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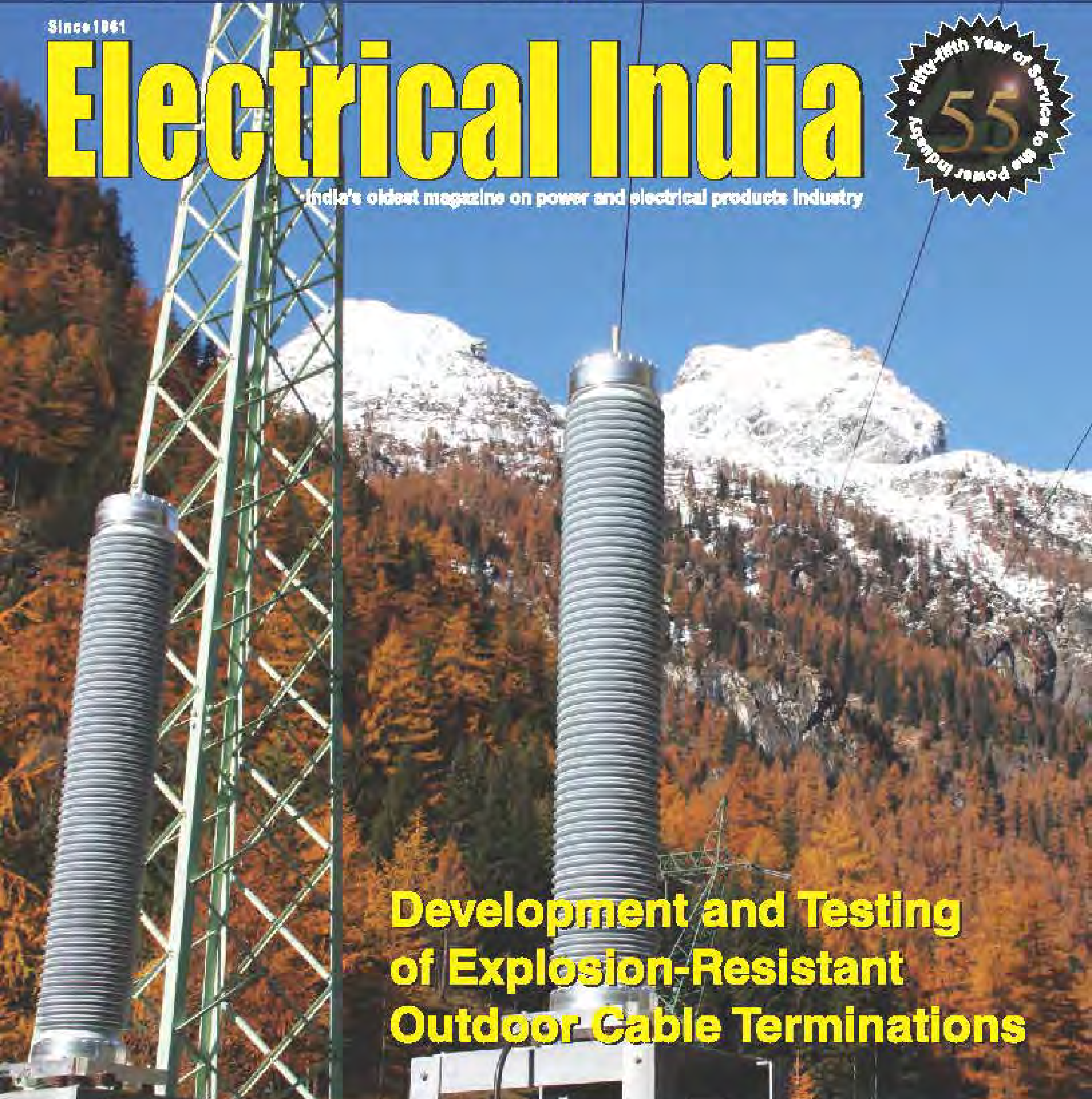

Development and Testing of Explosion-Resistant Outdoor Cable Terminations

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> **Adding 100 GW every year is an encouraging step in the Indian Power scenario**

A plan of the new government to accelerate the generation of wind energy by adding 100 GW every year is an encouraging step in the Indian power scenario. Wind energy is the perfect example of how we can produce power and at the same time help our future generations, have a better life and cleaner air to breathe in and as an addition to alternative resource meeting the energy gap.

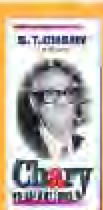
The rising gap between demand and supply of electricity is the major factor of concern for developing countries like India. The power generation cannot be increased over night, and involves lot of investments. However, the present day scenario can be improved if we apply some more scientific techniques and methods to reduce power loss in distribution system. The writeup 'Minimization of Power Loss & Improvement in Voltage Profile of 11kV Feeder' highlights different techniques that can be optimized as well as through grids.

Microgrid design is an essential technology and has been detailed in an article 'Control and Operation of Main grid with Renewable Energy Based Distributed Generators' describes the principles of microgrid design, considering the operational concepts and requirements arising from participation in active network management. The article provides a comprehensive review of microgrids, including advanced control techniques, energy storage systems, and market participation in both island and grid-connected operation. The control techniques and principles of energy-storage systems are summarized in a flowchart.

Among other interesting articles, this issue has post event report of a new initiative 'Intelect 2015' with focus on smart energy, held in Mumbai.

Do send in your comments at miyer@charypublications.in

Mahadevan



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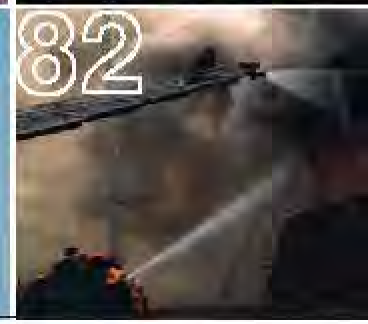


Departments

Interview

Energy Practices for Integrated Smart City Solutions

> *Institutional, Physical, Social and Economic Infrastructure constitute four pillars on which a smart city rests*

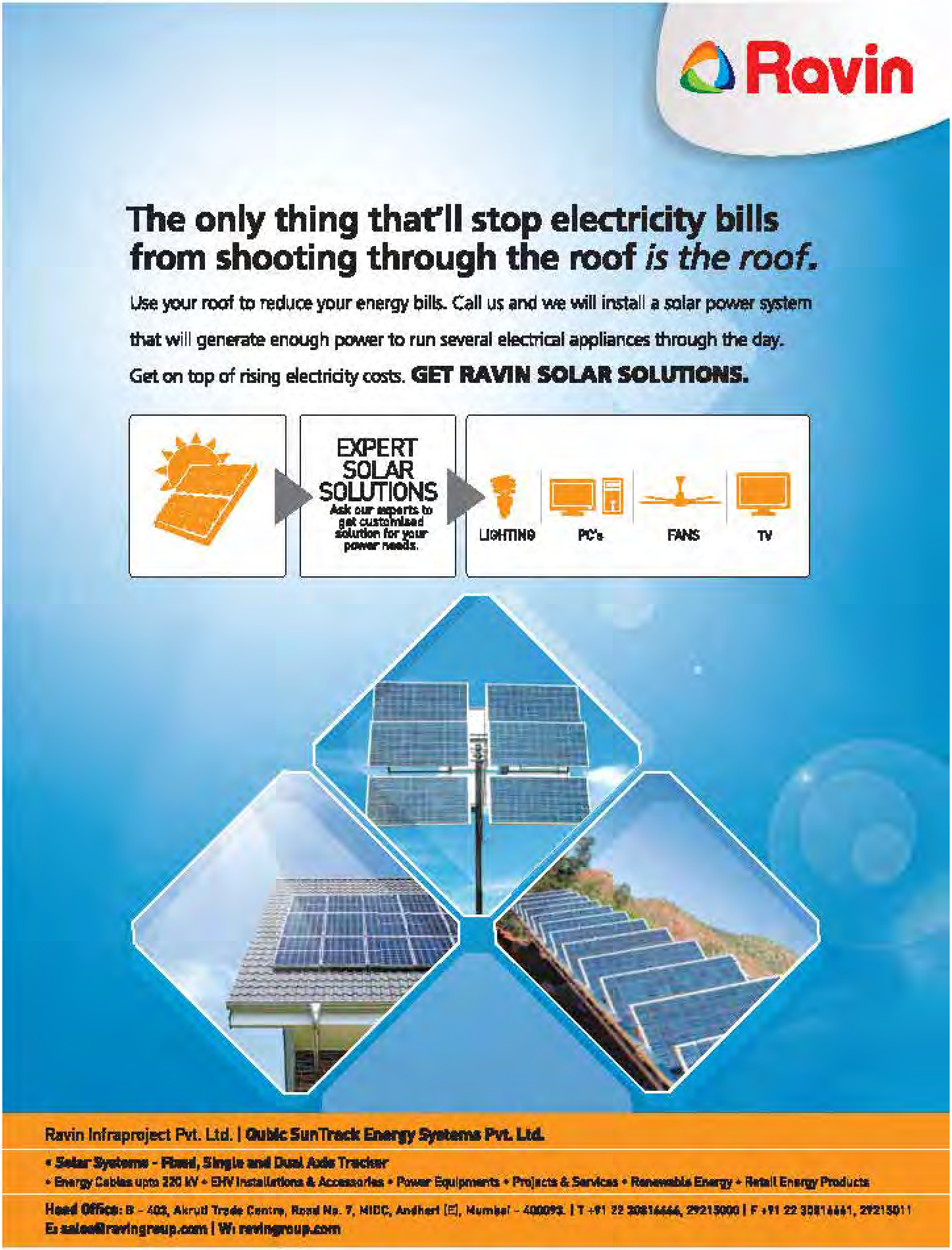
Gopal Krishna Anand

Everyone is talking of the 100 smart cities announced in this year's budget, for which the key 'smart' sectors include transport, energy, healthcare, water and waste. Smart city uses digital technologies and solutions to enhance performance, to reduce costs and resource consumption; and to engage more effectively and actively with its citizens. A smart city should be able to respond faster to energy requirements, global needs and changing practices.

Changing scenario of innovative development in power sector is inducing the exhibitions' core theme as energy efficiency offering a first-hand experience of simulated environments that deploy solutions across smart energy, mobility, water, public services and smart integration, highlighting prominent and select companies as providers for integrated smart city solutions. Major challenges, including climate change, are motivating the smart cities move to online. The terms 'intelligent city' and 'digital city' are synonyms to that. According to reports, global market for smart urban services will be $400 billion per annum by 2020.

Furthermore, Institutional, Physical, Social and Economic Infrastructure constitute four pillars on which a smart city rests. Energy concerns are vital features of Smart Cities. Energy efficient practices are adopted in transportation systems, lighting and all other services that require energy. For it awareness programs lead to a culture of conservation. Smart Grid is an electricity network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end-users. Intelligent cities - the communities, clusters, regions - stand defined as multi-layer territorial systems of innovation that bring together knowledge-intensive activities, institutions for cooperation in learning and innovation, and digital spaces for communication in order to maximize the problem-solving capability of the city.

As per statistical analysis, by 2050, about 70% of the population will be living in cities. It will need about 500 new cities to accommodate the surging figures. Urbanisation is inevitable, and will only change when the benefits overcome costs involved. Smart city is an opportunity for achieving faster growth and the changing expo themes, albeit energy conservation has its own incentives.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Siemens Ltd reinforces commitment to India's sustainable future at Vibrant Gujarat Summit 2015

Siemens Ltd showcased its range of integrated solutions for building sustainable, Smart Cities at the Vibrant Gujarat Summit 2015. Gujarat as a base for manufacturing and business operations has witnessed unparalleled success in the past decade, and Vibrant Gujarat has been making crucial contributions to the state's economic progress. With increasing globalization and urbanization, it is essential that India develops Sustainable and Smart cities as envisaged by the Government of India. This makes the theme 'Sustainable Cities – Smart Future' highly relevant, along with Make in India and 24/7 Power. Sunil Mathur, Managing Director and Chief Executive Officer, Siemens Ltd., said, "Cities drive economic growth, increased investment and job creation for millions of people who are increasingly converging on them with the hope of security and a better standard of living. For Cities to be able to deliver true value, they need to be able to provide their inhabitants with the highest standard of living while ensuring sustained protection of the environment. Only Cities which are able to reach this equilibrium will be capable of meeting today's challenges and can look forward to a more sustainable future. Siemens has the portfolio, the know-how, and the expertise to help Cities become more liveable, more competitive and more sustainable."Globally, Siemens is a leader in providing technology solutions for setting up intelligent (smart), sustainable cities. With solutions for Smart Grid, Building Technologies, Mobility and Power Distribution, Siemens has successfully set up smart cities in Vienna and New York, and is already involved in the Restructured Accelerated Power Development and Reforms Programme (R-APDRP) Program of the Government of India for installing Smart Grid solutions in multiple cities in India. It has also been a preferred technology solution provider for the Indian Railways for close to six decades. Siemens has been present in Gujarat through its two factories in Vadodara – for Steam Turbines and Laboratory Diagnostics – as well as the Memoranda of Understanding signed with the Government of Gujarat to set up Centres of Competence.

Ministries of Power, Coal and New & Renewable Energy-new websites

In consonance with Narendra Modi's vision of "Digital India", Ministries of Power, Coal & New & Renewable Energy have re-designed their websites to make them user-friendly, mobile/tablet responsive and engaging. These websites will continue to be further improved in the days to come to make them even more communicative and easy to navigate. Speaking to the media persons after launching websites, Goyal said that "Digital India" is a mission for this government. In the words of Prime Minister himself, "E-governance is easy, economical and effective governance", and departments are taking great strides towards this endeavour. The Minister further stated that the new websites launched on the eve of the World Economic Forum at Davos will also help showcase India's energy sector to the international business community in a professional manner, which will attract investments and aid in fulfilling our targets particularly in developing renewable energy. Giving details of features of new websites, Goyal said that the websites have been designed with user requirements in mind with categorizations by industry type (e.g. power generation, transmission, distribution, coal mining, coal linkages, coal auction etc.). In this way a specific user interested in coal auction can directly see all information related to the initiative with one click. Additionally, the initiatives and achievements of the first 200 days have been compiled into e-books in Hindi and English, which are featured prominently on the sites. The websites have been updated with all the recent schemes and latest news. Moreover, with the proliferation of mobile devices, the critical sites / sections have also been designed to provide a seamless experience on mobile devices.

Adani & SunEdison to invest $4 billion in solar PV manufacturing facility in Gujarat

Adani Enterprises Ltd, the flagship company of Adani Group and SunEdison Inc., a leading solar technology manufacturer and provider of solar energy services, announced that they have signed a Memorandum of Understanding (MoU) to establish a Joint Venture to build the largest, vertically integrated solar photovoltaic manufacturing facility in India with an investment of around $4 billion. The facility will create enough solar panels to fuel substantial solar growth in India, furthering India's goals for clean, renewable energy independence."India has embarked on an ambitious program to become a world leader in power generation from renewable technologies, and sees solar as a key part in realizing that goal," said Vneet S Jaain, Chief Executive Officer of Adani Power Limited, a subsidiary of Adani Enterprises Ltd."The development of the largest integrated solar manufacturing facility is a step towards the vision of our Prime Minister's "Make in India" campaign. We are happy to partner with SunEdison, a leading solar technology manufacturer to build this facility. This facility would further integrate our Power – Renewable business value chain and would significantly increase the socio-economic benefits," said Vneet S Jaain."We are proud to be partnering with Adani Enterprises to build the largest solar photovoltaic manufacturing facility in India," said Ahmad Chatila, President and Chief Executive Officer of SunEdison Inc. " The new $4 billion facility will be constructed in Mundra, Gujarat, India, over a three to four year period.


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Alstom T&D India to supply 765 kV switchyard for NTPC's Darlipalli Super TPP in Odisha

Alstom T&D India has secured an order worth around €23 million (INR 1800 million) from NTPC Limited to supply a 765 kV switchyard at the 2x800 MW Darlipalli Super Thermal Power Project (STPP) in Sundergarh, Odisha. The 765 kV switchyard will facilitate evacuate the 1600 MW of power produced by STPP to the state grid of Odisha. Alstom T&D India will design, engineer, manufacture, install and commission eleven 765 kV bays and fourteen 132 kV bays. All equipment will be manufactured and supplied from Alstom T&D India's manufacturing facilities located in Padappai, Hosur and Pallavaram.Rathin Basu, Managing Director, Alstom T&D India said, "After establishing India's first 765 kV substation at Sipat, we are pleased to earn the confidence of NTPC to execute the switchyard for the Darlipalli project. Alstom T&D India, with its repertoire of high-end, localised extra high voltage products and solutions, is playing a significant role in the evolution of the country's transmission landscape." Alstom has a full range of locally manufactured products up to 765 kV and beyond. Over 50% of India's 765 kV extra high voltage substations are built with Alstom's technology and solutions.

Renewable Energy Programmes gets a New Impetus; Focus on Development of Energy Infrastructure

Giving a fillip to the country's renewable energy programme, the new government led by Narendra Modi has taken a slew of decisions in a span of six months to boost "Clean Energy" in the country. These include providing support to Rs 1000 crore to Central Public Sector units to set up over 1,000 MW grid connected solar photovoltaic power projects, setting up of 25 solar parks each with a capacity of 500 MW requiring financial support from the centre of Rs 4050 crore and setting up of over 300 MW of solar power projects by Defence and Para military establishments. With these decisions, India will emerge as a major solar power producing country as nowhere in the world are solar parks are being developed on such a large scale. The Government restored Accelerated Depreciation benefit in the Union Budget 2014 to give much-needed relief to wind power developers and to ensure ramp-up of production. This will enable to kick start & ramp up wind capacity addition expeditiously. The Government amicably resolved the anti-dumping duty dispute. A whole host of measures have been undertaken to make India "Solar manufacturing" hub with priority for domestic players in line with 'Make in India' programme. With these initiatives, domestic manufacturers will have greater visibility on order books, have an opportunity to upgrade technologically and be able to reduce costs.

Jindal Steel & Power Ltd's first Business Sustainability Report showcasing Innovation

Jindal Steel and Power Limited (JSPL), India's leading steel and power company, released the company's first Business Sustainability Report for FY2013-14; showcasing Innovation as the corner stone of Sustainable Business. The Global Reporting Initiative confirms that JSPL's Business Sustainability report is the first G4 report in the Metals sector in India.Ernst & Young LLP has also independently assured the report, establishing its merit..GRI is the most widely respected sustainability reporting framework worldwide. The report outlines JSPL's efforts to integrate sustainable business solutions through catalysing innovation, infusing global talent at top management, maintaining robust internal processes through a system's driven approach, and ensuring environmental security. Naveen Jindal, Chairman, Jindal Steel and Power Ltd. said, "JSPL is committed to nation building and in the process has always stepped forward to nurture a sustainable business environment. We firmly believe in ensuring a holistic growth of the organisation with authenticity, and reaching out to a diverse group of stakeholders by reinvesting in avenues that will boost the future growth of JSPL and the society at large." It is important for the industries in steel and power sector to deploy environment management systems and make continuous efforts to reduce greenhouse gas emissions and air emissions. JSPL has adopted state-of-the-art technology and world class practices to spearhead the environment security issue and safeguard future generations. Ravi Uppal MD & Group CEO, JSPL said, "The business environment and regulations in which JSPL operates is changing and focusing on business sustainability ensures that we leapfrog on the opportunities that change always offers, and ensure that JSPL's growth path remains holistic and indeed authentic." During the assessment year, JSPL had spent more than 4% of PAT towards social activities. As a responsible corporate, JSPL has also been making significant efforts to resolve issues of national and global significance.The report also deep dives into five detailed case studies which showcase innovations within the company detailing JSPL's socio-capitalist business model.


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Schneider Electric demonstrates 'Smart Energy' solutions at Intelect 2015

Schneider Electric India, showcased its innovative and diverse range of smart energy solutions at Intelect 2015 organized by IEEE in Mumbai. The theme of the event was smart electricity and Schneider Electric, being one of the foremost solutions providers, exhibited solutions which can save up to 30% energy, thereby reducing capital costs significantly. The platform allowed Schneider Electric to provide a virtual, graphic-facilitated demonstration of how smart electricity integrates different aspects of a smart city. Schneider Electric showcased how it's smart and adaptive solutions help manage the challenges thrown open by the complexity of networks. Top officials across different business units from Schneider Electric were also present at the exhibition and shared their views on how smart solutions will play a major role in the whole digital revolution that has gripped India today. Prakash Chandraker, Vice President, Energy BU, Schneider Electric India and. Charbel Aoun, Senior Vice President, Schneider Electric delivered keynote address on the topic of smart cities. Anil Chaudhry, Country President and MD, Schneider Electric India said, "The year 2015 is expected to be a turnaround year for the Indian power sector as the centre aims to meet its goal of providing uninterrupted electricity supply to all households and smart solutions will play a major role in achieving energy efficiency and sustainability. The Government has set the ball rolling with a plethora of announcements that are set to revive the power sector in 2015 and Schneider Electric whole-heartedly supports the favourable and progressive announcements by the government." Smart Energy will define the future of real estate and the definition of quality living. Using energy efficiency measures and focussing on sustainable practices building owners and operators who invest in green building strategies will reduce the impact of climate change, preserve the quality of human life, improve business performance, and meet governmental regulations. In sync with this view, Schneider Electric displayed the virtues and facilities of its Smart solutions across Energy, Power, Buildings and Solar business.

Sterling Generators presents its Solar CSS Solutions

Importance of solar power as a renewable energy source is rapidly growing globally. Solar power is generated at low voltage DC levels and transformed up to medium voltages for network distribution. The transformation of Power from less than 1000VDC to 11/33KV HVAC is being done at local substation comprising of Inverter, Transformer and HT Panel. Conventionally all these equipment are erected and integrated at site. Sterling Generators, one of the largest manufacturers of HT / LT Panels & DG Sets in Asia, is proud to present its latest offering – SG Solar CSS. The SG Solar CSS completely eliminates the site work by offering a pre-connected integrated solution. Solar CSS boasts of a compact enclosure that houses an inverter, transformer, and a highly reliable RMU/HT Panel. The Solar CSS comes with a remote monitoring option which makes it a state of the art and safe to handle power generation machine.Sterling Generators have always been pioneers and value engineers when it comes to building and implementing complicated projects for DG sets and Panels. With the Solar CSS, Sterling Generators have gone a step further for quality by manufacturing a solar compact substation that's a plug and play kind of a device to suit your power generation needs. The Solar CSS is a modular device with max capacity of 2MW; however multiple units can be used to augment the capacity. Easy to set up and maintain, the Solar CSS is a one stop solution for your power generation needs.

Innovative Centork CK modular valve actuation system

Centork reports a worldwide launch of the innovative CK range of modular electric valve actuators at the 2014 Valve World Expo. Designed to deliver a highly reliable, economical and flexible solution for duties and applications of all descriptions in many industries, the CK incorporates features developed with the benefit of decades of operating experience. Designed as a series of interchangeable modular building blocks, the CK design can facilitate quick delivery, a benefit that is of great interest to many of the valve makers and end-users who visited the Centork stand. The modular construction presents a wide range of options and features, enabling each actuator to precisely match its specific valve duty and function. The choice ranges from basic actuators requiring separate motor controls to sophisticated versions equipped with the state-of-the-art Centronik intelligent digital control unit. Centronik provides integral control with data logging for diagnostics and asset management. The module is compatible with hardwired, digital or analogue control protocols and offers cost-effective integration with centralised and distributed control systems. Centronik display provides position indication, status and alarms plus user-friendly menu-driven configuration screens.


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BHEL commissions 600 MW Thermal Unit in Odisha

Bharat Heavy Electricals Limited (BHEL) has achieved one more landmark by commissioning another 600 MW thermal unit in Odisha. The unit was commissioned at Jindal India Thermal Power Limited (JITPL)'s upcoming 2x600 MW thermal power project located at Derang in Angul District of Odisha. This is the second unit of the pit-head project commissioned by BHEL. The first 600 MW unit was commissioned by the company in May, 2014. BHEL's scope of work in the contract envisaged design, engineering, manufacture, supply, erection and commissioning of Steam Turbines, Generators and Boilers, along with associated Auxiliaries and Electricals, besides state-of-the-art Controls & Instrumentation (C&I) and Electrostatic Precipitators (ESPs). Notably, this in-house engineered 4-cylinder 600 MW rating TG set establishes the engineering prowess of BHEL. The company has so far contracted 21 sets of 600 MW sets, out of which eleven have already been commissioned. These sets have a very high level of indigenisation. A large number of similar sets ensures easy availability of spares and operator's familiarity. The 500 MW sets of this rating class, supplied earlier by BHEL, form the backbone of the Indian power sector and have been performing much above the national average as well as international benchmarks. In Odisha, BHEL is presently executing 3,970 MW of thermal power projects which include 2x800 MW NTPC Darlipalli, 2x660 MW OPGCL IB valley and 2x525 MW Monnet Power Company Ltd., in addition to this JITPL project. BHEL is the market leader in the Indian Power Sector with practically 2 out of 3 houses in the country, being lit by power generated by BHEL sets.

India to Join Global High-end Scientific Club soon

INO, India now on a threshold to join the global high-end scientific Neutrino club and its way has been cleared with the Union Cabinet clearing Neutrino Observatory, INO. According to Prof. Naba K. Mondal, Project Director of the India-based Neutrino Observatory and Inter Institutional Centre for High Energy Physics it would open up avenues for experiments in high energy physics. Cabinet Committee on Security had cleared the project on December 26 last year, at an investment of Rs 1,500 crores. It will be funded jointly by Department of Science and Technology and Atomic Energy, while the Infrastructure will be created with help of Tamil Nadu government. Prof. Mondal, said on the sidelines of the ongoing Indian Science Congress in Mumbai. He said, India will also seek international participation in the project, so that it turns out to be an international hub for high-end research like the CERN in Geneva. He however, said, Indian participation in the Large Hadron Collider (LHC) project will continue. Dr. Mondal said with the closure of the Kolar Gold Field project this kind of high-end physics projects were not undertaken here in the past. Hence the global community had to be convinced that India is sincere in this regard. "Now with the formal approval for the project we will really want to open the space for the international community, to come and participate in the experiments or even propose new experiments. The experiment that we are doing is only the first experiment. There can be other experiments like on the dark matters. So India would like to invite the international community to come here and join us and participate so that this centre becomes a global hub for such things." The Inter Institutional Centre for High Energy Physics will come up in Madurai, about 110 kms from the Observatory.

Azure Power signs MoU with GERMI to launch 'National Certification Programme' for high quality Rooftop Solar PV Systems

Azure Power announced that it has signed a Memorandum of Understanding (MoU) with Gujarat Energy Research and Management Institute (GERMI), a Gujarat Government enterprise to launch the "National Certification Programme for Rooftop Solar Photovoltaic Installer." Under the MoU, Azure Power and GERMI will work towards establishing a cooperative and supportive team with adequate resources including skilled manpower, capital equipment, facilities, amongst others for the effective implementation of the new certification. The national certification will help in developing a skilled workforce and also transfer the knowledge and training techniques that Azure Power has gained, to empower the technical trainers from

Gujarat for undertaking such skill building initiatives locally. Speaking on the association, Inderpreet Wadhwa, CEO and Founder Azure Power said, "In order to meet the Governments vision of achieving 100 GW of Solar Power generation by 2022 will require a significant scale up of skill in the solar PV, engineering, construction and operations pan India. This initiative with GERMI will help us bridge up the skill gap between the industry while providing the youth employment as well as entrepreneurship opportunity in solar power in the country." While GERMI will comprehensively develop the training course curriculum, modules and provide certification to successful trainees of different institutions, Azure Power will recognize the certification program and promote it locally within its areas of activities. In addition, Azure Power will identify institutions for setting up training environment and promote the job placement of resultant skilled workforce. Through such initiatives, Azure Power aims to further strengthen its contribution towards the country's economic development, environment and society by providing unique and distributed solar power service to communities, governments, and commercial customers throughout India.

Investment opportunities in Australia's resource and energy sector

A 63 member Australian delegation visited India to showcase resources, minerals and energy investment projects to investors as part of Australia Business Week in India (ABWI) from January 12-16, 2015. Led by the Hon Andrew Robb AO MP, Australia's Minister for Trade and Investment, ABWI is the largest Commonwealth-sponsored trade, investment, education and tourism mission ever undertaken to India, comprising around 450 business delegates. Nicola Watkinson, Australian Trade Commission's Senior Trade and Investment Commissioner for South Asia, said this mission reinforces the message that Australia is keen to identify, strengthen and deepen relationships with India."ABWI participating delegates represent a significant cross section of Australia's industries and services in areas with significant opportunity for Australian companies to partner with Indian colleagues. Delegates will meet with leading representatives of India's business community and attend a series of high level investment roundtables," said Ms. Watkinson. "India's expanding economy; growing population and rapid industrialisation are driving an increased demand for energy security. As a world leader in resources and energy, Australia is well placed to supply India with coal, iron ore, uranium and liquefied natural gas (LNG)." Kylie Bell, Trade Commissioner, said the resources and energy delegation comprises Australian peak industry bodies; mining companies; mineral exploratory companies; geoscientific research agencies; LNG companies; Government agencies and Australia's leading banks and financial institutions. "The delegation will showcase Australia's resources and energy capability. That includes resources, minerals and energy projects in Australia of interest to Indian corporate investors, particularly projects in uranium, LNG, coal and iron ore," said Ms Bell. "Australia is a long-term dependable supplier of energy and mineral resources and its abundant reserves of mineral and petroleum deposits provide investors with extensive exploration, development, operations and maintenance opportunities. There is a substantial pipeline of projects with 25- to 50 year life cycles in mining, oil, and conventional and unconventional gas. "Indian investors can also seek collaborations with or enter the supply chains of the world's largest mining, oil and gas companies, many of which have substantial, long-standing operations in Australia. In addition, there are opportunities to participate in research and development," said Ms. Bell.

Energy partnership brings solar tracker to solarize Connecticut program

The partnership between C-TEC Solar of Windsor, Ct. and solar tracker manufacturer AllEarth Renewables of Williston, Vt. will bring an innovative, award-winning solar energy system to homeowners in the greater Hartford area consisting of the towns of Windsor, Windsor Locks, East Granby, and Suffield. C-TEC Solar recently won the ability to serve the four-town coalition for the Solarize Connecticut program. The 18 week program began in December and offers progressing discounts to homeowners looking to go solar based on community adoption. Solarize Connecticut, a partnership between the Connecticut Green Bank and SmartPower, has resulted in over 1,800 new residential solar installations, totaling 14 MW of clean, renewable energy in the state. The partnership provides homeowners in the program the choice of a ground-mounted solar array with AllEarth Renewables' innovative solar tracker.Designed and manufactured in Vermont, AllEarth Solar Trackers use innovative GPS and wireless technology to follow the sun throughout the day to boost solar energy production by up to 45% over roof-top installations. The pole mounted solar systems are designed for homes, businesses, non-profits, and commercial-scale installations. A single 6 kW solar tracker will produce enough energy to power most of an average Connecticut home.

Technology Roadmap: future of nuclear power

Nuclear power is a critical element in limiting greenhouse gas emissions, and a new Technology Roadmap co-authored by the IEA and the Nuclear Energy Agency outlines the next steps for growth in the aftermath of the Fukushima Daiichi accident in Japan and the economic crisis and its effect on financing. The new publication finds that the prospects for nuclear energy remain positive in the medium to long term despite a negative impact in some countries in the aftermath of the accident. While nuclear power's share of global electricity generation was 10% lower in 2013 than in 2010, principally because of Japan's 48 operable reactors remaining idle, it is still the second-largest source worldwide of low-carbon electricity. And the 72 reactors under construction at the start of last year were the most in 25 years. Yet global capacity must more than double, with nuclear supplying 17% of global electricity generation in 2050, to meet the IEA 2 Degree Scenario for the most effective and efficient means of limiting global temperature rise to the internationally agreed maximum. Nuclear energy's attractiveness lies in how it allows countries to build scalable, efficient and long-term power sources.

PT PLN with CG to manufacture, supply and installation of power transformers

Avantha Group Company CG seals deal with PT PLN (Perusahaan Listrik Negara) Indonesia, for the manufacture and supply of 37 units of 60MVA, 30MVA and 150/20kV Power Transformers. Valued at USD 26 million, CG's power transformers will be installed across PT PLN's transmission network, in 36 different substations in Sumatra, Java, Bali, Kalimantan and the Sulawesi islands of Indonesia. This project is being funded by IBRD - World Bank, in collaboration with the Government of Indonesia, for the purpose of strengthening Indonesia's power networks. The order was won under a competitive international public bidding process and represents the first of its kind won by CG Indonesia. The project scope includes the design, manufacturing, factory testing, site installation and testing, and the pre-commissioning of the transformers over a period of 18 months. CG was selected for this project due to its successful track record in Indonesia, backed by a global recognition of its technical expertise in manufacturing and supplying high-voltage transformers at the best quality to price ratio. PT PLN is the sole government-owned corporation in electricity generation, transmission and distribution in Indonesia and is one of the largest state-owned enterprises. It has an installation base of 48 GW and ambitious plans to ramp up the electrification of Indonesia from the current 67-100% in the next decade. From 2013 to 2022, PT PLN has a long-term plan for an additional generating capacity of 59.5 GW, with a total estimated expenditure of around USD 125 billion. From 1993 onwards, CG is regularly providing PT PLN's generation and transmission divisions, power transformers in the range of 30MVA to 500MVA, with voltage levels up to 500 kV.

Eritrea chooses MAN B&W low-speed engines again

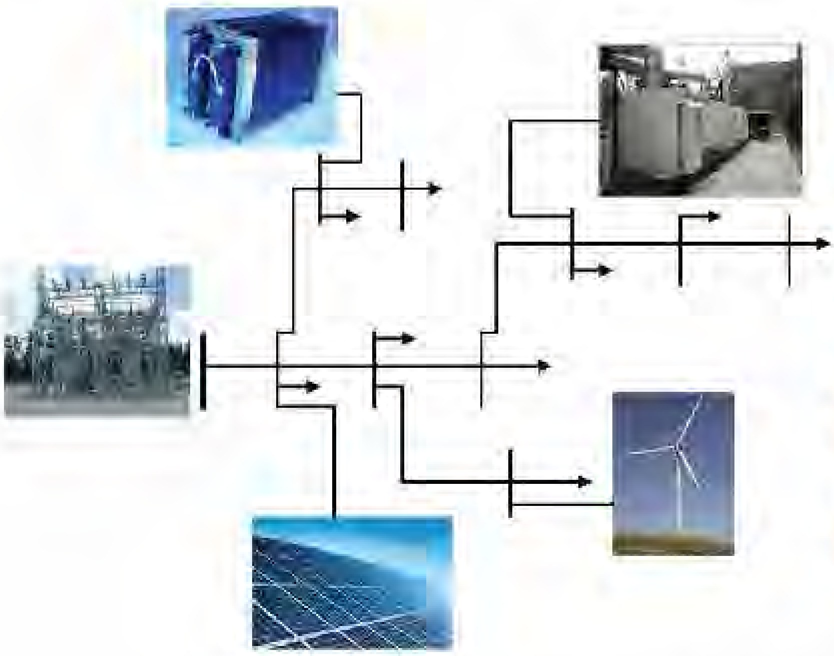
Qingdaohaixi Marine Diesel Co., Ltd. (QMD) and EPC contractor Shanghai Marine Diesel Engine Research Institute recently signed a contract to supply Eritrea with two MAN B&W 12K60MC-S low-speed engines that will run on liquid fuel. The engines will play a key part in expansion of Hirgigo power plant, located southwest of Massawa, major city on the Red Sea coast. Shanghai Electric will manufacture generators for the engines, being produced for Eritrean Electric Corporation (EEC). EEC has chosen the latest mark of the K60MC-S engine type and the two units will provide a joint mechanical output of 47.52 MW at 150 rpm. The engines will comply with the NOx emission limit of the World Bank's 2008 regulation, i.e. 1850 mg/Nm3 at 15% O2 dry. Based on statistics, distribution of the electrical consumption in Eritrea is 57% for industrial purposes, 22% for residential areas and 21% for commercial use. When two new engines enter operation, MAN B&W two-stroke, low-speed diesel engines will account for 73% of Eritrea's total power supply. MAN Diesel & Turbo views new order as a breakthrough, primarily because it is the first time a Chinese licensee has received an order for a stationary application with MAN B&W engines outside of China. It is also QMD's first order for MAN B&W engines, also the first occasion where a Chinese company will supply low-speed generators outside of China for engines with an MAN B&W design.

Algerian-French centre of excellence for training in energy and electricity trades

Schneider Electric announced a three-way partnership agreement with Algerian Ministry for Vocational Training and Education and the French Ministry for National Education for Education and Research. The agreement relates to the implementation of an Algerian-French centre of excellence for training in the energy and electricity trades. It was signed at the Hotel Matignon (Paris), in the presence of Amar Bendjama Ambassador of Algeria in France, Geneviève Fioraso, Secretary of State for Education and Research, Akli Brihi, Executive Country President of Schneider Electric Algeria and Gilles Vermot Desroches, Sustainability Senior Vice-President of Schneider Electric and Managing Director of the Schneider Electric Foundation. This signature took place in the presence of the Algerian Prime Minister, Abdelmalek Sellat

From L to R: Amar Bendjama Ambassador of Algeria in France, Geneviève Fioraso, Secretary of State for Education and Research, Akli Brihi, Executive Country President of Schneider Electric Algeria and Gilles Vermot Desroches, Sustainability Senior Vice-President of Schneider Electric and Managing Director of the Schneider Electric Foundation.

and the French Prime Minister Manuel Valls. In the context of major worldwide technological change, the agreement is the result of a common aim to develop high-level initial and continuing training in the field of energy and electricity. The agreement is one of the measures put in place by the Ministry for National Education to create a network of centres of excellence for technical training abroad. It also extends the joint declaration of intent signed in Algiers on December 16, 2013, by the Algerian Ministry for Vocational Training and Education, the French Ministry for National Education, for Education and Research and Schneider Electric Algeria, to promote vocational technical education and training in the energy and electricity sector. The agreement enables the deployment of new teaching strategies through the development of long-term relationships between training institutions and companies; participation in the creation of strategic training channels in the fields of energy and electricity; and training etc.



Optimal Placement Techniques for **Distributed Generation**

Electrical power is transmitted through the transmission systems from the central generating stations to the end users using a series of distribution transformers and lines. From around 1990, there has been a growing interest in connecting generations directly to the distribution system, known as Distributed Generation (DG) or Distributed Energy Resources (DER). In some countries, a strict definition of distributed generation is made, based either on the rating of the plant or on the voltage level to which it is connected to the grid. However, these definitions usually follow technical documents.

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Distributed generation includes the application of small generators, typically ranging in capacity from 15 to 10,000kW, scattered throughout a power system, to provide the electric power needed by the end-users. Most types of distributed generators utilize traditional power generation paradigms – diesel, combustion turbine, combined cycle turbine, low-head hydro, or other rotating machinery. But in addition, DG also includes fuel cells and renewable power generation methods such as wind, solar, etc. The renewable generators are often lumped into the "DG" category because their small size makes them convenient to connect to the lower voltage (distribution) parts of the electric utility grid. The plant efficiency of most existing large central generation units is in the range of 28 to 35%, meaning that they convert between 28 to 35% of the energy in their fuel into useful electric power. By contrast, efficiencies of 40 to 55% are attributed to small fuel cells and to various "hi-technology" gas turbine and combined cycle units suitable for DG application.

A DG unit does not require transmission and distribution network but provide reliable to the end user as it is located near to electric power demand. In area where incremental expansion cost is high, DG may not only offer a good economic alternative, but appeals on its reliability merits alone. There are many situations where there is no local electric utility grid in an area, and DG of any type is the only possible source of electric power at lower costs. The architecture of modern power systems with distributed generation is shown in Fig. 1. The major turnouts that made electric utilities to interconnect DG into the distribution network are as follows:

- There is growing electricity demand and increase in environmental pollution due to emissions from central power generations which is causing adverse effects to whole ecosystem.
- DG units are closer to customers and T&D system can be expensive to design, build and operate.
- DG is tailorable in both cost and reliability, to a degree than the electric utility often cannot match.
- Usually DG requires shorter installation period and the investment risk is not high.

Distributed generators are generally either utility owned or individual owned. The placement decision is taken by their owners or investors. In most cases, distribution network operators have no control over DG location and size, however, interconnection of DG alters the distribution network operation. These factors drew the attention of distribution network operators for

Fig. 1: Architecture of modern power systems with distributed generation

the decision making about the optimal/proper siting and sizing of the DG. The problem of DG placement has attracted many researchers since last decade.

Classification of Distributed Generation

The classification of DGs from their connection & technological points of view is shown in Fig. 2. The different DG technologies that are being deployed into the power systems are Wind Turbine (WT), Micro Turbine (MT), Combined Heat & Power (CHP), Squirrel Cage Induction Generator WT (SCIG WT), Double-Fed Induction Generator WT (DFIG WT), Fuel

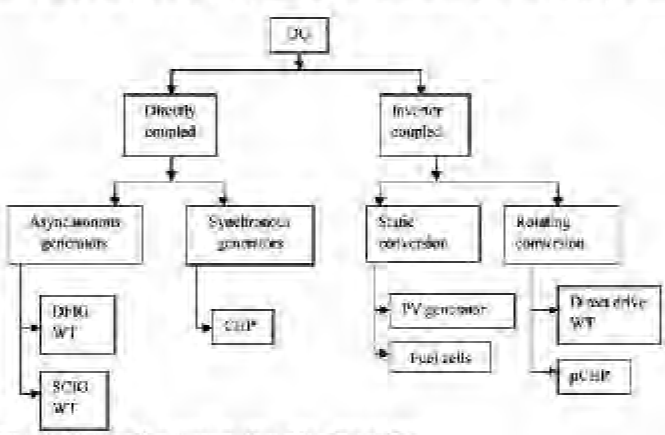

Fig. 2: Connection based classification of DG

Implementation of the different DG technologies is covering a wide range of applications according to the load requirements

Cells (FC), Photo Voltaic (PV) and storage devices. Usually DGs are classified according to their different types and operating technologies. However, it is more convenient to classify them from the electric point of view to study their impact on the electric system. Different classifications can be obtained to differentiate between DG types according to their electrical applications, supply duration, generated power types, electric ratings & renewable and non-renewable technologies.

Implementation of the different DG technologies is covering a wide range of applications according to the load requirements. The DG type is different for different applications which are discussed below:

- **Standby:** DG can be considered as a standby to supply the required power for sensitive loads, such as process industries and hospitals, during grid outages.
- **Stand-alone:** Usually, isolated areas utilize DGs as a power provider instead of connecting to the grid. These areas have geographical obstacles, which make it expensive to be connected to the grid.
- **Peak load shaving:** The electric power cost varies according to the load demand curves and the corresponding available generation at the same time. Hence, DGs can be used to supply some loads at peak periods, which reduce the electricity cost for large industrial customers who used to pay time-of-use rates (TOU).
- **Rural and remote applications:** DG can provide required power by the stand-alone remote applications. These applications include lighting, heating, cooling, communication, and small industrial processes. Even more, DGs can support and regulate the system voltage at rural applications (sensitive loads) connected to the grid.
- **Base load:** Utility owned-DGs are usually used as a base load to provide part of the main required power and support the grid by enhancing the system voltage profile, reducing the power losses and improving the system power quality.

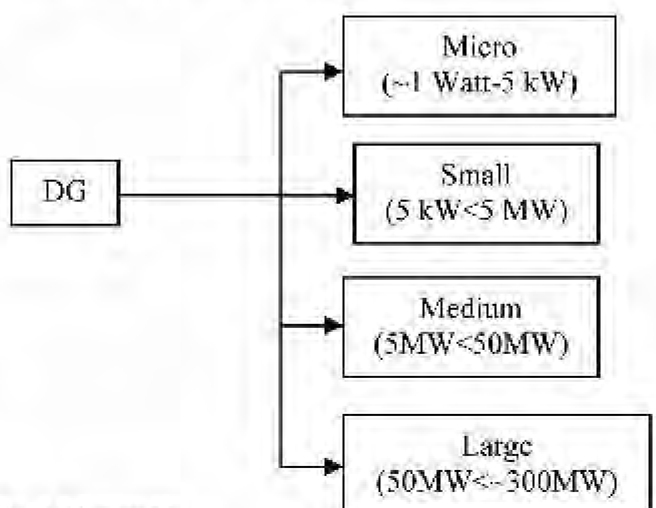

Fig. 3: DG capacities

- **DG capacities:** DG capacities are not restrictedly defined as they depend on the user type (utility or customer) and/or the used applications. The most commonly used classification is shown in Fig. 3. These levels of capacities vary widely from one unit to a large number of units connected in a standard form.
- **AC/DC power type:** The output electric current can be either direct or alternating. Fuel Cell (FC), PV and batteries produce direct current, which is suitable for dc loads. However, we can convert this current to an alternating one for AC loads and for grid connections. This conversion can be done through a power electronic interface between the DG device and the grid. Other types of DGs like Micro Turbine (MT) and Wind Turbine (WT) provide an alternating current, which for some applications must be controlled using modern power electronic equipment to get regulated voltage.
- **Technology:** Another attempt for DG classification can be done according to the type of the fuel used. It can be either non-renewable or renewable sources as shown in Fig 4.

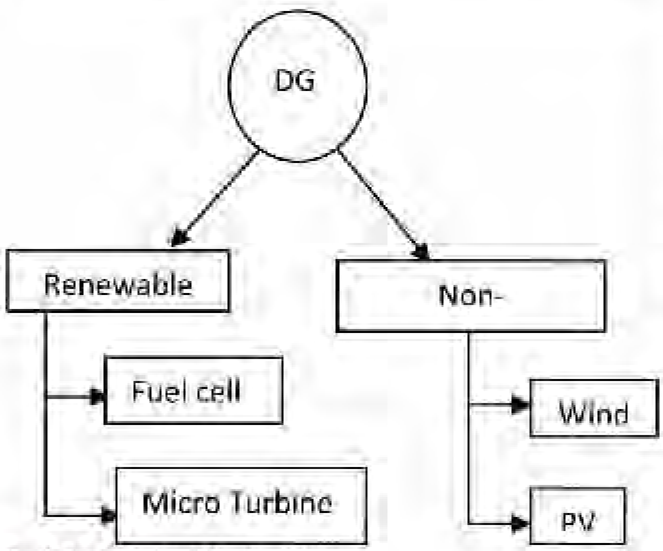

Fig. 4: Technological DG classification

DG Placement

In literature, various objective functions have been considered and optimized, subject to different operating constraints, using conventional methods, intelligent searches and fuzzy set application for the placement of DG. A detailed study of the literature on DG Placement (DGP) is summarized by the objective function model, the constraint model, and the mathematical algorithms to solve these objectives.

Objective and Constraint Functions

In, the DGP deals with the optimal allocation of distributed generation for minimizing the total real power loss in the system using second order method based on Newton's method. The basic formulation is done with the concept that a sum of all nodal injections of power in a network represents losses. In [5], the impact of DG in power transfer capacity of distribution network and voltage stability has been studied. The overall impact is positive due to the active power injection with objective to minimize the losses. In, problem is formulated using exact loss formula. In, the objective function considered as total power loss in the system to find the optimal DGP. The objective for optimal allocation of Distributed Generation (DG) has been taken as maximization of DG capacity in and with same objective for constant load is developed in, respectively. A method that evaluates the capacity or headroom available on the system and models fixed-power factor distributed generation as negative loads and uses optimal power flow to perform negative load shedding in.

The objective in is to maximize the amount of energy that can be harvested from DG by making best use of the existing assets and available energy resource. To obtain most appropriate DG location, nodal price variation at each bus and line loss sensitivity has been utilized in, as economical and operational criteria. Then mixed-integer non-linear programming (MINLP) approach was used to find the optimal location and the number of DG in appropriate zone. The objective function is to minimize the fuel cost of conventional and DG sources as well as to minimize the line losses in the network. In the maximum DG capacity has been determined by modeling DG as generators with negative cost coefficients. By minimizing the cost of these generators, the DG capacity benefits are maximized. In the problem is formulated with two distinct objective functions, namely, social welfare maximization and profit maximization. In, authors evaluated the impact of DG using multi-objective performance index considering range of technical issues as indices. In, authors have considered the composite technical and economic benefits of DG in multi-objective function and optimized to reduce the voltage and frequency deviation.

Mathematical Algorithms

Analytical Methods

An analytical method, based on the exact loss formula, is proposed for a single DG optimal location & sizing. Analytical expressions for finding optimal size and power factor of different types of DGs are suggested in. An analytical method using a loss sensitivity factor that is based on the equivalent current injection is developed in to find the optimum size and location of a single DG. Two analytical methods for determining the optimal location of a fixed size single DG is proposed in; the first method is applicable to radial and the second one to meshed power systems. An analytical method is proposed in for finding the optimal locations of multiple DGs in combination with the Kalman filter algorithm for determining their optimal size. An analytical method described in computes the optimal location & size of multiple DGs, considering also different types of DGs.

Conventional Optimization Methods

An exhaustive search based method is proposed in evaluating DG placement for optimal power losses and reliability, and a multi-objective performance index, respectively, taking into account the time-varying behavior of demand. A discrete probabilistic generation-load model is reduced into a deterministic model considering all possible operating conditions solved using a Mixed Integer Nonlinear Programming (MINLP) technique for optimally allocating either only wind DG units, or different types of DG units. The optimal DGP is formulated as a multi-period AC Optimal Power Flow (OPF) that is solved using NLP. Optimal DGP of various technologies considering electricity market price fluctuation employing MINLP is proposed. An integrated distribution network planning model, implementing ODGP as an alternative option, is solved by MINLP.


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Power electronic devices interfaced DG units are considered with an objective of improving the voltage stability margin for the placement and sized using MINLP. Dynamic programming based optimal DG placement model is proposed which maximizes the profit of the Distribution Network Operator (DNO) considering light, medium, and peak load conditions. The optimal placement and sizing of single and multiple DGs in a distribution level is carried out in, applying sequential quadratic programming utilizing the sensitivity indices and stability.

Intelligent Search Based Methods

The algorithm presented in uses Genetic Algorithm (GA) as a technique to solve the problem of static planning of distribution system expansion considering possible reinforcements or commissioning of new feeders and substations. GA is used to solve an Optimal DG Placement Problem (ODGPP) that considers variable power concentrated load models, distributed loads, & constant power concentrated loads. A GA is employed to solve ODGPP that maximizes the profit of the DNO by the optimal placement of DGs. A GA methodology is implemented to optimally allocate renewable DG units in distribution network to maximize the worth of the connection to the local distribution company as well as the customers connected to the system. A value-based approach considering the benefits and costs of DGs is developed and solved by a GA that computes the optimal number, type, location, and size of DGs. A GA-based method allocates simultaneously DGs and remote controllable switches in distribution networks. Goal programming transforms a multi-objective ODGPP into a single objective ODGPP, which is solved by a GA method. A hybrid GA and fuzzy goal programming is proposed for ODGP. A fuzzy GA is employed to solve a weighted multi-objective ODGPP model. A hybrid GA and immune algorithm solves an ODGPP that maximizes the profit of the DNO.

GA solves a weighted multi-objective ODGP model in. Multi-objective ODGP formulations are solved using a GA and a constrained method. A Non-dominated Sorting GA (NSGA) is used to maximize the distributed wind power integration. NSGA-II (a variant of NSGA) in combination with a max-min approach solves a multi-objective ODGPP. ODGP models with uncertainties are solved by Monte Carlo simulation in conjunction with GA. Placing a single DG based on the ranking of the energy not supplied index or the ranking of the power losses in the network lines. Heuristic methods for sizing wind farms based on modes of voltage instability are proposed. A heuristic cost-benefit approach for optimal DGP to serve peak demands in a competitive electricity market is introduced. A heuristic value-based approach determines the optimum location of a single DG by minimizing the system reliability cost. A heuristic iterative search technique is developed that optimizes the weighting factor of the objective function and maximizes the potential benefit thanks to the optimal DG placement. The ODGP is solved by a heuristic iterative method in two stages, in which clustering techniques and exhaustive search are exploited. A heuristic method calculates the regions of higher probability for location of DG plants. The ODGPP for small distribution networks is solved by a heuristic method.

Problem Formulation

The DG planning is basically a non-linear mixed integer optimization problem which finds the optimal DG siting and sizing that are to be located into the distribution networks subjected to various network operating constraints, DG operating constraints, etc. The objective function may be single or multi-objective in order to maximize the benefit of DG satisfying various network equality and inequality constraints.

Objectives

The main objective functions that are being considered are

Minimization of power loss

$$Min \sum_{i=1}^{n} P_i \tag{1}$$

where P_i is the power injection at i^{th} node & n is the total number of buses in the system.

Maximizing the reliability

Network reliability assessment contains two types of indices: load point indices and system indices. Load point indices are calculated at each load point connection and are used for the evaluation of system indices. The system indices that can be considered for reliability evaluation are System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI).

$$SAIDI = \frac{\sum u_i \times N_i}{\sum N_i}$$

$$SAIFI = \frac{\sum r_i \times N_i}{\sum N_i} \tag{2}$$

$$Min\ W_1 \frac{SAIDI_{DG}}{SAIDI_{base}} + W_2 \frac{SAIFI_{DG}}{SAIFI_{base}} \tag{3}$$

Where N_i is the number of customers at the load point i, u_i is the outage time and r_i is the failure rate. The optimization algorithm is used to minimize the weighted composite index including interruption duration and frequency components. The smaller the value of the defined reliability index (i.e., objective function) is, the higher is the system reliability.

Maximizing the DG capacity

$$Max \sum_{i=1}^{N} P_{DGi} \tag{4}$$

where P_{DGi} is the DG capacity at the i^{th} node & N is the set of all possible DG locations.

Maximizing the profit and social welfare

Social welfare is defined as the difference between total benefit to consumers minus total cost of production. The objective function associated with social welfare has been formulated as quadratic benefit curve submitted by the buyer (DISCO), $B_i(P_{Di})$ minus quadratic bid curve supplied by seller (GENCO), $C_i(P_{Di})$ minus the quadratic cost function supplied by DG owner $C(P_{DGi})$.

$$Max \sum_{i=1}^{N} (B_i(P_{Di}) - C_i(P_{Di}) - C(P_{DGi})) \tag{5}$$

The profit maximization formulation is as follows:

$$Max \sum_{i=1}^{N} \lambda_i \times P_{DGi} - C(P_{DGi}) \tag{6}$$

where is the total number of nodes in the system, P_{DGi} is the DG size at node i, λ_i is the locational marginal price and $C(P_{DGi})$ is the cost characteristic of DG at i^{th} node.

Maximizing the voltage stability margin

$$V_i = \frac{V_{p\ with\ DG}}{V_{p\ base}} \tag{7}$$

$$Max\ V_{index} = \frac{\left(\sum_{i=1}^{N} V_i pr_n\right)}{96} \tag{8}$$

Where, N is the total number of nodes in the system, $V_{p\ with\ DG}$, $V_{p\ base}$ are voltage profiles of the system with and without DG, pr_n is the probabilistic nature of DG. The highest value of the voltage index implies the best location of DG in terms of improving the voltage stability of the system.

Constraints

The most commonly used constraints in DG placement (DGP) problem are

Power flow equality constraints

$$P_i = P_{Gi} - P_{Di} = \sum_{q=1}^{n} V_i V_q Y_{iq} \cos(\delta_i - \delta_q - \theta_{iq})$$

$$Q_i = Q_{Gi} - Q_{Di} = \sum_{q=1}^{n} V_i V_q Y_{iq} \sin(\delta_i - \delta_q - \theta_{iq}) \qquad (9)$$

Where, n is the total number of nodes in the system, P_i, Q_i are the real and reactive power injections at bus i, V_i is the voltage magnitude at node i, δ_i is the phase angle of complex voltage at node i, θ_{iq} is the angle of the i-q^{th} element of the bus admittance matrix & Y_{iq} is i-q^{th} element of the bus admittance matrix.

Bus voltage limitation constraints

$$V_i^{min} \leq V_i \leq V_i^{max} \qquad (10)$$

where V_i^{min}, V_i^{max} are the lower and upper limits on the voltage.

DG generation limits

$$P_{DGi}^{min} \leq P_{DGi} \leq P_{DGi}^{max}$$

$$Q_{DGi}^{min} \leq Q_{DGi} \leq Q_{DGi}^{max} \qquad (11)$$

where P_{DGi}^{min}, P_{DGi}^{max} are the upper and lower limits on DG real power generation at bus i & Q_{DGi}^{min}, Q_{DGi}^{max} are the lower and upper limits on DG reactive power generations at bus i.

Feeder thermal limit

$$S_k \leq S_k^{rated} \qquad (12)$$

The power carrying capacity of feeders is represented by MVA limits S_k through any feeder k must be well within the maximum thermal capacity S_k^{max} of the lines.

Short circuit level limit

A short circuit calculation is carried out to ensure that fault current with DG, SCL_{WDG} should not increase rated fault current of currently installed protective devices SCL_{rated} as

$$SCL_{WDG} \leq SCL_{rated} \qquad (13)$$

Design Variables

There are two main design variables, i.e., DG and load variables.

- DG variables that are generally considered are location, size, type, number. In case of renewable generation like wind etc, the location is fixed.
- Load profile is modelled as static load and time-varying load which are considered as load variables.

Solution Techniques

The solution techniques for DGP have been evolving and number of approaches have been developed, each with its particular mathematical and computational characteristics. The most of the techniques discussed are classified into three categories:

- Analytical methods
- Conventional methods,
- Intelligent search based methods

The conventional methods include Linear Programming (LP), Non Linear Programming (NLP) like AC optimal power flow and continuous power flow, Mixed Integer Non-Linear Programming (MINLP), and Analytical approaches. The intelligent search-based methods are Simulated Annealing (SA), Evolutionary Algorithms (EAs), Tabu Search (TS), Particle Swarm Optimization (PSO), GA, etc. have been given wide spread attention as possible techniques to obtain the global optimum for the DGP problem. Fuzzy set approaches has also been applied to DGP to address fuzziness associated with DG generation, demand, etc.

Simulation Results

The most commonly used objectives in the formulation of optimal DG sizing and siting is the power loss reduction and reliability improvement. The simulation results are demonstrated on IEEE 33-node test distribution systems and problem is solved using fminimax nonlinear optimization solver in Matlab. The single-line diagram of the IEEE 33 node test system is shown in Fig. 5. The total real and reactive power load on the system is 3715 kW and 2300 kVar, respectively. At base case condition, the maximum and the minimum bus voltage magnitudes are 1.0 and 0.898 p.u., respectively. The considered DG variables are location and size and fixed variables are type and number. The DG number is fixed to four. The varying load conditions considered, in this work, are normal load, 20% load increase and 20% load decrease. The DG penetration level is considered as 35% of the power supplied from main substation. The objective values are calculated in DIgSILENT programming and transferred into the Matlab and then the optimization tool searches for the optimal size for each DGs configuration. For each DGs configuration, the optimal sizing is found and obtained objective values are given to the fuzzy logic min-max approach to obtain best DG location.

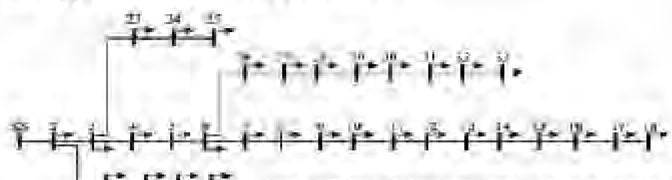


Fig. 5: IEEE 33 node test distribution system

The problem formulation for the optimal DG sizing for all possible DGs configurations is given in (14)-(21) as,

$$Min\ w_1 SAIDI + w_2 SAIFI + w_3 P_{loss} \qquad (14)$$

$$Subject\ to\ P_i = P_{Gi} - P_{Di} = \sum_{q=1}^{n} V_i V_q Y_{iq} \cos(\delta_i - \delta_q - \theta_{iq}) \qquad (15)$$

$$Q_i = Q_{Gi} - Q_{Di} = \sum_{q=1}^{n} V_i V_q Y_{iq} \sin(\delta_i - \delta_q - \theta_{iq}) \qquad (16)$$

$$\sum_{i=1}^{n} P_{DGi} \leq 0.35 \times P_{main} \qquad (17)$$

$$P_{DGi}^{min} \leq P_{DGi} \leq P_{DGi}^{max} \qquad (18)$$

$$S_l \leq S_l^{rated} \qquad (19)$$

$$P_L = \pm 20\% \times P^o{}_L \qquad (20)$$

$$where \sum_{K=1}^{n} w_k = 1 w_k \in [0,1] \qquad (21)$$

All the components are assumed to have identical reliability data. The failure rate, repair time, maintenance rate and maintenance time are 0.02 outages/year, 30 hours, 0.2 outages/ year and 20 hours, respectively. The upper and lower voltage limits considered are 1.0 & 0.95 p.u., respectively. Three cases are considered in which cases 1-2 represents single objective problems and case 3 represents the multi-objective problem, in which the weights are as follows:

$$Case\ 1: w_1 + w_2 = 1\ \&\ w_3 = 0$$

$$Case\ 2: w_3 = 1\ \&\ w_1 = w_2 = 0$$

$$Case\ 1: w_1 + w_2 + w_3 = 1\ ;\ w_1 + w_2 = 0.5,\ w_3 = 0.5$$

In case-3, reliability and power loss both were given equal weightage (0.5). Table I gives the results of the best DG locations and their optimal sizing for 35% penetration levels. It can be seen that, to minimize the loss and to improve the bus voltages, the optimal places of DGs are the low voltage buses whereas for improving only reliability, end feeder buses are the candidate buses for DGs placements.

Penetration level=35%	Base case (without DG)	Case-1 (Reliability Improvement)	Case-2 (Power loss reduction)	Case-3
Optimal DG sizing (MW)	--	0.476,0.010, 0.047,0.767	0.378, 0.148, 0.378, 0.396	0.299,0.170, 0.099,0.731
Optimal DGs placement	--	18,22,25,33	14,18,30,32	13,16,18,31
Power loss (kW)	211	59	51	52
SAIFI (interruptions/ customer yr)	1.1351	0.0045	0.075953	0.0843
SAIDI (hours/ customer yr)	14.618	0.108	0.510687	0.5580
Min voltage	0.898	0.9696	0.9663	0.9702

Table 1: Optimal Solution for the DG Placement & Size Corresponding to 35% Penetration Level & Varying Load (33-Node System)

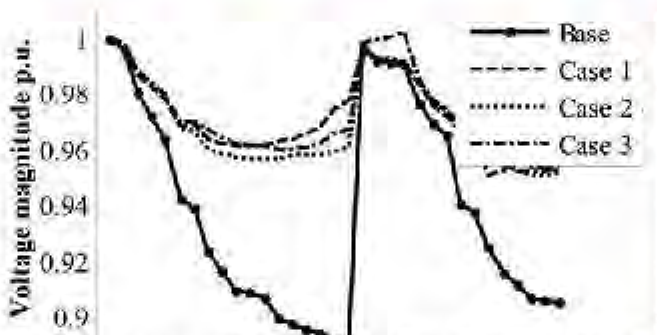


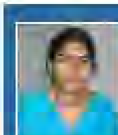
Fig. 6: Voltage profile of IEEE 33 node test distribution system for all the three cases

For meeting all the objectives, the low voltage end feeder buses are the candidate buses for DGs placement. This shows the validity of the approach. It can be seen that these buses are the best choice for DGs placement to improve the voltage profile and reliability of the system. Considering all the objectives together, these buses or nearer buses are selected for the optimal DG locations. It should be noted that the sizes of these DGs are different for different objectives. The voltage profiles with and without DGs corresponding to all the three cases are shown in Fig. 6. In the first two cases, only one objective at a time is emphasized, which makes optimization tool to give more importance to that objective. In the third case, all the objectives are considered with weights assigned to them and so the result obtained is the contribution of all.

Conclusions

The general background, objectives, constraints, and solution algorithms for the optimal allocation of Distributed Generation (DG) have been discussed in this paper. The objectives have been classified as single objective and multi-objective with equality and inequality constraints. In literature, different types of objective functions have been optimized for DGP using various conventional and artificial intelligent methods. In a general optimization formulation, single or multi-objective DG placement with various operational constraints may be solved with conventional optimization algorithms like Linear Programming (LP), Non-linear Programming (NLP), or MINLP. Due to the nonlinear nature of power systems, LP suffers from accuracy limitation to particular operating conditions. Consideration of nonlinear algorithms and integer variables will make the simulation time much longer and the algorithm possibly less robust. The intelligent search based algorithms such as Simulated Annealing (SA), Evolutionary Algorithm (EA), TS and PSO can deal the integer variable very well. However, these are more heuristic than conventional optimization techniques and needs further investigation regarding performance on different larger systems with their improved versions. Another interesting aspect is to include fuzzy set theory to model the uncertainties in objective function, load, generation, electricity price, and constraints for better compromised solution.

Profile



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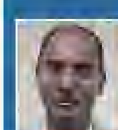

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Enabling Smarter Grid

Automation through Standardization

Power grid is a combination of various network elements and electrical components used to generate, transmit, distribute and supply power to end users of electricity. Complexity of power system has been growing tremendously over the last few decades, facing new challenges and targets during its operation. In order to overcome some of these major challenges, there is a definite need of automation which helps in automatically operating & controlling the power system under various situations of operating grid in day-day scenarios. The new era of smart grid in the 21st century has made automation and standardization really a need to operate grid under the dynamics of rapid load changes, making the system more time sensitive towards faults and failure modes. This research article presents analysis & overview on emerging technology and standards over past few years for smart grid automation, from generation to utilization making Indian power grids to operate in efficient manner and resilient to failure modes.

Balakrishna P & Swarup KS

Smart grid combines advanced telecommunications and information technology applications with 'smart' appliances to enhance energy efficiency on the electricity power grid

A Smart Grid is an electrical grid that uses information & communications technology to gather and act on information. According to the European Technology Platform, a Smart Grid is an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both 'Prosumers' – in order to efficiently deliver sustainable, economic and secure electricity supplies. According to the US Department of Energy, the smart grid is self-healing grid, enables active participation of consumers, operates resiliently against attack and natural disasters, accommodates all generation and storage options, enables introduction of new products, services and markets, optimizes asset utilization and operates efficiently, and provides reliable and high quality power for the digital economy. Smart grid combines advanced telecommunications and information technology applications with 'smart' appliances to enhance energy efficiency on the electricity power grid as shown in Fig. 1. Power system or smart grid automation includes processes and technologies associated with the generation, transmission, distribution and utilization that generate electricity, transmit and distributes it for end user applications and needs. Grid automation can be further classified into generation automation, transmission automation & substation automation/distribution automation blocks making it more decentralized in order to focus more on corresponding sector applications and meet its own challenges. More details about each automation block are explained in further sections. Initially when every vendor used to have their own proprietary technologies for automating the systems were non-interoperable & hence need for standards & standardization has evolved.

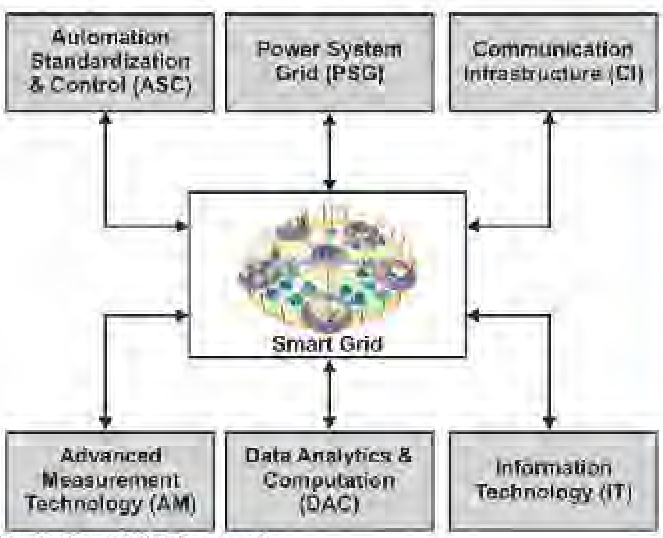


Fig. 1: Smart Grid Framework

Smart Grid Automation

Automating a power system or grid can bring substantial benefits to the operators and end-users by improving system reliability, planning, design, efficiency and response to various failure modes that may occur during day-to-day operations, which matches with some of the smart grid objectives. The availability of technology for automation has grown significantly over the past few years. Several challenges led to the birth of power system automation of which system growth, availability, reliability, engineering, planning expectations and most importantly smart grids are the key ones. As the system growth continues and expectations rise due to the tremendous growth of industrial and commercial consumers, it will demand even further automation of the system. As automation research engineers, we realize that the counterweight to implement technology on automation is the high cost which includes design, installation, equipment and maintenance. To accomplish this deciding the communications protocol and interoperability between various nodes plays a vital role. Hence there is a need of standardized automation systems which can communicate and operate on a standard protocol and design framework. Grid automation across the network can be further classified as combination of generation, transmission, substation and distribution automation blocks.

Sl No	Automation Block	Grid Automation Operational Requirements
1	Generation Automation	Develop in-built automation logics to control generation parameters based on load fluctuations using turbine (prime over) and excitation (voltage) control nodes.
		Ability to operate and control all auxiliary plant devices and equipment's automatically based on commands received from local or remote control (SCADA) applications.
2	Transmission/ Substation Automation	Execute State Estimation algorithm using measured data from Phasor measurement Units (PMU) to fill any missing data for transmission automation and control logic.
		Estimate Power System Security (minimum of "n-1" contingency level) and develop automated control strategies for each critical scenario (EMS/WAMS).
		Establish data acquisition between SCADA & RTU's in each transmission station and SCADA & Gateways in each substation for protection, monitoring & control.
3	Substation Automation	Ability to operate and control all auxiliary devices and equipment's in the substation automatically based on commands received from SCADA via substation gateway or based on in-built local automation logic in the gateway and IEDs in substation.
4	Distribution Automation	Estimate demand and forecast load at each substation/ distribution level, day ahead (using AMI).
		Establish communication between various automation nodes for performing fault identification, restoration of loads, feeder reconfiguration, load management (DMS) and demand response (DRMS) automatically using, AMI and smart meters.

Table 1: List of Grid Automation Functional Requirements

Many power system networks have adapted available technology for various benefits, apart from these hardware and software technology requirements for building automation, the other major consideration in developing automation network is ongoing need for human operators to continue in maintaining and extending the automation network, as per

Sl No.	Automation Block	Grid Automation Operational Algorithms
1	Generation Automation	Controlling generation in MW based on the instantaneous measured data on the grid or plant.
		Monitoring and controlling all the auxiliary devices and equipment's in generation plant based on the load and sending instantaneous generating station data to SCADA for wide-area control.
		Executing control commands in case of any abnormality conditions in generation system or grid. Ex: Frequency & voltage not in limits, loss of synchronism etc. Primary control by local automation for critical operations.
2	Transmission Automation	Performing optimal load flow analysis in transmission network based on generation/load data for online contingency analysis, security analysis, stability analysis and energy transactions.
		Controlling FACTS devices for power flow control and for increasing stability margin using wide-area measurement data. It also executes pre-programmed control logics built in EMS, in case of any real contingencies.
3	Substation Automation	Monitoring increase in load demand, communicating load shedding & control commands to individual feeders based on a gap in supply and demand for each substation managed.
4	Generation/ Transmission/ Substation Automation	All protection devices from generation to distribution monitor the condition of individual assets & trips in case of any fault occur, set points reached or violated.
5	Distribution Automation	Performing load shedding & curtailment at feeder level, reconfiguration/switching operations of lateral circuits for load and phase balancing, fault location identification, Isolation of fault zones & restoration of power to un-affected zones, and demand response functions in distribution system. Automatically controlling FACTS devices for reactive power and power factor control.
		Capturing load data for load forecasting to make day-ahead schedule & communicating price signals and commands to end customers in order to perform demand side management and load control during peak hours at distribution transformer level.

Table 2: List of Grid Automation Functions

requirements and operations listed in Tables 1 & 2, into the future as once the benefits of automations are realized by the execution side of power system or grid, there will be a demand to automate the entire existing system and any new devices added in the future, to be a smarter grid.

Smart Grid Automation Standardization

Smart grid objectives can be realized to a greater extent by grid automation, but major benefit of incorporating these automation technologies can only be realized by automation along with standardization. List of IEC standards relevant to smart grid automation as in Fig. 2 are-

- IEC 62270 – Power plant Automation
- IEC 61158 – Foundation Field Bus Automation

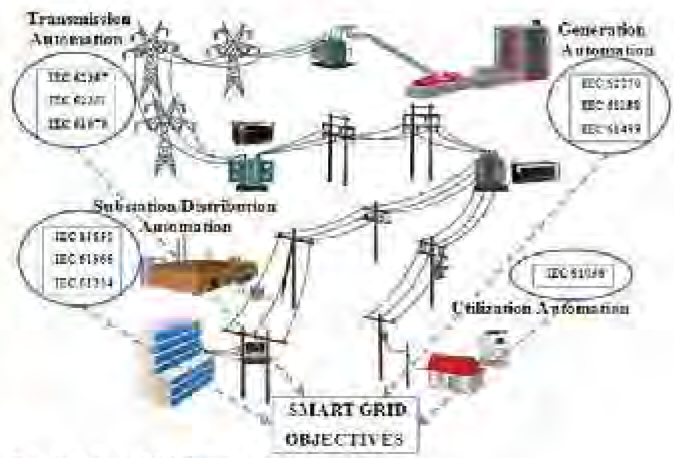


Fig. 2: Smart Grid Automation Standards

- IEC 61499 – Distributed Control & Automation
- IEC 62357 – Power system control and communications
- IEC 62351 – Power system security analysis
- IEC 61970 – Energy Management Systems
- IEC 61850 – Substation/Distribution Automation
- IEC 61968 – Distribution Management Systems
- IEC 61334 – DA power line communications
- IEC 62056 – Energy Metering Automation

Smart Grid Automation and Standardization Analysis

In this section we shall broadly review various recent trends in Power System Automation for each of the individual automation blocks as shown in Fig. 3 (generation, transmission, substation & distribution) that helps in meeting some of the smart gird objectives.

Generation Automation and Standardization

The automation controller (IEC 62270) in the Instrumentation & Control panel of power plant is a major component. Since the generation and demand should match for better operation of the grid and since it is not possible to store excess power or generate instantly more power, these controllers played a key role in automation for a fail-safe mode of operation in which the following functions are controlled automatically;

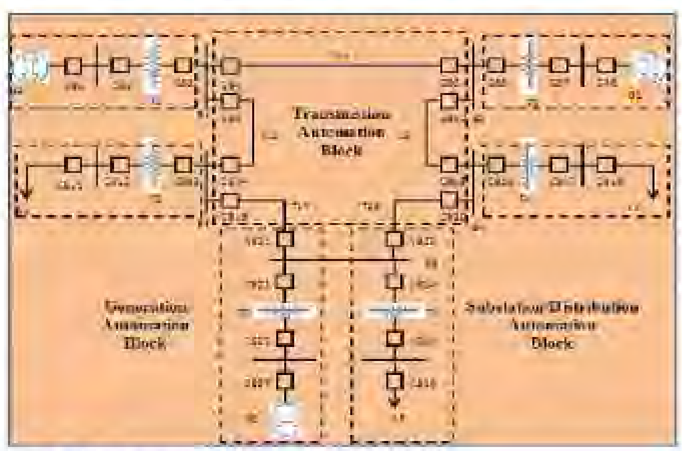
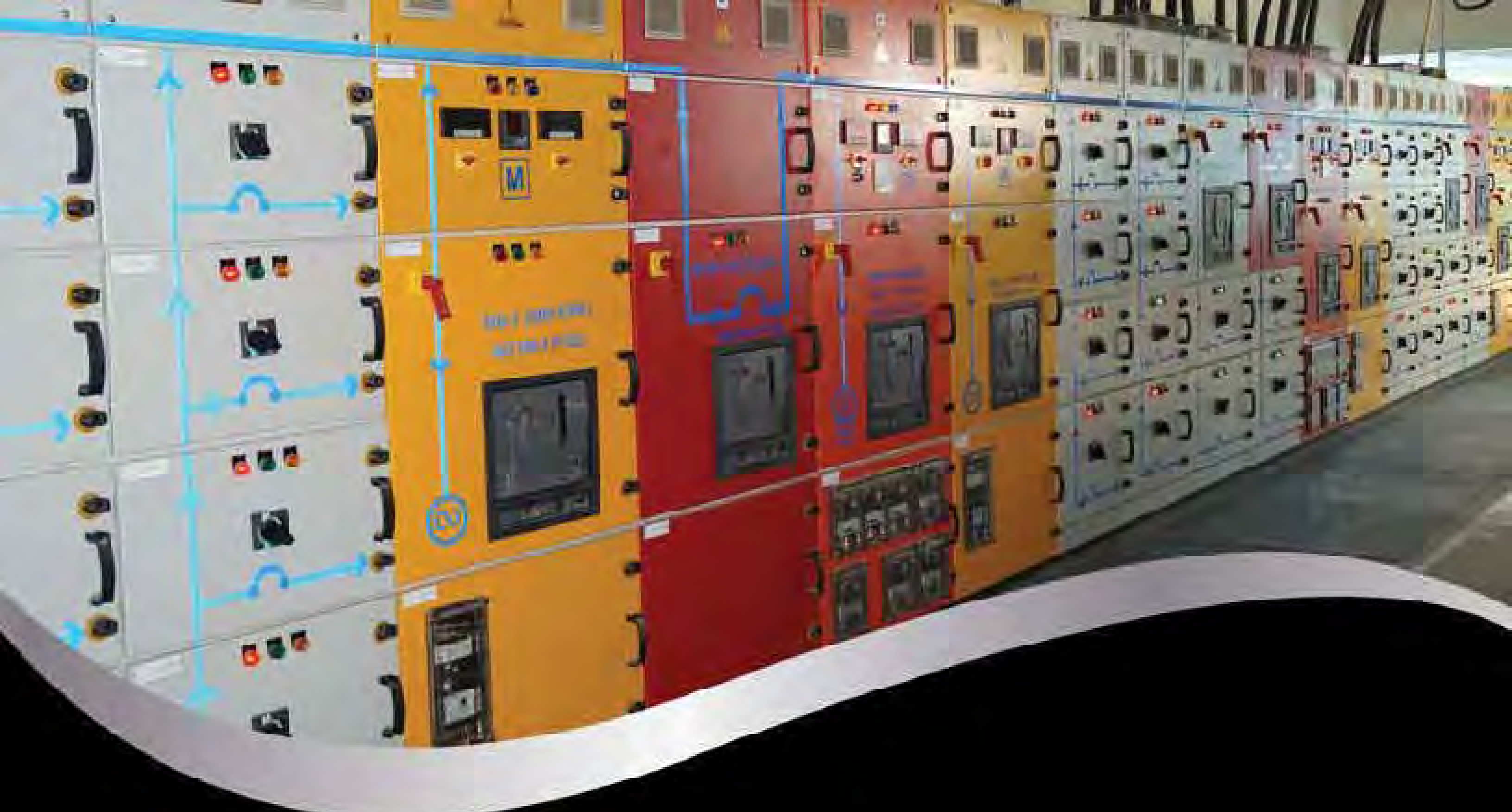
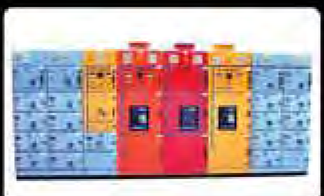


Fig. 3: Grid Automation Network View





Stress on turbine during startup & shutdown, Grid synchronization, Controlling the loading of turbine and generator, frequency stabilization to avoid penalties, managing plant load requirements apart from external load, Prevention of overloading of turbine & compressor unit, Protection and control against faults and possible failure modes. Embedded systems platform forms heart of control systems. Use of advanced communication technologies in a highly integrated control environment has drastically improved the performance of control systems.

The distributed platform (IEC 61499) as realized by incorporating various logical control nodes (LCN) which computes their own algorithms without the need of any central node for functioning, offers wide variety of flexibility in plant control and automation. These algorithms are realized by a set of equations governing the operation of a specific logical node. After its successful implementation and operation in substation automation, IEC 61850 standards have been attracted by generation automation engineers to realize protection, control and automation functions in a power plant. IEC 61850 GOOSE messaging and necessary logic programming on protective relay IEDs has resulted in higher performance with more data to monitor and troubleshoot the issues in real time. Such applications of configurable GOOSE messages are, to reserve interlocking or reverse blocking, breaker failure protection, high voltage direct transfer trip and load shed/transfer, while the traditional advantages of GOOSE such as reducing the amount of copper wire and relays necessary for protection is well acknowledged. Also, custom defined object oriented models of IEC 61850 helped in realizing various logical node operations.

Later, Foundation field buses (IEC 61158) being the digital serial two-way communication system for plant or factory automation after successful implementation in the process industries has attracted power plant engineers to use it. Its targeted applications based on regulatory control offer discrete control & automation. With the advent of advanced software technologies, it seems that web based control mechanisms are well suitable for automation environments like SCADA to certain extent like monitoring functionality but the need to provide direct access to automation system parameters will set limitations. These advanced software based HMI's helps in viewing the exact field conditions by means of animations, 3D visualization and different coloring schemes for differentiating different types of faults for the critical plant equipment.

Transmission Automation & Standardization

As the power systems becoming large and exhibiting increasingly complex nature, there is a need for advanced measurement technology, tools, data analytics and operational infrastructure that facilitates the better automation, control and management of complex power system. Such system is called as Wide Area measurement System (WAMS) which uses advanced satellite based time synchronization technology for complete monitoring, protection and control of the power system. Though Energy Management Systems (IEC 61970) and SCADA (IEC 62357) were available predominantly from quiet long time performing operations like state estimation, optimal power flow, security analysis, contingency analysis, stability analysis etc. The present trend in automation in this area are automatically scheduling inter-area power exchange, computing online power transactions, handling deregulated and restructured power system operations, allocating costs to various generating participants, monitoring system security against possible physical and cyber-attacks, wide area stability analysis, state estimation based on WAMS, optimal bus load shedding based on critical bus synchronism lost etc. Security assessment, shown in Fig. 4, through WAMS is an important outcome of Smart Grid automation as it helps in performing real time operation and decision making. The power electronic based systems offering control of AC transmission parameters for enhancing stability and increasing power transfer capability were traditionally based on series and shunt compensation devices. FACTS has now become much more robust in control due to the accurate and timely measurement of reference parameters. Communication has been added to these FACTS devices which made it interoperable with remote control operations based on WAMS. The present trend in automation is to automatically control transient stability of the line, damping of the system, voltage stability, sub-synchronous resonance, short-circuit current levels, integration of wind power generation to the grid & terminal performance of HVDC converter using the FACTS based device.

Fig. 4: Security Assessment using WAMS data (Source: CRIEPI)

Today's Energy Management Systems and SCADA systems are predominantly based on Local Area Network (LAN) and Wide Area Network (WAN) communications. Multivendor protection, control and monitoring IEDs integrated with various control centers or gateways at substation carry information to a central control center. Hence methods for information security to assure privacy of data and information, integrity of data and commands from control centers and authentication of the source of receiving data and commands play a critical role (IEC 62351). In the present trend, automated security systems that complement the existing SCADA system, performs the intruder detection for possible physical & cyber-attacks based on a set of protocols and executes data integrity based algorithms using the knowledge of power system components, control actions to differentiate authentic and false trip commands due to malware. Cyber Security indeed is required for all automation blocks.

Substation Automation & Standardization

Earlier when protection devices were based on electro-mechanical technology with hard-wired communication they offered some limitations in terms of speed and operation. They were slowly replaced with micro-controller based devices which increased the speed of operation. With the advent of advanced micro-controllers today the diversification and

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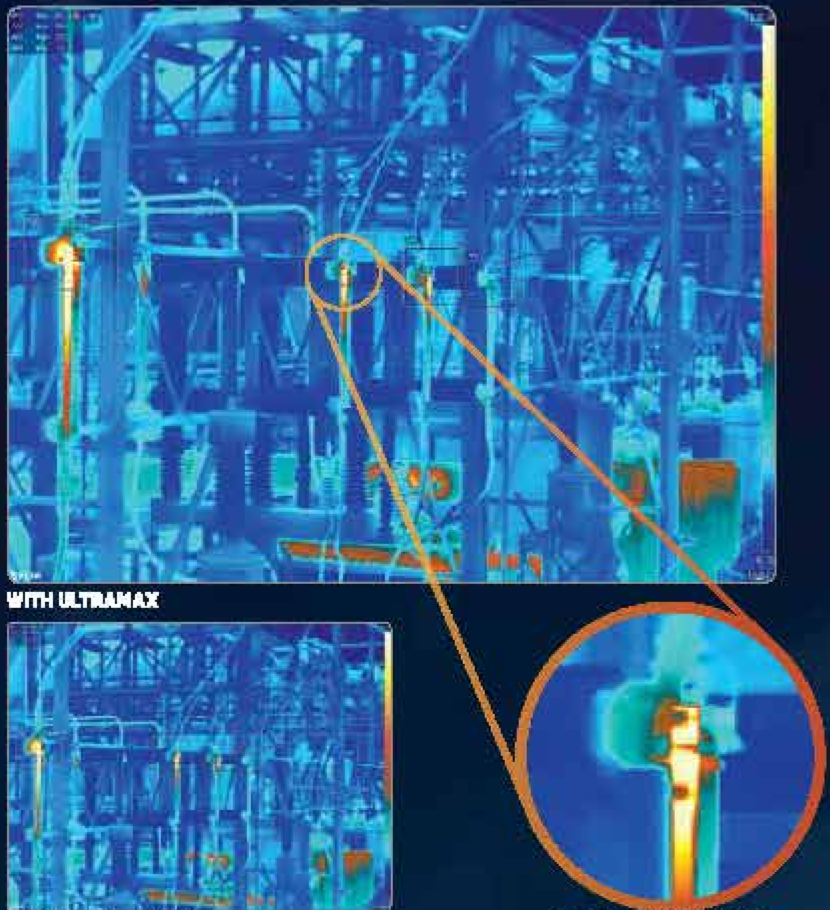

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complexity of functions required by automation becomes a strong trend of evolution. IEC 61850 standard for substation automation has totally revolutionized the power delivery industry since its introduction in 2005 time frame. The major breakthrough happened with the realization of "Interoperability" between multi-vendor IEDs. 61850 also offer easier configuration, standardized logical nodes and functions for every equipment, high-speed Ethernet communications on station bus, and peer-peer communications called GOOSE, enhanced security controls, predefined XML file formats etc. Initially IEC 61850 Substation automation was focused on operations and control within a substation, later the same has been extended to feeder automation by a virtual extension of SAS having built-in intelligence in IED along with high speed communications and controls (Fig. 5) Feeder automation can be realized in a centralized or decentralized approach based on number of feeders covered.

The automation and control of the current electric power systems based on the SCADA model though provides adequate reliability and speed of operation it does not offer flexibility in terms of open access to information. Due to the intrinsic distributed nature of power systems, multi-agents based technology can provide greater autonomy for each component in power system. In present trend, agents play key and distinct roles in monitoring and control, communication by means of messages,

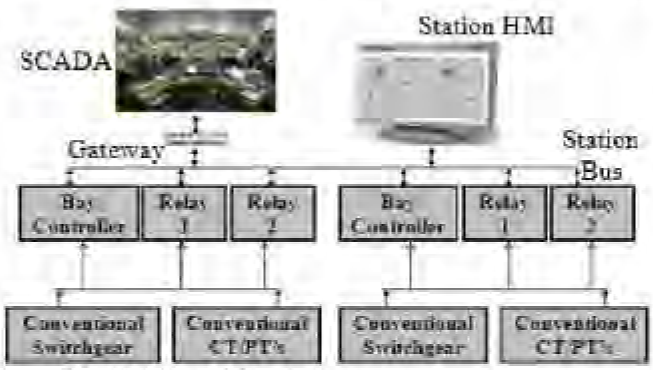


Fig. 5: IEC 61850 based SA system

information retrieval through mobile based agents travelling over the network and interaction between agents for specific tasks.

The substation secondary equipment such as sensors, transducers etc, measures various analog parameters like voltage, current, temperature and transfers to main relay using hard-wired cables. When it comes to replacement and maintenance of substation secondary equipment's, it may impact the overall substation availability because of complex wiring and relay obsolescence. To overcome this problem IEC 61850 has introduced process bus which is similar to field bus in generation plant, where in a standardized Ethernet bus is used to provide interfaces to primary equipment. A merging unit (MU) collects all the data from field sensors in a synchronized manner, digitizes the signals and transfers the sample values automatically on high speed Ethernet or process bus (1Gbps) to the subscribed primary equipment's. This helps in reducing maintenance cost and time for re-configurations. IEEE 1588 precision time protocol (PTP) over SNTP made even 20ms time period wave analysis possible today and multiple IEDs to look at same zone using these accurate time measurements increasing reliability of protection.

Distribution Automation & Standardization

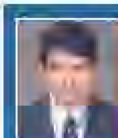
While there is an overlap between the substation and distribution automation, based on IEC 61850 the main aims of the distribution automation system being Supervisory Control and Data Acquisition (SCADA), Volt & Var Control (VVC), Fault Location (FL), Feeder Reconfiguration (FR) (Self-Healing), FLISR (Fault Location, Isolation, and Service Restoration), which is a hybrid of FL and FR. It is far possible to realize automation without communication which offers remote monitoring and control of the distribution system. Though there are only one TCP based protocol being used for communications from generation to substation automation, however distribution automation is being realized on a wide variety of communication types like PLC (IEC 61334), Ethernet, RS 485, wireless, 3G, CDMA, WI-Max, Zigbee, GPRS, GSM etc, the reason being distribution closer to end users who use these communications often in day-to-day life. The AMI systems, usually collect data from various smart meters in the field in an automated manner using DLMS/COSEM (IEC 62056) standard specification and transfer it to a central location called Meter Data Management System (MDMS). AMI network offers low-bandwidth two-way communication links between meters & back office.

With the evolution of a variety of energy resources like solar, wind etc, apart from regularly used natural resources for power generation led to the formation of Micro-Grids, which can operate in synchronization with grid or in an isolated mode during an outage of the grid, supplying power to local load in a distributed manner to fill the supply and demand gap

Fig. 6: Distribution Automation and AMI

during peak loading conditions on the grid. When the micro-grid is operating in islanding mode and when the demand increases beyond its supply, it may lead to grid collapse; hence automation of micro-grid environment is a key for smart grid.

Profile



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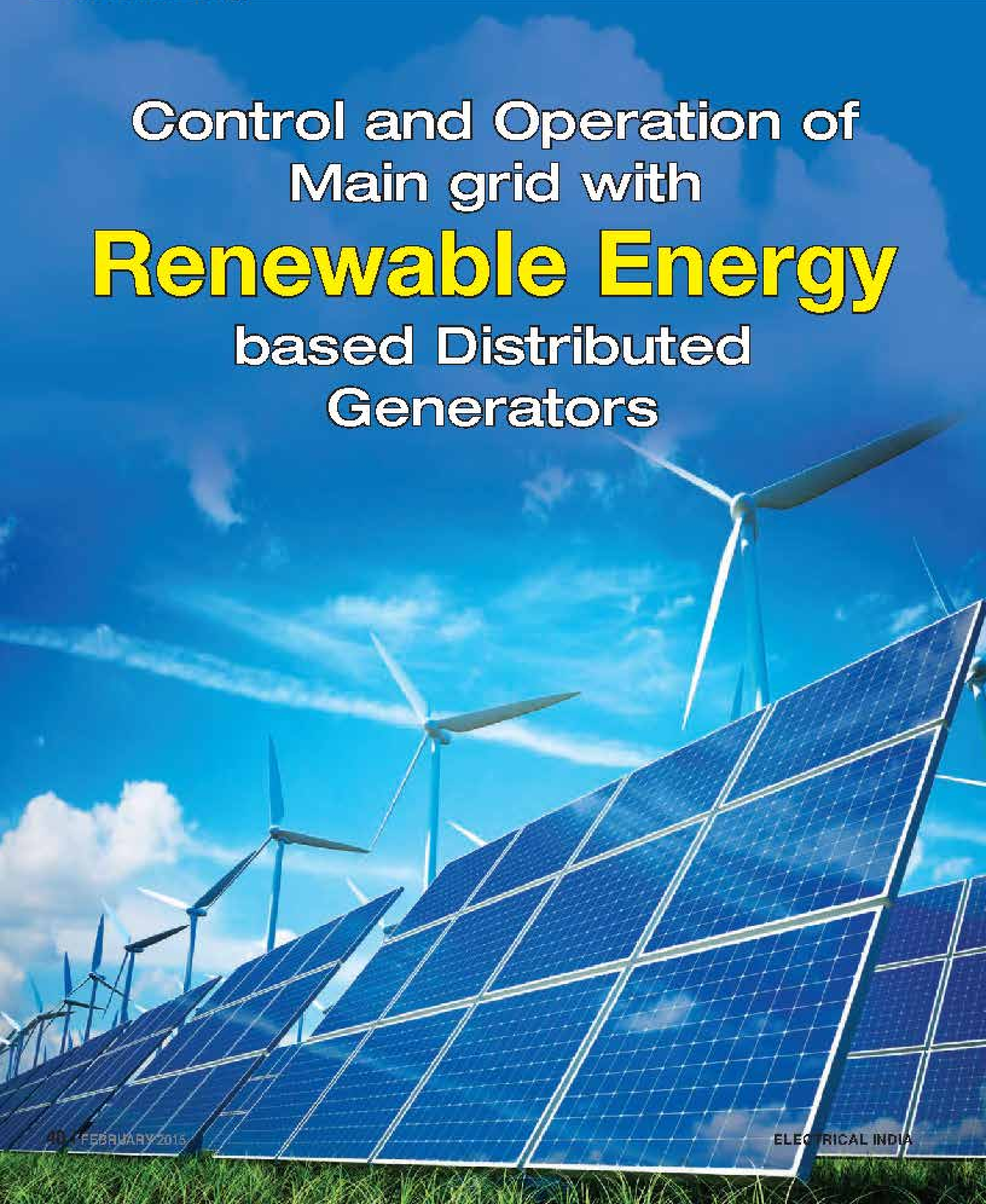
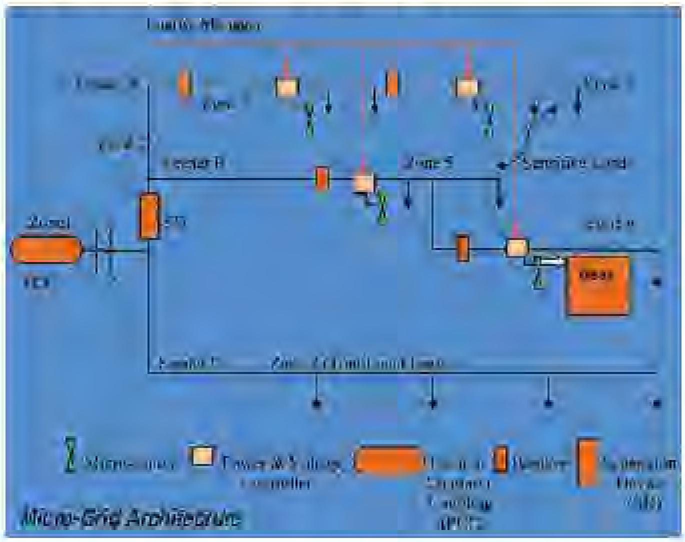
Control and Operation of Main grid with Renewable Energy based Distributed Generators



This article describes the principles of microgrid design, considering the operational concepts and requirements arising from participation in active network management. The article gives a comprehensive review of microgrids, including advanced control techniques, energy storage systems, and market participation in both island and grid-connected operation. The control techniques and the principles of energy-storage systems are summarized in a flowchart.

Future distribution systems will contain microgrids and hence it is necessary to understand the steady state & transient operating conditions of such systems to evaluate their impacts on the current Grid



Micro-Grid Architecture

The front image illustrates the basic Micro-Grid architecture. The electrical system is assumed to be radial with three feeders, A, B and C, and a collection of loads. The micro-sources are either micro-turbines or fuel cells interfaced with the system through power electronics. The Point of Common Coupling (PCC) is on the primary side of the transformer and separates the grid and the Micro-Grid.

The sources on Feeders A & B allow situations where the micro-sources can be placed away from the common feeder bus to reduce line losses, and support voltage. Multiple micro-sources on a radial feeder, however, increase the problem of power flow control and voltage support along the feeder when compared to all sources being placed at the feeder's common bus. Placement of micro-sources away from the common feeder, however, is useful for the plug-and-play concept. Each feeder has several circuit breakers and power and voltage flow controllers.

The power and voltage controller near each micro-source provides the control signals to the source, which regulates feeder power flow and bus voltage at levels prescribed by the Energy Manager. As downstream loads change, the local micro-source's power is increased or decreased to hold the total power flow at the dispatched level. The main challenge in micro-grids with renewable energy distributed generators is similar to that of the current power systems from the point of view of stability and power quality, particularly, when the micro grids operate in islanded mode. Future distribution systems will contain microgrids and hence it is necessary to understand the steady state and transient operating conditions of such systems to evaluate their impacts on the current Grid. It is necessary to develop intelligent control algorithms for optimum operation when interconnecting distributed generators such as fuel cells, wind turbine, photovoltaic system and micro turbine to the power grid through inverters, in an islanded or grid connected mode of operation.

Distributed energy resources (DER), small power generators located at users' sites where the energy (both electric and thermal) they generate is used, have emerged as a promising option to meet growing customer needs for electric power with an emphasis on reliability and power quality. DER include generators, energy storage, and load control. Significant potential of smaller DER to meet customers' and utilities' needs is to organize these resources into Microgrids.

Customers benefit from a Micro-Grid because it is designed and operated to meet their local needs for heat and power as well as provide uninterruptible power, enhance local reliability, reduce feeder losses, and support local voltages and correct voltage sags. The pattern of exchange of energy services between the Micro-Grid and the bulk power provider grid is determined by prevailing economic conditions.

Micro-Grid Structure

The Micro-Grid structure is an aggregation of loads and micro-sources operating as a single system providing both power and heat. The majority of the micro-sources are power-electronic based to provide the required flexibility for controlled operation of a single aggregated system. This control flexibility allows the Micro-Grid to present itself to the bulk power system as a single controlled unit, having plug-and-play simplicity for each micro-source, and meeting the customers' local needs.

Key issues that are part of the Micro-Grid structure include the interface, control and protection requirements for each micro-source as well as Micro-Grid voltage control, power flow control, load sharing during islanding, protection, stability, and over all operation. The ability of the Micro-Grid to operate connected to the grid and allow smooth transition to and from the island mode is an important function.

Renewable Technologies

Photovoltaic systems, medium to large, possibly building integrated, are a promising technology, while other renewables are also considered. In addition to generating technologies, Micro-grids also include storage, load control and heat recovery equipment. Renewable generation could appear in Micro-Grids, especially those interconnected through power electronic devices, such as PV systems or wind turbines.

Micro-turbines, currently in the 25-100 kW range, although larger ones are under development, will ultimately be mass-produced at low cost. These are mechanically simple, single shaft devices, using high-speed (50,000-100,000 rpm), typically with airfoil bearings. Despite their mechanical simplicity, micro-turbines rely on power electronics to interface with loads. The primary fuel of Micro-turbines is natural gas, although they also burn propane or liquid fuels in some applications, which permits clean combustion, notably with low particulates.

Fuel cells are also well-suited for distributed generation applications. They offer high efficiency and low emissions but are currently expensive. Phosphoric acid cells are commercially available in the 200-kW range and high temperature solid-oxide and molten-carbonate cells have been demonstrated and are particularly promising for Micro-Grid application. Fuel cell engine designs are attractive because they promise high efficiency without the significant polluting emissions associated with internal combustion engines. Environmentally, fuel cells & most renewable sources are a major improvement over conventional combustion engines.

Storage technologies (batteries, ultra-capacitors) are important components of Micro-Grids. Storage on the micro-source's DC bus provides ride-through capabilities during system changes. Twenty eight-cell ultra-capacitors can provide up to 12.5 kW power for a few seconds.

Environmentally, fuel cells and most renewable sources are a major improvement over conventional combustion engines. Micro-turbines are also acceptably clean running. NOx emissions, which are a precursor to urban smog, are mainly a consequence of combustion. Some traditional combustion fuels, notably coal, contain nitrogen that is oxidized during the combustion process, but even burning fuels that contain no nitrogen emits NOx, which forms at high combustion temperatures from the nitrogen and oxygen in the air.

Combined Heat and Power (CHP)

One important potential benefit of Micro-Grids is an opportunity to utilize the waste heat from conversion of primary fuel to electricity. Because typically half to three-quarters of the primary energy consumed in power generation is ultimately released unutilized to the environment, the potential gains from using this heat productively are significant.

Unlike electricity, heat, usually in the form of steam or hot water, cannot be easily or economically transported long distances, so CHP systems typically provide heat for industrial processes, on-site space heating, local district heating, or for domestic hot water or sterilization. To make CHP systems viable, a sufficiently large need for heat must exist within a sufficiently dense area so that circulation of steam, hot water, or another appropriate medium is feasible and economic.

Principle of Microgrid Control

The most suitable control design should cover all the tasks of microgrid controllers, which are:

- The system should function at predefined operating points, or within satisfactory operating limits;
- Active & reactive power must be transferred by optimal means;
- System stability should be maintained;
- Local microsources production should be optimized for best market participation and power exchanges with the utility;
- Loads must be classified according to priority, e.g. medical equipment is the highest priority consumer and finally;
- Energy storage systems should support the microgrid & increase the system's reliability and efficiency.

Microgrid hierarchical controls are defined at four levels (zero to three), as shown in Fig. 1.

Level zero is the inner control loop for controlling the output voltage and current from the sources. The target of this control level is to manage the power of Microsources. The power electronic interface in voltage control mode manages frequency and voltage inside the microgrid while the system is connected to energy storage devices (island mode). In current control mode, where the system is often joined to the main grid (grid connection mode), the active and reactive power are managed. The inner control loop, for wind and solar power, which are the most common renewable energy sources, is created by the power converter. For instance, a Doubly-Fed Induction-Generator (DFIG) wind turbine consists of two AC/DC (rotor side) and DC/AC (grid side) converters with a DC-link that can either inject or absorb power from the grid, actively controlling the voltage. The task of the rotor side is to optimize power generation from the source, and the duty of the grid-side converter is to provide control of active and reactive power & maintain the DC link voltage. The optimization and inner controls need to have accurate reference values for the frequency and voltage amplitude, which is the duty of the primary control.

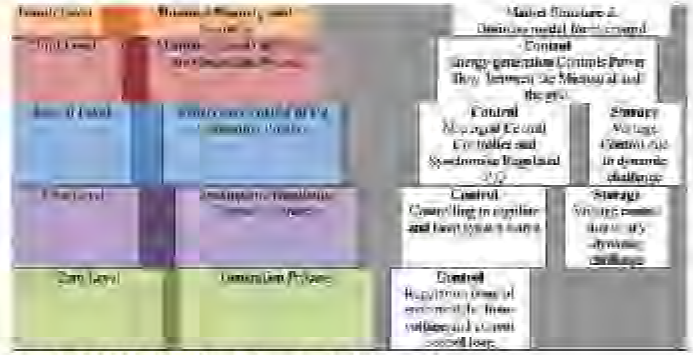
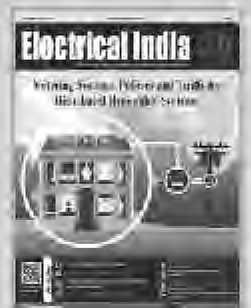


Fig.1: IEC/ISA 62264 std. Levels, in Microgrid context

Level 1, (primary control) generates the reference value for the inner control loop. The target of this control level (level one of IEC/ISO 62264 std.) is to adjust the frequency and amplitude of the voltage references that are fed to the inner current and voltage control loops. The primary control should have the fastest response (on the order of milliseconds) to any variation in the sources or the demand. The fastest response increases the power system stability. The primary control can also be used to balance energy between the DG units and the storage elements (batteries). The contribution of active power can be adjusted in line with the availability of energy from each DG unit, depending on the batteries' state of charge. The DG power converter control techniques in AC microgrids are classified into grid-following and grid-forming methods. Grid-forming converters are voltage-control based with an equivalent circuit of a voltage source in series with a low impedance. Grid-forming converters create a reference value for voltage and frequency by using a proper control loop. On the other hand, grid-following power converters are designed as control-based and can be represented by a current source in parallel with a high impedance. In addition, power delivery to the main network in grid-connection mode is the responsibility of the grid-following power converter. Power converters in the island mode must be of the grid-forming model in order to determine the voltage reference value. Grid-following converter cannot control microgrid in island mode.

Level 2, (secondary control) monitors and supervises the system with different methods. The secondary control section (second level of IEC/ISO



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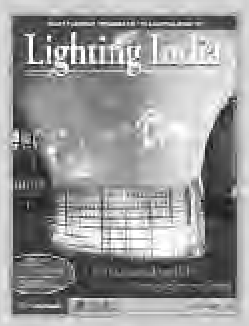

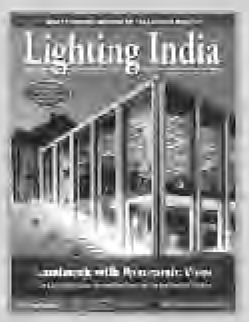

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62264 std.) works to compensate for voltage and frequency errors and to regulate the value in the operational limits of the microgrid. It ensures that the frequency and voltage deviations are regulated towards zero following each load or generation change in the microgrid. It serves power systems by correcting the grid-frequency deviations within allowable limits, for example by ± 0.1 Hz or ± 0.2 Hz. The response speed of the secondary control is slower than the first control level because of limitations due to availability of primary sources and battery capacity.

Level 3, (tertiary control) manages the power flow and interface between the microgrid and the main network..

As a result of recent widespread application of power-electronics devices, operation of a microgrid requires both energy management and classification of a control strategy. Power flow control, resynchronization between microgrid and main grid, adjustments of voltage and frequency in both modes, and improvements in microgrid efficiency together comprise the key principles of microgrid control structure. The most suitable control design should cover the following tasks of microgrid controllers:

- The system should function at predefined operating points, or within satisfactory operating limits.
- Active and reactive power must be transferred by optimal means.
- System stability should be maintained.
- Processes of disconnection and reconnection should run seamlessly.
- Production of local micro-sources should be optimized for best market participation and power exchanges with the utility.
- Loads must be classified according to sensitivity, from highest to lowest. Eg. medical equipment is the highest priority consumer load.
- If a general failure occurs, the microgrid should be able to operate through a black start, and
- Energy storage systems should support the microgrid & increase the system's reliability and efficiency. Storage of energy can be achieved by converting electrical energy into another form, such as chemical or mechanical energy, Fig. 2.

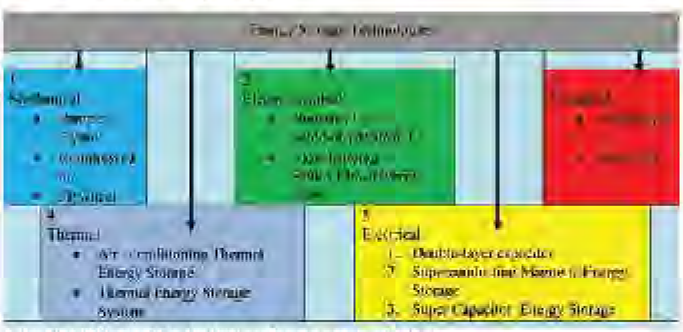


Fig. 2: Different techniques for energy storing

Microgrids in power market competition

A microgrid can participate in the energy market, as in ancillary service markets. The oligopolistic (Oligopoly means the market condition that exists when there are few sellers, as a result of which they can greatly influence price and other market factors) method, based on a multi-agent system, is the best market structure for microgrids. Multigrid agents are divided into production, consumption, power system, & microgrid central controller (MGCC) agents. MGCC must also coordinate the priority of loads. MGCC, along with the consumption agent, participate directly in the marketing operation. Moreover, the power system agent is one of the most effective components for determining the buying and selling price for electricity, but does not itself participate in marketing operations. Microgrids buy and sell the shortage or surplus of power to or from a main grid through an aggregator. Therefore, the microgrid and the main grid have different perspectives to the aggregator. For instance, during the selling of power by the microgrid to the main grid, the aggregator is the seller from the point of view of the main grid, and is the buyer from the perspective of the microgrid, Fig. 3.

Virtual Power Plant

Microgrids and Virtual Power Plants are two concepts of the LV distribution network that can participate in active network management in a smart grid. The VPP is an energy management system tasked with aggregating the capacity of a number of distribution generators, energy storage systems, and controllable loads. Fig. 4 shows the concept of the VPP, which is based on providing centralized control for multiple microgrids, distributed energy resources, and loads. VPPs are divided into two different types: commercial and technical. Commercial VPPs have a competitive participation in the electricity market and try to optimize the relation between generation & demand without respect to network limitations. Technical VPPs, on the other hand, try to optimize control and coordination, as well as system operation. To cover the two categories, there are three different approaches that can be used:

Fig. 3: Role of the aggregator in the market participation

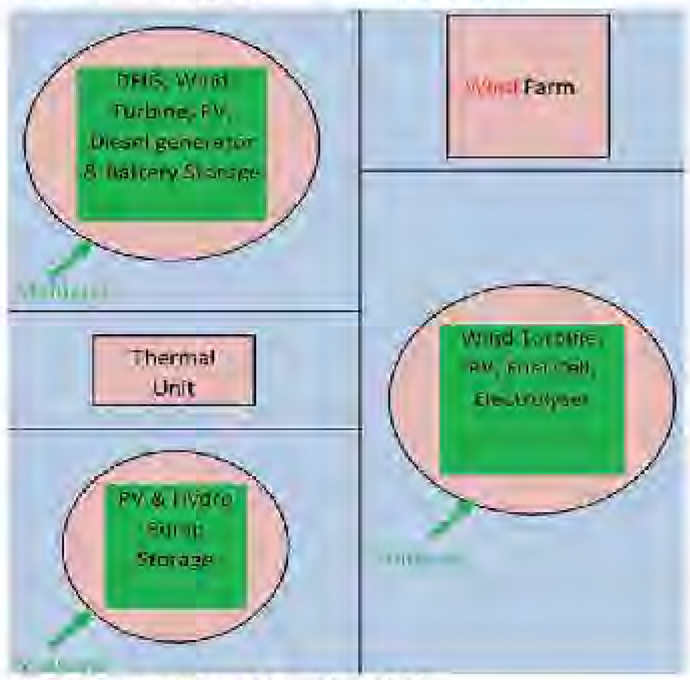


Fig. 4: Concept of Virtual Power Plant (VPP)

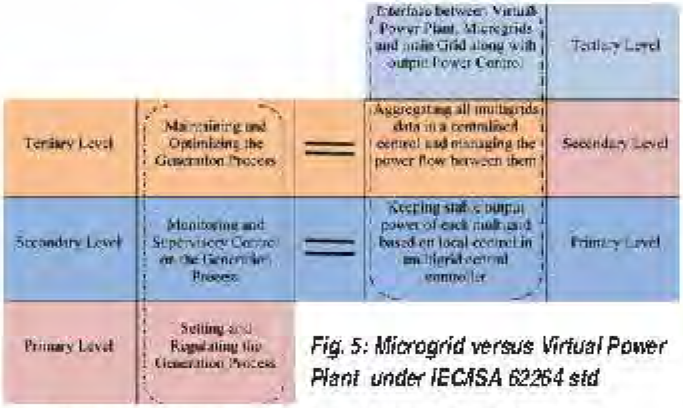


Fig. 5: Microgrid versus Virtual Power Plant under IEC/ISA 62264 std

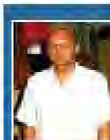
- Centralized Controlled Virtual Power Plant (CCVPP)
- Distributed Controlled Virtual Power Plant (DCVPP)
- Fully Distributed Controlled Virtual Power Plant (FDCVPP).

VPPs must always be connected to the main grid and do not have the capacity to work in island mode. Hence, all their control levels are always enabled—unlike in multigrids, where the third control level is sometimes disabled. However, there are some different responsibilities in controlling multigrids based on the standard level, compared with VPPs. These differences are shown in Fig. 5.

Conclusions

The article discusses the microgrid structure, renewable technologies, and uses of CHP, and virtual power plants. In future, all new production units above certain sizes will have to be equipped with both active-power and reactive-power control. This will make it easier to maintain stability of the grid which is an important aim of the grid codes. However, from a market viewpoint, compulsory requirements of both active and reactive power controls are not the best solution. Normally, the price and availability of a product is determined by investment costs and operational costs. But if it becomes compulsory for production units to invest, then it will only be the operational costs that matter for the market bids. For eg, the use of demand for frequency and voltage regulation becomes less attractive because of the compulsory investment. An owner company's ability to participate in an ancillary market in future is determined or even prevwented by an investment decision it takes now. A profit prospect in an uncertain future market will be discarded in a decision one takes now. Also, a future choice to participate in the market will cover operational and retrofit costs, which are higher than installation costs.

Profile



C S Indulkar

retired from IIT Delhi as Professor and Head of Electrical Engineering. He has authored a number of technical papers in various refereed journals, including IEEE Transactions and IET Proceedings. He has also been a reviewer of papers for the above journals and for several other International Journals of Electrical Engineering.

Microgrid Energy Trading

In India, there is a shortage of installed electric power and the demand supply gap is expected to increase if we continue to generate power using conventional sources only. With about 300 clear and sunny days, India has a huge potential to generate clean solar energy and this study is an attempt to make the use of solar energy more cost effective. Our objective is to build a Trading Model which makes profitable trading decisions by minimizing the overall cost of operation.

K S Swarup

In a fully deregulated market, a case study is performed, with the Microgrid connected to the utility grid. Microgrid under consideration has two sources (Solar and Diesel) of generation and battery storage. The trading model uses historic data and various forecasting techniques to get Day-ahead forecasts of solar irradiation, load and the market prices. Based on the forecasts available the model issues directives to all the components of the Microgrid to maximize the Trade balance and in turn increases the return on investment (ROI). It also greatly reduces the energy produced from the Diesel Generator and hence helps in cutting the CO_2 emissions making it more eco-friendly.

In economic terms, electricity is a commodity capable of being bought, sold and traded. An electricity market is a system for effecting purchases, through bids to buy; sales, through offers to sell; and short-term trades, generally in the form of financial or obligation swaps. Bids and offers use supply and demand principles to set the price. Long-term trades are contracts similar to power purchase agreements and generally considered private bi-lateral transactions between counter parties. Wholesale transactions (bids and offers) in electricity are typically cleared and settled by the market operator or a special-purpose independent entity charged exclusively with that function. Market operators do not clear trades but often require knowledge of the trade in order to maintain generation and load balance. The commodities within an electric market generally consist of two types: Power and Energy. Power is the metered net electrical transfer rate at any given moment and is measured in Megawatts (MW). Energy is electricity that flows through a metered point for a given period and is measured in Megawatt Hours (MWh). To move to a more open and democratic energy market, certain changes have to be made to the current market. There is very little knowledge of how to properly design a retail electricity market and how to effectively incorporate other services. The energy distribution service requires quality improvements for the new market to function correctly, because of the higher granularity of the energy contracts. Because of this increased granularity they would need to handle a huge amount of operations in the system. Also, searching for the best sellers in the new market with millions of suppliers should be done autonomous. The concept of intelligent control for regulating the power network variables is to be realized. The intelligent multi-agent based control can be a solution in today's power network to maintain the dynamics such as adequate power balance along with quality voltage under changing system conditions such as load and power injection. The technology with multi-agent intelligent control may be main module of Smart Grid architecture. The idea behind any multi-agent system is to break down a complex problem handled by a single entity – a centralized system – into smaller simpler problems handled by several entities – a distributed system.

Micro Grids

Micro grids are modern, small-scale versions of the centralized electricity system. They achieve specific local goals, such as reliability, carbon emission reduction, diversification of energy sources, and cost reduction, established by the community being served. Like the bulk power grid, smart Micro grids generate, distribute, and regulate the flow of electricity to consumers, but do so locally. Smart Micro grids are an ideal way to integrate renewable resources on the community level and allow for customer participation in the electricity enterprise. They form the building blocks of the Perfect Power System. Micro grids allow power generation and consumption to be managed so that the load is balanced with the supply. Smart power meters allow power to be stored in batteries and reused at times of peak demand. This smart approach to managing energy use can result in lower energy costs to the consumer because it encourages making smarter choices about power use.

- Micro grids can be broadly classified into four categories as
- Remote grids, which are necessary due to geographical features, such as islands. Consider a country like Indonesia that has more than twenty-three-thousand islands. It is simply not practical to connect all these to a single national grid. The power sources in these grids are on the same conventional lines are using fossil fuel.
- Military and security are grids necessary to maintain data and security during a national catastrophe. The power sources in these grids are also on the same conventional lines using fossil fuel.
- Commercial or industrial grids catering to a specific industrial community. The energy sources could be fossil fuel based or energy recovered for the process like waste heat, bio fuels, or waste products. These are mainly captive energy systems.

Smart Micro grids are an ideal way to integrate renewable resources on the community level and allow for customer participation in the electricity enterprise

Community grids that optimize and utilize the specific regional renewable resources to give cost effective power supply. Fossil fuel usage is only used as an emergency backup. This is the really effective Microgrid.

We also need to know why Microgrids play an important role in the future. The centralized transmission grid system is definitely the backbone of the electricity distribution system, but has its drawbacks.

- The energy loss is almost 8 -10%.
- There are high investment costs in transmission lines, step-up and step-down transformers, right of way and other legal issues.
- Grid management is a constantly juggling act where it balances the generation and the demand over a wide geographic area.
- The generating capacity has to match the peak load, which means a lot of excess capacity is built into the system, which increases the investment cost.
- All the users feel the grid disturbances, outages, frequency changes and voltage fluctuations, blackouts and brownouts. This can affect the performance and life of electrical equipment.

The Microgrid, even though not a replacement of the national grid, improves certain aspects especially for communities and regions that have adequate renewable resources.

- They have much smaller financial commitments.
- They use renewable resources hence are more environmentally friendly with lower carbon footprints.
- They require fewer technical skills to operate and rely more on automation.
- They are isolated from any grid disturbance or outage.
- They place the consumer out of the grip of large corporations that run the generation networks.

Microgrids are cost effective only if you can tap into locally available renewable energy resources. Solar energy is available everywhere but with limitations. Wind, mini hydro, geothermal and biomass are regionally available and can augment Solar energy. This combined with a storage device, battery or super capacitors and backup diesel generator makes Microgrids highly reliable and cheap. Storage devices in very large grid systems are not economically or technically proven. The advent of latest technologies in nano batteries and nano super capacitors makes electricity storage a reality in the smaller capacity range. This is an advantage for Microgrids. Advances in computerized control technology make it possible to have simple and efficient controls with less human interference and is the key ingredient that makes Microgrids feasible.

High technology products like nano solar cells, nano super capacitors, nano batteries and fuel cells will make the Microgrid with storage capacities a reality. Advances in automation, power electronic control systems will also help in the popularity of Microgrids. Even hybrid cars plugged into the home wiring can act as a generating sources or a storage device. In larger communities mini nuclear plants could be the ideal source of energy for the Microgrids.

Government policies and Effects of deregulation

The Central Electricity Regulatory Commission (CERC) on February 6, 2007 issued guidelines for grant of permission to set up power exchanges in India. Financial Technologies (India) Ltd responded by proposing then tentatively named 'Indian Power Exchange Ltd' and applied for permission to set it up and operate it within the parameters defined by CERC and other relevant authorities. Based on the oral hearing on July 10, the CERC accorded its approval vide its order dated 31st August, 2007. IEX thus moved from the conceptual level to firmer grounds. On 9th June 2008 CERC accorded approval to IEX to commence its operations and 27th June 2008 marked its presence in the history of Indian Power Sector as Indian Energy Exchange Ltd (IEX), India's first-ever power exchange goes LIVE. Within 5 years it gets and Average Daily Volume for Q1 FY 2011 - 20,921 MWh with 86% market share in India. It also took the market price of a KWh to a record low of 13 paisa in November 2009, demonstrating the true potential of supply demand economics. Also, Benefits of having a deregulated market are worth talking about.

Access a diversified portfolio: Exchange offers a broader choice to generators and distribution licensees so that they can trade in smaller quantities and smaller number of hours without additional overheads.

- Payment security: Exchanges stand in as the counter-party for all trades; so participants need not be concerned about the risk-profile of the other party.
- Minimal transaction overheads/charges: All charges are public information and due to the economies of scale the charges are minimal.
- Efficient portfolio management: Exchanges enables participants to precisely adjust their portfolio as a function of consumption or generation. Participants, especially distribution licensees, are enabled to precisely manage their consumption and generation pattern.

Energy Trading

Energy trading is a basic economic concept that involves multiple parties participating in the voluntary negotiation and then the exchange of one's goods and services for desired goods and services that someone else possesses. Energy trading is much more than this and there are a few factors which make is special. The development of electricity markets is based on the premise that electrical energy can be treated as a commodity. There are, however, important differences between electrical energy and other commodities such as barrels of oil or even cubic meters of gas. These differences have a profound effect on the organization and the rules of electricity markets. The most fundamental difference is that electrical energy is inextricably linked with a physical system that functions much faster than any market. In this physical power system, supply and demand – generation and load – must be balanced on a second-by-second basis. If this balance is not maintained, the system collapses with catastrophic consequences. Such a breakdown is intolerable because it is not only the trading system that stops working but also an entire region or country that may be without power for many hours. Restoring a power system to normal operation following a complete collapse is a very complex process that may take 24 h or more in large, industrialized countries. The social and economic consequences of such a system wide blackout are so severe that no sensible government would agree to the implementation of a market mechanism that significantly increases the likelihood of such an event. Balancing the supply and the demand for electrical energy in the short run is thus a process that simply cannot be left to a relatively slow-moving and unaccountable entity such as a market. In the short run, this balance must be maintained, at practically any cost, through a mechanism that does not rely on a market to select and dispatch resources.

Another significant, but less fundamental difference between electrical energy and other commodities is that the energy produced by one generator cannot be directed to a specific consumer. Conversely, a consumer cannot take energy from only one generator. Instead, the power produced by all generators is pooled on its way to the loads. This pooling is possible because units of electrical energy produced by different generators are indistinguishable. Pooling is desirable because it results in valuable economies of scale: the maximum generation capacity must be commensurate with the maximum aggregated demand rather than with the sum of the maximum individual demands. On the other hand, a breakdown in a system in which the commodity is pooled affects everybody, not just the parties to a particular transaction. Finally, the demand for electrical energy exhibits predictable daily and weekly cyclical variations. However, it is by no means the only commodity for which the demand is cyclical.

Micro Grid Energy Trading

The Microgrid under consideration, as shown in the Fig 1 has multiple sources of generation i.e. Solar panels and Diesel generator set. The Microgrid is connected to the utility grid through an Energy trading model which takes profitable decisions satisfying all

Fig. 1: Single line diagram of the Microgrid with arrows indicating the direction of the flow of power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the constraints. What makes the trading decisions complicated is the presence of the Battery, which is the only element with memory. In simple words, using it in the ith hour will have an effect on using it in the (i+1)th hour unlike any other element. The electricity markets intrinsically have very cyclical patterns, each cycle being 24 hours. So to take care of the battery (memory element) we forecast the data 24 hours in advance and obtain the most profitable trades for the next 24 hours and implement only the next hour's trade. Thus every hour we project the next 24 trades and implement the next hour trade only. This way, we sell the energy stored in the battery at the maximum possible price, thus generating maximum returns. The working of the model is explained in detail in the further chapters. The roadmap of the project is also briefly discussed to give the readers a better understanding of the approach to the problem. The project is split into two parts, the first being forecasting and the second being trading.

- **Part A: Forecasting**

The most essential part of any forecast is acquiring good quality data. Once the data is acquired various techniques can be used for day ahead forecasting. For working of the model we need to forecast Solar energy output (SG), non schedulable demand (D) in the Microgrid and the market price of power (MP) a day in advance. Day ahead forecasting of solar irradiation is imperative in finding out the solar energy output and hence we need to find out on what measurable data it depends on. Forecasting is discussed in detail in the next chapter.

- **Part B:Trading**

This is the core part of the project, where we build the model which makes key decisions on trading to maximize the trade balance. The detailed working of the model is discussed in the chapter on trading.

Microgrid systems targeted in this study are autonomous areas serving their power demand of several kilowatts with diesel engines (DE), photovoltaic panels (PV) & batteries (B). Fig. 3 shows the structure of the proposed Microgrid. Microgrids can also be connected to the external power system by tie lines for reducing frequency/voltage fluctuation in the normal and emergency conditions. Such Microgrid systems are operated independently with zero tie-line flow under normal conditions. In this project a dynamic simulation is conducted assuming the Microgrid is operated connected to external electric power systems actively trading energy. To maintain the frequency near constant under this operation, the demand-and-supply balance is controlled by the diesel governor and battery output control.

Diesel Generator

Diesel engine output is controlled by the governor which is installed in the generator set. This achieves generally a good load following operation.

Battery Storage

The operating condition of the battery storage is decided depending on the frequency responses of the Microgrid system. The steady-state output of the battery storage is the amount of load with the total output of diesel engine and of the PV panels subtracted.

Photovoltaic (PV) Panels

The output of photovoltaic cells change by the weather, so in this project, we have used the pattern of output that has been measured by the field tests of photovoltaic panels available on National Renewable Energy Laboratory website. For each daylight hour average output is assumed under the different weather conditions such as clear, cloudy, or rain. In addition, the max capacity of the photovoltaic panels installed in the Microgrid is assumed to be around 500 kW.

The Microgrid is connected to the utility grid through an Energy trading model which takes profitable decisions satisfying all the constraints. What makes the trading decisions complicated is the presence of the Battery, which is the only element with memory. In simple words, using it in the ith hour will have an effect on using it in the (i+1)th hour unlike any other element. The electricity markets intrinsically have very cyclical patterns, each cycle being 24 hours. So to take care of the battery (memory element) we forecast the data 24 hours in advance and obtain the most profitable trades for the next 24 hours and implement only the next hour's trade. Thus every hour we project the next 24 trades and implement the next hour trade only. This way, we sell the energy stored in the battery at the maximum possible price, thus generating maximum returns. The most essential part of any forecast is acquiring good quality data. Once the data is acquired various techniques can be used for day ahead forecasting. For working of the model we need to forecast solar energy output (SG), non schedulable demand (D) in the Microgrid and the market price of electrical energy (MP) a day in advance. Day ahead forecasting of solar irradiation is imperative in finding out the solar energy output and hence we need to find out on what measurable data it depends on.

Energy Trading Formulation

Trading is done to maximize the total profit by minimizing the total cost incurred in the next 24 hours (Fundamental Cycle) and the optimal values for the current hour (hour 0) are implemented at that time. As shown in Fig 2 the trading model receives data from all the sources and loads and it will use the forecasted data to make profitable trading decisions without compromising on the constraints. It will also

Fig. 2: Information flow diagram of the Microgrid with arrows indicating the direction of the flow of information

make the decision of taking power from the main grid, Battery and the emergency Diesel Generator set. It will make sure that the schedulable load is supplied power when the price of the power is the least. There are two sets of independent variables i.e. 48 variables which can be varied to find the minimal value of the total cost.

Energy Trading Architecture

The Energy Trading Model is shown in Fig. 3. The trading model receives data from all the sources and loads and it will use the forecasted data to make profitable trading decisions without compromising on the constraints. It will also make the decision of taking power from the main grid, Battery and the emergency Diesel Generator set. It will make sure that the schedulable load is supplied power when the price of the power is the least.

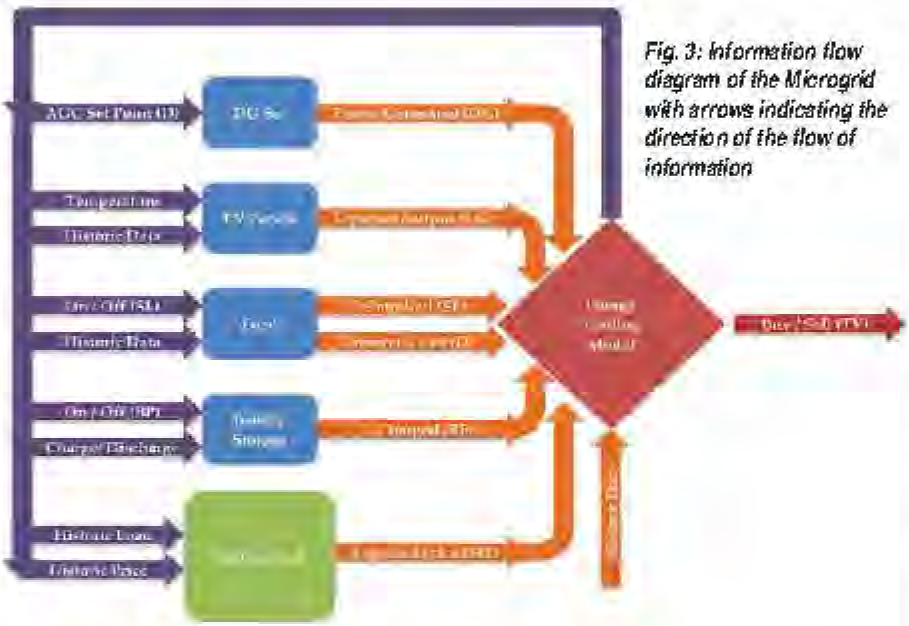

Fig. 3: Information flow diagram of the Microgrid with arrows indicating the direction of the flow of information

The Objective is to make profitable trading decisions, adhering to constraints.

So, Introducing a function, $\psi_n(\bar{u})$

$$\psi_n(\bar{u}) = \sum_{i=n+1}^{n+23} \left\{ \begin{matrix} u_i \dfrac{\partial}{\partial u_i}\left\{\sum_{j=n}^{n+23} c_j\right\} - \\ \dfrac{1}{2} u_i^2 \dfrac{\partial^2}{\partial u_i^2}\left\{\sum_{j=n}^{n+23} c_j\right\} \end{matrix} \right\} \quad (1)$$

where, $\bar{u}$ is a vector consisting of all the independent variables in $\sum_{j=n}^{n+23} c_j$

The output variables of the model are the independent variables associated with and they are assigned the values they take at the global minimum of within the boundary conditions by the model.

Results

Using the energy trading model drastically reduces the over costs and increases the bottom-line considerably. We have taken a case study with near – real time values and simulated it with both, the model operating on it and without the model operating on it.

The model has two sources of generation, they are:

- Solar panels with a maximum generation of 500 kW
- Diesel generator with a maximum generation of 300 kW, with the cost generation function:

  DC (Rs/h) = a + b (DG) + c (DG)^2 (2)

  Where,

  a = 200 Rs/h

  b = 10 Rs/ kW-h

  c = 0.005 Rs/ (kW)^2-h

The model also has a super storage facility (Battery) with maximum usable energy range of (BEMAX) of 500 kWh and maximum power (BPMAX) of 200 kW. There are two sources of revenue, one from trading and other from consumers in the Microgrid who are charges and fixed rate of Rs.8 / kW-h. (all the data used in this project is from S1-S2 regions of India and hence consumer charge is also fixed at Rs.8 / kW-h).

Advantages of having a trading model in place are clearly visible from the Fig. 4. The area below the graph gives the total cost incurred in a day after trading. The trading model makes optimal trading decisions and reduces the cost by over 60%.

The results are surprising but we have to remind ourselves that we did not take into consideration the losses in charging and discharging the battery and also the usage cost of the battery. The life of a battery

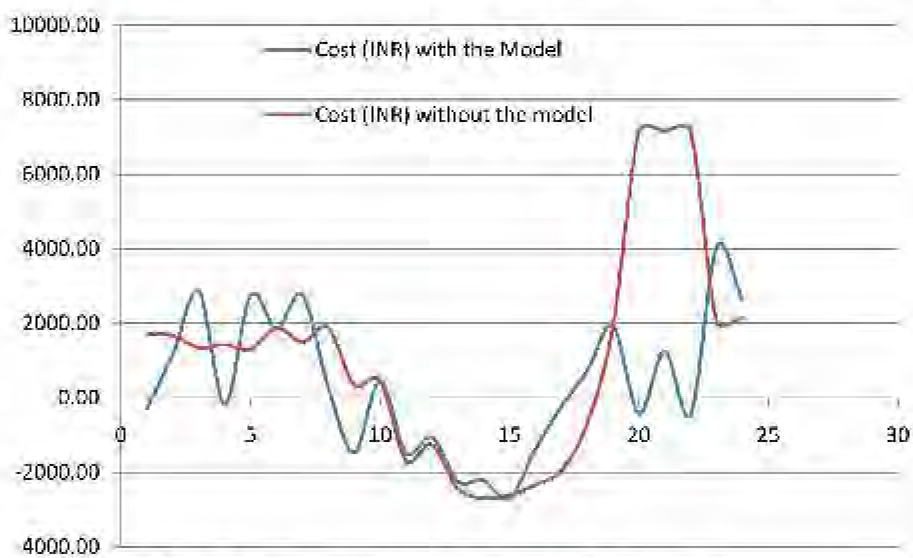

Fig. 4: Plot showing hourly cost incurred after trading during a day (24 hours)

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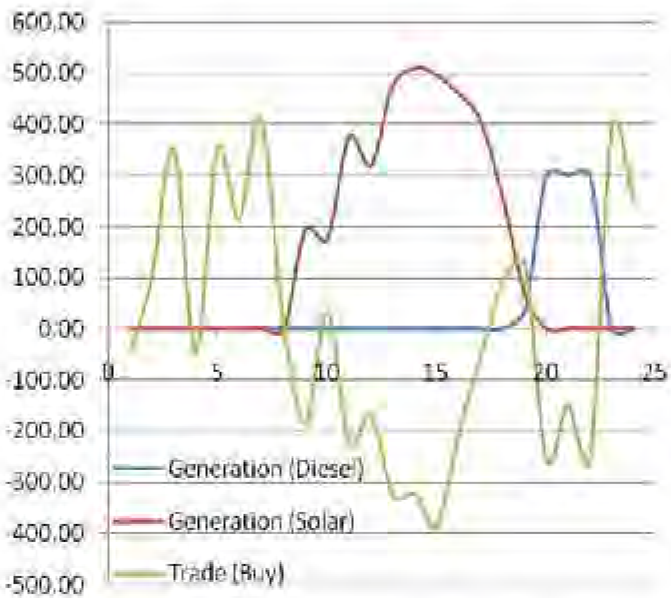

Fig. 5: Plot giving the details of hourly generations from Diesel Generator, Solar Panels and also hourly trade volumes

depends on its usage; excessive usage will reduces the life of the battery at a very high rate. Also, the cost of capital on such a high investment will considerably reduce the return on investment (ROI). But, such a high increase in the bottom-line is worth discussing as there is a lot of research going into improving the storage devices which have a very long lifetime and a very high efficiency in converting it to electricity again. Let us go a step further and analyze how the model makes such a high profit. We can make some inferences from Fig 5. Where we can see the generation curves and also the trading decisions the model has taken to increase the bottom line. It is clear

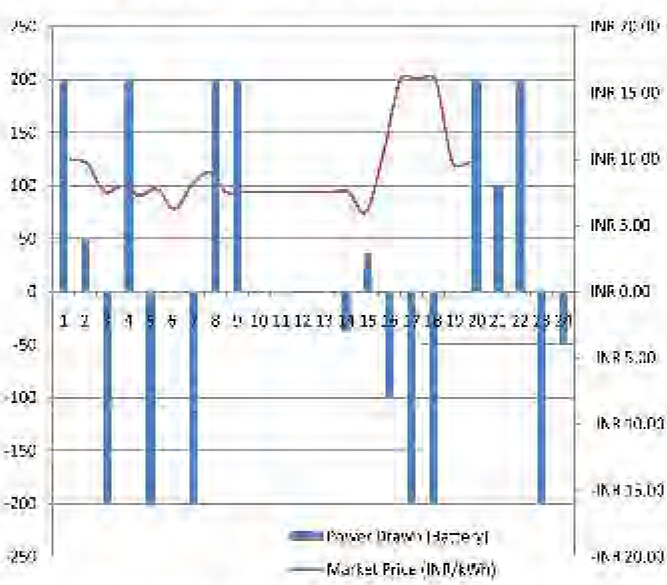

Fig. 6: Plot showing the battery usage and the Market price for every hour

that Microgrid Energy Trading Model (MTEM) has bought power from the utility grid when the net-generation is negative, and has sold power to the utility grid when there is excess of power in the Microgrid. But, this is very intuitive and simple and the working of the model is not very clear from the above plot, i.e. even without the model nothing different would have happened but what is counter intuitive from the plot is that it sold power it generated using diesel generator and at the same time the net generation was negative. That means the power was sourced from the storage device, but what compelled the trading model to take that decision can be understood from the plot showing the usage of battery and the hourly market price.

Fig. 6 gives a better idea of working of the METM. The model charged the battery when the market price was low and sold it when the Market price was relatively high. Looking at both the plots together gives a much better idea of what really happened. From hour 20-22 (peak time) Market price went up to around 16 `/kW, making the use of Diesel generator with the incremental cost (b) around `10/kW economically viable. Hence, the Trading Model sold power from the battery and also sold the power generated using the Diesel generator to reach a local maximum in trade volume and to make maximum profits. This was possible only because it could see the opportunity of making such profits before hand and charge the battery hours in advance when the cost of power was considerably less, i.e., cheaper than the diesel generator also and seized the opportunity of making such high profits.

Summary

The Microgrid Energy Trading Model (METM) built using multiple coding languages and applications is has achieved very good results. In the case study, where we have assumed multiple sources of generation and a storage facility, it has reduced the net costs incurred by over 60% by trading efficiently and making maximum use of the storage facility. It has also increased the bottom-line by over 175%, this is a little surprising but once we take losses in charging and discharging into consideration it will reduce to a little over 100% increase. In addition to increase of profits and increase in the Return on Investment (ROI), it also reduces the carbon dioxide emissions thus producing clean energy. A typical 300 kW Diesel Generator produces with a load factor of 20-50% produces approximately 0.8 kg of CO_2 for every kW-h generated. With the METM in place the Diesel Generator in the Microgrid produces approximately 900 kW-h less than what it produces without the METM. This implies that the model reduces CO_2 emissions by 720 kg/day.

Profile

K S Swarup

is professor with the Department of Electrical Engineering, Indian Institute of Technology Madras. His areas of research are Restructuring, Power System Economics, Electricity Markets, Operation, Optimization, Pricing, Forecasting and Planning.

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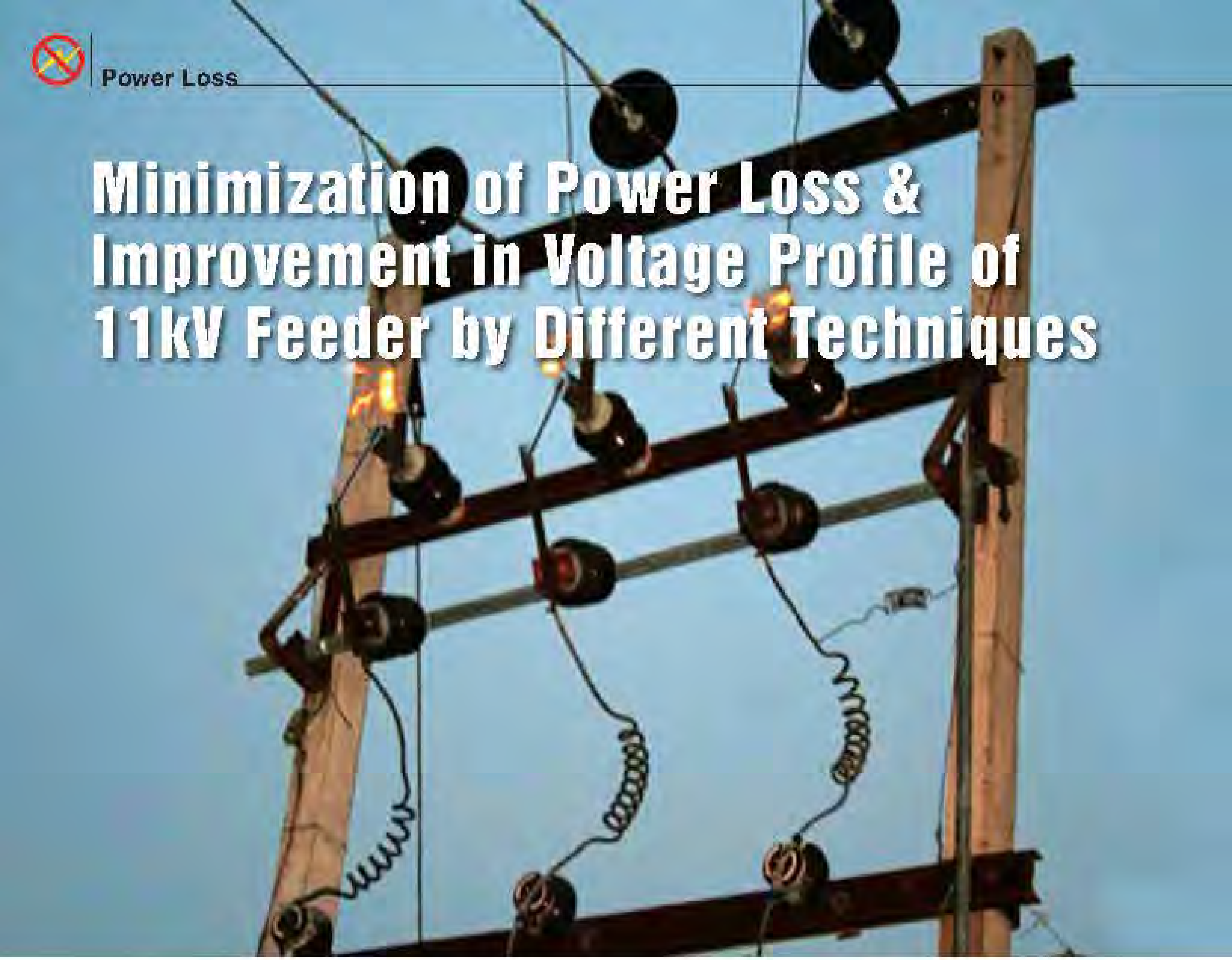


Minimization of Power Loss & Improvement in Voltage Profile of 11kV Feeder by Different Techniques

One of the greatest and the most obvious problem that India & the other developing countries are facing today is the increasing demand of electricity and its poor supply. The rising gap between demand and supply of electricity is the major factor of concern to developing countries like India. The power generation cannot be increased over night, and involves lot of investments. However, the present day scenario can be improved if we apply some more scientific techniques and methods to reduce power loss in distribution system.

Rahul Sharma

India's power sector is a 'Dripping Vessel' and the logical thing to do would be to fix the bucket properly rather than persistently emphasize shortage of power. China is way ahead of to meet with increase in demand of electricity, the increase in production and reduction in losses has been equally given importance. The distribution reforms are identified as the main area to improve gap between supply and demand.

The distribution system plays an important role in any electric power system and requires a detail analysis of various types of losses occurring in a distribution system and methods / techniques are required to be developed for reducing the same. The losses occurring in a distribution system can be classified into following three categories.

- Technical Loss
- Non-Technical Loss
- Administrative Loss.

Thus in this article it is clear that distribution sector is an area where by

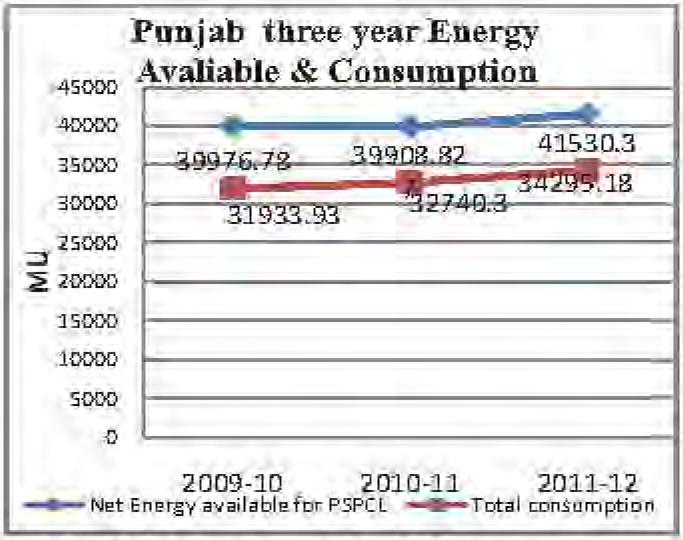


Fig. 1: Punjab last three year energy available & consumption (Source: psebea.org)

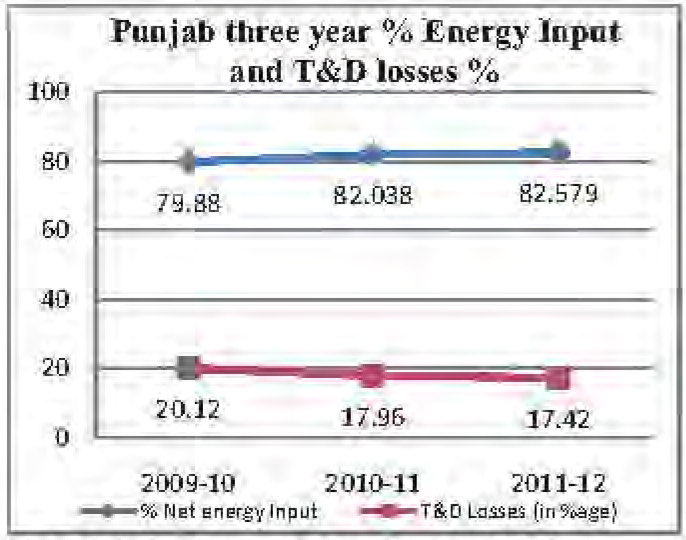


Fig. 2: Punjab last three year % Energy inputs and T&D losses (Source: psebea.org)

applying the different techniques the efficiency, voltage profile can be improved. In this article the following techniques are applied for loss reduction and improvement of voltage profile.

- By restructuring of transformer or relocation of transformer,
- By VAr compensation incorporation at different busses and
- By changing the conductor size / type of feeder. In order to bridge the gap between demand and supply. The Technical and economic feasibility is also conducted in this work.

Restructuring Parameters

In order to restructure the Feeder – 11kV of the Sub Station we need to achieve the following objectives.

- **Transformer loading**- Under normal conditions a distribution transformer is not loaded more than 50%. Transformer will generally have an overloading capacity of 200% (double their rating) but these conditions are avoided by load shedding. As per standards [IS-6600] or [IEEE Guide for loading] transformer loading is kept at 50% loading, with 3-4% loss.
- **Transformer relocation/ restructured**- Also known as Distribution Transformer (DTR) relocation. In such cases either the transformer of lower capacity will be replaced by a higher one or may be replaced by the desired one. For instance if the load demand is 60 kW it is feasible to put a 100 kVA transformer and not 200 kVA because the balance 100 kVA will not be used.
- **VAr compensation**- Reactive power neither consumes nor supplies energy. It is useful to visualize the impact of various devices on the reactive power of a power system as follows:

  Sources of reactive power which raise voltage:
- Generators
- Capacitors
- Lightly loaded transmission lines due to the capacitive charging effect.

  Sinks of reactive power which lower voltage:
- Inductors;
- Transformers;
- Most heavily loaded transmission lines due to the I2 *XL effect;
- Most customer load (due to the presence of induction motors and the supply to other electric fields).
- **Changing the conductor size / type of feeder**- Changing the feeder effectively reduces the loading on the line/cable. This due to the reason is the capacity of the line and Impedance of the cable. A Cable which can carry 4 MVA can carry 4.8 MVA depending 20% growth rate in the load [IEEE Cable 57.91] or [IEC 60853] or [IEC-60287]. More the conductor size less is the impedance and better power flow with less line losses or voltage drops.
- **Improving Voltage profile**- Voltage profile will be improved by the following methods:
- VAR Compensation
- Changing the Conductor for better power flow / loading.

Modeling of a Feeder

One of the most common computational procedures used in power system analysis is load flow study. The planning, design and operation of power systems requires such calculations to analyse the steady-state transient performance of the power system under various operating conditions and to study the effects of changes in equipment configuration. A load flow calculation determines the state of power system for a given load and generation schedules. A number of operating procedures can be analysed, including contingency conditions, such as the loss of a generator, a transformer, a transmission line, or a load. These studies will alert the user to conditions that may cause equipment overloads or poor voltage levels. Load flow studies can be used to determine the optimum size and location of capacitors for power factor improvement.

Basic features of the feeder include:

1.	Total Circuit Length of the 11kV Existing feeder	20.781 KM's
2.	Type of conductor: (MVA Rating at 65 C⁰ - 3 MVA)	RABBIT (ACSR)
3.	Total capacity of the distribution transformer (DTR's) in KVA	11,679
4.	Number of distribution transformer	68

Table 1: Basic Features of 11kV Feeder

This shows the conversion of the above data which is taken from public utility company into a simulated diagram which has been obtained with the application of MiPower software. This helps in computing the load flow analysis and actual losses at the feeder level in a more scientific accurate manner.

Fig. 3: Analysis of results

Application of the VAr compensation, better choice of feeder type and transformer loading are the best techniques for voltage profiling. Real power loss is found to be minimum by the use of above features. Following is the outcome of the application of transformer loading (A), VAr compensation (B) and changing the conductor / type of feeder (C) which clearly substantiates how power loss can be reduced or minimized effectively.

Analysis of results

The study of feeder showcases the reduction in real power loss by:

- The transformer loading helps in reducing the power loss from 8.58% to 3.84% if we reduce the loading on the transformer.
- The technique of VAr compensation with Q optimization helps in reducing the power loss from → [(8.58: 6.54: 3.84) to (6.988: 5.181: 3.128) with 100%, 80% and 50% loading respectively].
- The technique of changing the conductor size / type of feeder from Rabbit to Coyote reduce the power loss from → [(8.58: 6.54: 3.84) to (3.42: 2.66: 1.59) with 100%, 80% and 50% loading respectively].

Thus the methodology and techniques used clearly shows the efficacy of in power loss reduction. These techniques are very scientific and accurate in handling the power loss as they help in reducing the quantum of power loss to great extent, thus, minimizing the loss of power. And they are also very financially viable and thus can boost the recovery of the game. The remedial measures suggested in the dissertation can help in ameliorating the poor power supply in our state and can address the power leakage in big way. As they say "A penny saved is penny earned", similarly "A unit saved is unit earned".

Fig. 3 shows the gradation from voltage drop to perfect voltage status by using the transformer loading, MVAr compensation and changing feeder/conductor.

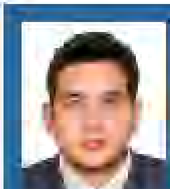
Thus by the application of three distinct strategies-

- By restructuring of transformer or relocation of transformer,
- By VAr compensation incorporation at different busses and
- By changing the conductor size / type of feeder,

we can certainly reduce the power loss at 11kV Feeder from 8.58 to 1.59.

When looked at a large scale the strategies can be very effective in addressing the power shortage in Punjab. As well as they are very economically viable. The restructuring strategies adopted of MiPower software can proved to be panacea for bridge the demand and supply of power in Punjab or India. On the whole, therefore, it is suggested that this innovative research should be applied immediately and urgently to meet the growing demand of electricity. As in terms of energy "A unit saved is equal to a unit earned". If the suggested measures are adopted then definitely the tall promises are made in the manifesto that "Power for all in 2017" can definitely be meted out.

Profile



Rahul Sharma

Assistant Professor, Department of Electrical Engineering, CT Group of Institutions, Four International Journal Publications Two National Conference Publications Two Articles Published in Electrical India

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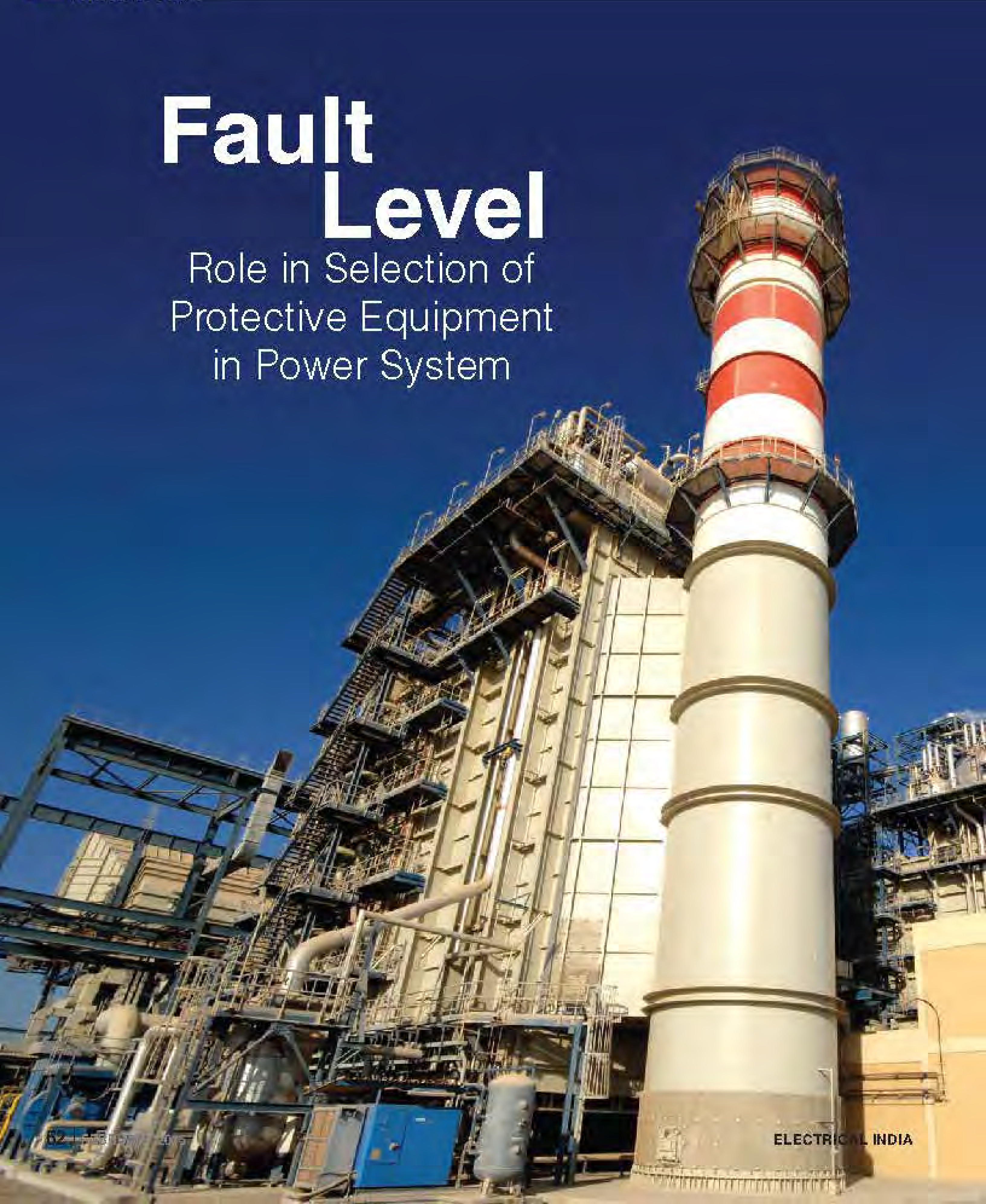
Fault Level

Role in Selection of Protective Equipment in Power System



Almost after a decade, US economy on rising trend, a very good news for all of us. India is also an emerging economy, where power sector has to play crucial role. After years of silence, Indian power sector has risen to embrace multi million rupees i.e. Rs 23000, crore deals in the last few months under the new regime at the center. In addition to this there is significant rise in monthly power generation too, since May 2014 as compared to year 2013 in India, according to CEA.

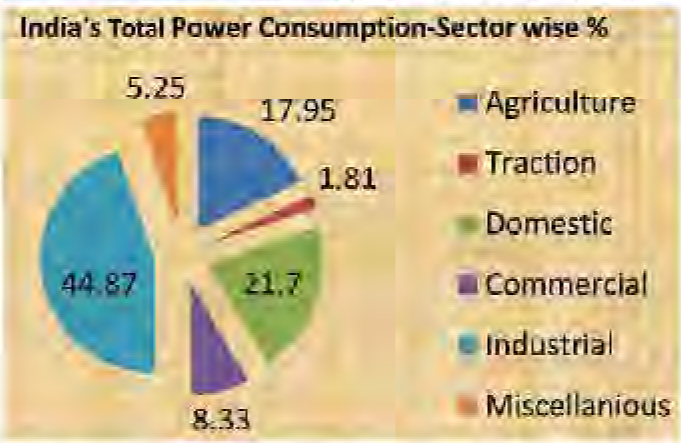
Year	May-13	May-14	Jun-13	Jun-14	Jul-13	Jul-14	Aug-13	Aug-14	Sep-13	Sep-14	Oct-13	Oct-14
In million units	87	90	80	89	83	90	81	90	80	86	77	90.5

Power Generation in India in 2013-14

Sector	Power Consumption %
Agriculture	17.95
Traction	1.81
Domestic	21.7
Commercial	8.33
Industrial	44.87
Miscellaneous	5.25

All India Electrical Power Consumption - Sector wise
(Source: CEA)

Over the years, tsunami of troubles hit the power sector like shortage of quality coal and gas supply, problems in land acquisition etc. But in spite of all these problems India was adding roughly 20 GW annually. Transmission and distribution losses 23.65% have been on reducing trend in last few years but still long way to go to match the level of developed countries like USA 5.04%, Canada 4.01%, Australia 4.53%, China 6.45%,South Africa 11.44%, world average 9.8% according to 2010 report of CEA. In India, in fact, some sectors it was found around 40-45% according to expert sources. Fault level is an important criterion in designing the basic parameters of an electrical setup. Fault Level at any given point of the electric power system is the maximum current that would flow in case of short circuit condition.



The aim of this article is to discuss the short circuit requirements of HV switchgear i.e. generator, distribution circuit breakers, both indoors and outdoors in brief for basic understanding of a crucial parameter. It identifies the various short circuit withstand capabilities, their significance and importance in relation to short circuit and other transient conditions that exist in a power system under fault conditions. Many electrical engineers often confuse the real meanings of these requirements and generally depend on manufacturers in selecting the right switchgear for the intended application.

Usual Causes and Nature of Faults

It may be of following types of faults -

- L–E (Line to Earth)
- L-L (Line to Line)
- L-L-L (3 phase fault).

Short circuits are generally caused by insulation failure, flashovers, short circuits, broken conductors, physical damage or human error. Short circuits involving all three phases simultaneously are of symmetrical nature, whilst those involving only one or two phases are asymmetrical faults. The balanced three phase faults are normally analyzed using equivalent single phase circuits. Use of symmetrical components helps to resolve the asymmetrical system faults.

Short circuits do occur even in well-designed power systems, which result in disruptive electro-dynamic and thermal stresses that are potentially damaging. Fire risks and explosions are often inherent.

Sources of Short Circuit Current

There are four basic sources of short circuit current such as-

- Generators
- Synchronous Motors
- Induction Motors
- Electrical Utility systems.

What to do if it occurs?

It is essential to isolate the power source to the faulty section, and away from the healthy section as quickly as possible in order to protect both equipment and personnel. It is essential that the short circuit withstand ratings of the protected equipment such as transformers, reactors, cables and conductors are not exceeded and thus the consequential damages are either eliminated or limited. Fast isolation/ interruption reduces the transient instabilities and the power system will remain in synchronism. The fault current interrupting device is the 'switchgear' or the 'circuit breaker' & it should withstand the dynamic effects of short circuits.

Purpose of Fault Level Calculations in Power System

- For selecting short circuit protective device of adequate safety
- For selecting Circuit Breaker and other switch gear of sufficient Short Circuit making and breaking capacity
- For designing Bus bar and its supporting structure, cable and other switchgear to withstand thermal and mechanical stresses in case of fault
- To do current based discrimination of protective switchgear.

Usual Methods for Finding Fault Level

- Direct Method
- Per Unit Method.

Short Circuit Analysis

There is plenty of software available in the market to calculate them today but as a design engineer, we should have alternative methods to cross check them too, because it is very crucial parameter in designing of entire electrical setup and its costing will be effected drastically with slight variation in calculated values.

Short Circuit analysis is used to determine the magnitude of short circuit current, the system is capable of producing and compares that magnitude with the interrupting rating of the over current protective devices. Since the interrupting ratings are based by the standards, the methods used in conducting a short circuit analysis must conform to the procedures which the standard making organizations specify for this purpose. Short circuit currents impose the most serious general hazard to power distribution system components and are the prime concerns in developing and applying protection systems. Fortunately, short circuit currents are relatively easy to calculate. The application of three or four fundamental concepts of circuit analysis will derive the basic nature of short circuit currents.

The three phases bolted short circuit currents are the basic reference quantities in a system study. In all cases, knowledge of the three phase bolted fault value is required and needs to be singled out for independent treatment. This will set the pattern to be used in other cases.

Device that interrupts short circuit current, is a device connected into an electric circuit to provide protection against excessive damage when a short circuit occurs. It provides this protection by automatically interrupting the large value of current flow, so the device should be rated to interrupt and stop the flow of fault current without damage to the over- current protection device. Here are reference values that will be needed in the calculation of fault current.

Impedance Values for Three phase transformers

- HV Rating 2.4KV – 13.8KV 300 – 500KVA Not less than 4.5%
- HV Rating 2.4KV – 13.8KV 750 – 2500KVA 5.75%
- General Purpose less then 600V 15 – 1000KVA 3% to 5.75.

Reactance Values for Induction & Synchronous Machine X

- Sub transient Salient pole Gen 12 pole 0.16, 14 pole 0.21
- Synchronous motor 6 pole 0.15, 8-14 pole 0.20
- Induction motor above 600V 0.17
- Induction motor below 600V 0.25.

Transformer Fault Current

Calculating Short Circuit Current, When Transformer is in the circuit. Every transformer has '%' impedance value stamped on nameplate.

So what does this mean for a 1000KVA 13.8KV – 480Y/277V.

First you need to know the transformer Full Load Amps

Full Load Ampere = KVA / 1.73 x L-L KV

FLA = 1000 / 1.732 x 0.48

FLA = 1,202.85

The 1000KVA 480V secondary full load ampere is 1,202A.

When the secondary ampere meter reads 1,202A and the primary Voltage Meter reads793.5V, the percent of impedance value is 793.5 / 13800 = 0.0575. Therefore; % Z = 0.0575 x 100 = 5.75%.

This shows that if there was a 3-Phase Bolted fault on the secondary of the transformer then the maximum fault current that could flow through the transformer would be the ratio of 100 / 5.75 times the FLA of the transformer, or 17.39 x the FLA = 20,903A. Based on the infinite source method at the primary of the transformer, a quick calculation for the Maximum Fault Current at the transformer secondary terminals is -

FC = FLA / %PU Z FC = 1202 / 0.0575 = 20,904A

This calculation can help you determine the fault current on the secondary of a transformer for the purpose of selecting the correct over current protective devices that can interrupt the available fault current. The main breaker that is to be installed in the circuit on the secondary of the transformer has to have a KA Interrupting Rating greater then 21,000A. Be aware that feeder breakers should include the estimated motor contribution too. If the actual connected motors are not known, then assume the contribution to be 4 x FLA of the transformer. Therefore, in this case the feeders would be sized at 20,904 + (4 x 1202 = 25,712 Amps).

Generator Fault Current

Generator fault current differs from a Transformer. Below, we will walk through a 1000KVA example.

800KW 0.8% PF 1000KVA 480V 1,202FLA

KVA = KW / PF

KVA = 800 / .8

KVA = 1000

FLA = KVA / 1.732 x L-L Volts

FLA = 1000 / 1.732 x 0.48

FLA = 1,202

(As listed in the table for generator sub transient X" values is 0.16)

FC = FLA / X"

FC = 1202 / 0.16

FC = 7,513A

So, the fault current of a 1000KVA Generator is a lot less then a 1000KVA transformer. The reason is the impedance value at the transformer and Generator reactance values are very different. Transformer 5.75% vs. a Generator 16%.

System Fault Current

Below is a quick way to get a MVA calculated value. The MVA method is fast and simple as compared to the per unit or ohmic methods. There is no need to convert to an MVA base or worry about voltage levels. This is a useful method to obtain an estimated value of fault current. The elements have to be converted to an MVA value and then the circuit is converted to admittance values.

Utility MVA at the Primary of the Transformer

MVAsc = 500MVA

Transformer Data

13.8KV - 480Y/277V

1000KVA Transformer Z = 5.75%

MVA Value

1000KVA / 1000 = 1 MVA

MVA Value = 1MVA / Zpu = 1MVA / .0575 = 17.39 MVA

Use the admittance method to calculate Fault Current

1 / Utility MVA + 1 / Trans MVA = 1 / MVAsc

1 / 500 + 1 / 17.39 = 1 / MVAsc

0.002 + 0.06 = 1/ MVAsc

MVAsc = 1 / (0.002 + 0.06)

MVAsc = 16.129

FC at 480V = MVAsc / (1.73 x 0.48)

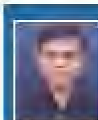
FC = 16.129 / 0.8304

FC = 19.423KA

FC = 19, 423 A

The 480V Fault Current Value at the secondary of the 1000KVA transformer based on an Infinite Utility Source at the Primary of the transformer as calculated in the Transformer Fault Current section in this article is 20,904A.The 480V Fault Current Value at the secondary of the 1000KVA transformer based on a 500MVA Utility Source at the Primary of the transformer as calculated in the System Fault Current section in this article is 19,432A.The 480V Fault Current Value at the secondary of the 1000KVA transformer based on a 250MVA Utility Source at the Primary of the transformer the calculated value is 18,790A When the cable and its length is added to the circuit the fault current in a 480V system will decrease to a smaller value. To add cable into your calculation, use the formula. Cable MVA Value MVAsc = KV2 / Z cable. Use the cable X & R values to calculate the Z value then add to the Admittance calculation as shown in this article. The conclusion is that you need to know the fault current value in a system to select and install the correct Over current Protective Devices. The available FC will be reduced as shown in the calculations when the fault current value at the primary of the transformer is reduced. If the infinite method is applied when calculating fault current and 4 x FLA is added for motor contributions, then the fault current value that is obtained will be very conservative. This means the calculated value in reality will never be reached, so you reduce any potential over current protection device failures due to fault current. In view of sizing an electrical setup and the related equipment (HV & LV), as well as determining the means required for the protection of life and property, short-circuit currents must be calculated for every point in the network.

Profile



Aqeel Ahmad

BSc Engg (Elect),DME,ACPDM,DELF Substation & Solar Energy Expert has graduation with electrical & diploma in Mechanical engineering from Aligarh M. University. He has diploma in French language. He has over two decades experience in Steel Authority of India Ltd, Gulf Ferro Alloys company in Saudi Arab & UNDP, govt. of Germany sponsored project in Ethiopia, Africa in the areas of 230 KV substations & solar power. He is regularly writing articles & books and for national & international magazines.

Electric Vehicles

Charging up for a Better Future

As vehicle use continues to increase, many countries around the world are focusing on ways to decrease pollution, greenhouse gas emissions and dependence on oil. Promoting less polluting non-oil based propulsion systems is an effective way to address these issues. Of all emerging the road transportation technologies that use fuels other than carbon based fuels, Plugin Electric Vehicles (PEV) are the ones closest to mainstream. India, with its high dependence on oil imports and having cities with some of the highest air pollution levels in the world, can benefit with large scale adoption of PEVs on this roads as the technology matures.

Girish Shirodkar and Shantanu Gautam

PEVs can be broadly classified into two types – Battery operated vehicles (BEV) which derive power from battery packs and have no internal combustion engine, and Plugin hybrid electric vehicles (PHEV) which have battery packs as primary source of power and an internal combustion engine as a backup. Both BEV and PHEV allow the user to plug it into the electrical grid for charging. Comparatively, pure hybrid electric vehicles (HEV), a separate segment in itself, get most of their power from internal combustion engines with electric motor as a backup and getting charged on the go. Unlike internal combustion engines, BEVs do not emit any pollutants and greenhouse gases while PHEVs result in drastically lower CO_2 emissions than its internal combustion engine powered counterpart.

The global sale of PEVs has almost doubled in each of the past four years. The PEV market has grown from less than 10,000 in 2009 to about 45,000 in 2011, more than 110,000 in 2012, and more than 210,000 in 2013. As of June 2014, there were over 500,000 plugin electric passenger cars and utility vans in the world, with the U.S. leading plugin electric car sales with a 45% share of global sales.

The demand for PEVs is driven largely by developed economies including USA, parts of European Union, Japan and in recent years China. The US market is currently the largest market for PEVs with over 95,000 vehicles sold in 2013, almost

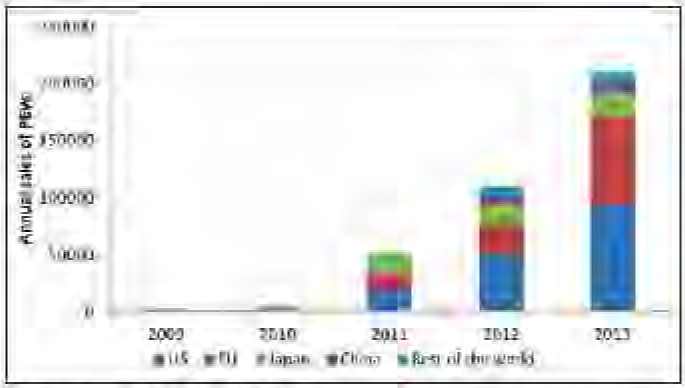


Fig. 1: Annual sales of PEVs
Source: ICCT: Driving Electrification - A Global Comparison of Fiscal Incentive Policy for Electric Vehicles

100% y-o-y growth over 2012. Japan is the second largest market for PEVs with around 30,000 vehicles sold in 2013. Around 66,000 vehicles were sold across Europe in the same year with Norway, Denmark, Netherlands and France constituting the main markets.

Along with exponential rise in sales, PEVs are also slowly becoming part of the mainstream automotive markets. In countries like Norway and Netherlands PEVs constituted around 6% of automobile sales in 2013. The growth trend is continuing - PEVs captured 11.2% of the auto market in Norway in September 2014, and four electric vehicle models are among the country's top 20 selling cars. While in US these form ~1.5% of overall auto sales, regions like California are emerging as early adaptors of PEVs with these constituting over 4% of total automobile sales.

Most of the traditional global auto manufacturers are now present in the electric vehicles space including Nissan, Mitsubishi, Renault Toyota, Volvo, BMW, Ford and Chevrolet. There are also players like Tesla, whose market capitalization has grown from ~$150M in 2010 to $31.2B today, who are dedicated focusing only on PEVs as a segment. Nissan Leaf is the most popular electric car capturing around a quarter of the global market with sales across all major demand centers.

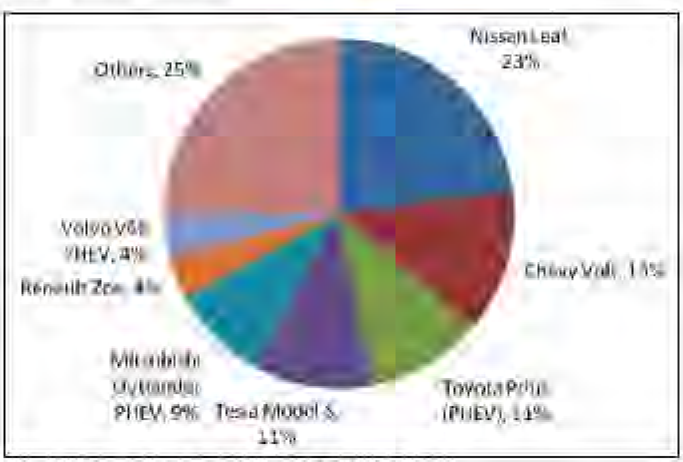


Fig. 2: Global market share of PEVs in 2013
Source: EV Obsession

The growth trend of plug-in electric vehicles is expected to continue going forward. Major countries including US, Japan, Netherlands, France, Germany, Portugal, Spain, China and India have together set targets that add up to 5.9 million sales by 2020. A new study by Navigant Research predicts that the sales of these vehicles will increase from 350,000 in 2014 to reach 2-3 million units per year in the next ten years. While the current rise has been predominantly centered in US and Europe, the research expects Asia Pacific region to become a major market as well in the next decade.

Auto companies are also betting big on the future of PEVs. Tesla has already started work on its proposed battery "Gigafactory". When it reaches full production in 2020, the Gigafactory would alone produce more lithium-ion batteries than currently are produced globally. This would allow it to sell nearly 500,000 vehicles a year – as many as the entire fleet of electric vehicles on the roads today.

What is Driving this Growth

A number of demand and supply factors coupled with government support are coming together to fuel the growth in PEV market. A multi government policy forum, The Electric Vehicles Initiative (EVI), whose 16 member countries including India, was established in 2010 to accelerate the introduction and adoption of electric vehicles worldwide.

Overall, we see five major trends which are facilitating adoption of electric vehicles and will continue to drive their growth in the future.

- **Declining price:** PEVs are becoming more affordable, and vehicle sales are rising correspondingly. In 2013, the Nissan Leaf slashed its sale price by $6,500, to $28,800. The 2014 Chevy Volt is also selling $5,000 cheaper, with a starting price of $34,995. The thrifty Mitsubishi i-MiEV is now selling at $22,995, or $6,130 less than it used to. Ford is the most recent price cutter. The Detroit automaker announced that its Focus Electric will now sell for $6,000 less, coming in at $29,995. That's after a $4,000 price reduction in 2013.
- **Improvements in battery technology:** Batteries form the most critical component of an PEV. Their large size, low energy density, long charging time and high costs have been traditional deterrents for consumers to invest in PEVs. However, now battery innovation is leading to new batteries which are a lot smaller and are also stronger, longer lasting and can also recharge a lot faster than in the past. Because batteries used in electric cars today weigh less, the power as well as the range of electric cars has significantly increased. Battery costs have come down from $1000 per kWh in 2008 to $485 per kWh in 2012. Even then batteries are still hugely expensive - usually around $12,000 to $15,000, or one-third the price of the vehicle — and can provide only limited range. According to a research by McKinsey the cost of batteries can come down to less than $4,000 by 2025 through just slow and steady improvement.

Fig. 3: Light Duty PEV sales in the World
Source: Navigant Research

These will include increase economies of scale, lowering component costs through increase in completion and doubling of energy density of batteries through steady improvement in technology. According to Tesla's CTO J B Straubel, battery technology is improving at 5-8% annually which will lead to doubling in core performance metrics every ten years. Tesla expects that, in its first year, the Gigafactory would also reduce its battery costs by more than 30%. Along with steady improvements in current lithium-ion batteries companies are also working on disruptive battery technologies. IBM is working on a lithium air technology which approaches the energy density of a petrol tank and can quadruple the current car range of PEVs. Super-capacitors, which are already being implemented in commercial vehicles, have nearly unlimited cycle life and can charge/discharge thousands of times more quickly than lithium ion batteries without getting damaged. Power Japan Plus recently announced Ryden, or Dual Carbon, battery, with carbon anode and cathode that allows for charging at 20 times the rate of current lithium ion batteries. The ability to charge faster would lead to shorter stops at recharging stations. For example, the Nissan Leaf can be charged from empty to full in four hours. The Ryden battery would cut that time down to 12 minutes.

- **Government incentives:** Many countries have put in place incentives in different forms, including direct subsidies on purchase of PEVs, fiscal incentives in the form of reduced taxes and levies, other perks like use of bus lanes, free parking. Most large markets have some form of direct subsidies in place to support PEV buyers:
- ***US and California:*** A federal subsidy program, depending on the size of the battery, allows for a maximum of $7,500 in the form of tax credit, on a one-time basis. In California, in addition to the federal subsidy, $2500 and $1500 in one-time bonuses are granted to purchasers of BEVs and PHEVs respectively.
- ***Japan:*** A one-time bonus, subject to a maximum of EUR 6,300 is allowed on PEV purchases since 2009.
- ***France:*** Vehicles emitting less than 20g/km of CO_2 receive a one-time bonus of EUR 7,000 or 30% of the vehicle purchasing cost, whichever is lower.

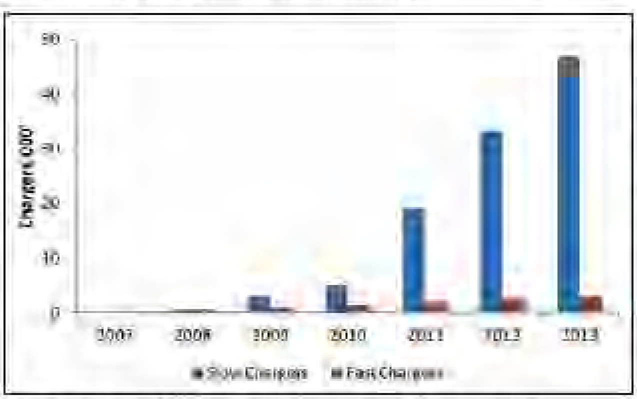


Fig. 4: Non residential EVSE growth in EVI countries
Source: EVI

- Apart from these a number of other enabling policies are being put in place to support the growth of PEVs. In Norway, PEV owners are exempt from parking fees and tolls. Many other forms of fiscal incentives for PEVs exist in different markets, including waiver of road tax in Sweden, waiver of acquisition tax in Japan, and many more.
- **Improvements in facilitating infrastructure:** Deployment of electric vehicle supply equipment (EVSE) is taking place across different locations (residential, office, street, etc) and by different modes of charging, which can be generally grouped as 'slow' (charging times range from 4-12 hours to full charge) and 'fast' (charging times range from 0.5-2 hours). EVSE deployment has risen sharply since 2010 as governments have invested in enabling infrastructure for electric vehicles. Countries are approaching non-residential EVSE deployment in their own separate ways. Japan has already installed 1,381 fast chargers, which is the highest for any country worldwide, but has placed less emphasis on slow chargers. In US emphasis is on slow charging, perhaps due to more reliance on home charging and the prevalence of PHEVs. Comparatively in Netherlands a mix of slow and fast chargers is being employed, resulting in the most EVSE per capita worldwide. By 2020 most major EV markets have set cumulative targets of around 2.4 million slow charges and 6000 fast chargers. The rise in absolute number of EVSEs and EVSE/EV density will both be important for facilitating adoption of PEVs by consumers.
- **New business models:** Electric vehicle manufacturers are experimenting with different business models which improve the overall cost of ownership or convenience of end consumers. Some of these include electric vehicle leasing model (Nissan offers $ 199 per month lease for the electric Leaf), battery swapping (Tesla is planning to set up battery swapping stations where

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Tesla car batteries can be swapped within 90 seconds and replaced with a fresh pack) and free charging programs (Nissan is offering its buyers free charging facilities for first two years of ownership). These schemes and more would go a long way in facilitating conversion to electric vehicles and improving the cost of ownership of consumers.

Where is India in This Scheme of Things

In 2013, India unveiled the ambitious National Electric Mobility Mission Plan (NEMMP) with a target to create a potential demand for 5-7 million PEVs (including 2 wheelers) by 2020. Under the plan, the government was to invest Rs 14,000 Cr ($2.5Bn) in creating infrastructure and promoting use of environment-friendly electric vehicles in the country.

Unfortunately, the plan has mostly remained on paper. Without any government support, the sales of PEVs has plummeted in the last two years. Mahindra & Mahindra, which bought Reva Electric four years back, had set a target of monthly selling 500 units of electric car e20. However, the company has merely managed to sell 1,000 units in the past 15 months post launch. Electric two wheeler sales have also crashed to a mere 21,000 from 100,000 two years ago.

The government is now rethinking of introducing a subsidy of Rs 14,000 Cr to push green vehicles in Indian car market. The heavy industry ministry, which has moved a proposal for clearance by the finance ministry, has suggested that the maximum subsidy of 35% should be given to pure electric vehicles, while a 25% benefit should be provided for plug-in vehicles that can drive for at least 15 km at one go.

A large scale adoption of PEVs on Indian roads can bring about many benefits:

- For city commuters, an affordable electric car would help reduce fuel costs.
- WHO's study of air pollution in 1600 cities across the globe indicated that 13 of the top 20 most polluted cities were in India with New Delhi, Patna, Gwalior and Raipur in the top four spots. PEVs will go a long way in reducing the air pollution levels in these cities.
- Over time, India has become increasingly dependent on crude oil imports for meeting its energy requirements – becoming the fourth largest net importer of crude oil and petroleum products in the world in 2013. The oil import bill rose from $87.1 billion in 2009-10 to $167.6 billion in 2013-14. Increased reliance on PEVs will reduce oil demand. The government's estimates indicate that the Rs 14,000 Cr subsidy for PEVs would lead to saving of Rs 60,000 Cr in fossil fuel spends by 2020.
- Large scale adoption of PEVs will improve the overall energy efficiency of the economy and reduce energy costs. The energy efficiency of electric cars is significantly higher than conventional 'internal combustion' vehicles. Drive efficiency of the Tesla Roadster is 88% while the same for a petrol car is ~25%. The electricity for charging PEVs comes mostly from a mix of coal fired power plants (35%-40% energy efficiency) or hydro power plants (>90% efficient). This would mean any reduction in petrol driven vehicles would improve the energy efficiency of the economy.

However, if we look at the growing success of PEVs in other countries, subsidies and financial incentives are only one part of a larger support ecosystem. The government would also need to invest in establishment of a large scale EVSE infrastructure to enable easy outside residence charging and ensure reliable supply of electricity.

Policies and mechanisms are needed to make the Indian market attractive for major global electric car manufacturers. These players which are on the forefront of PEV evolution would help drive down prices, bring in the latest technology and develop a self-sustaining ecosystem in the long run.

Conclusions

PEVs are in an early stage of adoption across the world. If battery technologies improve and ownership costs go down, PEVs will become an increasingly attractive option.

Through PEVs, India has a chance to reduce its dependence on oil and build a cleaner environment in its cities. PEVs are further suitable for India as low driving speeds are common, speeds at which electric power trains operate at a much higher efficiency than internal combustion engines.

However, PEVs have little chance of succeeding in India without proactive government support. The government needs to expedite the NEEMP roll out. Along with subsidies developing the supporting infrastructure would be crucial for consumer acceptance. There is a need to create a conducive environment to make large international PEV car companies take interest in the Indian market and the government has a big role to play in it.

Profile

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Harnessing Waste Heat Potential

Generation of heat from combustion was the first man made source of energy in addition to natural source of energy i.e., light. Our ancestors, though with plenty of heat resources, were very intelligent, environmental friendly and well aware of energy conservation.

Dr S S VERMA

While utilizing heat generated through the combustion of mostly wood for cooking purposes they had innovated and developed ways to make maximum use of the heat being generated & in simplest manners by designing 'Chullahas' having minimum two and maximum four interconnected places to use heat to its maximum capacity. The demand of different energy forms being generated and used increased with time. Presently, heat energy is produced by using many means other than wood like petrol, diesel, coal and many other solid, liquid and gaseous fuels. Heat energy is also used to generate electricity, the life line of present day civilization.

Waste heat is by necessity produced both by machines that do work and in other processes that use energy, for example in a refrigerator warming the room air or a combustion engine releasing heat into the environment. The need for many systems to reject heat as a by-product of their operation is fundamental to the laws of thermodynamics. Coal-fired power station transforms chemical energy into 36%-48% electricity and remaining 52%-64% to waste heat. Industrial processes, such as oil refining, steel making or glass making are major sources of waste heat. Investigations indicate that about 50% of all fuel burned by industrial sources becomes waste heat, mostly low-grade. The thermal conditions of the industrial waste heat are industry dependent. Although small in terms of power, the disposal of waste heat from microchips and other electronic components represents a significant engineering challenge. Animals, including humans, create heat as a result of metabolism. In warm conditions, this heat exceeds a level required for homeostasis in warm-blooded animals, and is disposed of by various thermoregulation methods such as sweating and panting. Thus, every year, billions of rupees of energy are thrown away as waste heat.

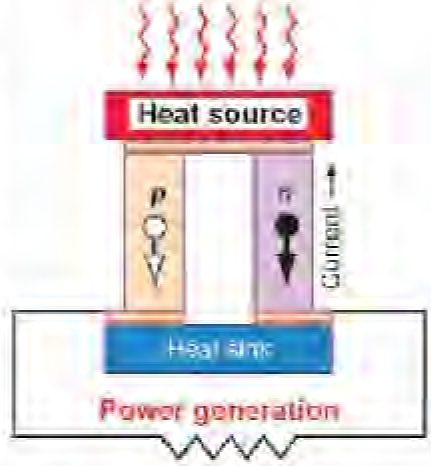
In all forms of heat utilization, the wastage of heat is inevitable and also in very large quantities and its tapping was not given any thought before.

In all forms of heat utilization, the wastage of heat is inevitable and also in very large quantities and its tapping was not given any thought before. It is estimated that 60% of that energy is wasted as heat. But with the growing demand of energy, depleting natural resources of fuels & with alarming environmental pollution, people have started to think about the tapping of waste heat from almost all sources for its optimum use. Technologies are being developed to make use of waste heat from machines, industrial units, and automobiles to human body. The concept of replacing existing energy devices with more energy efficient and economically competitive energy devices is still lacking. Efforts are being directed to develop energy conversion devices which can make use of waste heat and covert it (waste heat) into useful form of energy. In this article, new developments taking place to tap waste heat from various sources is discussed.

Thermoelectricity

Thermoelectric devices, which enable the conversion of heat into electricity, are still at an early stage in the energy innovation chain, but the principle behind how they work can help to highlight a crucial aspect of energy waste across the world that is often ignored in the policy realm. No doubt, emerging thermoelectric technology could give energy efficiency a whole new meaning by tackling the huge energy waste that happens before the watts even reach our homes.

The ability of thermoelectric materials to accomplish direct conversion between thermal and electrical energy in compact, durable, solid-state devices without moving parts and pollution free makes them an attractive technology for waste heat recovery applications. Presently, thermoelectricity is thought as a very attractive option to tap waste heat available at various sources in abundance and convert it into useful power without any further environmental effects. Thermoelectricity (based on Seeback effect) is



the use of a system of suitable materials for converting heat into electricity. Basically, a thermoelectric device works just like an engine (based on Seeback's effect): it converts, using a thermocouple (a combination of two dissimilar metals) whose junctions are maintained at a certain temperature difference, into an electric potential to generate power. For a given temperature output, a very efficient system will generate a high voltage, while a low-efficiency device will only create a modest voltage. In order to achieve real energy savings, the world would need thermoelectric devices with very high efficiency. Good thermoelectric materials should have high thermo power, high electric conductivity, and low thermal conductivity. Recently, there have been significant advances in direct thermal-to-electrical energy conversion materials and this has generated increased interest in the field.

Growing application

Scientists and engineers are working on efficient thermoelectric materials to design thermoelectric devices to harvest waste heat and turning it into electrical power. Taking advantage of nanotechnology and quantum effects, the technology holds great promise for heat recovery and thus making cars, power plants, factories and solar panels more energy efficient. In addition to scavenging waste heat, thermoelectric devices will improve efficiency

of fuel consumption and limit the use and exhaust of greenhouse gases. At present, this efficiency remains discouragingly low: even state-of-the-art thermoelectric devices can only convert 10% of the energy from a waste heat source at 500 degrees. This is why thermoelectrics have only met success for limited 'niche' applications. Fortunately, this efficiency is only limited by the basic laws of thermodynamics, and there is considerable room for progress. New advances in nano-structured materials, resonant modes, insulating materials and other state-of-the-art physics could help boost thermoelectrics' contribution to energy efficiency throughout the world. Thermoelectric is not a market-ready technology and is still at an early stage in the laboratory because the science behind the devices is so complex. Therefore, to reach market, thermoelectric will have to overcome a number of technological and policy related barriers. If the next generation of thermoelectric materials can be manufactured inexpensively, they could be used in more demanding applications. Some the applications are as:

- Cars and other light vehicles produce a great deal of waste heat in the engine's exhaust and coolant. Automotive industries are hoping to increase fuel efficiency and eventually replace alternators and possibly even internal combustion engines with thermoelectric generators.
- Heavy equipment powered by diesel engines (such as tractors, earth movers, trucks) has medium exhaust temperatures and can make waste heat recovery via thermoelectric generation more efficient.
- Stationary power generation represents an enormous technical market for thermoelectric generators.
- Roughly a third of the energy consumed by industry is discharged as waste heat to the atmosphere or to cooling systems. These discharges are the result of process inefficiencies and the inability of manufacturing plants to utilize the excess energy. Industrial waste heat energy is considered to be an economic opportunity for waste heat recovery.
- The discovery of the unique properties of a new material for thermoelectrics may make it possible to recycle heat from computers and cars as electric power.
- With the cost effective thermoelectric devices, scientists think thin-film thermoelectric technology could eventually lead to slap-on thermoelectric patches (using body heat) that produce enough power to run battery-powered pacemakers, cochlear implants, brain stimulators, cellphone or iPod from our body temperature itself.

Latest developments

- Researchers get increasingly good at manipulating materials at the nanoscale and reported a material called tin selenide with the record ZT of 2.6.
- Recently discovered thermoelectric materials and associated manufacturing techniques (nanostructures, thin-film super lattice, quantum wells) have been characterized with higher thermal to electric energy conversion efficiencies.
- Mismatched alloys are a good match for the future development of high performance thermoelectric devices.
- Enhancement in thermoelectric performance can be achieved by reducing thermal conductivity through nanostructuring and structural modification of materials.
- Molecular thermoelectric device making use of quantum laws of physics holds great promise. Such devices could help to solve an issue currently plaguing photovoltaic cells harvesting energy from sunlight more efficiently.
- The thermoelectric devices in a flexible configuration can exploit small temperature differences occurring naturally in the environment of the application like ground-to-air, water-to-air, or skin-to-air interfaces.
- An international team of researchers from the US, India & Australia has demonstrated thermo-electrochemical cells (thermo cells) in practical configurations (from coin cells to cells that can be wrapped around exhaust pipes), that harvest low-grade thermal energy (temperature below 130°C), using relatively inexpensive carbon multi-walled nano-tube (MWNT) electrodes.

Profile

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working as Associate Professor in 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).


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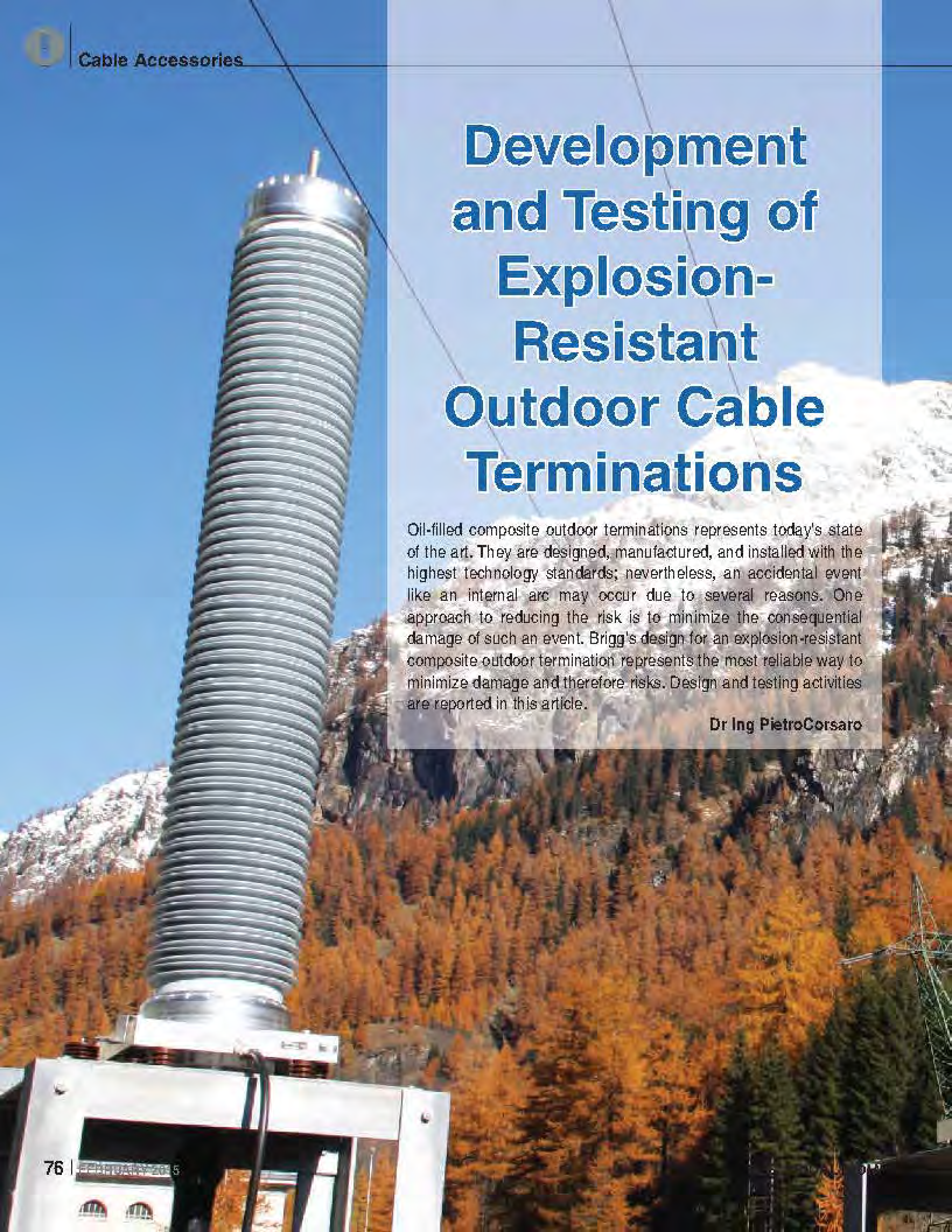


Development and Testing of Explosion-Resistant Outdoor Cable Terminations

Oil-filled composite outdoor terminations represents today's state of the art. They are designed, manufactured, and installed with the highest technology standards; nevertheless, an accidental event like an internal arc may occur due to several reasons. One approach to reducing the risk is to minimize the consequential damage of such an event. Brigg's design for an explosion-resistant composite outdoor termination represents the most reliable way to minimize damage and therefore risks. Design and testing activities are reported in this article.

Dr Ing PietroCorsaro

During an internal arc in a termination, the electrical discharge channel in the form of plasma causes a fast phase transition of the insulating medium from liquid to vapor

Self-supported fluid-filled outdoor terminations have been successfully used as long as high-voltage cables have existed, and they continue today to be the network operator's first choice due to their excellent long-term performance record. The basic construction of a modern fluid-filled termination consists of a composite supporting insulator and a silicone rubber stress cone installed onto the cable insulation; the remaining space within the construction is filled with silicone oil compound (1). The main advantages of this modular design are its wide application range of cable types and sizes and its easy adaptation to the environmental and mechanical requirements of the cable installation site. Thanks to the remarkable properties of the silicone oil, this design is preferred not only due to its excellent electrical performance but also as an environmentally friendly solution. Although the terminations are extremely reliable and safe, electrical breakdowns cannot be totally avoided. The worst-case failure is the occurrence of an internal power arc as result of an electrical breakdown. The very high temperature of the electrical arc can cause a rash vaporization and thermal expansion of the insulating medium. As a result of the high overpressure within the termination, an explosion of the construction may occur, resulting in scattering of the debris of the termination that may produce serious damage to property, other equipment, or even human life.

For cable installations very close to valuable property or public areas, Brugg's explosion-resistant outdoor terminations provide a cost-effective and reliable solution.

Presented here are conclusions from the main development challenges and the basic functional principles of the patented solution and results obtained from type tests and field installations.

Mechanical stress produced by internal power arcs on outdoor terminations

During an internal arc in a termination, the electrical discharge channel in the form of plasma causes a fast phase transition of the insulating medium from liquid to vapor, thus producing a sudden increase of pressure in the vapor phase. This phenomenon generates pressure waves that stress the entire construction.

If the developed dynamic stress is at any time higher than the admissible mechanical strength of one or more termination components – the hollow insulator body, top and bottom flanges, or the fixing bolts that fasten the termination to the foundations of the supporting structure – a mechanical breakdown of the termination itself or its support may occur, with projection of debris all around the installation.

There are fundamentally two options for addressing this problem. The first option is to design a termination able to withstand the high pressures developed during an internal electrical breakdown. However, this approach leads to excessive over engineering of the components mentioned above, which will strongly limit the field of application of such a solution. Consequently, this approach can only partially solve the problem.

A second and more effective approach is a controlled release of the internal pressure in the early stages of a power arc, thus limiting the maximum overpressure and the projection of debris that may follow. To achieve this result, the termination should have embedded pressure release devices able to operate within a few milliseconds after the ignition of the internal arc.

Design of pressure release devices

Following the second design approach, the main challenge during the development phase was to design a reliable pressure release device. As a limiting condition, such a device must be capable of releasing the pressurized fluid in less than 2 ms after the arc ignition, while ensuring the necessary mechanical strength for prolonged, safe service at the pressure levels of normal operation conditions. Starting from the well-proven design of Brugg's outdoor termination with hollow insulators, a way of integrating the pressure release devices into the termination had to be found. As a result, the pressure release devices were placed on the top of the termination (integrated in the corona shield) and at the bottom (integrated into the base plate of the termination) (Fig. 1).

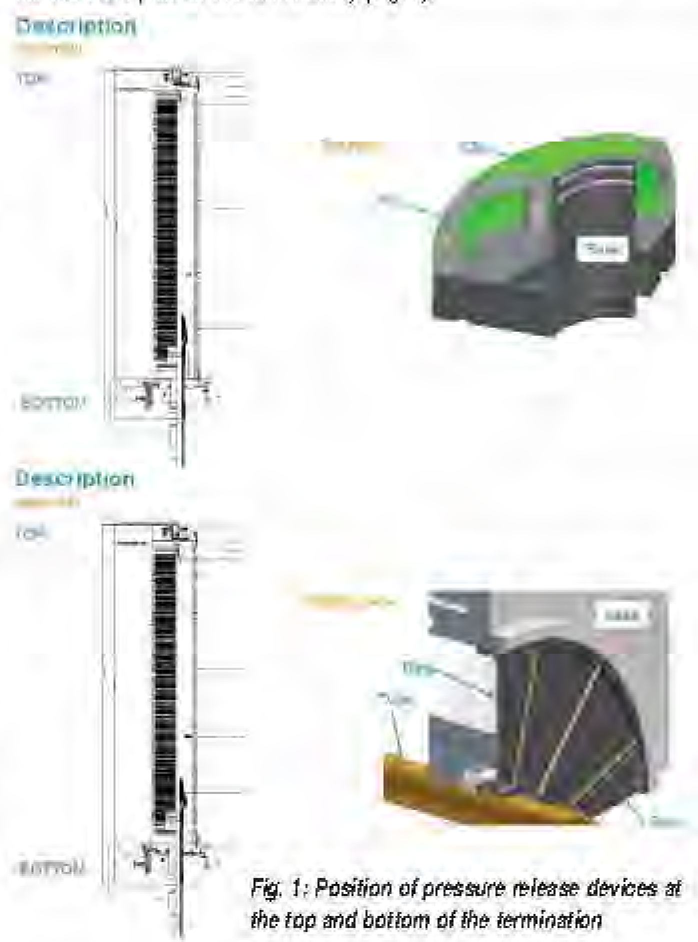


Fig. 1: Position of pressure release devices at the top and bottom of the termination

Although they have different shapes, both devices act similarly to a burst disc, albeit with different dynamics. In order to minimize the experimental activity and limit it only to a final development stage, the design phase required a large use of finite element method analysis.

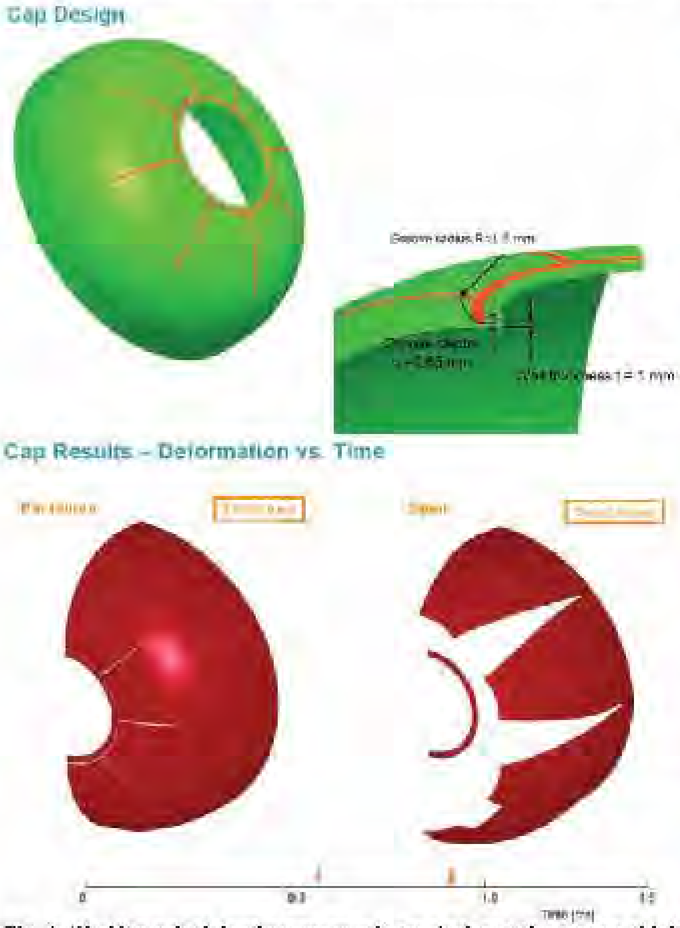


Fig. 2: Working principle of pressure release device at the corona shield

To work as corona shield, the pressure device at the top of the termination takes the shape of a cap with 8 grooves that break at a predefined mechanical stress, allowing the cap to open like a tulip flower (Fig. 2).

The pressure device placed at the bottom of the termination is integrated into the gland of the termination and is supported by pins

Fig. 3: Working principle of pressure release device at the base plate

fastened to the base plate (Fig. 3). When a predefined pressure is reached, the disc is expelled in an axial direction to the bottom of the termination.

Type test of a 400 kV outdoor termination

To classify an outdoor termination as resistant to internal power arcs, the solution is tested according to European standard HD 632:2008 S2 (2). The standard stipulates that no debris shall be found beyond 3 meters from the test object after the test.

Fig. 4: Installation of 1,5 mm² copper during termination assembly for power arc testing

The internal arc test is conducted for a duration of 0.5 seconds and is performed in a single-phase test circuit with a supply voltage of 20 kV and a symmetrical 50 Hz short-circuit current of 63 kA provided by a 2,500 MVA power generator. To induce an internal power arc in the termination, the test setup consists of a short-circuiting the cable conductor to the cable screen with a 1.5 mm² copper wire (Fig. 4) prior to the final assembly of the termination. The test object arrangement prior to and during the test is shown in Fig. 5.

Fig. 5: Internal power arc test of a 420 kV outdoor termination

Field installations

The installation of explosion-resistant outdoor terminations requires no special measures on-site, besides reinforced support to counteract the force following the rapid release of oil. By following its basic modular configuration, this type of termination is installed in practically the same manner as a conventional one. Both pressure release devices are pre-assembled at the factory and under controlled quality procedures prior to the delivery, thus minimizing the risk of undesirable installation errors.

Since their release in 2011, around 20 units for 150 kV and 51 units

Fig. 6: 420 kV outdoor termination after the power arc test

for 220 kV cable systems have been installed by the Italian TSO Terna and are currently in service (Fig. 6). Since then the demand for explosion-resistant outdoor terminations has significantly increased, with more than 120 installations per year worldwide for voltage systems up to 245 kV.

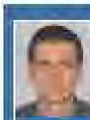
Fig. 7: Installations of 245 kV cable system close to a highway, Turin, Italy

Conclusions

Brugg's design for an explosion-resistant outdoor composite termination has been described here, together with the relevant testing activity. The integration of an overpressure release device in Brugg's composite outdoor termination design represents a reliable solution to minimizing consequential damage in the event of an internal arc in an oil-filled outdoor termination.

Ease of installation and no additional maintenance compared to other terminations allow this product to be integrated as a standard component in any network. Only some reinforcement of the steel structure to counteract the pressure wave will be required.

Profile



Dr Ing PietroCorsaro

Dipl. Ing. OldrichSekula, M.Sc.E.E. Diego Cisilino, Brugg Cables, Switzerland.

Interview

Prime Meiden Ltd is Indo-Japanese joint venture company of Prime Group

Rohan Mehta, Managing Director
Prime Meiden Limited (PML)

Prime Meiden Ltd, is a company of the highly diversified Prime Group, which is a leading force for over 28 years in the field of high technology equipment & systems. PML is one of the leading players in the field of power transformer having the most modern and state-of-the-art factory for supply of EHV power transformer up to 765 kV located in Special Economic Zone. PML Lab is accredited by NABL. In an exclusive interview to **Electrical India, Rohan Mehta** says, our vision is to see Prime Meiden Limited as a leading Transformer manufacturer and EPC Project solution company.

➢ **What is your perception about transformer market in 2015?**

The transformer market is growing both nationally and internationally. EHV Power transformer market is growing rapidly along with the growth of economy of our country. As a thumb rule for power installation of per 1mw, there is a requirement for approximately 7MVA of transformers and this translates the demand for transformer to a huge number considering that the transformers are required in Power Generation, Transmission and Distribution segments as also for replacement market in huge numbers.

➢ **What are the core areas in power sector that your company is involved in ?**

Prime Meiden Ltd (PML) is an Indo-Japanese joint venture company which is primarily focused into manufacturing of EHV Power Transformers upto 765 kv, EPC projects and mobile substations upto 132 kv. However, Prime Group as a whole is, a highly diversified group which has been a leading force for over 28 years in the field of high technology equipment's & systems covering the entire spectrum of power sector including generation, distribution and transmission. We have brought into India, highly cost effective sophisticated technologies in collaboration with leading giants from across the world.

➢ **With your vast experience in power sector how do you see it emerging in the changed scenario of power in India.**

The new government in our country has already recognised the importance of this sector as the key driver to the economic growth of the country. They have initiated the process of reviving the so far stalled power projects to achieve the targets capacity addition. This is surely going to trigger the demand of power transformers which we expect to start showing up from mid of coming financial year.

➢ Could you detail about product range and services as well as your manufacturing facility?

Prime Meiden Ltd is one of the leading players in the field of Power Transformer having the most modern and state-of-the-art factory for supply of EHV Power Transformer up to 765 kV located in Special Economic Zone (SEZ), Naidupeta, district Nellore, Seemandhra the Southern State of India, spread over 100 acre of land. A fully integrated plant with an annual capacity 15,000 MVA and manufacturing capability upto 765 kV, which is proposed to be expanded to 35000 MVA per annum & upto 1200 kV makes. It has the latest and the most advanced EHV static test system from High Volt of Germany the world leaders in the field of EHV testing of power transformer since 1904 and it can test the transformers at 50 Hz as well as 60 Hz frequency systems. Fully air – conditioned and moisture controlled, the manufacturing facility also includes core lifting platform, coil up ender, horizontal and vertical winding machines, ISO static press for sizing of the coils, vapor phase drying for final dry out etc., from the world class manufacturers. The facilities also include highly sophisticated in house tank fabrication and fully air–conditioned PICC manufacturing. PML also has Automatic core Slitting machine with de-burring attachment for burr-free laminations– from Georg GmbH, Germany Automatic core cutting machine with v-notch cutting, hole piercing, step-lap joints and stacking facilities - from Georg GmbH, Germany with dedicated 10 MT EOT Crane. It also has Brockhaus test system from Germany for testing magnetic characteristics and insulation resistance of CRGO steel sheets.

➢ Could you share features of the order procured for 90 MVA 400/132 KV single phase making 270 MVA in 3 phase bank?

These are auto transformers meant to evacuate power from a hydel plant being set up at Dickhu in Sikkim. The total quantity is 4 Nos. and the scope includes supply and installation.

➢ What do you envision for the company in the next two years?

Our vision is to see Prime Meiden Limited as a leading Transformer manufacturer and EPC Project solution company in India with its export business expanded more particularly to the west of India, especially to the Middle East and Africa.

➢ Do you recall any one of the best projects which involved challenges towards completion of it, also some projects being done with foreign collaboration?

There are many challenging projects we have executed in terms of short delivery and complex specifications. Our supply to Ukraine of 2 Nos. 40 MVA, 132kv class transformer was to cater to an environment at -32°C and complying to GOST standards. Both the transformers are in operation to its full capacity for the past more than one year.

➢ The company has been proud recipient of many awards, even you were awarded as "Young Entrepreneur of the year" during 2012. What characteristics would you ascribe for receiving such honours?

First and foremost to be a successful entrepreneur, you need to be fortunate to have a good and committed team, because no business can be successful without the collective efforts of a good team and I feel fortunate to have a very committed and hardworking team. And individually, I would say that among many others things, it is important to be realistically ambitious to achieve success in business or for that matter in any other field.

Preventing Electrical Fires

Shockingly, almost 90 percent of all fire accidents originate from "electrical" causes, and behind a vast majority of these fires are low-quality wires and cables, that is, either low-quality insulation or inferior conductor or both. The article provides a snapshot of how consumers, consultants, specifiers and decision-makers can avoid dreadful consequences by choosing the right kind of wires and cables.

Pratap M Anam

The past several decades have been a grim reminder of countless human lives lost in fire accidents resulting from electrical fires. The fatal fire of Delhi's Uphaar Cinema is just one of endless examples of electrical fire accidents that occur routinely year after year, taking toll of precious human life, property and data.

Yet when it comes to give a serious thought to choosing the right kind of wire, many decision makers just shrug off this vital link between purchase decisions and electrical safety while specifying their requirements, thus leaving a gaping hole in their safety strategy and endangering their own life as well as the lives of others. The basic problem of such irrational buying decisions is a general lack of awareness or insensitivity to safety issues until such a calamity strikes.

Essential Considerations

The Conductor

Conductors are classified under different categories as given below.

Class 1: This category is characterized by a solid conductor, which is used mainly for power application cables that are laid without undergoing much of bending and are restricted up to 10 sq. mm. Copper as well as aluminium conductor is used.

Class 2: In this category, the conductors are made of a number of strands - 7, 14, 19 - depending on various sizes. The bunched strands offer greater flexibility than a solid conductor. Wires with bunched conductor is normally used in building wires as well as power cables.

Classs 5: The cable is made with a higher number of strands than in Class-2, offering still-higher flexibility and is typically used for panel wiring, industrial wiring, as the number of bends that the cable undergoes during installation is very high and also there is also space constraint in these cases.

Class 6: The cable construction is designed to offer very small cross sections of strands, often as low as 0.05 mm in diameter, while using conductor strands in large numbers. This type of cables are necessary typically in moving applications such as drag chain, drum reeling, and robotics. In these applications, the cable is constantly moving and also needs to bend in very tight radii. Higher number of strands with very small diameter offers far greater higher flexibility.

PVC cable insulation catches fire easily and continues to burn rapidly, spreading the flame all along its entire length. During a fire situation, the burning PVC insulation produces hydrochloric acid gas, which causes severe toxic suffocation and even death

An example of this case type using a 2.5 sq mm cable is given, for which the following constructions are possible:

Class 1: A solid wire of 2.5 sq mm

Class 2: A cable conductor made of 7 strands of 0.67 mm diameter or 19 strands of 0.41 mm diameter

Class 5: 50 Strands of 0.25 mm diameter

Class 6: 140 strands of 0.15 mm diameter, or
512 strands of 0.1 mm diameter, or
651 strands of 0.07 mm diameter, or
1280 strands of 0.05 mm diameter.

Properties of Conducting Material

Ideally, copper is the material of choice, as it is a far superior conducting material. However, for greater economy, aluminium is often preferred. But apart from this, there are other things to consider also:

- Efficiency of electrical conductivity of an electrical cable depends on the purity of the conducting metal. 'Electrolyte-grade' copper provides the best option for highest conductivity while greatly minimizing the heating up of the conductor and resistive losses.
- It also provides better ductility, which reduces internal physical stresses inside the conductor strands, thereby minimizing the possibility of abrupt rupture during cable installation.
- Better malleability imparts higher flexibility to the conductor.

Bunching of Conducting Strands

Unilay-type Bunching: Typically, the conductor of an electrical cable is made of several strands laid out in a traditional linear manner and encapsulated within the insulation. This kind of strand arrangement causes uneven spacing of conducting strands inside the cable, resulting in air gaps, which in turn can cause overheating of the conductor. Better to avoid these traditional wires if you desire highest fire safety. Unilay-type conductor, on the other hand, provides a sophisticated alternative. The bunching of this type of conductor is carried out by a high-precision process, in which the strands of the conductor form a highly uniform and compact, precision-twisted bunch that makes any physical deformation impossible under all normal operating and installation procedure. Thus, unilay-type conductor is a significant advantage over traditionally bunched conductor, for long, safe service life of the cable and to avoid overheating.


Unilay-type precision conductor

PVC cable insulation catches fire spontaneously and continues to burn rapidly, spreading the flame all along. On the other hand, halogen-free cables do not burn readily nor spread fire, thereby saving lives.

What's more, even the contractor is also happy because the pre-twisted precision unilay conductor makes insulation-stripping easier and also does not require manual twisting of conductor ends to make connection or while terminating a lug on the conductor.

PVC Cable Fire Hazard

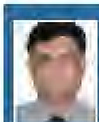
Polyvinylchloride (PVC) insulation is traditionally used as insulation in electrical wires and cables. However, PVC cable insulation catches fire easily and continues to burn rapidly, spreading the flame all along its entire length. During a fire situation, the burning PVC insulation produces hydrochloric acid gas, which causes severe suffocation and even death. In fact, a majority of fire-accident victims die of toxic suffocation rather than by the flames. To add to the calamity, the dark dense fumes reduce visibility drastically, making rescue operation extremely difficult. In pitch darkness and amid intensely toxic fumes that cause breathing impossible, saving victims becomes ever more challenging. If enough time is lost in fumbling and searching, many lives are lost even due to toxicity of the PVC flames before the actual fire can reach the fire-accident victims. On the other hand, halogen-free cables do not catch fire readily nor spread it. When a burning candle is applied at one end of a piece of cable, a PVC-insulated cable will spontaneously catch fire and will continue to burn all along its length even after the candle is removed. There will be dark intense smoke coming out of the burning cable. In comparison, a halogen-free cable does not catch flame. In fact, only some charring (blackening) of the wire tip occurs, but it does not readily burn, neither does it spread fire. Unbelievable but true! Needless to say that choosing halogen-free insulated wire saves lives.

Some Insulation Types at a Glance

- Polyvinylchloride (PVC) – suitable for moderate temperature of up to 70^{O}C
- Cross-linked Polyethylene (XLPE) - Suitable for up to 90^{O}C - for outdoor applications
- Cross-linked Polyolefin (XLPO) - Suitable for up to 105^{O}C
- Electron Beam Cured XLPE- Suitable for 150^{O}C – For special applications
- Silicon (Si) - Suitable for up to 180^{O}C
- Polyethylene (PE)
- Thermoplastic Elastomer (TPE)
- Polypropylene (PP)
- Polyurethane (PUR) - High abrasion resistance
- Rubber (EPR) - Resistant to weathering effects like temperature, moisture, oil, water, gasses, chemicals, wind pressure etc.

International Certifications: Last but not the least, for choosing the finest and the safest wires and cables, one should specifically look for reputed international certifications like UL, UN, VDE, BS, ISO, DIN, DEMKO, CSA, PSB, SABS, etc. in addition to ISI.

Profile



Pratap M Anam

is a writer and media consultant. He writes about issues related to science and technology, including energy, environment, human development and nature conservation.

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100 GW: Challenges, Opportunities and Strategies for Success

Plans of the new government to accelerate the generation of wind energy by adding an ambitious 100 GW every year is a welcome change in the Indian power scenario. Wind energy is one the best form of renewable energy where we can generate power from wind, which is freely available. India is the 5th largest producer of wind energy. The power deficiency in the country needs to be addressed by increasing the production of renewable energy and reducing energy produced from costly energy imports. Globally, the energy market trend is to reduce fossil fuels in energy mix and phase out coal and oil, keeping in mind emission and climate change considerations. There has been a shift from traditional markets (Western EU and USA) to new emerging markets (several major Asian markets like China and India as well as Brazil, South Africa and Mexico. From distribution of energy generation, larger investments in cost efficient energy storage to smart energy systems, the future of renewable energy will see a promising change from what we see today.

The wind energy sector is a promising sector in India. It has the lowest capital cost and generates power at rates lower than the grid rates. The turbine industry presently employs about 60,000 people and with the expansion of the industry it is expected to create 1, 20,000 new jobs by 2020. Since the turbines are mainly installed in the rural areas, it leads to development of the rural community. The turbines have a life of 25 years and hence the energy manufacturers invest in the development of the community around it. The wind industry contributes to the manufacturing sector and also creates export potential for the country. As the country fights to reduce the effect on environment, wind energy is the perfect example of how we can produce power and at the same time help our future generations, have a better life and cleaner air to breathe in.

With the government, ministries and entrepreneurs talking about the 100 GW vision, the country is already looking forward to a sea change. The target is achievable provided issues like grid, storage, high cost of interest and inflexible regulations are addressed and a strong supply chain established. The need of the hour is a change in mindset, understanding core competencies and leveraging them. For India to grow at the projected eight per cent, with even its best energy initiatives in place, more energy generation is needed. Hence, the goal of 10,000 MW is just the beginning.

The investment fraternity has shown willingness to invest in the industry. It is necessary to win investors' confidence and make wind energy projects bankable. One of the key drivers of the industry is the gestation period. It takes about 4-6 months to set up a wind energy farm. Investments come from equity and debt investors. Debt investors will only invest when they see equity investments are conducive and equity investors will invest once they see value and attractive returns. More than 80% of investments come from the private sector hence the government needs to assure the investors of a viable market to invest. Some of the key changes to be brought in are: mandatory enforcement of renewable purchase obligation, open access, permission to sell to private players, development of grid infrastructure, generation based incentives and also acceleratory depreciation.

One of the significant factors that can accelerate the growth of the industry is government policies. Enforcement of RPO compliance with penalties to achieve NAPCC goals, conducive policy environment, standard methodology for tariff determination across the country, removal of regulatory and purchasing of power by Discoms are some of vital steps the government absolutely needs to take.

At SKF, we have a vision to equip the world with SKF's knowledge with a view to create a better tomorrow. Keeping in line with this vision and the need for development of the wind energy segments SKF is association with the Indian Wind Turbine Manufacturers Association (IWTMA) had organized a Knowledge Forum in Pune to explore the future of renewable energy and wind power in India. The event was attended by wind turbine manufacturers, independent power producers, wind farm developers, sub system manufacturers, innovators and government representatives. The SKF Knowledge Forum is natural progressions of our vision where industry thought leaders interact together to define, understand and find solutions for tomorrow's challenges in the field of renewable energy.

In the forum we agreed that challenges of wind farm management in India were unique to the country and different from other markets. Hence, offerings need to be customized as per geographies. Also, since reliability and availability of turbines, along with extension of the machine's life and performance, were of primary importance to wind farm owners, manufacturers need to innovate and stay updated with latest technological developments. To make the wind industry more sustainable, the forum also discussed ways to use technology. The focus should be on improvement of the power curve and annual energy production, bringing down cost of energy. Technology should also aim to make wind power more predictable, complete with brilliant turbines, smart wind farms and storage to make it more mainstream.

Abhijit Kulkarni
Head of Sales-Renewable Segment, SKF India.
Profile

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DC Cables

An important factor in performance of Solar PV Installations

Energy delivered from a Solar PV system is not only dependent on the efficiency of the module but also on other system components like DC Cables, Connectors & Junction Boxes. While designing the solar farm, engineers have to factor the losses from modules to the inverters to calculate the over-all performance ratio of the farm. Low quality solar cables and connectors will lead to small increases in resistance and result in higher losses of energy (I^2Rt). The loss of energy already harvested, when calculated over a twenty five year life represents a substantial loss & would affect the profitability of the project.

A high quality Solar DC Cable is expected to perform for the complete lifetime of the installation which is about twenty five years. The cost of replacing a defective installed cable is very high. The replacement costs increase when factoring in manpower used for removal, reinstallation and testing of the system. In addition, there are losses in power output and revenue generation. The cost of these cables and connectors is very small in the total cost. Since the differential cost of the high quality cables is insignificant, it makes sense to invest with higher initial cost and reduce the "total cost of ownership" of a PV plant.

Solar cables have to withstand a wide range of environmental conditions – and continue to do so over a long period. High temperatures, UV radiation, rain, humidity, dirt and attack by moss and microbes are all a serious challenge to solar cables. Cables tested in accordance with EN, TÜV and UL requirements (120^{O}C; 20,000 hours) can be used at environmental temperatures of – 40^{O}C to +90^{O}C. They should therefore achieve the target service life of 25 years. Apart from temperature, UV radiation is the other significant factor. Trials have shown that untreated material (free of any colour additive) will lose more than 50% of its performance capacity within less than six months. In order to avoid this deterioration, fine soot particles are added to the plastics (leading to a black colouring in the sheath). These particles absorb the UV radiation and convert it into heat. Optimum UV resistance can therefore only be achieved by using black solar cables with enough black carbon content.

There is a new European Standard EN 50618 published for Solar DC Cable, this standard specifies cables for use in Photovoltaic (PV) Systems, in particular for installation at Direct Current (DC) side, with a nominal DC voltage up to 1.5kV between conductors as well as between conductor and earth. These cables are suitable for permanent outdoor use for many years under variable demanding conditions. Relatively stringent requirements are set for these products in line with the expected harsh usage conditions. EN 50618 requires cables to be low smoke halogen free, flexible tin coated copper conductors, single core power cable with crosslinked insulation and sheath. The testing requirements in EN 50618 are more stringent, the most important change is that all the test are done on material taken from finished cable ensuring that the product to be installed is passing all the testing requirements. Cables are required to be tested at Voltage of 11KV AC 50Hz. An IEC standard for Solar DC Cables based on EN50618 is also in preparation.

To meet the stringent requirements insulation and sheath in modern solar cables consist of cross-linked polymers. Two different processes can be used for cross-linking – a choice between electron beam cross-linking and chemical cross-linking. Chemical cross-linking is a process that cannot be stopped once it has started. As a result, chemically cross-linked cables suffer from the same phenomenon as old car tyres. They can harden and become porous. By contrast, electron beam cross-linked cables are irradiated with beta rays. This improves the synthetic material. Once the cables have passed the electron beam, the cross-linking process is complete. These cables remain soft and elastic throughout their whole service life.

A chain is only as strong as its weakest link – which is why LEONI offers high quality electron beam cross-linked BETAflam® solar cables. These quality cables are produced in Switzerland and fulfil all the requirements: long service life, excellent weather resistance and security of investment for the operator of the facility. LEONI started electron beam crosslinking in 1984 and supplied beta beam irradiated cables for solar application in the 90's. These are still performing in installations in Europe. LEONI produces and develops compounds for insulation and jacket materials in-house. With capacity improvements over a period of time, it today has the world's largest beta beam cross linking facility contributing to the highest production of solar DC cables. LEONI first launched UL/TUV dual approved cables in 2005 & invented 1,000 VAC UL and 1,500VDC TUV cables which will be used for solar installations. LEONI can supply the complete system from junction boxes for module manufacturing to cable systems and connectors for Solar PV installations from its production facilities all over the world. To support our customers for fast installations of PV power plants LEONI has stocks available in India, Europe and USA.

LEONI BETAflam Solar products meet the highest requirements for solar PV system providing the same high expectations that are demanded from the solar modules - which are longevity and high weather resistance. We offer BETAflam Solar DC cables, TRAFOflex UV cable, SOLARpowerAlu-ATA cables, BETAsolar Junction Box and BETAsolar PV connectors.

Coutresy!
LEONI Cable Solution (India) Pvt Ltd

MAS Series

Online Transformer Moisture Absorption System

Generator, transmission and distribution transformers are some of the most critical and expensive assets in a power network. Moisture is a necessity in cellulose materials, but too much is absolutely detrimental to the service life of power transformers. Moisture, more specifically excessive moisture, has been enemy number one in power transformers utilizing cellulose insulation with insulating oil for a long time.

In modern day networks transformers are increasingly over stressed due to power demands. These instances have a habit of occurring at higher rates of change than in the past. The impact of this, on a transformer deemed 'wet', is a higher possibility of failure. This is primarily due to moisture being driven out of the cellulose faster than what the mineral oil can absorb creating a very low dielectric (voltage withstand) in confined spaces in the windings. The consequences are normally catastrophic. Ageing and degradation in power transformers create moisture, acid and sludging, all contributing to weakening the insulating system, thus increasing the risk of shortening the normal service life.

KVTEK developed a system (MAS10) that would remove moisture continuously in a gentle manner. A unique molecular sieve technique is applied to continuously remove moisture and particles from the transformer oil.

System Description

The MAS10 complies fully with IEEE Standard C57-140 - 2006, section 7.2 Guide for the evaluation and Reconditioning of Liquid Immersed Power Transformers. The system continuously circulates transformer oil and dries it through moisture adsorption by a molecular sieve granular adsorbent material contained in the cylinders. The transformer oil is circulated through the system without heating by a small electric pump and remains at the same temperature and pressure conditions as the transformer. By constantly reducing the level of water contained within the oil, water contained within the solid insulation, where over 95% of the water is trapped, will migrate into the oil to maintain the natural water equilibrium. In this way water gradually moves from the solid insulation, to the oil, and then trapped by the molecular sieve.

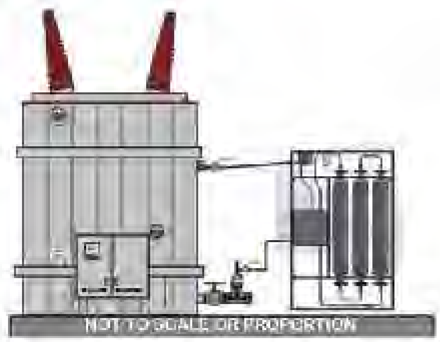
A particulate filter prevents particle carry-over to the transformer. MAS10 is designed to be a slow, non-invasive, gradual process that will over a period of time, reduce the water contained within the solid insulation, and therefore reduce the rate of ageing, and extend the life of the transformer.

MAS10 system has the capacity to remove approx. 10 liters of water from a transformer before saturation, but the rate at which it will absorb water will depend on many factors, mainly, how much water is available in the oil, and the temperature range through which the transformer will operate. The design flow rate of the pumped oil is nominally 90 litres per hour to give maximum absorption through the molecular sieves.

Operation and Maintenance

MAS10 operates in an external location on a continuous basis with the transformer on-line. It is constructed of stainless steel so needs no additional protection. The pump is a totally immersed canned rotor type, designed for continuous operation. Although the electrical connection box has a rating of IP45 the stainless steel cover offers total environmental protection for the pump, which increases the rating to IP65. MAS cylinders will continue to absorb water from the oil until saturation occurs.

MAS10 has option for permanently mounted moisture monitor taking readings from the inlet and outlet bypass valves. To measure the degree of saturation a reading of ppm water in oil must be taken from both the input and output and compared. When the molecular sieves are new and dry, the reading at the output will be far less than the reading at the input, because the oil will have had its water removed during the pass over the molecular sieves. However, when the molecular sieves saturated, the reading at the output will be very similar to that at the input and requires regeneration.



When the cylinders are found to be saturated they must be replaced. KVTEK offers a cylinder exchange where we supply previously 'regenerated cylinders to fit in place of the existing ones. This is done by simply using the quick fit couplers on the top and bottom of each cylinder, and removing each cylinder in turn. The couplers self-seal, so there is no oil loss. The replacement cylinders are then fitted and the quick couplers snapped shut. At the same time the particulate filter should also be changed.

Application

New Transformers

After manufacture, the total moisture

content in new transformers is typically less than 0.5%. MAS maintain this moisture content and eliminate moisture buildup.

Repaired Transformers

After a major overhaul in a workshop, and after having undergone a vapor-phase treatment, the moisture content of a repaired transformer is similar to that of a new transformer (< 0.5%). Therefore, the application is the same as for new transformers.

In-Service Transformers

Transformers, irrespective of age, should be fitted with a MAS10 to reduce the moisture in the transformer and eliminate moisture buildup. Transformers that have been in service for many years typically have high moisture content (2% and beyond). The objective is to reduce the moisture content of the paper insulation to an acceptable level and then maintain that level. This will substantially increase the life of the transformer.

Option 1: MAS10E

Upon selection of this option you will get the complete system is duly fitted inside the IP 55 enclosure instead of being mounted on the SS Frame.

Option 2: MAS10A

Additionally allows automatic switching of oil circulation pump and giving alarms

With this option conventional MAS10 unit gets integrated with PLC unit and is designated as MAS10A which monitors the moisture level of inlet valve (IN ppm) and outlet valve (OUT ppm) oil flowing through MAS by turning ON/ OFF electrically operated oil flow valves. The time duration of inlet and outlet monitoring is user selectable.

If the difference between IN ppm and OUT ppm is below a user settable value, the pump is stopped and a potential free contact is energized which can be configured to generate an alarm.

Additionally if IN ppm falls below some user settable value, pump is turned OFF and another potential free contact is energized which can be used to generate another alarm.

The above sequence is repeated after periodically after set time.

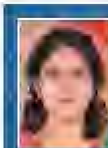
Option 3: MAS10-H2M

Additionally allows monitoring of H2 gas besides automation

MAS can also be supplied with H2 gas monitoring Module TM1 of Serveron make.

Technical details of this Hydrogen monitoring device is available in TM1 catalogue.

In addition to the two alarms for moisture level, a third alarm is energized if H2 level increases beyond a value set by the user.



Setu Vora
Regional Manager - Sales,
KVTEK Power Systems
Pvt Ltd, , Gurgaon.
Profile

Energy Efficiency Services Limited Signs MoU with South Delhi Municipal Corporation for LED Street Lighting

All 5 lakh street lights in Delhi would be replaced by LED lights within 1 year, saving over Rs 1,000 crore over a 7 year period. This was stated by Shri Piyush Goyal , Union Minister of State (IC) for Power, Coal and New & Renewable Energy here today, while witnessing the ceremony of signing of MOU between South Delhi Municipal Corporation (SDMC) and Energy Efficiency Services Limited (EESL) for replacing 2 lakh conventional street lights in the SDMC area with energy efficient and smart LED lights at no upfront capital cost to SDMC.

Inspired by the Prime Minister Narendra Modi's announcement on the national launch of the LED lighting program on January 5, 2015 that initially 100 cities in India would be covered by LED lighting, The nationwide rollout will be completed in 3 years. Within 4 days of the Prime Minister's announcement, EESL and SDMC signed an agreement. LED lights offer significantly greater luminescence, for the same wattage. For instance, in Ward No. 161 in Adchini Village, a 150W sodium lamp was replaced with a 70W LED luminaire and the luminescence improved from 30 Lux to 312 Lux i.e. over 10 times. SDMC's street lights today consume 10.7 crore Units today, but the twin features of lesser wattage and higher luminescence, the energy consumed can be reduced by upto 70%, thereby saving over Rs. 500 crores in 7 years i.e. 3 times more than the Rs. 175 crore required to install LEDs.

The repayments to EESL will be out of savings in energy and maintenance cost of SDMC over a 7 year contract period. EESL will also provide free replacements and maintenance of lights at no additional cost. Within just ten days of the LED street programme launch in Delhi on December 25, 2014, street lights in three wards have been completely replaced by LED at Naraina, Laxmi Nagar and Malaviya Nagar areas.

In addition to this, as part of the pan India home lighting programme, domestic energy efficient lighting program for Delhi shall cover distribution of 1 crore energy efficient bulbs (with 7 year warranty) which shall lead to an overall energy saving of 25 crore units every year translating into a saving of over Rs. 1,000 crore on a 7 year period.

Surveys conducted in Malaviya Nagar, after installation of 1,100 LED street lights in place of conventional lights revealed immense satisfaction particularly for women (better security), small businessmen (increased lighting attracted more customers to their establishments), and the general public at large sense of safety and lower propensity for road accidents.

Contact solutions for High and Medium voltage systems in PTD

Even today, electric contacts in power transmission and distribution systems are still made using screw or nut-bolt. Most of the time, however, there is a simpler and quicker alternative: plug-socket connectors. For Multi-Contact (MC), the Swiss connector specialist, there are a number of applications in which plug-socket connectors are more efficient to screw connectors.

As per Mr. Oliver Semling, Product Manager, Power Transmission and Distribution (PTD): "At Multi-Contact, we have over 50 years of experience with high-voltage systems. Our connector solutions are based on our well-known, tried and tested MULTILAM contact technology. This technology guarantees exceptionally low contact resistance and low heat generation at the contact point, which results in energy transfer with minimal loss."

Principles of contact technology

The requirements that must be met by a high-quality contact are:

Sufficient and constant contact force: to break through pollution layers throughout life cycle

Constant, low transmission resistance: over the whole life cycle

High heat dissipation: in continuous operation

High resistance to thermal shock: in event of short circuit

Low constriction resistance: i.e. many and large effective contact areas

The MULTILAM principle

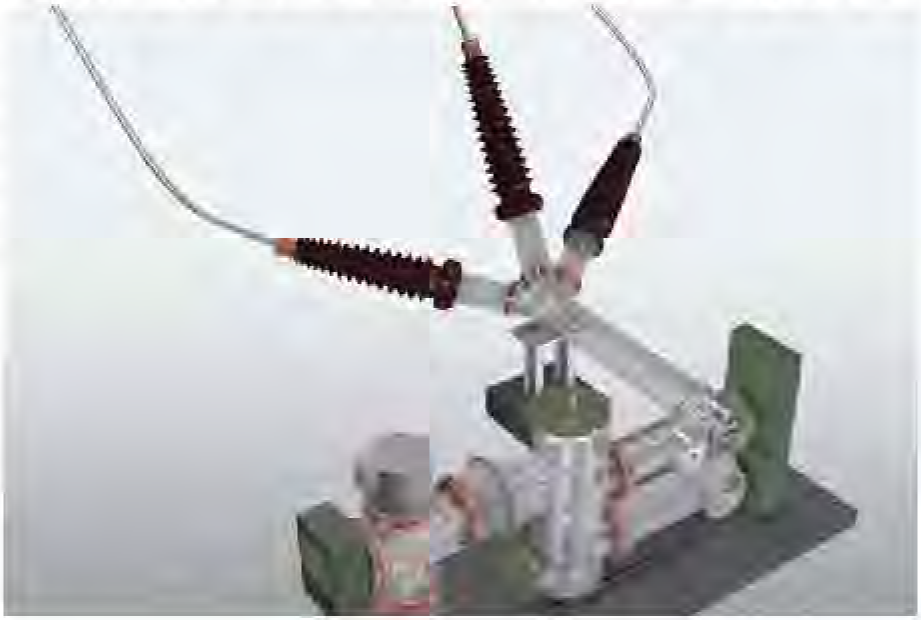
Although a plug connection is not a stationary contact, it is subject to the same theoretical principles. MC MULTILAM are made from specially shaped contact strips and according to application they are plated with silver, gold or nickel and mounted in a slot.

The MULTILAM creates parallel contact points between the two surfaces from which each individual louver serves as an independent, resilient 'bridge' for the transmission of current, thus substantially reducing the contact resistance. The constant spring pressure of the louvers ensures a permanent contact with the contact surfaces which results in a low and constant transmission resistance.

They have a high current-carrying capacity in both short-time and continuous operation, and ensure a dependable performance over a wide temperature range a well as a long life.

Solutions for the Switchgears (GIS, AIS), Transformers, Disconnectors, Circuit Breakers

Using this MULTILAM technology and principles MC has designed various



connector solutions for the Switchgear systems which not only increases the current carrying capacity and reduce the voltage drop but also offers many other electrical and mechanical advantages. Typical MC solutions in a Switchgear are in:

- Bushings and sockets
- Busbar interconnections
- Disconnector and Earthing switch (3 position switch)
- Pluggable cable termination
- Many others

Bushing and Socket

A special socket system with MULTILAM offering advantages of low losses and ease in installation and maintenance of Bushings.

Busbar Interconnection

Here is MC special press-in socket with MULTILAM both inside and outside maintaining the efficient current flow.

Disconnector and Earthing Switch

Here comes the MC MULTILAM within the switch taking care of both required plugging and sliding cycles apart from low

resistance contacts. MC has various MULTILAM and are technically chosen by our Engineering team depending on the application parameters.

Circuit Breaker

Here also MC MULTILAM is carefully selected to meet higher sliding force and high short-circuit current requirements. The advantage achieved is low sliding force which increases the reliability.

Three Position Switch (Disconnector and Earthing Switch)

Here a customized MC solution is designed to make the system compact and offer required mating cycles meeting the electrical parameters.

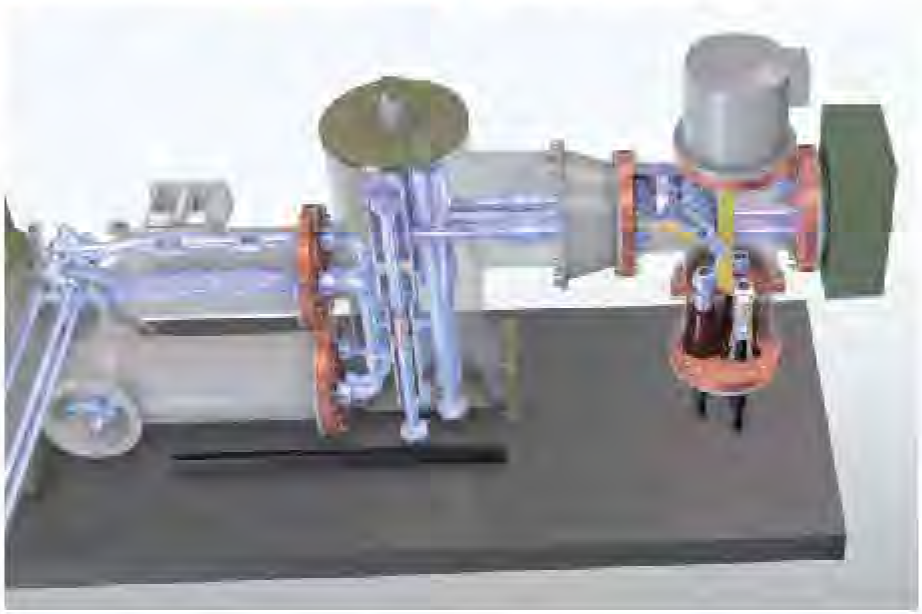
Pluggable Cable Terminations

The cable ends can be enhanced as pluggable so as to reduce the losses and increase the ease of installation and maintenance.

What is shown above are just a few applications examples and we can customize solutions for your specific application needs to improve the performance of electric joints or connections.

The possibility of creating a solution is manifold meeting all your specific application needs. This MULTILAM technology and our experience of more than 50 years in designing and engineering customized solutions will enhance the features and capabilities of your PTD equipment. Our solutions are running successfully into various demanding applications of HV/MV/LV switchgears (GIS, AIS), transformers, disconnectors, circuit breakers, VCB etc.

For further details:
india@multi-contact.com



IEEE and IEEMA create Pioneering Platform at INTELECT 2015

Three-day conference & exposition to discuss Efficient Consumption of Electricity

Electrical India participated in INTELECT, the three-day conference and exposition on the efficient consumption of electricity. It was hosted by IEEE in collaboration with the Indian Electrical & Electronics Manufacturers' Association (IEEMA), was inaugurated in Mumbai by Anant Geethe, Union Minister for Heavy Industry & Commerce, Government of India, Tanga Byaling Chairman, North Eastern Regional Power Committee, Minister for Home, Power & Non-Conventional Source of Energy, Arunachal Pradesh and Chandrashekhar Bawankule, Minister for Energy, New & Renewable Energy, Maharashtra.

INTELECT, organized by the IEEE Power Energy Society, IEEE Computer Society and the IEEE Communications Society in association with IEEMA, took place during January 22 – 24, 2015 at the Bombay Exhibition Centre in Mumbai, India. Keeping in line with the Government of India's vision, INTELECT brought together, policymakers, business leaders, and academicians to discuss smarter cities, optimizing grid efficiencies and overall, improving the quality of life for the citizens of India.

Also participated in the inauguration ceremony were Dr. Howard E. Michel, President & CEO, IEEE; Vishnu Agarwal, President, IEEEMA; Dr. James Prendergast, Executive Director, IEEE; Bruce Kraemer, President, IEEE Standards Association; Babu Babel, Vice President, IEEMA; Sunil Misra, Director General, IEEMA; Laurent Schmitt – Smart Grid, Global VP, Alstom, France; and Ananth Krishnan, Chief Technology Officer, Tata Consultancy Services.

Dr. Howard E Michel, President & CEO, IEEE said, "IEEE is dedicated to advancing technology for humanity. We must integrate appropriate technologies with relevant standards to improve infrastructure and create employment opportunities. Power and Energy are crucial elements for a successful and comfortable living environment. Hence, with growing pressure on the world's rapidly diminishing natural resources, it is important that we work toward a two-fold objective, first to effectively channelize existing resources smartly and second to leverage new forms of renewable resources."

Vishnu Agarwal, President, IEEEMA said, "INTELECT is one of the pioneering platforms, bringing together under one roof, players in the home and office electrical sector. Our vision for INTELECT is to showcase the latest innovation and technology in lighting, modular wiring, measurement, conservation, drives, HVAC, storage of electricity, off-grid generation, house and building security, and automation control systems. Conserving energy with smart and intelligent usage is the need of the hour, and we at both IEEE and IEEEMA are committed to ensuring this."

The highlight of INTELECT is the roundtable on Distribution Reforms. The opening address on New Initiatives on Distribution Reforms was delivered by B N Sharma, Joint Secretary – Distribution, Ministry of Power, Government of India. Shri Sharma's address was followed by a panel discussion moderated by P. Uma Shankar, Former Secretary, Power, Uttar Pradesh.

The other keynote addresses and tracks include subjects pertinent to the intelligent deployment and distribution of electricity including, smart cities, rural electrification, smart living technology, smarter grids and micrsame grids, smart living security & privacy, integration of renewables and microgrids, integration of renewables, and IEEE's Global Humanitarian Initiative.

Cable Corporation of India Ltd

Year 1957, when formal international joint ventures were unheard of, The Khatau and Thakersey groups, already renowned names in Indian industry, joined hands with German promoters Siemens and F & G and set up a power cable factory. The new venture commenced operations in Mumbai and began with the manufacture of PVC insulated wire and cables for the first time in India. Three and a half decades later, a second plant was set up at Nashik in Maharashtra. Today, Cable Corporation of India (CCI) is a leading manufacturer of a wide range of power and control cables.

CCI is equipped with state-of-the-art hardware, software and infrastructure to retain its leadership position in the industry. Besides being a household name in the manufacture of high quality cables, the management has played a key role in influencing major decisions and embarking on innovative solutions. Its strong vision, emphasis on team work and customer satisfaction, has earned it repute in international industry circles. Over the years, CCI was represented in CIGRE, Paris and other forums like BIS, IEEMA etc. Its Tropothen-S® XLPE cables have received IEC-840 Certification from KEMA, Netherlands; its testing laboratories have been approved by the South African Standards Institution for electrical items exported to that country; the company is ISO- 9001 certified and has exported its products to markets in South Africa, Bangladesh, Mauritius & Middle East. CCI's technocrats were one of the first in India to use Aluminum as a substitute for Copper as a conducting material in their cables. They have worked with the Railway and Defense authorities to manufacture special types of cables. Research and development have always been high on their agenda, and they have helped develop industry standards for electric cables and wires.

The company's range of products includes power and control cables ranging from 660 V to 230 KV, marketed as Tropodur, Tropothen, Tropothen-S®, Tropoflex, Tropoplast and Tropotherm brands. CCI also manufactures specialty cables like HVDC cables, mining cables and aerial bunched cables. CCI was the First Company in India to manufacture and supply Extra High Voltage cables of 220 KV way back in 1994. As part of its expansion and diversification process, the group has now ventured into the real estate sector through its associate company, CCI Projects Private Limited (CCP). CCP has launched its first project called Rivali Park at Borivali East in Mumbai. Spread over an area of 22 acres with a planned investment of Rs 1000 crore, Rivali Park is one of the largest mixed-use real estate spaces in Mumbai and is expected to redefine the suburb of Borivali.

Since the Indian cable industry is largely unorganized, there are a lot of opportunities for companies like CCI to set benchmark standards. With its excellent quality products and services, it now has its sights trained on making new inroads in domestic and international markets.

For further details contact:
stephanie@carmine.co.in

Jindal Institute of Power Technology

Jindal Institute of Power Technology (JIPT) is recognized by the Central Electricity Authority (CEA), Ministry of Power, Government of India as a Category - 1 Institute, as per the provisions of Sub Rule 2A of Rule 3 of Indian Electricity Rules 1956. It is promoted by the Jindal Education and Welfare Society and is a part of the US$ 18 billion OP Jindal Group. JIPT is located inside the 4x250 MW and 4x600 MW O P Jindal Super Thermal Power Plant in Tamnar, Raigarh, Chhattisgarh. The Institute aims to produce technically trained professionals for power utilities in India and abroad and prepares them to operate or undertake maintenance of Power Generating Stations of 100 MW and above capacity.

Academic Program: Post Graduate Programme in Thermal Power Plant Technology

Eligibility: A full time 4 year BE / B. Tech. degree or equivalent in Mechanical / Electrical / Electronics / EEE / C & I with 60% or above marks in Class X, XII & BE / B. Tech.

Duration: 1 year

Training Programs

JIPT provides Need Based Customized Training to Power Plant Professionals at all levels including Power Plant Familiarization, Operation & Maintenance of Power Plant, 250 MW / 600 MW Simulator Training, etc.

Power Utilities like Abhijeet Power, ACB (India), Alstom India, Athena Chhattisgarh Power, DB Power, GVK Power & Infrastructure, R. K. M. Powergen & NPTI to name a few have trained their GETs / Senior Level Executives at our Institute on various aspects of O&M and Simulator of Thermal Power Plant.

Training Facilities

- Training Simulator
- Self Learning Laboratory
- Miniature Engineering Models

Infrastructure Facilities

- Knowledge Centre
- Classrooms
- Hostel
- Auditorium.

For further details contact:
www.jipt.org

Ensuring Quality, Aesthetics, Easyness and optimizing total cost of ownership

Wide span cable support systems upto 10 meters

Wide span cable trays

Wide span cable ladders

Key accessories

Wide span systems – Features and Merits

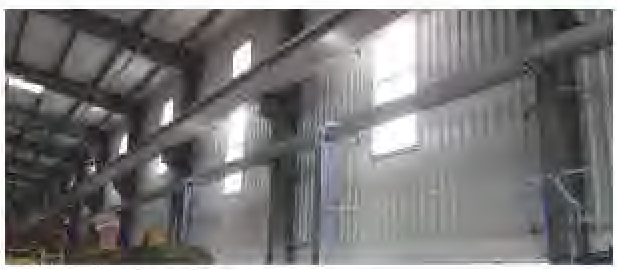
- Supports span distance upto 10 metres
- Reduced installation and accessories costs
- Strip galvanized - EN 10327
- Hot dip Galvanized - EN ISO 1461
- SS 304 Grade
- Side height – 110, 160 and 200 mm
- Widths of 200 to 600 mm
- High load capacity with parallel wide span
- Ventilation for cables and circuits
- Side rail perforation for heights of 110 mm, 160 mm
- Wide Span cable ladder with C-profile rungs for adequate cable fitting with OBO BBS clamps.

Key application areas (Heavy and medium duty)

Any PEB building,
Tunnels, steel, cement, food, textile, railways, power stations, airports, healthcare and automobiles,.etc

Compliant towards CE

Existing practice



Wide span installation

OBO BETTERMANN India Pvt. Ltd.

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Tel: +91 44 710 33 900/01/02
Fax: +91 44 710 33 999
Website: www.oboindia.com
Email: sales@oboidia.com

THINK CONNECTED.

NTPC Awarded as Best Performing Thermal Utility

NTPC bagged the Best Performing Thermal Power Utility award of CBIP. A K Jha, Director (Technical) received the award from Union Minister of State for Water Resources, River Development & Ganga Rejuvenation Prof. Sanwar Lal Jat at a function held in New Delhi. NTPC is the largest power utility of the country. With addition of 15 MW Solar PV Power Station at Singrauli, the total capacity of non-conventional energy projects of NTPC has become 110 MW and the total installed capacity has increased to 43,143 MW.

HARTING Electronics receives Factory of the Year award

The specialist publication "Produktion" and the corporate consultancy A.T. Kearney have named the subsidiary company HARTING Electronics, based at Plant 1 in Espelkamp, as the overall winner of the "Factory of the Year" award. "Factory of the Year/Global Excellence in Operations (GEO)" is the most well-established benchmark competition for the manufacturing industry in Germany having been launched in 1992. Torsten Ratzmann, Senior Vice President Production and Logistics at the HARTING Technology Group, was delighted with the award: "It is like winning the Champions League. Our continual efforts to achieve streamlined and effective production processes have been acknowledged with receipt of the overall winner award." Above all, the jury lauded "outstanding continuous development over a period of years" in its verdict and the "strong focus on people and employees." Its reasons also including HARTING having "clear orientation on strengths and differentiation in global competition." The jurors went on to praise the "extremely good production system focused on continuous improvement" and the "development of in-house systems e.g. for electroplating to ensure technical differentiation." "I wish to thank all HARTING employees. This award provides us with an incentive to further improve our processes in future," remarked Ratzmann.

HANNOVER MESSE 2015: Get New Technology First
Government announces big subsidies to Indian Participants

India has been named official Partner Country for year 2015 edition of the world's leading industrial trade fair. Together with **German Chancellor Angela Merkel, Prime Minister Narendra Modi** will officially open HANNOVER MESSE 2015 on the evening of 12 April, then take part in the traditional opening day tour on 13 April. India's role as the Partner Country at HANNOVER MESSE underscores the new Indian Prime Minister's ambitious economic course. Under the slogan of "Make in India", Modi is promoting the modernization of India's factories and infrastructure and greater foreign investment in local production. Modi is convinced that production industries form backbone of Indian economy.

What India Achieved During Previous Partner Country					
Total Business Generated worth			1.3 Billion $USD		
Spot Orders Booked worth			15 Million $USD		
Enquires worth			100 Million $USD		
Highlights of Previous Show (7-11 April 2014)					
Trade Visitors			180,000 (100 different nations)		
Highly qualified visitors from all across the Globe					
69% Europe	19% Asia	8% South and North America	3% Africa	1% Australia Oceania	64% Decision Makers
4.2 Million Business contacts in 5 days					

Electrical India, publication from India would be present to promote Make in India brand at HANNOVER MESSE 2015, Germany during April 13-17, 2015. The event will comprise following ten flagship fairs.

- Industrial Automation
- Motion, Drive & Automation (MDA)
- Energy and Wind
- MobiliTec and Digital Factory
- ComVac
- Industrial Supply
- Surface Technology
- Research & Technology.

India, a nation with over 1.2 billion inhabitants, will be at the focus of the world's leading industrial technology show. Last year the German Government approved loans amounting to approximately €1 billion. This money will be invested in energy efficiency, renewable energy and the sustainable use of natural resources. Exhibitors from Germany and other countries will encounter Indian visitors who want to invest in modern technology in order to strengthen their nation's economy.

String inverters VS 8, 11, 15 by voltwerk

Optimized wiring - up to 1000 V DC voltage per string
Highest yields – peak efficiency factor of 98.0 %
Wide range of applications – outdoor installation (IP 65) in temperature range of up to +60^0
Solar Magazin 'Photon' Test: 'A+' for medium irradiation and 'A+' for high irradiation
Winner red dot award: product design 2010

Efficiency

Thanks to the innovative patented VTL topology Voltwerk inverters can reach peak efficiency factors of 98.0%. The new technology also ensures highest European efficiency factors of up to 97.4%. The exceptionally fast and precise MPP tracking guarantees that there is no loss of output in case of irradiation changes.

Solar generator optimization

Voltwerk string inverters allow an immediate documentation of the current-voltage-curve. There by in particular cases wiring faults can already be determined & eliminated during commissioning on site.

Reliability

The new patented PowerCool cooling concept optimises heat distribution in the inverter. The sophisticated cooling system and the high-quality components prevent premature ageing of the power electronics and guarantee a maximum service life expectancy for the inverters. The protection type IP 65 and the ambient temperature range of -20^{0}C to +60^{0}C allow an installation of the inverters in practically any environment.

Flexibility

Due to the wide input voltage range of the VS series, modules can be flexibly wired. The high input voltage (UDC = up to 1000 V) permits maximum string lengths for low string losses and cost-effective photovoltaic module wiring.

Website:
www.voltwerk.com

RIOSYSTEM: Retrofit Integrated Optics Super Pulse Start Ceramic (SPC) Metal Halide Systems

Venture Lighting India Ltd brings RIO system.
The paradigm shift in street/ Area lighting

44% Energy Saving;
118 Lm/W, Efficiency Surpassing LED Street Light;
Imported Reflector from Auer Lighting, Germany
Longer Life 30000 Hrs;
Fits into existing Fixture;
Simple Solution, Delivers Quality Light;
Fully Adjustable Cut-Off Optics;
Highly Efficient Electronic Gear with 0.95 PF;
Also Available in Magnetic Ballast.

Energy Saving VIS a VIS HPSV
HPSV

250W HPS; 15000 Hours Rated Life; 2100K Color; 40 CRI; 0.3 Minimum Maintained Foot candles; System Watts: 285.

RIO

RIO140W; 30000 Hours Rated Life; 2800K Color; 70 CRI; 0.6 Minimum Maintained Foot candles; System Watts: 154.

For further details contact:
marketing@vlindia.com

Solar water heaters by Supreme Solar Systems

Better performance in winter and cloudy days. No scale Formation and no pipe blockage will occur by using salt and hard water. High density compressed PUF insulated storage tank to retain the hot water up to 48 hrs. Inner tank made of high grade stainless steel used in marine applications. Suitable for bore well water and hard water usage.

Extra auxiliary tank is fitted instead of air vent, withstands high pressure of cold water also minimize mixing of hot and cold water. ISI marked 2KW 3 KW back-up heater with Thermostat (optional). Completed 10 year of service with satisfied customers globally.

Technical Specifications

Type of collector: ETC;
Specifications: 47-1800 mm or 58-1800 mm;
Frame Angle: 27 degrees;
Inner tank materials: high grade stainless steel;
Insulation: high quality PUF materials.

Website:
www.supremesolar.in

UniGear-ZS1 12/24KV Metal-Clad Switchgear by Xiamen Minghan Electric Co ltd

Structure and Features

Metal-Clad enclosed, air composite insulation, VCB (ABB VD4) withdrawable.
Four compartments (VCB, busbar, cable terminal and LV).
Interlocking system; Wall mounted or back-to-back installation.
Internal arc classified IAC AFLR (arc duct).
Motor operation for withdrawable VCB and earthing switch.
Power automation system (optional).
Dimensions: H (mm): 2200; W (mm): 650/800/1000; D (mm): 1340/1840.

Technical data

Standardized by: GB/DIN/IEC.
Rated voltage: 12/24KV; Rated frequency: 50/60Hz.
Rated main busbar current: 4000A.
Rated short time withstand current: 50KA/3S.
Arc proof withstand current: 40KA/1s 50KA/0.5s.
Lightning impulse withstand current: 125/100KA.
Degree of protection: IP4X.

Website:
http://en.minghan.com.cn

mbSPIDER by MB Connect Line GmbH

The mbSPIDER receives and stores the current counter readings, measurements, logic states and analog values of plants and objects. All measured values can be viewed, analyzed and visualized on a web browser, even on a smartphone or tablet. All relevant data of the connected devices can be easily saved by script control.

Simple, secure and flexible

Remote monitoring, diagnosis and configuration of e.g. solar, biogas and wind turbines; Data collector for all major asset data; Quick detection of malfunctions; Communication service by email or SMS; Automatic monitoring via LAN / WAN or RS232/485 interface and analog / digital inputs; Quick and easy setup.

The mbSPIDER allows you to record and continuously monitor digital or analog meters.

Possible peripheral connections include a switchable RS232/485 interface, an ethernet port, digital or analog inputs and one relay output. The reading of the data and the signal preprocessing is coded by using an easy to use programmable scripting language. User-defined messages and alerts can be specified to send a SMS or email when a specific event occurs or a predefined limit has been exceeded.

Advantages

An integrated web visualization feature ensures that Smartphones and tablet PC users can be informed about the current status of values; stored data can be saved to a USB drive or transferred to a FTP Server; The mbWEB2.go service of the portal enables safe and barrier-free access for mobile devices; No HTML or programming knowledge needed.

Technical data

Power supply: 10 - 30 VDC.

Inputs: 2 digital 24 V, 2 analog, 0 - 10 V or 4 - 20 mA (12 Bit).

1 relay output: 24 V DC/AC/1A changeover contact.

1 RS232/485: (RxD, TxD, RTS, CTS, GND) / (A+, A-, B+, B-).

1 ethernetport: 100 Mbit/sec. via VLAN als LAN und WAN nutzbar.

1 USB host: 2.0.

If GPRS: Quadband Class 10.

Connections: OpenVPN, FTP / Telnet, SQLite Database, Webserver.

Website:
www.mbconnectline.com

Menzel Labortechnik brings WAT-221S

Characteristics & Functions

Multi functions; high sensitivity; simultaneous output of composite video & Y/C signals; white balance control; shutter speed control; electronic iris; flickerless mode; AGC; back light compensation; gamma correction; video level switch (100 IRE / 75 IRE); video/DC iris auto-select; iris level control.

Specifications

Effective pixels: 380k (N), 440k (P); Resolution: 450TVL, 480TVL(Y/C); Minimum illumination: 0.1 lx. F1.2; Gain control: AGC ON (HI: 8-36dB, LO: 8-24dB), OFF (8dB); Back light compensation: ON/ OFF; S/N ratio: 50dB; Shutter speeds: EI(1/60(N) or 1/50(P)-1/100,000), EI(FL-1/100,000), FL, OFF, 1/250, 1/500, 1/1000, 1/2000, 1/4000, 1/10000; White balance: ATW, PWB, MWB, 3200K, 4200K, 5100K, 6300K; Gamma: 0.45/1.0; Weight: 160g.

Accessories

WPDC12 (DC plug); AIC-G (Iris plug); Hex. Wrench.

Options

MS50 (Stand); 34CM-R (C-mount adaptor).

Website:
www.menzelab.com

10kV, SC(B) Dry Type Transformer by Shandong Luneng Mount Tai Equipment Co., Ltd

SC(B)10-30~3150/10 series 3-phase resin-casting DDT is a new product developed for the reform of the rural and urban power network, for the requirements of the market, and for improving the performance of products and manufacturing efficiency. The product is in compliance with GB6450, GB/ T10228. Making the principle in the light of performance level of dry type transformer and on the basis of SC (B) 8 and SC (B) 9 product series, it optimizes and lowers the no-load loss, load loss, and meanwhile optimizes the design of the electromagnetic plan and construction design. The product could be used extensively for 10kV and less than 10kV power.

Website:
www.ltds.com.cn

S Bhattacharya appointed as CMD of Coal India Ltd

S Bhattacharya, senior IAS officer has been appointed new chairman and managing director of Coal India Ltd. (CIL) during December 2014. The CIL had produced 452 million tonnes of coal during the 2012-13 financial year and earned INR 882.81 billion from the sale of coal in the same period. The company was without a full time chairman for the past six months. The appointments committee of the Cabinet had cleared Bhattacharya's name for the position in mid December. In November 2014, the Public Enterprises Selection Board had recommended his name for the post. Bhattacharya, who is a 1985 batch IAS officer, has taken charge from Additional Secretary (Coal) A K Dubey, who was given the additional charge as CMD on June 26, 2014.

T N Veeraraghavan assumes charge as Director (E, R&D) BHEL

T N Veeraraghavan, has assumed charge as Director (Engineering, Research & Development) on the Board of Bharat Heavy Electricals Limited (BHEL). Prior to this, he was heading the company's Boiler Auxiliaries Plant at Ranipet as Executive Director. An Electrical Engineer from University of Visvesvaraya College of Engineering, Bangalore and an MBA in Financial Management from the Department of Commerce and Management, Bangalore University; He is a gold medalist of Visvesvaraya University & Bangalore University and also holds the unique distinction of getting a state award in 1987 for academic excellence. He has 38 years of diversified and

versatile professional experience through working in major segments of BHEL. He has handled a variety of assignments in strategic as well as operational areas in various capacities and functions. He was elevated to the position of Executive Director in July, 2011. Starting his career in BHEL as an Engineer Trainee at Bangalore in 1977, he was involved in production of control equipment and engineering of controls for combined cycle plants. He was instrumental in setting up state-of-the-art facilities for manufacturing and testing of Electronic Automation Systems for steam turbines at Bangalore in line with practices at KWU/Siemens. Subsequently, he was involved in establishing the manufacturing and testing facilities at Bangalore for speedtronic Mark-IV controls for gas turbines in line with those established at General Electric, USA. Under his stewardship, a number of productivity projects were mentored by him in the manufacturing and engineering areas.

Rémi Gruet appointed CEO of Ocean Energy Europe

Rémi Gruet who has been appointed CEO of Ocean Energy Europe. He succeeds Dr Sian George, who was appointed to oversee the reinvention of the association as Ocean Energy Europe in 2012. Dr George, who stepped down as CEO on the 1st January 2015, will continue to serve as an advisor to the board. Gruet joined Ocean Energy Europe as Policy & Operations Director last year. He will be tasked with shaping the policy context that will help Europe's ocean energy sector reach commercialisation over the coming decade. "Consistent and stable support from Brussels and Member States will be vital to the success of the ocean energy industry. Rémi has the experience and expertise to secure and shape this support and put the sector on a solid path towards mainstream power production", said Ken Street, Vice President of Ocean Energy Europe. Rémi Gruet spent six years in the private sector, followed by 10 years working at EU level; first as a Political Advisor at the European Parliament, then as Senior Advisor on Climate and Environment at the European Wind Energy Association. He is a leading EU authority on the Emissions Trading System (ETS) and renewable energies, and authored the 2011 report, Wind Energy and 2020 EU Climate Policy. He is a visiting lecturer on climate and energy at the University for Political Science in Lille, France. Gruet has a degree in economics and a master's degree in Environmental Management. "I am very pleased to be appointed CEO of Ocean Energy Europe. The sector faces significant challenges over the coming years, and I look forward to working with the industry, academia and policy makers to help find solutions and turn ocean energy into a real EU industrial success story", said Rémi Gruet. Everyone at EMEC wishes Rémi and Sian all the best in their new roles. Rémi Gruet (5th left) and Sian George (6th left) at Billia Croo as part of the Ocean Energy Day jointly hosted by EMEC and Ocean Energy Europe (Credit Colin Keldie).

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