pretty popular stall during Elecrama. This was because of the hard work put in by all our people, and also because of the enthusiastic response that we received by the visitors. Of course we spared no effort in trying to have our customers and of course all the visitors enjoy a one of a kind experience during Elecrama 2014. This was a new venue and there were some areas which could have been better off but overall we are satisfied with the response we obtained from Elecrama 2014 and now look forward eagerly to the next Elecrama in 2016.

Where would you envision your company in the next two years?

Rather than talking about the company, I would like to talk about the Group, as the Group consists of various companies present in the electrical field.

About a decade or so ago, when we were purely a Cable company, we have now evolved and grown ourselves to be a truly diversified power products company. We see ourselves operating in six clear verticals, five of which have already been enlisted by me above and the sixth one is under development. With the five verticals we have already been identified among the key technology players in the electrical segment and with the sixth one coming in we aim to establish ourselves in the space as market innovators in the Power and energy sector and would always strive to give the best to our customers in terms of products as well as in terms of services.

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Boiler Performance for enhanced Thermal Power Station Optimisation

Boiler one of the key equipment in Thermal Power Generation Plant, operates for controlled transfer of heat energy from fossil fuel to water producing superheated steam safely and efficiently. Design of modern Steam generators or Boiler has gone through various phases of continuous improvement and presently mostly pulverized coal suspension firing reheat boilers are used in Coal based thermal power stations; however their type may vary depending on firing types.

Avijit Nayak

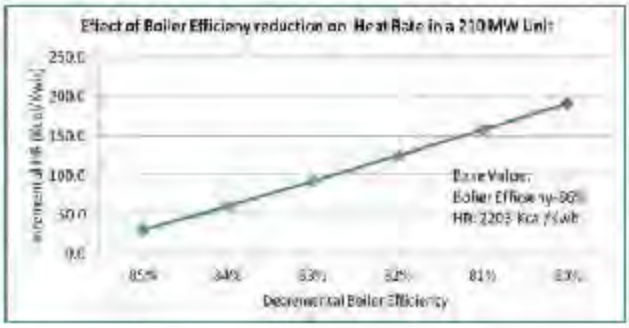
The performance of Boiler is one of the key factors for determining the plant performance in terms of Heat Rate. The Boiler efficiency shares an inverse relation with the Station Heat Rate. In a 210 MW plant with 2040 design heat rate and 2206 operational heat rate every one percent reduction in Boiler efficiency results in higher heat rate approximately by 30 Kcal/Kwh. (Heat Rate increases more on further detrimental Boiler efficiency)

Performance assessment is important for determining operational efficiency. Plant performance testing is being simplified through the use of automated data collection and processing devices. As – run Performance Assessment Tests can also be conducted as per ASME PTC 4.2 code or any other applicable code on steam generators for checking the operating efficiency against the guarantee and evaluating the performance improvement activities, as well as maintenance efficacy.

This article will discuss on performance evaluation of pulverized coal suspension firing reheat boilers and various key areas to be looked into for Boiler efficiency optimization.

Boiler Performance

The prescribed methodology for Boiler performance evaluation are carried out either by direct comparison on Input and Output Heat (Direct) or through segregating the Loss components by Heat Loss method (In-Direct). Though the Direct method is simple and gives an indicative figure of the operational efficiency, it cannot identify issues contributing to efficiency degradation. In-direct method or Heat Loss method quantifies all the loss components and evaluate Boiler efficiency by eliminating the loss figures. Heat-Loss method prescribes calculation of Losses like Loss due to Un-burnt Carbon in Refuse, Sensible Heat Loss in exit Gas, Moisture in Fuel, air and burning of H_2, Heat Loss due to carbon monoxide, atomizing Steam, Radiation & Convection loss from Boiler surface apart from an estimated figure of un-accounted losses. Basic in-situ instrumentation and few portable instruments are required for cross-checking key parameters. Recommended trial duration should not be less than 4 Hrs.



Prescribed methodology as per Test codes were followed for performance evaluation of a 210 MW 1986 commissioned pulverized suspension firing reheat boiler and the results vis-à-vis designed figures are presented as follows:

All the losses were calculated based on several trial readings of the Boiler. While Radiation & Convection loss can be quantified by study of temperature profile on boiler surface, the un-accounted loss was assigned a mutually agreed value. The unaccounted loss may include: Heat Loss in cooling water,

Heat in pulverizer rejects, sensible heat in flue dust, radiation to ash pit, un-burnt hydrocarbons, shoot blowing etc. Though it is possible for calculating these losses; the loss percentage is very minimal in comparison to other loss figures, therefore it is advisable to assign a mutually agreed value under head of unaccounted losses. Boiler performance degradation is not only because of problems associated with boiler internals itself but also the performance of Boiler auxiliary equipments greatly affect the operational efficiency. The following areas may be addressed to take up necessary up-bringing activities.

Fuel Characteristic

Boilers are designed for a design fuel. The design fuel is the basis for Boiler heat transfer area designing. Designing a steam generator for a wide range of fuel flexibility degrades the performance of the unit. Unless the steam generator is a mine mouth unit with a dedicated fuel source sufficient for the life of the boiler, it is difficult to ensure supply of design fuel. During the study of the above mentioned unit the following observation was made in respect of fuel fired vis-à-vis design fuel.

The above observed Grade of coal supply having GCV in range of 3500Kcal/Kg is the common supply to most of the power stations in India. It is also expected that the Heat value of fuel may further deteriorate. Firing fuel of lower heat value results handling & preparation of higher quantity of fuel, which increases auxiliary power consumption (APC) and burden on mills, burners, ash handling system associated equipments.

The high ash content results in lowering boiler efficiency, erosion of boiler tubes, clinkerisation (in case of coal having low ash fusion temperature) leading to outages. The balance draft of the boiler needs optimization to provide sufficient residence time for fuel particle for complete combustion and re-verifying the same from un-burnt carbon in refuse. The draft has to be re-adjusted based on change in fuel properties. The moisture content of the fuel also affects heat loss of the boiler and creates problem for achieving desired steam temperature. The typical performance deficiencies from firing off design fuels are failure to achieve superheat and/or reheat steam temperature, or excessive superheat and/or reheat de-superheating spray water. However the fuel properties are uncontrollable parameters and necessary corrections shall be applied to account the same.

S. No.	Parameters of Coal	Unit	Design	During trial
1	Fixed. Carbon	%	41	32.0
2	Volatile matter	%	21	17.0
3	Total moisture	%	6	6.5
4	Ash	%	32	46.5
5	G CV of coal	KCAL/KG	5000	3570.0

Sl. No	Operating Parameters	Unit	PG Test	Avg
A.	**Unit Information**			
A_1	Power Generation (Avg.)	MW	210	175
A_2	% Unit Loading	%	100.0%	83%
A_3	Steam Flow	TPH	645	530
A_4	% Of NCR	%	-	82%
B.	**Heat Losses In The System :**			
B_1	Unburnts In Ash :			
	Bottom Ash	%	2.0	1.3
	Fly Ash	%		0.8
B_2	Sensible Heat In Flue Gas	%	4.3	5.0
B_3	Moisture Loss In Fuel & H2	%	4.0	4.4
B_4	Moisture In Comb. Air	%	0.5	0.3
B_5	Radiation & Unaccounted Loss	%	1.7	2.0
C.	**Total Losses**	%	12.5	13.8
D.	**Boiler Efficiency**	%	87.5	86.2

Fuel Preparation & Firing

The fuel preparation parameters like size, temperature, Fuel Air ratio are the controllable parameters which has the impact on other losses like, Stack loss, un-burnt loss. The coal Mill being the major equipment for fuel preparation should have

capability to accommodate the fuel with the worst combination of properties that still allow the steam generator to achieve the design steam flow. Three fuel properties affecting pulverizer fuel processing capacity are: moisture, heating value, and Hardgrove Grindability Index. Before arriving at conclusion on Mill loading and energy performance, the mill capacity has to be corrected according to fuel properties. The fuel rank determines the pulverized fuel fineness requirement. The use of Low Nox burners present days because of strict environmental regulations result in further stringent fineness criteria. The burner performance also affects the loss percentages of Un-burnt loss.

Correct temperature of Mill output fuel also affects the combustion efficiency. Lower or higher Fuel mix temperature may lead to improper moisture removal or loss of heat value of the fuel, respectively. The primary air mixed with fuel is not only the fuel carrying media to the furnace chamber but also assists in combustion process. Lean or rich fuel mixture will affect the flame profile and combustion efficiency un-burnt etc. The Fuel Pipes to be balance for uniform heating profile. Also for Secondary air the wind box pressure to be optimized for proper Primary air & secondary air ratio. Air factor also contributes to un-burnt percentage on refuse. One of the basic functions of a steam generator is to produce steam at design temperature. There are both primary and secondary systems for steam temperature. Control mechanisms like gas flow control, burner positioning are advantageous than de-superheating spray.

Flue Properties

Flue properties (Constituents and temperature) give a direct indication of the combustion efficiency. Every Unit has online O_2 and temperature monitors for control operation of the boiler. Prescribed excess air level has to be maintained for complete combustion. Air ingress in Air pre heater being one of the common areas observed in plants. Frequent seal leakage, and achieving ingress close to the design value being a challenge for plant personnel. Requisite flue properties are not only important at chimney exit but also at each location in the flue path right from the furnace zone. The flue properties do have a direct impact on boiler efficiency as well as auxiliary equipment performance. During Flue analysis CO monitoring to be done and necessary corrective actions to be taken for minimizing un-burnt flue loss. ID, FD & PA Fans are to be balanced to achieve desirable Flue property and lower auxiliary power consumption. The draft adjustment has to be dynamic and in accordance with fuel characteristics.

Performance of Heaters & Economizers

The Boiler is nothing but a series of heat exchangers. Where LP & HP Heaters are there in Water side, in flue side there are radiative heat transfer zone (furnace) convective zone (Super heater, re-heater) Economizer and Air pre-heater (APH). Though Heaters (also Economizer) are a part of turbine cycle, but the performance of economizer and heaters greatly dictate the quantum fuel firing in boiler. Any deviation of water temperature in any of the heater affects the thermal loading of next heater or economizer in the series. This also dis-balances the heat flow both in water side as well as flue side. In creased thermal loading on any heater may lead to frequent tube leakage in economizer or heaters. The effectiveness of economizer may affect the performance of Air pre heater and change in Dry flue loss.

Fire Side Contamination

Cleanliness in boiler internals is one of the key factors for effective heat transfer from gas side to water side. Soot blowing is provided to clean the boiler tubes from the fire side deposits resulting from combustion of coal. The ineffective soot blowing leads to lower heat transfer to boiler tubes, wastage of thermal energy lead to higher exit flue gas temperatures which affect boiler efficiency adversely. Soot deposition also cause to loss of heat transfer in the main furnace area, leading to higher flue gas and steam temperature at super heater zone and higher de-superheater spray. Soot deposition in boiler tubes also may cause frequent boiler tube leakage and forced outages. However Shoot blowing process is itself wastage of energy therefore a balance to be maintained. As general approach, shoot blowing optimization may be approached through observing its impact on efficiency, on tube metal, steam & exit gas temperature and on reduction of fouling in specific boiler section. The optimization of shoot blowing needs to be a dynamic process. Water side tube cleanliness is equally important and scaling of tubes to be avoided by proper water chemistry control.

Outer Surface of Boiler

Though the radiation and convection loss accounts are normally limited within 1.5-2%, deteriorated boiler insulation may further escalate the loss. It is advisable to carryout thermal insulation mapping of the boiler surface and take-up remedial measures at regular intervals. The pay back on re-insulating or repairing damaged insulation is immediate in comparison to heat loss.

Conclusion

While Performance enhancement of new generation boilers is being continued effort by the manufacturers, ample scope exists to operate existing boilers close to best efficiency point by fine tuning operating and controlling parameters. This needs continual monitoring and trial evaluation of boilers. The modern generation plants use automated software applications for capturing, monitoring and analyzing boiler performance.

Profile

Avijit Nayak

working as Assistant Director (Energy Management) at National Productivity Council, is BE, has Post Graduation Certificate in Energy Management and has worked at CPRI, Bangalore. His experience includes energy auditing, energy conservation in thermal power stations, industrial establishments and electrical distribution system.

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Interview

"Fibox enclosure will guarantee that your equipment has protection"

Viren Shah, Country Manager
Fibox India Pvt Ltd

Fibox India Pvt Ltd is a Finland based MNC, 100% subsidiary of Fibox Oy Ab manufacturing the broad range of Standard polycarbonate and ABS plastic enclosures for the electrical and electronics industries. Fibox is the industry leader in developing both new products and new technologies for moulding thermoplastic enclosures with manufacturing base in Finland, Poland, Germany, Korea, China & US and is known for innovation and brilliant engineering. In an exclusive interview to **Electrical India, Viren Shah,** states, we use input from our global customer base to produce new enclosure ranges, useful accessories and on-going product improvements and enhancements.

➢ **What major trends do you perceive in the power sector domestically and globally?**

Indian market is full of opportunities for all the companies who has proper business plan. Power reforms have changed the dynamics of power sector. Power generation and distribution should continue to attract private investment. India is a country with high power demand and peak power deficits is a big market for any serious player in this business. Worldwide, many countries aware of the urgent need to make better use of the world's energy resources. Although renewable energy power generation has recently attracted attention, thermal power generation, which has long been supporting power supply, is also making great progress.

➢ **Could you brief about the activities being involved as country manager in the company?**

As Country Manager, I will have a wide array of tasks. The range of activities will include, but are not limited to: customer acquisition, sales negotiations, prospecting business opportunities, managing the Fibox India sales team, managing Fibox Pune site operations, and administrative and human resource related duties.

➢ **What is the scope of operation and product range of the company? Which of the products are in major demand?**

The FIBOX enclosure range features over 1000 different standard enclosures made of polycarbonate, ABS, fiberglass and aluminium. All our products are designed in close

cooperation with our customers. We use input from our global customer base to produce new enclosure ranges, useful accessories and on-going product improvements & enhancements.

The core products marketed in India are:

- MNX: Our bestseller, thermoplastic enclosure with IP 66/67 Protection & this range have over 260 versions.
- EURONORD: This range is designed to house DIN-rail mounted terminal block and Various types of sensors.
- ALU: Our ALU enclosure can be mounted almost anywhere so it's Just as well they withstand so much!
- PICCOLO: IP 66/67 thermoplastic enclosures mainly used for Pushbutton station & Sensor box application.
- TEMPO: These are easy to use because they are designed to save time and money in assembly and installation. Fibox Tempo is fully compatible with the most common PVC enclosures in the market.
- CARDMASTER: This range is ideal for packaging instrumentation, measurement, Monitoring and process control equipment. It provides two compartments - one for circuit boards and sensors with slots for printed circuit board insertion, and another one for terminal and wiring.
- MCE: Small type distribution boards or MCB enclosure with IP 66 protection.
- QUICK: Wall mounting cabinets are manufactured of high impact resistance Polycarbonate or ABS withstanding harsh industrial and outdoor environments.
- CAB: Major Impact resistance available with Hinged door & locking system & Available in PC, ABS & Polyester material with IP 65/66 protection.
- EK: Combinable and modular thermoplastic polycarbonate panel systems with IP 66 degree of protection upto 630A.
- Solid: This range is an excellent choice to house electronic and electrical components. It is available in polycarbonate and ABS with either screw or hinge covers.
- EX: These are specially made for use in hazardous environments. They are Designed,manufactured and tested to international standards. All certificates, such as ATEX/ IECEx, are issued by the manufacturer under license from a test authority. EX enclosures are made of either aluminium, polycarbonate or polyester.
- ACCESSORIES: This range provides excellent selection of cable glands, membrane glands flanges and cable entry solutions to easily manage cables with high IP rating.

➢ Fibox has introduced ARCA cabinets, designed for harsh and demanding environments. What are the features and their applications?

Fibox ARCA cabinets is a brand new range of robust Polycarbonate wall mounting cabinets which typifies the innovation and market driven approach to new product development. Over 2 years in the making, ARCA is a first, and the market now has what it has demanded, a viable and cost effective alternative to the many sheet steel cabinets which are being installed in totally unsuitable environments. In a nutshell, all the features of steel but the benefits of high grade thermoplastic. Here are few of the many features you will see in more detail further into the catalogue.

- No rusting – 100% corrosion free
- IP66 ingress protection
- IK10 Impact resistance
- Electrically isolated – 1500VDC
- Aesthetic design
- UV stabilized raw material – UL 508
- Can be safely machined without conductive swarf residue, in the workshop
- Flammability rating according to UL 94-5VA.

ARCA is recommended for SmartGrid, Water & waste water applications, automatic meter reading, pole mounting etc.

➢ Could you detail about company's involvement in the renewable energy sector and what are your expectations from it?

FIBOX serves renewable energy sector and provides a selection of enclosures ranging from standard enclosures to customized enclosures. FIBOX also offers entirely custom-made enclosure designs to meet specific customer requirements. FIBOX has a deep understanding of the customers' applications, a strong material and electrical engineering knowhow, rapid prototyping processes as well as wide enclosure range for protecting electrical and electronic components and systems. A FIBOX enclosure will guarantee that your equipment has the protection that it deserves. In solar energy segment these are our target applications.

- Tracking system control unit
- DC Switch & surge protection
- Generator access point & String connection
- Module Connection, Converter
- Analysis, monitoring & data control unit
- Charge controller (Off-grid)
- Traffic, Weather and Lightning Control (Off- Grid)
- Heating & Temperature Control Unit (Solarthermal).

Our expectations are very high. Since our products are well suitable with renewable energy sector, we are foreseeing huge opportunities specifically in solar segment.

➢ Who are the major manufacturers with whom you are involved in supplying customized enclosures?

We are directly or indirectly supplying customized enclosures to few major manufacturers. Some of them are our global key accounts.

➢ **What scope does the Channel partners or distribution network has got to boost sales?**

Fibox is friendly and professional organization. Fibox Channel Partner is a part of Fibox family. Fibox operates with one goal in mind i.e.of 100% customer satisfaction. Fibox is committed to provide the best quality products & our value is delivering our products with fast lead time to customers. This is possible only by making conducive relationship with our Channel Partners.

➢ **What major challenges do you see while introducing products in view of the competition in the same line of products made available by other manufacturers?**

Exchange rate-sinking rupee puts us in a difficult position with our pricing scheme. Since most of our competitor has started venture 10 years back, it is real challenge to compete and tackle the prices and margins.

➢ **Tell something about your manufacturing activities and expansion plans if any?**

Since India is a large and developing market, Fibox has made the decision to expand its geographical reach into India one year back. A No immediate plans to start molding. Fibox India started their sales in January 14 and Based on the next two years revenue targets achievements expansion plans will takes place.

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

I am an optimistic by nature and confident that, despite the present ups and down in our economy, with the laser focus on sales strategies along with our thrust on creating new opportunities, we will establish our position in the markets. Our vision is to serve and expand our reach to every corner of the India.

Workshop on DSM organized by UPERC and IIT Mumbai

Uttar Pradesh Electricity Regulatory Commission (UPERC) had jointly organized a Workshop on 'Demand Side Management (DSM) -Regulatory Perspective and Training workshop' with IIT Mumbai and Shakti Sustainable Energy Foundation (SSEF) at Lucknow on 4th April, 2014. The workshop was intended to help accelerating the DSM efforts by the stakeholders in the State. IIT Mumbai is involved in a Demand Side Management (DSM) project in collaboration with Shakti Sustainable Energy Foundation and had been given an opportunity to facilitate the capacity building measures for augmenting DSM leadership in the country.

Hon'ble Justice Karapaga Vinayagam, Chairperson, Aptel, inaugurated the program, and provided an opportunity to the State with his unique ideas on role of consumer in DSM, contribution in saving electricity, and in reducing the demand supply gap. This was incidentally his maiden visit in the largest state of India. He has made significant contributions in power sector dispute resolution with his focused and balanced approach emanating from his long experience as CJ of the Jharkhand HC and designated Senior Advocate of the Supreme Court. He was instrumental in shaping benefits of implementation of Electricity Act 2003 in its right tone and tenor in all the States. Earlier, the welcome address was given by Desh Deepak Verma, the Chairman, UPERC, IAS (retired), who joined the Commission as Chairman in September 2013. Welcoming the Chairperson's of APTEL and CERC, the apex power sector bodies in the country, he summarized the efforts of UPERC, and informed the gathering of the new draft regulations on the Demand Side Management, which the Commission had approved and proposed to implement and make it effective in the state of UP. Demand Side Management is described as the planning, implementation and monitoring of utility's activities, and is designed to encourage customers to amend their electricity consumption patterns, both with respect to timing and level of electricity demand so as to help the customers to use electricity more efficiently. Various factors such as increasing economic activity and population growth are resulting in additional pressure on ever increasing power demand when the State is already facing acute power shortage. The power shortage also causes the need for re-evaluation of Gadgil Formulae in reference of allotment of power to the State from Central Sector.

In such a scenario, DSM can complement supply-side strategies to help meet electric service demands by assisting utilities to avoid costly capacity additions by optimizing use of present supplies. UPERC has developed regulations on the basis of Modal Regulations as framed by Forum of Regulations (FOR) The one day DSM Training workshop was organized to give an hands on experience to the nominated participants from all across the stakeholders - Discoms, consumer organizations, the NGO, and the private sector utilities.

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Meter Data Management

After decades of declining investments in conventional energy distribution technology, utilities around the world are moving rapidly to employ new technology to extend the life of network assets, support renewables, and to improve power quality and reliability. At the same time, consumers faced with rising energy costs are looking for new energy choices and ways to become more energy efficient.

Tushar Pokhrankar

As there is demarcation between the consumer and energy supplier, the meter is authoritative source of information about the energy purchases by the consumer. At the same time, it is a uniquely positioned to monitor for distribution network operations and power quality at the point of delivery. Smart Metering or Advanced Metering Infrastructure (AMI) is applied to instrument for the delivery of these vital commodities to consumers. This instrumentation with remotely read "smart meters" provides more frequent access to information about energy consumption as well as finer detail such as energy use every 15 minutes. Smart meters also inform of critical events such as power failures and other critical operating conditions. And with remote communications these devices support operations that previously required a human visit to the consumer premise.

While these features are powerful, there are challenges. With the massive amount of data and new operational capabilities, it is not surprising that conventional utility information systems are not prepared. A plethora of new applications and services will emerge from this newly available information resource. Further complicating the situation is that AMI systems vary greatly in functionality and integration, and there are many legacy AMR and meter reading systems to consider. With this in mind, Meter Data Management (MDM) a new enterprise software platform bring together these new information sources and remote operational capabilities with existing and new business applications to better serve energy consumers, suppliers, and distributors.

MDM leverages the new, smart meter-based information to support the needs of AMI operators, and the transformation of network, market, and customer operations. With MDM, each part of the organization can rely on the platform as the "system of record" for up-to-date energy usage information and use that information with confidence for myriad operational and analytical purposes.

The Meter Data Management (MDM) system delivers event-driven information and automation in real-time to integrate utility operations and enable business applications delivering Meter-to-Cash, Consumer Engagement, and Operations Automation capabilities to the enterprise. With MDM utilities can-

- Reduce operating cost
- Optimize distribution and use of energy
- Rapidly adapt to changes in regulatory and business requirements
- Enable smarter energy decisions and informed behavior
- Improve customer satisfaction

MDM has three major functions:

- Acting as a highly flexible platform for linking multiple AMR/AMI and grid technologies with utility business information systems
- Providing highly scalable meter data processing and management as well as a common system of record to support Smart Grid Management functions
- Enabling business process integration and automation for Smart Grid Management.

MDM supports all aspects of smart meter deployment and operation for the mass market as well as Residential, Commercial and Industrial (C&I) customers. It captures the complex relationships among assets, premises, customer accounts, users, applications, and services that must be managed in any successful smart meter network. Incorporating automated business processes and workflows, MDM goes beyond to integrate utility operations and drive efficiencies. MDM platform architecture to be the most reliable and cost-effective for the following reasons:

- Centralization of all smart meter data management activities that links for example data collection, management and warehousing. The result is fewer personnel and less friction between business units than if these functions were separated into different departments.
- All smart meter data activities are placed in a platform focused on meter or other endpoint data. Reliable and efficient operation of that platform is its sole mission.
- Effective and safe management of the typical situation of utilities using multiple networks and technologies on the one hand, and multiple utility core business systems on the other.
- Reduced maintenance costs for both the networks and the utility business systems. Those systems can be operated, maintained, and even replaced, on an individual basis and without requiring major modifications to the other interconnected systems.

MDM supports all aspects of smart meter deployment and operation for the mass market as well as Residential, Commercial and Industrial (C&I) customers.

MDM core application components provide the flexible capabilities to process and prepare data from the AMI systems by performing various validations and integrity checks using configurable rule sets to ensure data is ready for use. These core processes are entirely event driven such that when data is received at an AMI Adapter interface it is instantly processed and prepared for use by any application, be it billing, web presentation to a consumer, delivery to a market interface, an analytic application or utilities IT systems.

The MDM core processes include extensive data version management features that ensure that any updates or changes in data are auditable and completely traceable. And once the information is recorded in the MDM data repository it is immediately available to any application using standards based web services and APIs.

MDM includes a powerful data synchronization engine that is used to keep the MDM data model in constant lock-step with other external "systems of record". For example, the Customer Information System will generally be the source for any information relating a consumer and account to a particular service delivery point. While a geo-spatial system may be the system of record relating a distribution transformer or circuit to that same service delivery point.

MDM core services provide these data acquisition and relationship maintenance functions described above. And as new data is streamed into the MDM repository, additional MDM core services provide a framework for building applications that react to event data, generate and process exceptions, initiate workflows, and prepare data for external delivery such as for billing or market settlements.

The diagram below illustrates how MDM core services and applications are organized and how they interact using a high performance message-based communications.

This loosely coupled architecture follows SOA principles and ensures flexibility as well as scalability in the face of changing requirements and new applications. Integration methods are also flexible, with support for web services transactions, JMS messages, and file-based interfaces all sharing a common IEC CIM-based schema.

India has one of the largest grid and electrical distribution network and it ranks fifth in the world. The size and complex nature of this grid and distribution system has posed serious challenges to the Indian Power Sector. Non technical losses, large outage period, power theft, reliability issues, poor bill collection are few of the problems being faced by the Indian power sector. Siemens with its long experience in the energy domain has answers to meet the challenges.

With metering and communication services from Siemens, data can be used to make power flows more transparent, metering at commercial boundaries more precise, processes more efficient and revenues more dependable. They're just some of the ways we're turning energy data into energy intelligence – making the future smarter.

Profile

Tushar Pokharkar

is a domain expert on Advanced Metering Infrastructure (AMI) and Smart Grid Applications. He works as the Solution Architect & Business Development Executive for Smart Metering Solutions in Siemens Ltd.

Vorecon variable speed planetary gear

regulates boiler feed pumps in power stations

According to a statement issued by the Indian Central Electricity Authority (CEA), the energy capacity in India is expected to increase by 82,000 MW by 2017. This high energy target requires technical solutions. A trend to so-called supercritical power stations with capacities in excess of 660 MW is becoming discernible in the power station industry. "The importance of high-efficiency power stations is growing parallel to the increasing demand for power," says Carsten Lenz, General Manager Sales "Variable Speed Drives" at Voith. The Vorecon variable speed planetary gear is particularly suitable for use in such power stations because of its excellent overall efficiency.

Compared to conventional power stations, these advanced systems operate with temperatures of up to 600 degrees Celsius and pressures of up to 300 bar. This increases the energy efficiency of the steam process. Raw materials are used more effectively – more electricity is produced with the same amount of fuel. This reduces emissions at the same time.

GMR, Indian infrastructure construction company, is currently building a high-performance, 685 MW supercritical coal-fired power station in Raipur, in the federal state of Chhattisgarh, India. To achieve the maximum in efficiency, the power station builder has opted for a state-of-the-art driveline system. The boiler feed pump configuration is 3x50 % electric motor driven. While two of these motors permanently drive the boiler feed pump, the other motor is responsible for start-up and stand-by operation. The efficiency of the drive system is considerably higher than that of the conventional driveline with steam turbines.

Voith's Vorecon is used to provide an effective speed control of the boiler feed pumps. This hydrodynamically variable speed planetary gear also increases the overall efficiency of the station. The hydrodynamic variable speed planetary gearbox is particularly well-suited for speed control because of its excellent efficiency. In the future, a total of six Vorecons of type RWE 14.5 F8 will regulate the speed of the electric-driven boiler feed pumps at the GMR Raipur power station.

The overall efficiency of the driveline is thus 2% higher than comparable electronically speed controlled drive systems. The mean time between failures (MTBF) of the Vorecon of 48 years is impressive; its statistical reliability of 99.98 % is just as noteworthy.

Voith Turbo, a Group Division of Voith GmbH, is a specialist for intelligent drive solutions and systems. Voith sets the standards in the energy, oil & gas, paper, raw materials and transportation & automotive markets. Founded in 1867, Voith generates € 5.7 billion in sales, operates in over 50 countries around the world and is today one of the biggest family-owned companies in Europe.

Vorecon Reliability Study 2013

	2006	2018
Objective		
Power rating [kW]	300 to 11 931	600 to 31 200
Pump speed [rpm]	495 to 1642	495 to 1673
Reported units	89	201
Reported operating hours [h]	2095921	6065000
Reported downtime [h]	546	1743
Results		
Reliability [%]	99.97	99.98
Mean time between failure (MTBF) [years]	39	48

Table 1: A current study shows that the availability of the Voith Vorecon variable speed planetary gear is 99.98 % and its MTBF is 48 years.

Fig. 1: Voith Vorecon, Type RWE 14.5 F 8, regulates boiler feed pumps at the GMR Raipur supercritical coal-fire power station in India

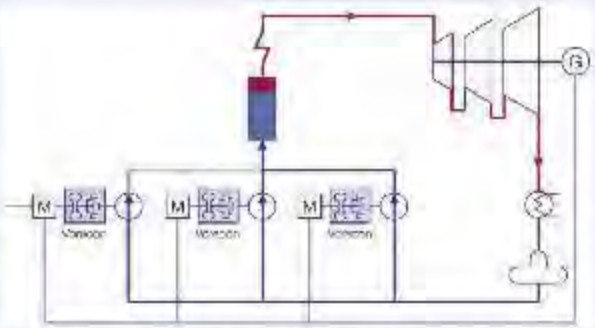

Fig. 2: Modern power station concept with three drivelines for boiler feed pumps and integrated speed control by Voith Vorecons.

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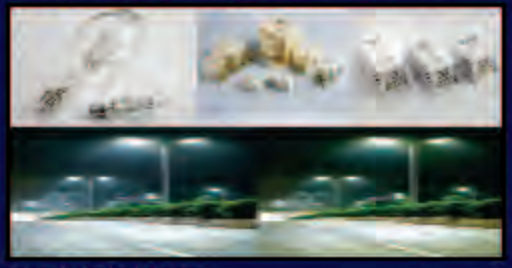

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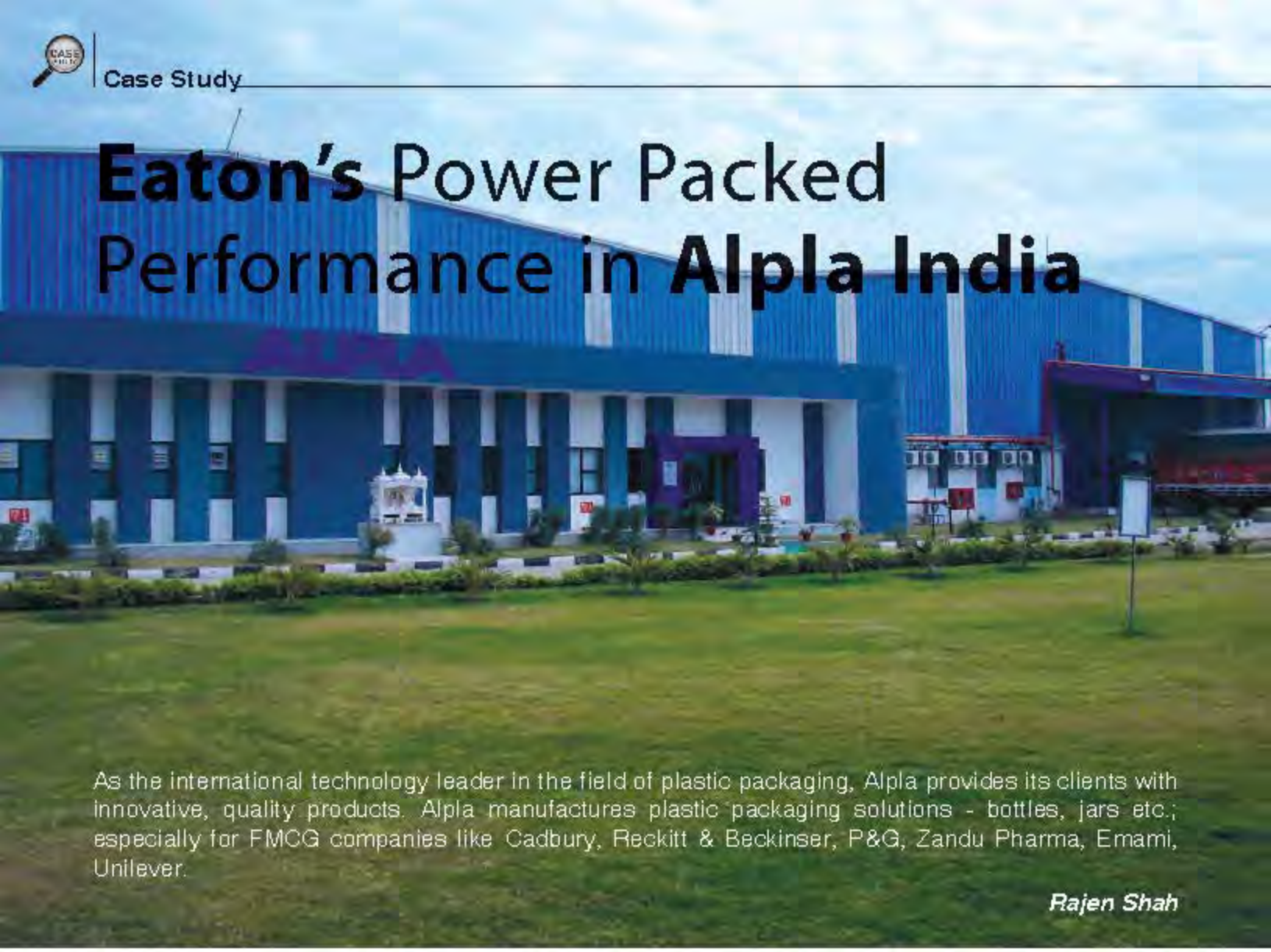
Can be rep aced n the existing Fixtures

Eaton's Power Packed Performance in Alpla India



As the international technology leader in the field of plastic packaging, Alpla provides its clients with innovative, quality products. Alpla manufactures plastic packaging solutions - bottles, jars etc.; especially for FMCG companies like Cadbury, Reckitt & Beckinser, P&G, Zandu Pharma, Emami, Unilever.

Rajen Shah

Alpla uses K- TEC Injection Molding machines (manufacturing double colored products) with a special designed mould in all its plants to manufacture plastic packaging products.

K-TEC, one of the most productive injection molding machines available on the market today, is known for exceptional precision and repeatability, fast cycle times, high injection rates and pressure and parallel functions. In the areas where Alpla India's plants are located, power cuts are frequent and last for a minimum 5 mins to many hours. Power failures and power incidents increase the chances of breakdown of Alpla's machines and the mould tool.

A power incident can be a Power Failure, Power Sag, Power Surge to Under voltage, Over voltage and onwards to Switching transients, Line Noise, Frequency Variation and Harmonic Distortion. These power incidents can lead to material wastage and productivity loss leading to a loss of business and loss of reputation.

Rajen Shah, Vice President - Engineering, Technology & Operational Excellence, Alpla India, says, "Our plants run on 80- 90% capacity at all times. We needed a power quality solution with very high availability. For us downtime translates into huge monetary losses. Continuous and Quality power is very essential for Alpla otherwise the Mould tool and K-Tec machines get damaged. The tools are very expensive and replacing them takes a long time."

Eaton 9395 offers the highest reliability® and availability with Powerware Hot Sync paralleling, superior battery management, inherent redundancy and a scalable architecture that adapts to increasing power requirements.

Solution

With prospects of huge production losses staring them in the face, due to daily power incidents, Alpla India started looking for an efficient, cost effective UPS with over 90% availability.

"Initially we had thought that genset solution coupled with utility power would be sufficient to service our needs. But the low quality and inconsistency of utility power supplied, made us do a major rethink," Rajen says.

Alpla started the sourcing process for a UPS suitable to their unique requirements.

Choosing Eaton

Eaton scored where others didn't. It offered a low TCO (Total Cost of Ownership) product, with company backed service support, thereby making it a superior solution amongst contemporaries.

The energy-efficient Eaton 9395 UPS provides backup power and scalable battery runtimes in a small footprint for critical manufacturing applications. Eaton 9395 efficiency was showcased to Alpla through Eaton customer sites where the product was working successfully.

After careful evaluation, Alpla decided to go for Eaton 9395 UPS with two units of 550 kVA each, at Sitarganj initially. Rajen says, "We were impressed with 9395 features like ESS, its efficiency and modular solution."

Eaton 9395 Energy Saver System (ESS) dramatically increase UPS efficiency without sacrificing protection, all the while reducing energy costs and putting money back into the budget. ESS technology enables UPS efficiency to reach an impressive 99%. It also allows the UPS to switch between three configurable operating modes.

Eaton did a Power audit and load study in Alpla facility before suggesting the appropriate power solution. Three units of Eaton 9395 550 kVA UPS, are now powering Alpla's K-tec machines at Sitarganj and Baddi.

Eaton Castle UPS, two units of 30 kVA each, are backing up Alpla's IT infrastructure and machines in Test Labs at Baddi and Hyderabad.

Installation

The installation process was smooth. Eaton 9395 not only reduces installation time and it also reduces costs with small footprint and flexibility to install against walls, using top- or bottom-entry cabling. Moreover, front-panel access for all services and operation increases serviceability and reduces repair time. "We were surprised with the ease of installation which was completed in good time, and with minimum disruption in our running operations," says Rajen.

External Audit

Alpla India got an external audit done on Eaton 9395 550KVA UPS installed in their Sitarganj facility from Zera, a german company considered a pioneer in meter test equipment. ZERA was founded in 1920 and specializes in electricity meter testing.

Many of its customers are electric supply companies and government metrological institutes. The results announced by Zera on 9395 installed in Sitarganj were as follows:

Alpla was delighted to see the results of this efficiency test, and found its decision to install Eaton UPS validated.

Operation

Since installing the UPS', with India's nascent utility power conditions, Alpla India experiences around 8-10 power incidents besides power failure in a day. These incidents can lead to major damage in sensitive and expensive equipment apart from damaged production and man-hours. But Eaton UPS installed in three facilities of Alpla India carry all equipment irrespective of incidents. "We have not had downtime or systems' damage ever since we installed Eaton UPS and we are absolutely confident that the Eaton UPS will deliver impeccable uptime," according to Rajen.

ZERA
India

WERKS- Prüfgeschein	Seite / Page	3 von / of 3
TEST REPORT	Prüfgeschein Nr. / Test Report No.	Zera(I)/10-11/066

- Measurement taken in Energy Saving Mode of UPS

Energy logged at Input of UPS (in kWh)	Energy logged at Output of UPS (in kWh)	Efficiency (in %)
5838.93	5857.45	99.38

- Measurement taken in Online Mode of UPS

Energy logged at Input of UPS (in kWh)	Energy logged at Output of UPS (in kWh)	Efficiency (in %)
100.06	94.70	94.64

After Sales Service

Alpla was very particular about insisting on a proactive service support in real time. Their production processes can derail from power incidents and this affects productivity and onward sales. "We have got an excellent and proactive service support from Eaton team, and find them quite flexible in their approach," says Rajen.

Expansion Plans

"Alpla plans to spend about Rs 50-100 cr for capacity expansion in this year and next, across India. For this, our power back up equipment needs to be foolproof. We are happy to see that Eaton 9395 has a flexible, upgradeable architecture for future expansion needs. We are also evaluating Eaton products for our South Asia and South East Asia operations," Rajen comments. To cater to its expansion plans, Alpla sought an efficient and reliable solution which could expand with the needs of the company. "We wanted a scalable Expansion Plans solution which we could rely on, for our constant & critical system needs."

Conclusion

Alpla India's systems and equipment are safe from utility power damage. They are now able to-

- Provide the highest level of availability for their critical systems at all times.
- Benefit from cutting-edge technology, with the UPS's advanced design.
- Energy Saver System (ESS) dramatically increase the UPS efficiency without sacrificing protection, all the while reducing energy costs and putting money back into the budget.
- Achieve redundancy for enhanced reliability.
- Easily maintain and service the UPS solution.

Customer Speaking

"We have not had downtime or systems' damage ever since we installed Eaton UPS and we are absolutely confident that the Eaton UPS will deliver impeccable uptime."

Rajen Shah
Vice President - Engineering, Technology & Operational Excellence, Alpla India.

WeSchool: Swedish renewable energy companies collaboration with Indian partners

The 'India-Swedish Collaborations for Innovative Energy Solutions' concludes on April 23, 2014 at WeSchool campus in Mumbai. The initiative is led by India-Sweden Innovations' Accelerator (ISIA), a bilateral program that will contribute to facilitating technology transfer and market entrance in India for Swedish innovative companies, focusing on scaling and adapting their technologies in the renewable energy space to the local context. This initiative aims to support Indian government's plans to reduce dependence on fossil fuels and increase capacity of renewable energy. Ministry of New and Renewable Energy of India has made a plan for a capacity addition of about 30,000 MW power during the 12th Plan period (2012-17) from various renewable energy sources mostly through private sector participation in the country. MNRE aims 20,000 MW grid power from solar energy by March 31st 2022.

The Initiative is supported by Swedish Energy Agency, Business Sweden and Confederation of Indian Industries (CII) – Green Business Centre. Prin. L. N. Welingkar Institute of Management Development & Research (WeSchool) and Mälardalen University are the academic partners.

Based on a 2009 EU directive to promote development of renewable energy sources, Sweden aims to increase renewable energy to 50% of national supply by 2020. The present 48% figure for renewable energy – including electricity, district heating and fuel – is higher than that in most EU countries.

Indian energy companies like Sahara India Pariwar, Reliance Infrastructure Ltd, Tata Power, Ultratech etc attended the event seeking potential partnerships with Swedish counterparts like Opcon, S Solar, HiNation, FOV Biogas, Clean Motion etc in the form of joint ventures, mergers, acquisitions and the like. The initiative will be taken forward by 11 teams which will comprise of one Indian company and one Swedish company in each team. The teams will also comprise of a total of 35 students from WeSchool and Institute for Future Education Entrepreneurship and Leadership (iFEEL), who would be working together for the next few months to create future proof business models that can be implemented in the Indian market. Also, technology innovations from Sweden included both Business to Business and Business to Customer solutions with emphasis on solutions for the rural market as well.

Over Five Golden Decades of dedicated service to Power Sector

For over five decades now, one name has facilitated Applied Research in electrical power engineering, enabling Testing and Certification of electrical Power Equipment as an independent Third Party Agency - CPRI. The institute is renowned Internationally as a reputed brand and well-recognised for its quality and excellence. CPRI is also adequately equipped with advanced infrastructure to handle Collaborative Research with Academic Institutions and Training to Utilities/Industry.

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Enabling Smart Grid Security through **Transaction Risk Profiling**

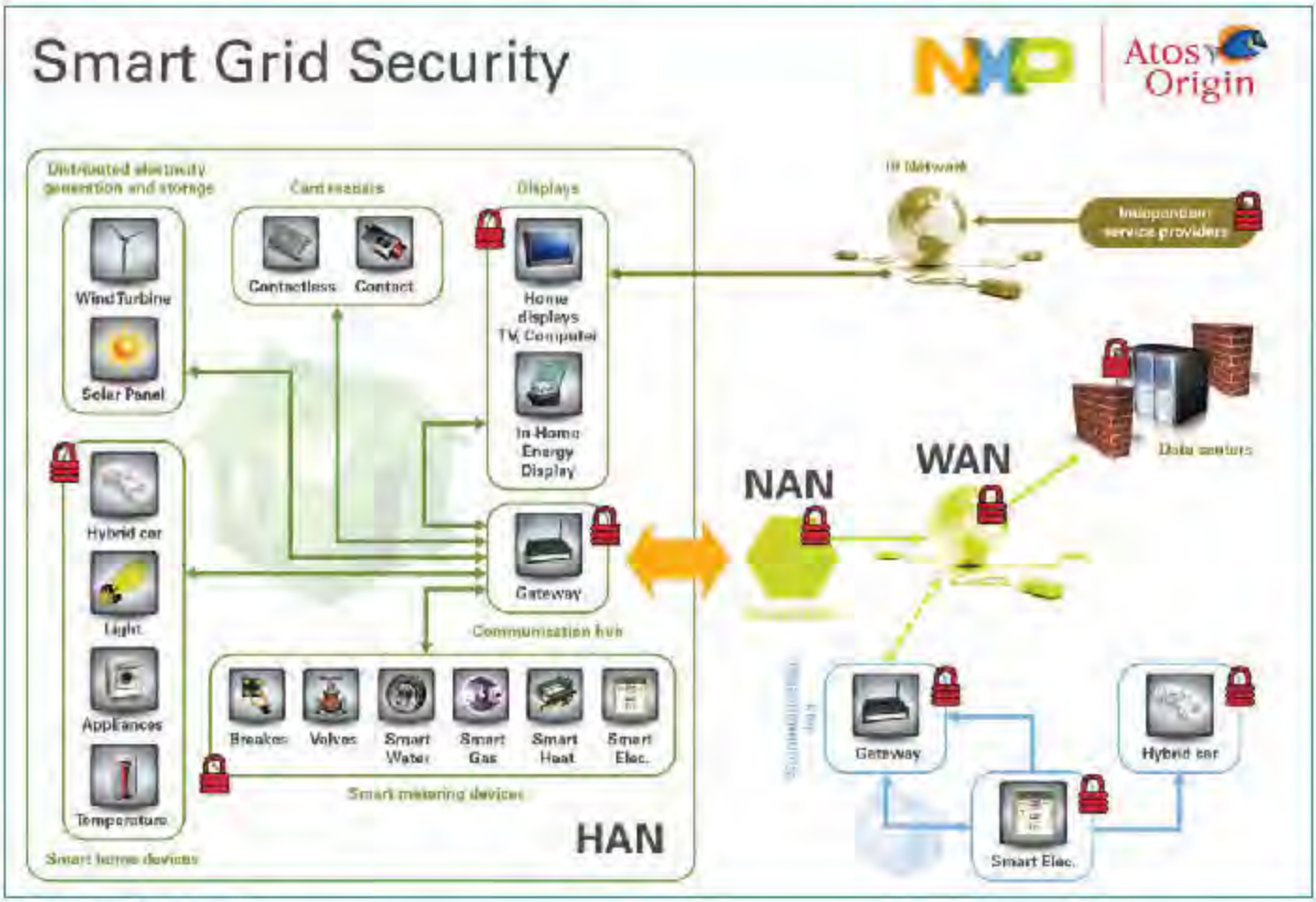

Fig. 1: Smart Grid Security
(www.32bitmicro.com) http://www.32bitmicro.com/articles/949-smart-grid/904-nxp-end-to-end-smart-grid-security-diagram

In this "the information age", units of information are synonymous with units of money and power. The rise and growth of e-commerce has resulted in widespread proliferation of credit card use, which, in turn, has consequentially given rise to credit card fraud – both in terms of quality of technique employed and quantity of occurrences. Concurrently, smart grid has emerged as the next-generation power grid via the convergence of power system engineering and Information and Communication Technologies (ICT); as a result of which, is susceptible to attacks in both the physical and the cyber spheres of operation. This article initially explains the nature of transaction risk profiling techniques before comprehensively tackling the question of a coherent framework for smart grid security. Following a brief discussion of the fundamental security techniques, an innovative graph-based dynamical system modeling approach for cyber attack impact analysis of the smart grid network.

Nirmal S Kartha, Saji K Mathew & Swarup K S

Subsequently, the article makes a brave attempt to tie up credit card fraud detection and smart grid security through a comparative analysis of credit card (Fraud Detection Methods) FDMs, which could be used as a benchmark to select a particular model as the choice for suitable Intrusion Detection System (IDS) in smart grid networks.

Smart Grid described in terms of information technology is nothing but e-commerce which enables purchasing and sale of electricity in real time through, enabling the consumers the choice of electricity though competition. Purchasing electricity by means of a credit card is a dream of the future. However the credit card is a small plastic card issued to specific users as a method of payment. Globalization and an increase in e-Commerce activities have resulted in the widespread proliferation of credit card users and transactions throughout the world. Currently, the most effective fraud screening tools are Transaction Risk Profiling/Scoring techniques that essentially sift through incoming transactions, employ machine learning algorithms and user databases to assign a "Suspicion Score" to each transaction and come to a decision about the authenticity of the transaction in question. Since Transaction Risk Profiling techniques provide comprehensive protection to intrusion in credit card networks, it would be intelligent to implement them as Intrusion Detection Systems in the smart grid network architecture. Also, before applying conventional Vulnerability Analysis on power utilities, it is imperative to have a framework for cyber attack impact analysis to understand the potential and severity of attacks.

Smart Grid Security

Ubiquitous adoption of electronic devices and complex electricity usage has rendered the traditional electric grid outdated, specifically its centralized management and unidirectional distribution channels. The next-generation smart grid, is expected to achieve the lofty goals of improved reliability, efficiency and security. However, combining the power grid and a communication network inevitably leads to attacks in both the physical and cyber space. Fig. 1 Shows the architecture of smart grid security. Hence, it is imperative to develop systems that ensure that the smart grid is tamper-proof and stays that way. Conceptualizing and designing the aforementioned systems would be more rigorous and fruitful with knowledge of the smart grid network architecture.

Smart Grid Network Architecture

The smart grid network is the necessary communicating platform for monitoring and controlling the grid operation. The hierarchical smart grid network structure includes several layers, as shown in Fig. 2 Residential Layer, Community Layer and Regional Layer. At the bottom layer are residential networks, each corresponding to a distinct customer. A residential network has a star-like topology, composed of a smart meter at the center and a few control switches (if any exist) at the periphery. As the interface of the network, the smart meter provides real-time raw metering data to the control center at the top layer, and detailed energy usage and cost information to the customer. It also accepts control commands from the upper layers to connect/disconnect particular appliances (through pre-installed control switches) for load balancing purposes.

At the middle layer are community networks. A community network connects the residential networks, intelligent electric devices (IEDs), and remote terminal units (RTUs) in a neighbourhood together. Data storage devices may additionally be included in the network to support networked storage, local fault diagnosis, and distributed decision-making. There is a communication gateway in each community network. It manages the communication among the network elements, performs data aggregation, and bridges the bottom and top layers to allow data exchange.

At the top layer are regional networks. A regional network connects the community networks, power plants, renewable power sources, substations, feeders, and other grid devices in a geographic region. Dedicated hub nodes may be deployed in the network to build a multiple-hop overlay structure for efficient and reliable data

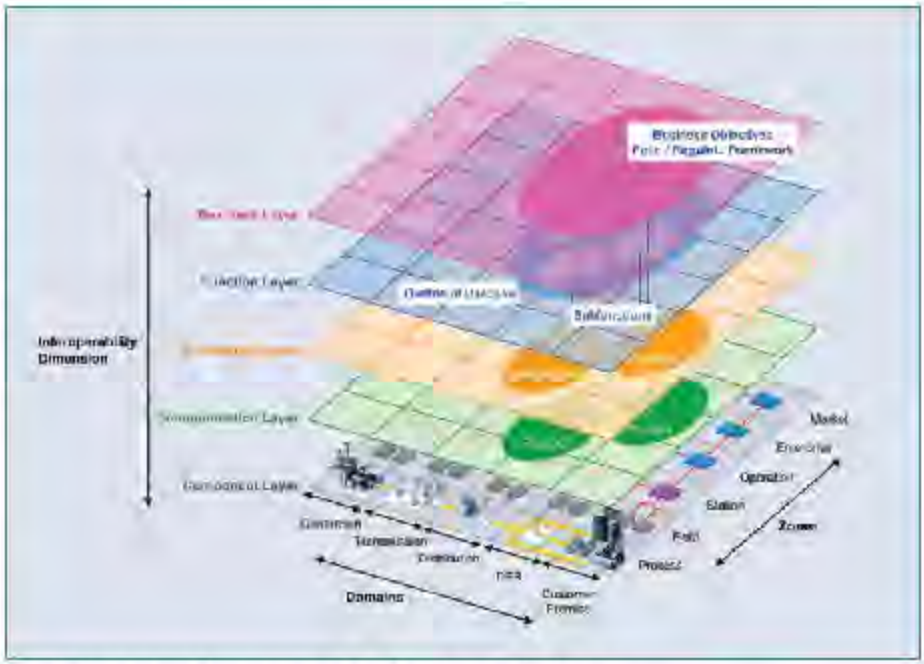

Fig. 2: Hierarchical 3-layered smart-grid network architecture (http://www.datacenterdynamics.com)http://www.datacenterdynamics.com/focus/archive/2012/05/siemens-promotes-smart-grid-architecture-model-0

communication. A control center is implemented in each regional network. It provides SCADA functionalities in the regional grid: collecting electricity usage data and grid operation status, detecting and responding to anomalies, and optimizing power generation, transmission, and distribution. In the architecture shown, each network is realized by high-speed wired or wireless links or a combination thereof, and runs IP based communication protocols. Supporting IP allows devices with different physical details to e effortlessly integrated and managed in a unified way. Furthermore, control centers, community gateways, and smart meters are connected to the Internet. Through the Internet connections, customers may access their own electricity use and cost information, utilities may obtain electricity usage information at different granularities, and control centers may share data and coordinate to make interregional decisions.

Conventional power grid employs dedicated power devices, which are usually integrated with control and communication functionalities, and uses closed networks composed of reliable, predictable serial communication links. In contrast, smart grid will decouple the communication and control functionalities from power devices, and be modularized from the expendability and maintenance perspectives. Its components will largely be commercial off-the-shelf products from different companies that may have unknown incompatibilities, and adopt broadband communications and IP-like technologies which are error-prone and have nondeterministic behaviors. This transformation inevitably decreases system operation reliability.

Since smart grid is a combination of the power grid and a communication network, security attacks may take place in both the physical space, as in the conventional power grid, and cyber space as in any communication network. A power device is traditionally located at a protected place (e.g. substation) and controlled through physical contact or following proprietary proto- cols via dedicated wired communication links. In smart grid, a power device is often microprocessor-based and running public protocols, the specifications of which can be obtained readily (e.g., from the Internet) by anyone interested. Also, it may have a human-machine interface and very likely support wireless connection for easy access. The increased openness conveniences adversaries and brings additional security vulnerabilities to the grid. In conventional power grid, there is normally only one access point to the grid management system in a neighbourhood. In smart grid, smart meters are massively deployed as access points, one per customer, in order to engage customers in utility management. They are connected to the inter- net for ease of management. These access points are ideal portals for intrusions and malicious attacks. As computer communications is extensively used in the grid for implementing advanced monitoring and control, the grid becomes increasingly like a computer network, and as a result, all kinds of cyber attacks present in computer networks will have their analogs in smart grid, with the purpose of jeopardizing the grid system.

Security Challenges in Smart Grid

With the elaborate smart grid architecture and composition as well as real-time grid operation status information, control centers may easily ensure power efficiency by applying optimization techniques to find the best power generation, transmission, and delivery strategies with respect to given constraints. Fig. 3 shows the important security challenges faced in smart grid. In smart grid development, major challenges lie in the delivery of reliability and security. Conventional power grid employs dedicated power devices, which are usually integrated with control and communication functionalities, and uses closed networks composed of reliable, predictable serial communication links. In contrast, smart grid will decouple the communication and control functionalities from power devices, and be modularized from the expendability and maintenance perspectives. Its components will largely be commercial off-the-shelf products from different companies that may have unknown incompatibilities, and adopt broadband communications and IP-like technologies which are error-prone and have nondeterministic behaviors. This transformation inevitably decreases system operation reliability. Faults caused by component incompatibility and communication failure will occur. In order to reduce greenhouse gas emissions,

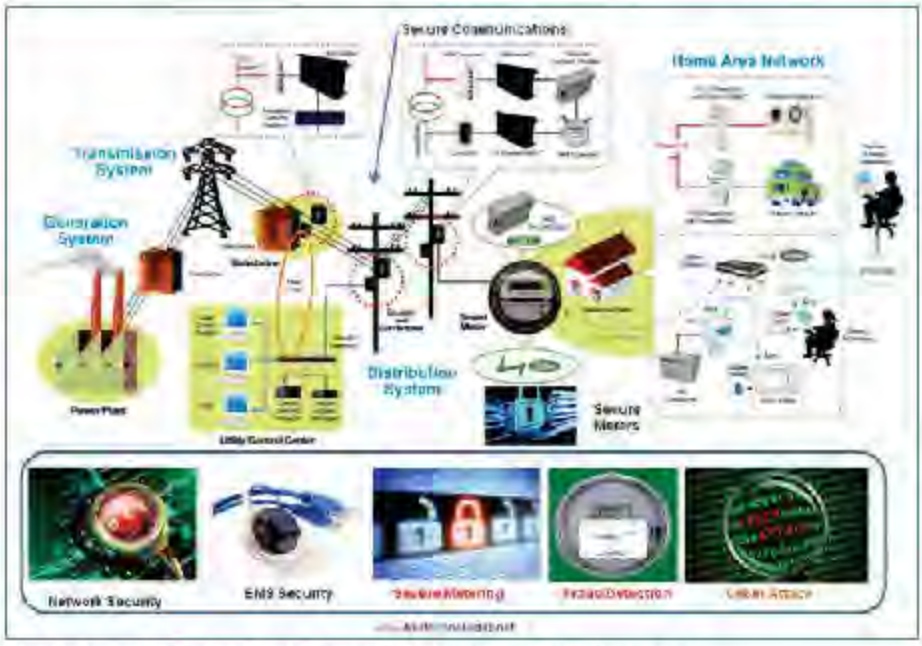

Fig. 3: Security Challenges in Smart Grid (www.bectechnologies.net)

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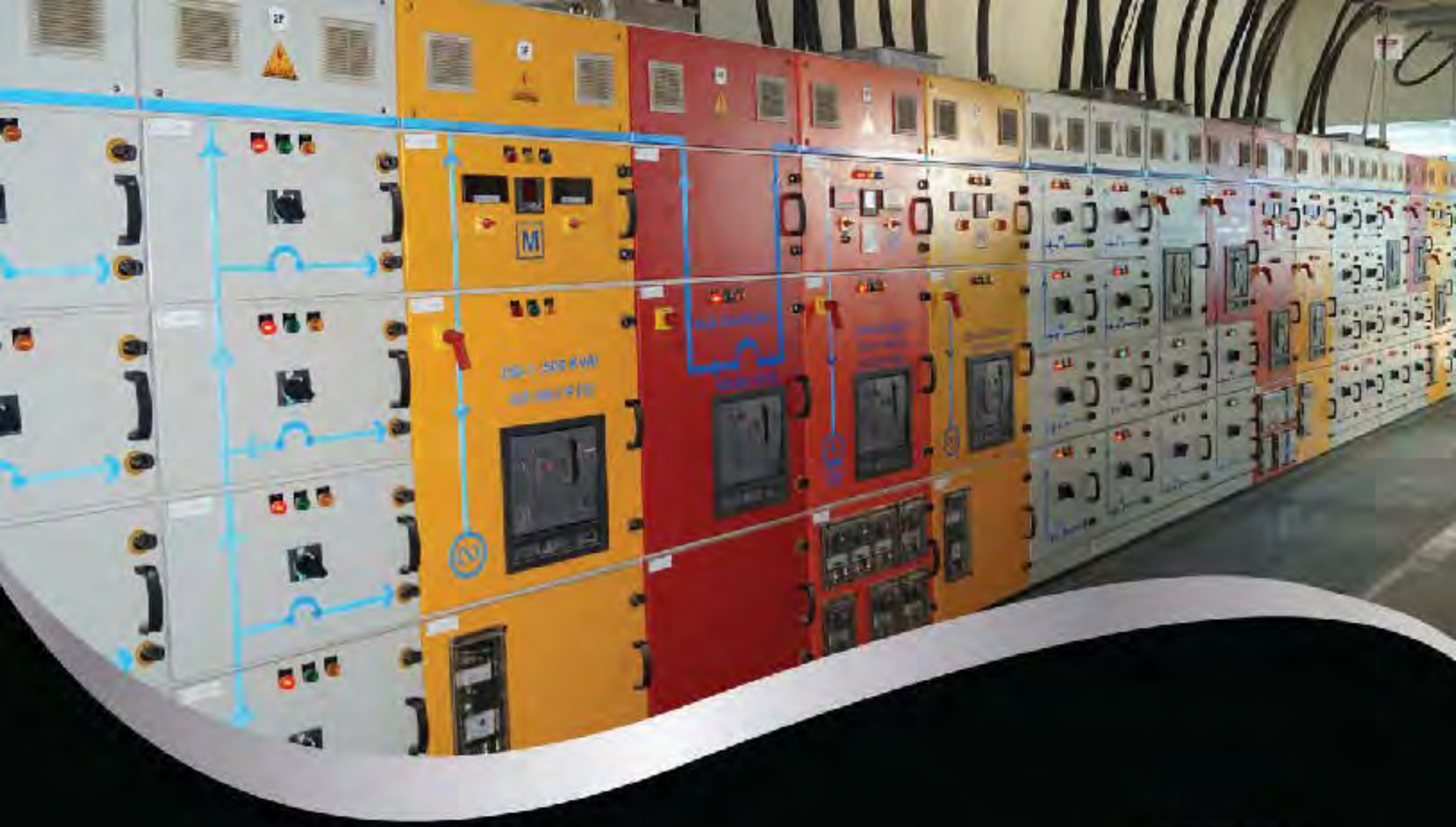

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renewable but unstable power generation by, for example, PV cells and wind turbines will be accommodated in smart grid.

Since smart grid is a combination of the power grid and a communication network, security attacks may take place in both the physical space, as in the conventional power grid, and cyber space as in any communication network. A power device is traditionally located at a protected place (e.g. substation) and controlled through physical contact or following proprietary protocols via dedicated wired communication links. In smart grid, a power device is often microprocessor-based and running public protocols, the specifications of which can be obtained readily (e.g., from the Internet) by anyone interested. Also, it may have a human-machine interface and very likely support wireless connection for easy access. The increased openness conveniences adversaries and brings additional security vulnerabilities to the grid. In conventional power grid, there is normally only one access point to the grid management system in a neighborhood. In smart grid, smart meters are massively deployed as access points, one per customer, in order to engage customers in utility management. They are connected to the Inter- net for ease of management. These access points are ideal portals for intrusions and malicious attacks. As computer communications is extensively used in the grid for implementing advanced monitoring and control, the grid becomes increasingly like a computer network, and as a result, all kinds of cyber attacks present in computer networks will have their analogs in smart grid, with the purpose of jeopardizing the grid system. To conquer the above reliability and security challenges and realize the ambitious vision of smart grid, innovative research is expected in all aspects of smart grid, from high-level architecture design to low-level implementation detail. With the information presented above in mind, the study proposes a taxonomy of cyber attacks and discusses resistive measures to enable smart grid communication. Combining the power grid and a communication network inevitably leads to attacks in both the physical and cyber space. The smart grid network is the necessary communicating platform for monitoring and controlling the grid operation.

Cyber Attack Taxonomy

Under the classification, cyber attacks are grouped into 4 categories:

- Device Attack
- Data Attack
- Privacy Attack
- Network Availability Attack

A device attack aims to compromise (control) a grid device. It is often the initial step of a sophisticated attack, in which the compromised device will be used to launch further attacks such as data attacks and network availability attacks toward the smart grid or perform malicious physical actuation (if the device is a control element). For example, a compromised IED such as a circuit breaker may break a circuit maliciously and cause power outage. Another example is that a compromised grid device might abruptly increase load to cause circuit overflow. To resist device attacks, strict access control is necessary.

A data attack attempts to adversely insert, alter, or delete data or control commands in the network traffic so as to mislead the smart grid to make wrong decisions/actions. One commonly observed data attack is that a customer jeopardizes the smart meter in order to reduce its electricity bill. Another example is that a compromised RTU is informed about a fault detected by a faulted circuit indicator (FCI) device, but it refuses to report the fault to the control center, resulting in increased outage time. To resist this attack, data integrity and authenticity must be protected, and effective intrusion detection mechanisms ought to be developed.

A privacy attack aims to learn/infer users' private information by analyzing electricity usage data. In smart grid, electricity usage information is collected multiple times per hour by smart meters so as to obtain fine-grained information about the grid status and improve grid operation efficiency. The detailed information may easily reveal customers' physical activities. For example, in a residential setting, lack of electricity use for stove and microwave during a certain time period indicates that the home is not occupied. Using this information, physical attacks like robbery can be planned when nobody is at home. Clearly, such privacy-sensitive information must be protected from unauthorized access.

A network availability attack takes place in the form of denial of service (DoS). Its objectives are to use up or overwhelm the communication and computational resources of the smart grid, resulting in delay or failure of data communications. For example, an adversary may flood a control center with false information at very high frequency such that the control center spends most of the time verifying the authenticity of the information and is not able to timely respond to legitimate network traffic. Communication and control in smart grid are time critical. A delay of a few seconds may cause irreparable damage to the national economy and homeland security. A network availability attack must be handled effectively.

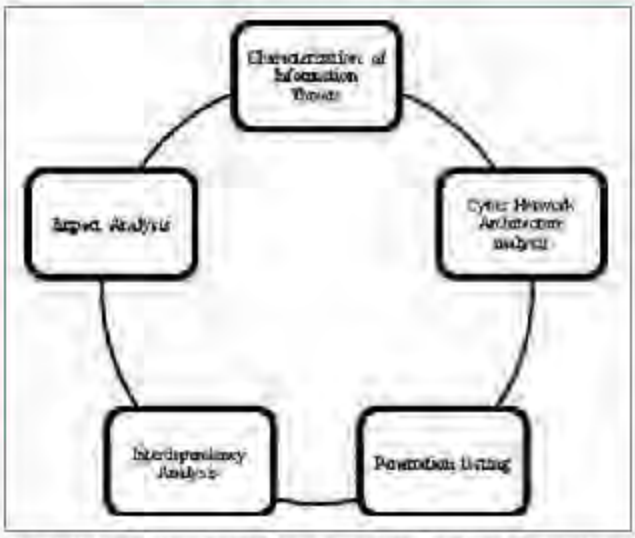

Fig. 4: Vulnerability Assessment for energy infrastructure providers

Smart-Grid Security Framework

Shown below are the fundamental security techniques for defending the basic cyber attacks in the smart grid communication networks outlined above. They can be used in combination to provide a comprehensive protection against existing/future malicious attacks, namely

- Access Control
- Authentication
- Privacy Preservation
- Intrusion Detection.

Fig. 4 shows the vulnerability assessment for energy infrastructure providers used for cyber attack impact analysis. The Fraud Detection Models can be employed to detect intrusion in an Intrusion Detection System designed for smart grids.

Cyber Attack Impact Analysis

One of the initial activities on cyber security assessment of power systems was the result of the Department of Energy Infrastructure Assurance Outreach Program that included a series of analysis stages: Risk of a given failure F is related to plausibility and severity of system vulnerabilities threats, and attack processes causing F as well as the impact quantifying the consequence of F on the power service.

Simply, the risk is defined as:

$R(F) = I(F) \times L(F)$

where, R(F), L(F) and I(F) represent the risk, likelihood and impact of a given failure F due to a cyber attack. It may be possible to estimate L(F) using conventional analysis methodologies for systems security, but the impact I(F) is difficult to assess given the complex system interdependencies that characterize a smart grid and the evolving nature of modern power systems. One needs to identify non-cookie-cutter vulnerabilities, the relative physical impact of cyber attacks, and cost-benefit tradeoffs for potential countermeasures. Based on these problem requirements, a paradigm for cyber attack impact analysis that employs a graph-theoretic structure and a dynamical systems framework to model the complex interactions among the various system components is proposed.

Proposed Approach

A basic overview of the impact analysis approach is shown in Fig. 5 (next page). Three stages, namely, model synthesis, analysis and validation are present. In addition, one can use the validation results to recalibrate the synthesis approach. Presented below is the proposed approach comprising of 3 stages, with the study focusing on the model synthesis stage. In the model synthesis stage, which the research specifically focuses on, dynamical systems are used for the systematic modeling of the cyber and electrical grids; this affords the flexibility to tune the granularity of detail.

The use of graphs conveniently facilitates incorporating complex dependencies within and between the cyber and electric components. This stage is critical as it determines the relative accuracy of a smart grid impact analyses and dictates the possible analysis tools available to glean insights about vulnerabilities and strategies for system hardening. a general and systematic approach to modeling a smart grid system using graph-based dynamical system approach is elucidated with a case study.

Dynamical systems are used for the systematic modeling of the cyber and electrical grids; this affords the flexibility to tune the granularity of detail. The use of graphs conveniently facilitates incorporating complex dependencies within and between the cyber and electric components. A general and systematic approach to modeling a smart grid system using graph-based dynamical system approach is elucidated with a case study. As shown in

Parameter		Fusion of Dempster-Shafer and Bayesian Learning	Hybridization of BLAST and SSAHA	HMM	Artificial Neural Networks and Bayesian Neural Networks		Fuzzy Darwinian detection
					ANN	BNN	
Method		Machine Learning	Sequence Alignment	Hidden Markov Model	Artificial Intelligence, Machine Learning	Artificial Intelligence, Machine Learning	Genetic Programming Fuzzy Logic
Fraud Detection	TP%	98	86	70	77	64	100
	FP%	10	10	20	10	10	6
Processing Speed		Medium	Very High	High	High	Low	Low
Training Required		Yes	No	Yes	Yes	Yes	Yes
Supervised Learning		Supervised	Unsupervised	Semi-supervised	Supervised	Supervised	Supervised
Cost		Implementation is expensive	Inexpensive	Quite Expensive	Expensive	Expensive	Highly Expensive
Accuracy		High	High	Medium	Medium	Medium	Very High

Table 1: Comparative analysis of Fraud Detection Dodels (FDSs) in Smart Grid.

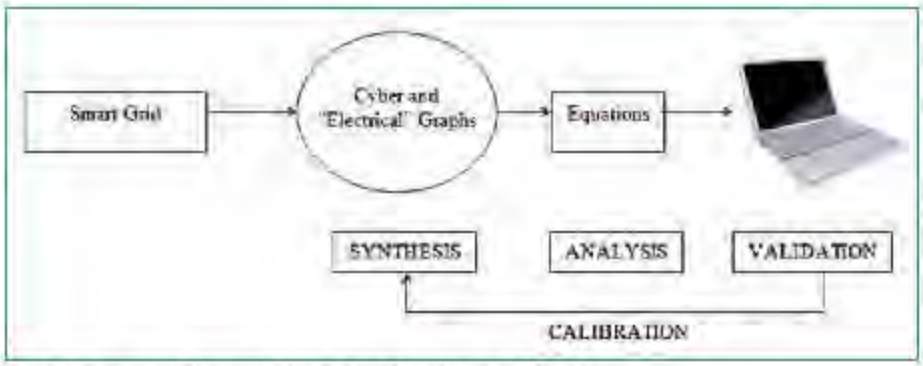

Fig. 5: Proposed Approach for Cyber Attack Impact Analysis

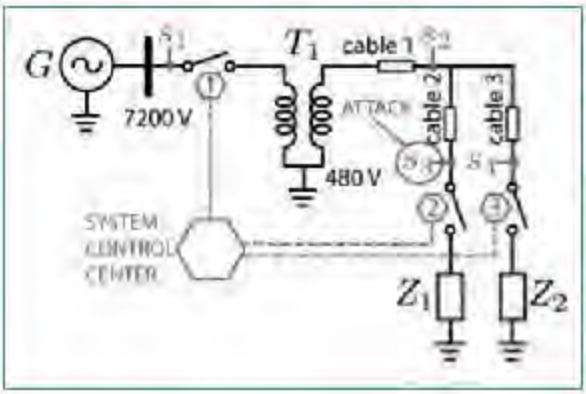

Fig. 6: Case Study of Single Generator System

Fig. 6, the single generator system, G represents a conventional generator (such as nuclear, coal and natural gas) that serves two loads Z1 and Z2. The transformer T1, which steps down the voltage, is connected to Cable 1. Cables 2 and 3 are connected to loads. The hexagon symbols represent cyber infrastructure. The system control center is shown and it communicates control signals to each of the three switches shown. For switch i (denoted with a hexagon with an i in the center), the control center communicates control signal ci (t) where ci (t) = 0 denotes open switch and ci (t) = 1 denotes closed switch at time t.

The control center senses information at the output of the generator denoted s1, and at the outputs of Cables 1, 2, and 3 denoted s2, s3 and s4, respectively. This information is passed to the control center that employs a simple load shedding algorithm to ideally avoid an overload situation if load demand exceeds generation. If the sensed overall load demand exceeds generation, then load management sheds one or both loads to avoid instability by opening their corresponding switches using control signals.

If sensed information reveals that neither of the two loads can individually be served by G, then both are shed. If it appears that only one can be served, then the smaller load is shed assuming G can serve the larger of the load; otherwise, the smaller load is served.

A typical cyber attack can involve fabricating or tampering with the sensor information, so that load management involves incorrect decision-making. In such a situation loads are dropped when it is possible to serve them or loads are not dropped when demand exceeds generation leading to decrease of generator frequency and finally generator trip out.

Transaction Risk Profiling

Risk scoring tools are essentially constructed from statistical models designed to recognize fraudulent transactions, based on a number of indicators derived from the characteristics of transactions.

Typically, they rate the likelihood of a transaction being fraudulent on a numeric scale. Transactions are comprehensively evaluated and their suspicion levels suitably captured in a single number. Thus, they can be prioritized on their risk score and given a limited capacity for manual review. Fraud detection involves monitoring the behavior of users in order to estimate, detect or avoid undesirable behavior. They are an integral component of Risk Scoring technologies to evaluate and prioritize transactions on the basis of their suspicion score.

This study performs a comparative analysis of 5 (Fraud detection Models) FDMs, wisely used in smart grids.

- Fusion of Dempster-Shafer Theory and Bayesian Learning
- Hidden Markov Models (HMM)
- Bayesian and Neural Networks
- Hybridization of BLAST and SSAHA
- Fuzzy Darwinian Detection.

Profiles

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Technological Advances in Controlling CO_2 Emissions

Global warming effects can be seen worldwide, and many experts believe it is only going to get worse. What is coming from power plants, traffic jams and industrial smog is causing our ozone to disappear, ice caps to melt, and temperatures to rise. The latest international report says carbon dioxide emissions are responsible for 60 percent of the greenhouse gases.

Dr S S Verma

One of the main scientific challenges facing the human race in the 21st century is controlling global warming that result from increasing levels of CO_2 in the atmosphere. Conventional methods of reducing greenhouse gases, such as simply producing less of them are always have their own importance but there is also a need to think about all possible non-conventional methods to control CO_2 emissions. Such concerns are getting scientists to think in unconventional ways about how to stem the carbon dioxide tide.

Environmentalists also argue that strict legislative regulations should be imposed that will prevent power companies from rushing to build large numbers of long-lived conventional coal plants before regulations on carbon dioxide emissions come into effect. Building such plants today, without making provisions for future control of carbon dioxide emissions, could make such future regulations far more expensive than they need to be. There are technologies available such as amine scrubbers, integrated gasification combined- cycles or oxyfuel plants that can capture and sequester CO_2 in deep geological formations. In addition to cutting down on carbon dioxide emissions by reducing the use of fossil fuels, researchers have focused on new technologies that remove the gas directly from the atmosphere. One solution to this problem, currently being given serious consideration, is carbon capture and storage, which involves concentrating and compressing CO_2 and then storing it, however, long-term storage remains to be demonstrated.

Global CO_2 emissions (mainly from coal-fired electric power plants) total an estimated 24 billion tons, so technology for capturing and storing the gas still are essential in a battle against global warming but new research aimed at finding ways to use carbon dioxide to make fuels, plastics, and other products and materials could easily triple the amount of this key greenhouse gas put to practical use, rather than released into the atmosphere or simply captured and buried underground. There are many other direct processes under investigation which can convert CO_2 directly into useful products but to date, alternative solutions for converting CO_2 emissions into a useful product has required a process so energy intensive that they generate more CO_2 than they consume. These technologies, if successful, could take out the carbon dioxide, turn it into a commercially-valuable product and at the same time eliminate the need to store waste CO_2. However, no one technology can solve the carbon dioxide problem alone hence there is a need to approach the problem with many solutions that could serve as efficient and cost-effective.

There are a wide range of research projects underway in academia and industry to find practical uses for CO_2. It is pointed out that the global chemical industry already uses about 115 million tons of CO_2 annually as a chemical feedstock, that is, as a raw material to manufacture other chemicals and products. Products routinely produced from CO_2 range from aspirin to fertilizer. A process under investigation focuses on converting CO_2 into formic acid, which could be used to power fuel cells for electric vehicles and a raw material to make other fuels where as another promising process being developed involves making polycarbonate plastics that contain up to 50 percent CO_2 by weight.

CO_2 Sequestration Technologies

The debate on what to do about global warming usually centers around two options: mitigation and adaptation. A third, less frequently discussed option also exists: sequestration of CO_2. The basic idea of carbon sequestration is to remove CO_2 from the atmosphere, or prevent it from getting there in the first place, and then store it elsewhere. While there are a wide variety of sequestration options that are currently being researched, three basic requirements for carbon sequestration to be successful are identified as:

- Be effective and cost-competitive
- Provide stable, long term storage
- Be environmentally benign

The process by which carbon dioxide sinks (natural and artificial) remove CO_2 from the atmosphere is known as carbon sequestration. The main natural sinks for CO_2 are, the oceans, plants and other organisms that use photosynthesis to remove carbon from the atmosphere by incorporating it into biomass and release oxygen into the atmosphere. Here are discussed some of the advanced methods of CO_2 sequestration.

Geological sequestration

Scientists believe that it may be possible to grab carbon dioxide before it shoots out of power plant smokestacks, diverting it to geological carbon sinks that trap carbon dioxide forever or, at least, for a very long time. The method of geo-sequestration or geological storage involves injecting carbon dioxide directly into underground geological formations. Declining oil fields, saline aquifers, and unminable coal seams have been suggested as storage sites. Carbon as plant organic matter is sequestered in soils as soils contain more carbon than is contained in vegetation and the atmosphere combined.

> *The basic idea of carbon sequestration is to remove CO_2 from the atmosphere, or prevent it from getting there in the first place, and then store it elsewhere.*

Oceans sequestration

Oceans are natural CO_2 sinks, and represent the largest active carbon sink on Earth. This role as a sink for CO_2 is driven by two processes, the solubility pump and the biological pump. The former is primarily a function of differential CO_2 solubility in seawater and the thermohaline circulation, while the latter is the sum of a series of biological processes that transport carbon from the surface euphotic zone to the ocean's interior. CO_2 separated from point sources can be placed directly into the oceans. Methods include using:

- Droplet plume: Liquid CO_2 is injected at a depth lower than 1000m from a manifold lying on the ocean bottom. Since carbon dioxide is less dense than seawater at that pressure and temperature, it would rise upwards, forming a rising droplet plume.
- Dense plume: Is a more concentrated, denser CO_2-seawater mixture created at a depth of 500-1000 m. As it sinks, a bottom current is formed, carrying the mixture into the deeper ocean.
- Towed pipe: Is similar to the droplet plume, but the CO_2 is discharged from a long pipe that is towed behind a ship.
- Dry ice: Solid CO_2 is released at the ocean's surface by a conventional ship.
- CO_2 Lake: Pipes running along the ocean bottom would pump liquid CO_2 into a seafloor depression, creating a stable 'deep lake' at a depth of 3000-4000 meters. This method, too, has potentially dangerous environmental consequences. The carbon dioxide does react with the water to form carbonic acid, H2CO3; however, most (as much as 99%) remains as dissolved molecular CO_2. Much more work is needed here to define extent of the potential problems.
- An additional method of long-term ocean-based sequestration is to gather crop residue such as corn stalks or excess hay into large weighted bales of biomass and deposit it in the alluvial fan areas of the deep ocean basin. Dropping these residues in alluvial fans would cause the residues to be quickly buried in silt on the sea floor, sequestering the biomass for very long time spans.
- Researchers are proposing a new method for reducing global warming that involves building a series of water treatment plants that enhance the ability of the ocean to absorb carbon dioxide from the atmosphere. About 100 such plants - which essentially use the ocean as a giant carbon dioxide collector -- could cause a 15 percent reduction in emissions over many years and about 700 such plants could offset all CO_2 emissions. In the new study researchers propose building hundreds of special water treatment facilities worldwide that would remove hydrochloric acid from the ocean by electrolysis and neutralize the acid through reactions with silicate minerals or rocks. The researchers say the reaction increases alkalinity of the ocean and its ability to absorb carbon dioxide from atmosphere. The process is similar to the natural weathering reactions that occur among silicate rocks but works at a much faster rate.

Mineral sequestration

Mineral sequestration aims to trap carbon in the form of solid carbonate salts. This process occurs slowly in nature and is responsible for the deposition and

accumulation of limestone (calcium carbonate) over geologic time.

Biochar sequestration

Biochar sequestration, combined with bioenergy production, does not require a fundamental scientific advance, and the underlying production technology is robust, clean and simple, making it appropriate for many regions of the world. It not only reduces emissions but also sequesters carbon, making it an attractive target for energy subsidies and for inclusion in the global carbon market. Most plants pull carbon dioxide out of the atmosphere and lock it up in their biomass or in soil organic matter but taking this a step further, which is heating the plant biomass without oxygen in a process known as low-temperature pyrolysis, when returned to the soil, biochar creates a stable, long-term carbon sink.

Biochar sequestration is to take CO_2 out of atmosphere by charring/partially burning trees, grasses or crop residues without the use of oxygen. Biochar has twice as much carbon in its residue than that from other sources. This makes bioenergy carbon-negative and improves soil health. The exhaust gases from this process and other biofuel production could then be converted into energy. Biochar also has been shown to improve the structure and fertility of soils, to enhance the retention and efficiency of fertilizers as well as to improve the productivity of soil. Capturing the exhaust gases from the pyrolysis process produces energy in such forms as heat, electricity, bio-oil or hydrogen. By adding the biochar to soil rather than burning it as energy source (which most companies do), bioenergy can be turned into a carbon-negative industry. Compared with ethanol production, pyrolysis that produces biochar and bioenergy from its exhaust gases is much less expensive.

Other methods of sequestration

Some methods include growing biofuel crops, shifting production to crops that absorb more atmospheric CO_2, active forest management to enhance carbon uptakes, and biologically based capture methods.

Carbon capture

Currently, capture of carbon dioxide is performed on a large scale by absorption of carbon dioxide onto various amine-based solvents. Other techniques are currently being investigated, such as pressure swing adsorption, temperature swing adsorption, gas separation membranes, and cryogenics. Recent studies include flue capture and conversion to baking soda and use of algae for conversion to fuel or feed. Another long-term option is carbon capture directly from the air using hydroxides. The air would literally be scrubbed of its CO_2 content. This idea offers an alternative to non-carbon-based fuels for the transportation sector.

CO_2 Separation and Capture Technologies

Chemical Absorption of CO_2 using an amine solvent (Scrubbing)

Chemical absorption using amine or carbonate solvents, also known as scrubbing, is the most well established method of carbon capture. After removing impurities from the flue gas, such as NOx, SOx and hydrocarbons, the gas is passed through an absorption column in which the amine reacts with the CO_2 and selectively absorbs it from the gas stream. The CO_2-rich amine is then heated, where the CO_2 is released from the amine as nearly pure gas.

Chemical absorption of CO_2 using alternative sorbents

The process of absorption using alternative sorbents is similar to that of using amine solvents, but tends to absorb more CO_2 with lower energy, material or space demands. Various sorbents have been tested such as aqueous potassium carbonate combined with the chemical piperazine; magnesium hydroxide; lithium silicate ceramic; and a nickel-based sorbent.

In a cryogenic separation system, CO_2 is physically separated from other gases by condensing it into a liquid form at an extremely low temperature.

Adsorption

Adsorption differs from absorption in that one substance is made to adhere or 'stick' to another, rather than being incorporated into the other substance. Adsorption is therefore based on physical, rather than chemical, interactions between materials.

Sas separation & absorption membranes

Gas separation membranes rely on differences in physical or chemical interactions between the different substances in a gas mixture and a membrane material that cause one component to move through the membrane faster than another. A gas separation membrane would allow carbon dioxide gas to pass through while excluding the other parts of the flue gas emitted industrial or power plants. Gas absorption membranes, on the other hand, simply function as a contact point between flue gas and an absorbing liquid, such as an amine-based solution.

Cryogenic separation

In a cryogenic separation system, CO_2 is physically separated from other gases by condensing it into a liquid form at an extremely low temperature. The liquid CO_2 produced would immediately ready for transport to the disposal site.

Iron Fertilization of Marine Phytoplankton

Photosynthetic carbon fixation by marine phytoplankton creates 45 Gt of organic carbon per year. While much of this is eaten by sea animals near the surface and ultimately ends up being recycled into the atmosphere, some eventually rains down into the deep ocean as waste and dead organisms. Bacteria feed on this organic carbon and produce CO_2, which dissolves while the rest of the detritus ends on the sea floor. The availability of nutrients, particularly iron, is the limiting factor on phytoplankton growth in large parts of the ocean. By depositing iron into the ocean, it may be possible to stimulate phytoplankton growth and hence encourage an increased biological uptake of carbon dioxide from the atmosphere, eventually depositing the carbon in the deep oceans for decades or centuries. Researchers will also look into another option, seeding the upper ocean

with iron (acting as a fertiliser) in order to produce a massive plankton bloom the so-called 'Geritol Solution'.

Using photosynthesis

Scientists are looking to nature to develop a cleaner, inexpensive way of removing carbon dioxide from smokestacks. The researchers are studying how algae and sunlight, in a natural process known as photosynthesis, can absorb some of the carbon dioxide produced after coal is burned. Though other scientists have used lakes filled with algae to absorb gas emissions, the Ohio University team has proposed growing and harvesting the organisms directly in the exhaust gas from power plants. Once the algae is grown, if it can't be used as fuel or a hydrogen source, it can be used as a fertilizer or soil stabilizer. The process works as the carbon dioxide exhaust moves toward the smokestacks, it would pass through tubes of running water, creating bicarbonates that would bubble in the water like soda pop. The water then flows through a bioreactor that contains a series of screens on which algae grow. The algae basically drink the bicarbonates and this system get carbon much quicker than trying to get it out of the air. Engineers have designed a simple, sustainable and natural carbon sequestration solution using algae. But to capture the CO_2 created from a power plant, algae would have to fill a building of a size of an acre worth of land space. As the algae can be harvested and made into biodiesel fuel and feed for animals make it cost effective.

Converting into cyclic carbonates

The research team of Newcastle University (USA) led by Michael North, Professor of Organic Chemistry, has developed a highly energy-efficient method of converting waste carbon dioxide (CO_2) into chemical compounds known as cyclic carbonates (chemical for which there is significant commercial demand). The team estimates that the technology has the potential to use up to 48 million tonnes of waste CO_2 per year. Cyclic carbonates are widely used in the manufacture of products including solvents, paint-strippers, biodegradable packaging, as well as having applications in the chemical industry. Cyclic carbonates also have potential for use in the manufacture of a new class of efficient anti-knocking agents in petrol which make petrol burn better, increasing fuel efficiency and reducing CO_2 emissions.

The conversion technique relies upon the use of a catalyst to force a chemical reaction between CO_2 and an epoxide, converting waste CO_2 into this cyclic carbonate. The reaction between CO_2 and epoxides is well known, but one which, until now, required a lot of energy, needing high temperatures and high pressures to work successfully along with a requirement of ultra-pure CO_2, which is costly to produce. Newcastle team succeeded in developing an exceptionally active catalyst, derived from aluminium, which can drive the reaction necessary to turn waste carbon dioxide into cyclic carbonates at room temperature and atmospheric pressure, vastly reducing the energy input required. The technique has been proven to work successfully in the lab. Team is currently carrying out further lab-based work to optimize the efficiency of the technology, following which they plan to scale-up to a pilot plant.

Converting into DVDs & CD-ROM s

Carbon dioxide is so readily available, especially from the smokestack of industries that burn coal and other fossil fuels and it's a very cheap starting material. If CO_2 can replace more expensive starting materials, then there is an economic driving force. Carbon dioxide removed from smokestack emissions in order to slow global warming in the future could become a valuable raw material for the production of eyeglass lenses, automotive headlamp lenses, DVDs, beverage bottles and a spectrum of other consumer products made from polycarbonate plastics. Dr. T.E. Müller and Dr.T. Sakakura (Japan) described innovative ways of making polycarbonate plastics from CO_2. Those processes offer consumers the potential for less expensive, safer and greener products compared to current production methods. Scientists from Japan also reported using CO_2 as an alternative feedstock to change carbonates and urethanes into plastics and also battery components. The team noted that the new process is simpler and faster than another process developed. It is well known that millions of tons of polycarbonates already are sold each year with the volume rising and perhaps no other consumer product has such a great potential for use in removing carbon dioxide from the environment. Trapping carbon dioxide in those plastics would avoid the release of many million of tons into the environment.

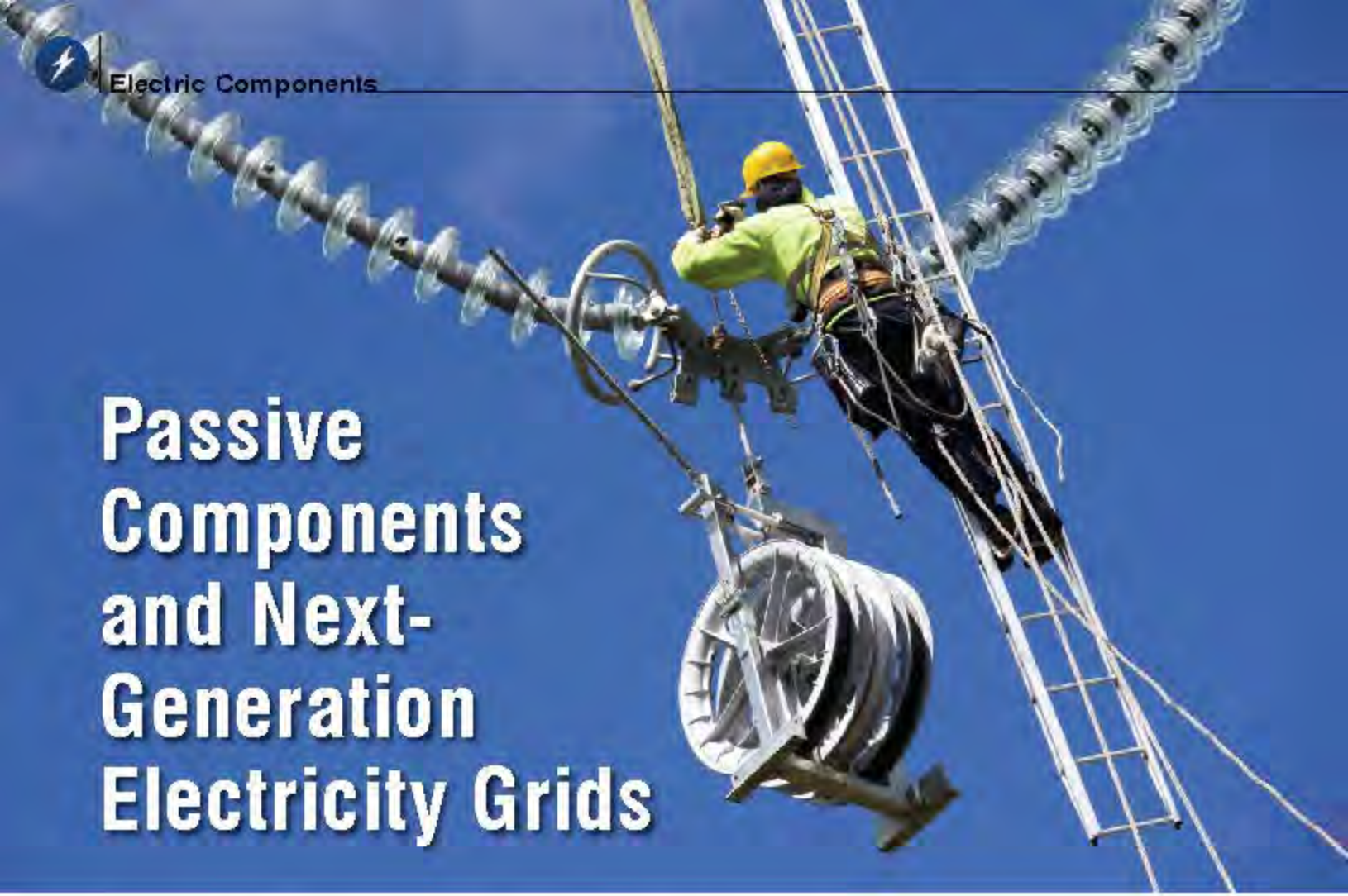
Looking for positive affects

Scientists are also not behind in studying the advantages associated with the increasing levels of carbon dioxide in the atmosphere. Too much carbon dioxide can be a bad thing, but sometimes it can have a positive effect on plants and trees. They have discerned and confirmed the unforeseen advantages of rising carbon dioxide levels. Through the processes of photosynthesis and respiration, scientists have been able to elucidate why plants are growing more rapidly than they are dying. The more carbon emissions we dump into the air, the faster forests and plants grow. The answer to these questions may have more to do with how plants use CO_2. Scientists hope to make photosynthesis a process that doesn't depend on any specific organism, to be used by any power plant.

Profile

Dr S S Verma

working as Associate Professor in the Sant Longowal Institute of Engineering and Technology is MSc and a PhD from IIT Delhi. He did postdoctoral studies in Japan at Toyohashi University of Technology. He has published about 40 research papers in journals and about 400 science and technology related articles. He has been nominated to various awards by International Biographical Centre (UK).



Passive Components and Next-Generation Electricity Grids

The supply of energy is in a state of structural change due to dwindling fossil energy resources, the shutdown of nuclear power plants, increasing environmental awareness, and the associated integration of alternative energy resources. The existing central energy supply system with a few large power plants is giving way to a system with numerous decentralized generators. However, continuous coordination between generators and consumers is still necessary to ensure stability of the voltage level and frequency in the electric supply and distribution grid at all times.

Ove Hach

While our electricity has mainly been generated by alternating current generators with the familiar 50 Hz 3-phase AC supply, future energy concepts must be able to integrate photovoltaic direct current and direct current from battery storage and low voltages. These different energy forms must be tailored for existing and future grid infrastructures, making the use of power converters and electronic measuring equipment increasingly important in guaranteeing the necessary grid quality and stability of a decentralized energy supply system.

Passive components such as resistors have a lasting effect on the efficiency and quality of these electronics, and play a significant role in the generation, transmission, distribution, and management of electrical energy.

Decentralized Energy Generation

The decentralized generation of energy is increasingly reliant on alternative energy sources, such as wind power, photovoltaic systems, and biomass combustion. As a result, the storage of electricity in static batteries will become increasingly important in the future in order to quickly satisfy peak load requirements. A key module in small- and medium-sized decentralized generators and storage systems is the power converter, which makes the various forms and

levels of feeder energy suitable for the supra-regional grid.

A power converter can normally be found in any alternative energy source that cannot be injected synchronously and at the required grid quality. The module takes the input current - alternating or direct - and generates an alternating current (and voltage) output at a specified frequency and amplitude, which is then injected into the transmission and distribution lines.

Optimum control and regulation over a power converter require accurate information on the voltage and current values at every stage. Filtering, adaptation, and measurement of the feed voltage and current are first performed at the input. Other functions at this stage include the determination and optimization of the converter operating point, protection against overload, and suppression of EMV noise signals.

The voltage is measured using an ohmic potentiometer resistor. The number of resistors required is determined by the voltage level, the voltage and current pulses occurring at the input, and the preferred resistor design. Requirements regarding measurement accuracy (tolerance), resistivity to temperatures occurring in the converter(temperature coefficient TK), and the permitted drift of the device during its lifetime (stability R/R) can be satisfied by wired metal-glaze layer, wired metal layer, or SMD MELF metal layer resistors. For converters with more demanding requirements, MELF resistors (Fig. 1) should be utilized. In addition to their excellent electrical properties, these devices keep the number of resistors in SMD voltage dividers to a minimum, thus lowering production costs and reducing assembly errors.

Current can be measured with a shunt resistor, current transformer, or current sensor. Shunt resistors, which offer very low resistance down to 0.1 m , measure the current by measuring the voltage drop of the resistor as the current flows through it. Shunt resistors are based on the type of resistor shown in Fig. 2, but numerous application-specific configurations are

Fig. 1: SMD MELF resistors

available, including with / without Kelvin contacts; screw, weld, or solder connection contacts; or coated/uncoated designs with different bending shapes of the connection contacts. Shunt resistors provide very precise current measurement at high current values (upwards of 1000 A) for a variety of energy applications.

Due to their long-term stability, resistors built on metal or thin film technology should be used for the analog signal processing

Fig. 2: WSBS Power Metal Strip®resistor

chain from the shunt resistor to the A/D converter. Depending on the application requirements and operating temperature range, a variety of discrete SMD flat chip components are suitable, in addition to the already mentioned SMD MELF resistors. SMD thin film chip arrays, such as the devices shown in Fig. 3, offer temperature coefficient synchronous operation and long-term stability for high-precision signal processing.

Current transformers and current sensors utilize the magnetic field generated by the electric current. Simple current transformers are a special type that must be terminated on the secondary side by a

Fig. 3: ACAS AT chip array

low-resistance resistor (burden resistor) with values up to 47Ω. These resistors should have a low temperature coefficient (TK: ± 50 ppm/K;± 15 ppm/K) to avoid measurement errors due to temperature fluctuations or self-generated heating. Depending on the current transformer and the level of the secondary current, wired resistors such as those shown in Fig. 4 and Fig. 5 can be used.

The disadvantage of simple current transformers is that only AC currents can be measured. Hall effect sensors are necessary to measure DC currents via the magnetic field. These devices require an additional supply voltage to ensure sensor analog signal processing. For high accuracy, closed-loop Hall effect current transformers should be used. The compensation winding of these devices is energized in such a manner that the magnetic flux within the coils becomes zero and cancels itself out. The current flowing through the compensation coil is proportional to the primary current, but several times smaller, allowing the compensation current to be measured using a low-resistance precision resistor, such as the device shown in Fig. 5.

Now let's move from the input of a power converter to its DC intermediate circuit, where another voltage divider for measurement is located. As mentioned above, the selection of resistors is dependent on the requirements for the power converter. Since the number of power converters injecting energy into the grid from wind turbines and photovoltaic systems has increased rapidly in recent years, power converters must contribute to the stabilization of the AC power grid.

Fig. 4: RH Series

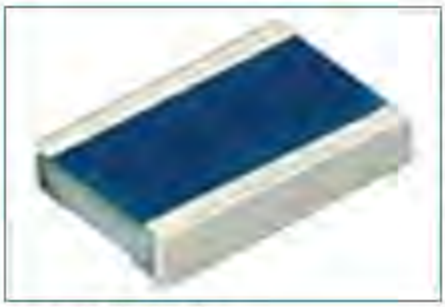


Fig. 5: MCW 0406 AT

Modern power converters can deliver capacitive and inductive reactive power to the grid if needed. The level of the DC intermediate circuit voltage plays a significant role in this. With the voltage level, the phasing of the injected current in certain areas can act capacitively or inductively. An increase in the voltage can either be performed directly at the input or by means of an internal boost converter. The intermediate circuit voltage can be reduced by decreasing the input voltage and connecting a chopper resistor. The size of chopper resistors increases with the power of the converter. For small-capacity converters, wire-wound resistors can be used. Available SMD solutions include thick-film resistors in D PAK casings (Fig. 6) or a combination of series/parallel circuits with SMD carbon film MELF resistors.

Fig. 6: D2TO20

Chopper resistors greater than 50 W require a connection outside the circuit board. Due to the pulsed operation, devices with the lowest possible induction should be employed to avoid voltage spikes, which can quickly reach a multiple of the maximum permitted voltage for semiconductors and capacitors and lead to component damage. The 57 mm x 60 mm x 25 mm device shown in Fig. 7 offers a dielectric withstand voltage of 12 kV, an ohmic range from 1 Ω to 1.3 kΩ, and can dissipate 1100W at a heatsink temperature of +25°C.

For high current pulses, resistors with flat wire windings should be used. Chopper resistors manufactured from meandered steel plates (steel plate/grid resistors) are available for converters with power outputs between 5 kW and 1 MW. The devices show in Fig. 8 and Fig. 9, for example, can handle power up to 20 kW or energy of up to 3.46 MJ (crowbar resistor) from the intermediate circuit and convert it to heat.

A B6 bridge arrangement of power semiconductors (high-voltage MOSFETs or IGBTs) switches the DC current from the intermediate circuit into a sinusoidal current that is fed into the respective phase of the transmission and distribution grid. At the converter's output, the voltage measurement is performed for each phase via a voltage divider, while current is measured via shunt resistors or current transformers and sensors.

Often overlooked devices that affect the quality and performance of a converter are series resistors, which activate the power semiconductors. Special consideration must be given to the devices' accuracy, long-term stability, and temperature behavior, since they decisively influence the switching behavior, and thus the efficiency, of the converter. Power switches are also frequently operated in parallel mode, where synchronization is very important, and a drift of the series resistor caused by temperature or other environmental influences could have significant consequences for the reliability and load distribution in the whole system.

Fig. 7: LPS 1100

The semiconductors mentioned above have internal capacities at each gate, and these must be charged during switch-on and discharged during switch-off. During continuous operation with switching frequencies between 10 kHz and 20 kHz, powers of several watts can be dissipated at the series resistors, depending on the size of the semiconductor switch. In addition to power dissipation, the series resistors used should be selected on the basis of their current load capacity. For this, exact knowledge of the resistors' design and materials utilized is required.

In power converters for photovoltaic applications with outputs up to 8 kW, switching currents of up to 25 A can flow through the series resistors during each switching operation. Therefore, robust and reliable devices with a high degree of pulse loading capacity should be utilized, allowing switching operations to be performed correctly even after years of continuous operation. SMD MELF resistors in particular are suitable, since these devices possess a larger surface area by a factor of nearly three compared to flat chip resistors. Low-inductive SMD MELF resistors are also available to address

special requirements for switching behavior and control signal quality, such as high switching frequencies or steep switching flanks. For converters with outputs greater than 100 kW, wire-wound resistors with connection caps offer very simple assembly in the serial production of power semiconductors.

Transmission and Distribution

Depending on their power output, decentralized energy generators feed electricity into low-voltage networks at voltages of 230 V/400 V. At higher power outputs, the feed into medium-voltage networks is up to 30 kV. Larger wind turbine parks feed their electricity directly into the high- and super-high voltage grids at 110 kV to 380 kV via a transformer station, without loading the low- and medium-voltage networks.

On-shore wind parks are connected to high-voltage overhead transmission lines; however, off-shore wind-parks at sea can only be connected by high-voltage cable. The output side of this cable delivers alternating current, which has the significant disadvantage of far greater capacitance than an overhead line. The charge of the capacitance is continuously reversed during operation; the electrical power required to charge and discharge capacitance is known as "reactive power." The higher the reactive power on an energy transmission line, the lower the ability to transfer the active power. Since electrical energy billing is based only on the active power flow, the profitable alternating current operation of high-voltage cable is limited to a length of tens of kilometers.

To avoid this disadvantage with cable, the alternating current at an off-shore wind-park is rectified to direct current in a centralized high-voltage converter. The high-voltage DC can then be fed into a single-pole cable, using the water or soil of the sea or earth as the return conductor. Another high-voltage converter is located on land, which converts the direct current back into a high-voltage alternating current that is injected into the existing alternating current grid.

This form of energy is known as HVDC (high-voltage direct current) transmission. The magnitude of the direct current voltage in HVDC plants is between 300 kV and 500 kV. Switching such high voltages using thyristors or IGBTs requires numerous semiconductor switches, mostly optically triggered,to be connected in series and galvanically separated in each phase. The use of resistors in HVDC engineering is restricted to the area of control and regulation. Key passive elements in HVDC transmission plants include film capacitors, which are either connected as snubber capacitors in parallel to the thyristors, or switch them on and off as stepped capacitive voltage dividers in multi-level, intermediate circuit-voltage HVDC by IGBT modules.

Energy Management

With the decentralization of the energy supply, the topic of energy management will preoccupy every consumer. Electricity in its original form cannot be generated on-demand, and can only be stored with great difficulty. For example, efficient storage of solar energy is only possible by electrochemical conversion (battery), conversion into mechanical energy (pump storage), or comparable processes with high costs and conversion losses. To stabilize electrical networks, demand must always be matched to the available offering. One of the most important roles in this interplay is that of the electric meter.

The electromechanical electricity meters used in the past only provided periodic consumption measurement for utility billing. More modern meters, known as E-meters, measure energy consumption using electronic technology. These devices can measure and display the dynamic momentary consumption of electrical energy at any point in time and, most importantly, evaluate and communicate with the help of integrated intelligence. Portable E-meters are also very popular with energy advisory bodies for the measurement of specific loads.

The ICs in electric meters, can only measure small voltages. Since standard

Fig. 8: WSGR Series

Fig. 9: ULDCR resistor

E-meters in low-voltage networks must measure AC voltages and currents, the resistors used in the measurement circuits are especially significant. Their task is to lower voltages using a voltage divider and convert currents to a voltage signal using shunt resistors or current transformers. Current meters are calibrated measuring instruments, which must display the values to be measured over a period of several years within a calibrated measurement tolerance.

Therefore, resistors must be selected with that offer corresponding temperature coefficients, tolerances, and low drift. Additional requirements are the short-circuit withstand capacity of the shunt resistors and the high-voltage pulse withstand capacity of the voltage divider resistors.

Fig. 10: WSMS Shunt Resistor

The shunt resistors shown in Fig. 10 were developed especially to meet these requirements in electric meters. They cover an ohmic value range from 0.00002 Ω to 0.0001 Ω, with low TC below 20 ppm/K.

For voltage measurement, SMD MELF resistors offer very high reserves against stresses from high-energy pulses, such as those caused in the supply network by lightning and grid switching operations. Voltage measurement can be performed with flat chip resistors; however, the number of resistors required will increase significantly. Utilizing a large number of flat chip resistors has a negative effect on the circuit board area housing the components, and also increases costs for logistics and assembly.

E-meters employed in industrial environments are connected to external current transformers and are equipped with standardized current measurement inputs of 5 A maximum. These inputs are in turn terminated via small internal current transformers with low-resistance precision resistors offering low TC of ± 15 ppm/K maximum.

The long-term stability of the resistors is an important consideration, as it is with resistors used in voltage dividers. By selecting the right measurement resistor, an E-meter will have a very long calibration period and minimized calibration costs.

As with every electronic device, an E-meter must also be supplied with energy over a wide voltage range. To prevent the damage or destruction of high-value ICs by high-energy voltage spikes, a stepped protection circuit is necessary in the power supply circuit. A combination of a resistor and a varistor protects against high voltage spikes.

Fig. 11: Z300-C Wire-wound Resistor

The resistor is located in the line of the supply circuit, and the varistor is connected behind the resistor between the supply line and the protective ground. The varistor limits the voltage spike to a threshold value, and the remainder of the voltage drops off at the resistor, allowing a large portion of the spike energy to be dissipated in the resistor as heat. Wire-wound resistors such as the device shown in Fig. 11 are used for such protection.

To accommodate additional safety requirements, e.g. if one of the components has a defect during the fault, a wire-wound resistor is necessary that possesses a reproducible failure behavior during overload, in addition to the required spike-withstand capability.

Resistors developed specifically for such additional requirements act with reduced noise at overload and without any significant external mechanical damage. This prevents further electrical faults, fatal errors, and/or the ionization of the surrounding air, which leads to dangerous and uncontrollable arcing.

Extending an E-meter with a communications interface creates a Smart Meter, which allows the user and supplier to monitor and control energy consumption. This extension allows the consumption and generation of electricity to be balanced, and the supply grid operator to be given the necessary information for stable and safe operation. Nothing is feared more in a supply network than a total grid failure due to voltage fluctuations or frequency shifts (black-out).

Conclusion

Passive components, such as the resistors discussed in this article, contribute to electrical engineering with a significance that should not be underestimated. Their properties have a lasting effect on the efficiency and quality of modern converters. A well-founded knowledge of passive components and their specifications is fundamentally crucial in order to guarantee their long-term, fault-free operation. Semiconductor components such as thyristors, IGBTs and ICs can be switched and triggered safely and reliably only by selecting the right passive components.

Courtesy

Ove Hack,
Senior Manager Product Marketing,
Vishay Intertechnology.

HONGFA Electroacoustic Co Limited

HONGFA Founded in 1984 specializes in developing, manufacturing and promoting relays. With a factory area of 3,30,000/- square meters, HONGFA has the annual production capacity of 1 billion relays of 160 series and 40000 specification. HONGFA consists of 21 wholly- or partially-owned subsidiaries, including HONGFA Europe GmbH and HONGFA America, Inc.

As one of the national High-tech enterprises, it has a state-level technical center post-doctoral research station, an academician research station and a UL, VDE and CNAS recognized testing and experimenting center for relay and its relevant products. It has also been actively involved in the formulation of multiple national standards. HONGFA is the only relay manufacturer in china who was awarded as "National Export-Oriented Enterprises of Automotive Components and the only Chinese relay manufacturer who has been awarded as "China Top Brand". HONGFA's quality control system confirms to ISO/TS16949.

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ElMeasure introducing 'Power Duos'

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Features:

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Applications

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Features

Monitors multiple parameters of the Generator; status display on the backlit graphics LCD; fuel wastage reduction; operational cost reduction.

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Website:

www.ems.gen.nz

New AC10 family of variable frequency drives from Parker Hannifin

Parker Hannifin India displayed their new series of AC variable frequency drive, the AC10Micro Drive. AC10 is a simple, reliable and extremely versatile drive providing economical solution to every-day motor control applications requiring speed or torque control and are available in the power range of 0.2 kW to 15 kW. The typical applications for AC10 include conveyors, centrifuges, fans, mixers, packaging machines and textile machines to name but a few. Offering extremely compact dimensions and features only associated with higher specification drives, AC10 provides an optimised solution for OEM machine builders and process industry users, seeking a simple cost-effective drive without any compromise in performance. The many functional benefits such as auto-tuning sensorless vector mode, built-in PLC functionality, multiple V/f etc are available as standard which makes the device beyond simple V/Hz motor control.

Some of the features are as follows

It is Built-in PID Controller; user selectable V/F curve; built-in brake chopper; multi-stage speed control; torque compensation; built-in EMC filter option; up to 650Hz output frequency; auto-tuning; advanced fault diagnostics; programming through keypad; built-in RS485/ModBus; It is compact in size; integrated application macros.

For further details contact:

sales.augindia@parker.com

Venture Lighting Introduces Metal Halide Lamp

Venture's Natural White product family is premium pulse start metal halide lamp line. It offers unparalleled 90% lumen maintenance, 90+ CRI, 5000K and up to 40,000 hours rated life for a variety of wattages. It is Venture's most sustainable product line offering low mercury weights, long life and quality light. Natural White lamps will make colors bloom, glass sparkle, and provide brilliant white light for any application. Each Natural White lamp has a special dosing. This includes a few rare earth metals contained in the exclusive formed body quartz arc tube shaped to follow the curve of the arc stream. The arc tube improves performance for maximum color and light output uniformity. These features deliver 90% mean Lumen (LLD factor of 0.90), high CRI (90+), and a color temperature (CCT) of 5000K. The majority of Natural White lamps contain a closed quartz shroud for open fixture protection, which blocks nearly all ultraviolet light and reduces UV damage.

Benefits

Fresh, bright light with 5000K CCT and 90+ CRI; 14% perceivable brighter light; available in both vertical and horizontal operating positions; 20-50% more energy savings than other technologies; low hazardous materials, less environmental.

Applications

It is applicable to energy saving retrofits, parking garage, roadway, site lighting, factory lighting, printing press, retail shops.

For further details contact:

marketing@vlindia.com

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Three new FLIR electrical meters

This brand new T&M product line includes three electrical meters – the FLIR DM93, FLIR CM83, and FLIR CM78. All feature large/clear LCD displays, bright dual-LED worklights to illuminate dimly lit work areas, Bluetooth® connectivity to Android™ mobile devices running the latest FLIR Tools Mobile® app, and the ability to wirelessly connect to METERLINK® enabled FLIR thermal cameras so that electrical readings can be embedded into IR images in real time.

FLIR DM93

Streamline VFD troubleshooting

The new FLIR DM93 is a rugged DMM designed with advanced VFD filtering and shielding that help professional users accurately analyze non-sinusoidal waveforms and noisy signals found in VFD-controlled equipment. Other features include Automatic Data Recording to detect intermittent glitches.

FLIR CM83

Simplify power & VFD analysis

The new FLIR CM83 is an industrial power clamp meter with power analysis and advanced VFD filtering for testing three-phase systems and VFD-controlled equipment. Other features include Harmonics Mode to find noise from different electrical sources, Phase Rotation to confirm phase orientation of three-phase systems, and Inrush Current to detect start-up transients.

FLIR CM78

Multifunctional clamp meter

The new FLIR CM78 is a 1000A clamp meter that combines the capabilities of a True RMS digital multimeter and clamp meter with a non-contact IR thermometer and Type K thermocouple. Useful for working on industrial equipment and complex machinery, this new clamp meter enables users to quickly capture accurate AC/DC readings up to 1000A or 1000V.

For further details contact:
flirindia@flir.com.hk

Fluke brings easy tools to identify energy waste

Fluke Corporation displayed how to easily identify energy waste in facilities. The following tools make it easy to identify energy waste that drives up electrical bills.

The 1730 Three-Phase Energy Logger is an intuitive, easy-to-use tool with professional-level energy data gathering capabilities. while the accompanying Fluke Energy Analyze software scales from the analysis and reporting needs of the facility manager to the advanced analytical requirements of electrical engineers. With calendar-based energy logging, facilities can easily identify which aspects of their operations are consuming excessive amounts of energy.

The rugged Ti400 Infrared Camera features LaserSharp Auto Focus, which uses a laser to pinpoint exactly where the camera should focus for consistently in-focus images every time. With the laser focus, it takes less training for facilities can detect a greater variety of energy waste. Thermal imaging analysis and SmartView™ reporting software comes with the camera.

The Fluke VT02 and VT04 Visual Thermometers blend a digital image with a thermal heat map overlay in an affordable, pocket-sized tool. Facility technicians can pick up the tool and immediately begin inspecting electro-mechanical equipment and other energy-consuming aspects of the building. The tools display & save images as full digital, full infrared, or in three blended modes (25, 50, and 75 percent) along with the center-point temperature measurement.

Website:
www.fluke.com/india

The PSK AFS compact volume flow sensors from Phoenix Contact India Pvt Ltd

The PSK AFS compact volume flow sensors from Phoenix Contact are based on calorimetric measurement and can detect consumption quantities as low as 0.06 Nm3/h. The sensors are also suitable for measuring operational consumption thanks to their large measuring range of up to 700 Nm3/h. In addition to the IO Link communication system that facilitates intelligent communication between the sensor and the controller, the compressed air counters can also output analog values and digital impulses, as well as measuring switching thresholds via two digital outputs. These versatile options for outputting flow and temperature measurement data facilitate a wide range of connections to process and control systems. The compressed air counters measure the current volume flow, the total volume consumed, and the temperature of the compressed air in the monitored process. The devices offer a value and status display in addition to the numerous configuration and measuring options available via the IO Link, providing users with an overview directly at the sensor.

For further details contact:
adverts@phoenixcontact.co.in

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Digital TRMS Multimeter by Kusam Meco

KUSAM-MECO has been marketing Digital Multimeter; model 406, this multimeter circuit has been upgraded by using the latest IC's & components thereby reducing the current consumption. This model is designed 406MK-1. Model 406MK-1 is a new Digital Multimeter introduced by "KUSAM-MECO", an ISO 9001-2008 certified company. This model has 4½ digits, 19999 counts LCD display, Auto Power Off, Auto Polarity display, Overrange indication, Low Battery indication, Data Hold function, Shock resistant & fire retardant casing, Input warning beeper, Duty Cycle function. This model is CE approved & safety CAT III 1000V. It can measure AC Current TRMS upto 20A upto 1kHz frequency, DC Current upto 20A, TRMS AC voltage 750V upto 500Hz frequency, DC voltage 1000V, Resistance upto 20M, Frequency upto 200kHz, Continuity Test, Logic Test, Diode Test, Data Hold function. Its dimension is 198(H) 90(W) 44(D) mm & weight is 400g including battery. This meter automatically shuts down after approx. 45 minutes of inactivity. It is supplied with Test leads pair, User Manual, Battery installed and Carrying Case.

For further details contact:
kusam_meco@vsnl.net

Slot Cell Inserting Machine by Electromech

Electromech introduces a new technology in motor manufacturing by developing pnuematically operated Paper Inserting Machine, Model SCI-100. This high speed machine automatically prepares end-folds, sizes and shoots the insulating paper into the slots of the Stator Stack. The Programmable Automatic indexing Table makes the machine felxible and user friendly which completely eliminates the need for changing Gears. This contributes to minimum machine set up time and thus enhances the productivity. The new design also facilitates the machine to adopt for different stack heights quickly without calling for additional tooling. Thus reducing the tooling costs. The machine is available in two models to cover the wide range of frame sizes. The model SCI-100 Covers Stack heights 25mm ~ 200mm, Stator ID 30mm ~ stator OD 200mm.

For further details contact:
electromech@datacne.in

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