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Publisher's Letter

Mahadevan Iyer

"I repeatedly recall the events of the previous years both internal and external..."

While writing this letter on the occasion of publishing current annual issue, I repeatedly recall the events of the previous years both internal and external. Electrical India is about to complete 55 years, and during this long and eventful journey we have always received continuous encouragement from our readers, advertisers and patrons. I heartily convey my thanks to all of them.

I am proud of saying that Electrical India has been a publication that has successfully portrayed the growth history of the Indian Power Sector during the last more than a half century. In this long span of time, the Indian Power Sector has undergone several changes.

From time to time, depending on the (then) prevailing circumstances, several new proposals came forward, based on that new plans were made then got started their executions. Although our Five-Year-Master Plans have failed to touch the respective targets, and prolonged execution periods have escalated the costs of most of the power projects, we have progressed a lot. Similarly, your favourite magazine Electrical India too has crossed several milestones of struggles and successes, and evolved to finally carve a niche for itself in the industry.

Today, Electrical India has its own e-version, a dynamic website and an informative newsletter. We have been successful in coping up with the changing trends in the publication industry. All these have been possible with your support. With our central government's sincere effort, the power scenario in the country is improving rapidly and sustainably. I hope, with your sustainable and ever increasing support, we too will be able to present you with more value-added issues in the coming days. Thank you.

Do send in your comments at miyer@charypublications.in

[signature]

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DEPARTEMENTS

FEATURES

Simply integrated: the energy meter with an Ethernet connection.

Stand-alone solution with standard components: Embedded PC plus power measurement terminals.

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Editorial

P K Chatterjee (PKC)

We Need Latest Technologies

In his recent speech at London, Prime Minister Narendra Modi reiterated that 18,000 Indian villages still do not have even a single electric pole. Also, villages where electric connection has reached, do not enjoy uninterrupted power supply throughout the year.

Recently I was traveling through the roads of a village in Maharashtra, which is around 60 kms from the capital of the state – Mumbai. There electricity has reached, but obviously every now and then power cut is prevalent. Street lights have been provided but in a very unorganised way, the connections are neither safe for the people walking around nor even secure against natural phenomena like rain and storm. The CUSTomers are just hanging from the live wires by means of hooks.

Although home connections are still pending, several houses are tapping power with the help of two hooks fixed at the end of two slender bamboos. If by any chance one such bamboo slips the entire load will go on the overhead wire and that may snap. You understand the consequence...

Our DISCOMS are in loss, they raise money in the name of security deposit whenever there is a shortage of cash. Power metering is absent. Now, the situation is – those who pay the electric bill promptly, they often receive sudden threat of hefty amount to be paid in the name of security deposits.

In his recent speech (referred above), the prime minister has also talked about bringing latest technologies. I appreciate his view on this area. Although he was not very specific about the latest technologies in the power transmission and distribution sector. We need to upgrade this area (especially distribution) immediately. Technologies are urgently needed to prevent power theft, ensure proper metering, enhance quality and safety of distribution. I feel decentralised renewable power generation can serve as a tool and help in a big way to improve the present situation.

Please e-mail me your views at pkcchatterjee@electricalindia.in

P. K. Chatterjee

We need to upgrade technologies in power transmission and distribution segment...

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AWARD

First Indian to be conferred with 'Asia CEO of the Year' award

Nishi Vasudeva

The Chairman & Managing Director (C&MD) of Hindustan Petroleum Corporation Ltd. (HPCL), Nishi Vasudeva, is to receive the honour of 'Asia CEO of the Year,' from Platts. She has steered the corporation to its best financial performance since its formation in 1974. Nishi Vasudeva is the First Indian to be conferred with this award in the Asia Pacific region.

Eight executives from energy companies in Asia pacific region were selected as finalists for the award. However, Hindustan Petroleum's C&MD's name was announced as the winner.

The Platts Top 250's Independent judges' panel, were impressed with HPCL's performance history – especially under the leadership of their C&MD, Ms. Nishi Vasudeva. In the past year i.e., 2014-15, HPCL recorded an excellent performance with the highest ever profit and market sales.

COMMISSIONING

Hindustan Powerprojects commissions Anuppur's 2nd unit

Ratul Puri

India's well known integrated power player, Hindustan Powerprojects has achieved a critical milestone towards commissioning its 1200 MW phase 1 (600 MW each for both the units) Anuppur thermal project by successfully conducting the boiler light-up test for the 2nd unit.

The test signifies the readiness of the boiler for power generation process, and the company has started the work for steam blowing and synchronisation of the unit well within the scheduled timeline.

Ratul Puri, Chairman, Hindustan Power said, "India has a unique opportunity over the next few years to become one of the leading economies, globally. For this to happen, we need a robust growth in our energy sector hence the objective of the organisation is to deliver a state-of-the-art thermal project capable of sustainably generating high efficiencies. Needless to say that improved performance would also mean increased power availability. We are now at the doorsteps of commissioning 1200 MW, which would play a critical role in addressing energy gap in the power deficient region. This milestone would not have been possible without the support and guidance of the community, local administration and stakeholders."

Raghav Trivedi President, Thermal business, Hindustan Power said, "The team of highly trained engineers conducted this test as per the prescribed best practices and standards. The focus now shifts to the take up steam blowing of the unit, which would signal the readiness of the power generation. Built using ESP technology, the plant at Anuppur is already being spoken about for its non-polluting operations."

The clean energy arm of Hindustan Powerprojects has recently achieved the distinction of entering in to the credit enhanced bond market with the issue fully underwritten by YES Bank Limited.

The clean energy arm is set to issue secured, rated, listed, partially guaranteed, debentures of ₹ 360,00,00,000 (Rupees three hundred and eighty crore) on a private placement basis to YES Bank Limited for three of its AA+ SO rated projects in, Gujarat.

PHOTOVOLTAIC MODULE

Viessmann to buy solar modules from Vikram Solar

Viessmann Photovoltaik sales team with Davide Marro of Vikram Solar...

Viessmann, one of the well known international manufacturers of heating, industrial and refrigeration systems, is to become a sales partner to Vikram Solar, an international solar company. As part of the collaboration, Vikram Solar will supply Viessmann with solar modules from the Eldora Ultima series with an output of between 250 and 260 Wp.

The new module type is a valuable addition to Viessmann's photovoltaic package, which includes solar modules, as well as inverters and mounting systems. There are plans to expand the collaboration to other countries as well.

Joachim Rupp, Viessmann Photovoltaik GmbH's Managing Director said, "When serving our discerning trade partners and customers, we depend on partners like Vikram Solar to produce and supply reliable solar modules that are proven to meet our exacting requirements. We look forward to working with Vikram Solar, our new collaboration partner."

Davide Marro, Head of Business Development Europe at Vikram Solar, adds. "We are absolutely delighted about the prospect of working with such a renowned system provider. Viessmann is a company with a long tradition, making it very compatible with the Vikram Group, which itself has been around for over forty years. Both companies have diversified, meaning that they don't just deal with renewable energies – a sound basis for a sustainable and stable partnership."

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NEW ORDER

S&W bags order from Sindicatum Renewable Energy

Sterling and Wilson (S&W) has received a contract from the Singapore-headquartered Asian clean energy developer Sindicatum Renewable Energy, to set up a new Solar Photovoltaic power plant in the Clark region of the Philippines. The solar photovoltaic power plant will be installed in Clark Freeport Zone, and possess a solar power generation capacity of 23 MW. With this order, Sterling & Wilson has scaled a new peak as a trusted Global Solar EPC company.

Sterling and Wilson's order book now stands at 101 MW in Philippines alone. The new project in Clark will be constructed under the Department of Energy (DOE) Philippines Solar Power Procurement Program under the Feed-in-Tariff mechanism. The output power will be evacuated to the nearest NGCP substation.

No terrains are too tough for Sterling & Wilson when it comes to setting up efficient solar power plants. Technologically advanced services and comprehensive know how of thin film, mono crystalline, and polycrystalline modules; along with different foundation of ramming and rafting type leads the organisation to provide best solutions to its customers internationally. Sterling and Wilson will design the plant structure to withstand adverse soil conditions and high wind speeds. Sterling & Wilson will hand over the fully functional solar power plant to its owners by February 2016.

Bikesh Ogra, President, Sterling and Wilson, Electrical & Solar Business said, "Our hard work and persistence in being ever present and relevant in the international Solar market has started reaping good results. The fact that we have been awarded the contract for setting up a solar power plant in Clark Freeport Zone bears testimony to our superior engineering capabilities, experience and expertise in setting up solar power plants internationally. We are confident of providing a technically superior and robust solar power plant that will stand the test of time."

EXPANSION

ABB strides to contribute to India's economic development

ABB plans to double its workforce at its global engineering and operations center in Chennai. Also the company's local Power Protection Product Group has opened a production facility for the assembly of Uninterruptible Power Supplies (UPS) near Bengaluru. The competency center whose workforce will be doubled to 1,200 over the next two years, brings together professional engineering resources under one roof, serving ABB units across the world from its base in Chennai, among the largest industrial and commercial centers in India. The move will increase the number of ABB employees in India to close to 10,000.

"This expansion reaffirms ABB's commitment to India as a key growth market and an important resource base. Our focus in India will continue to be on organic growth, which we will drive by increasing our investment in technology and our team, expanding our local footprint, and strengthening our operations in line with the country's 'Make in India' objectives. The investment is part of ABB's Next Level strategy, which aims to accelerate sustainable value creation for our customers and shareholders," said Ulrich Spiesshofer, CEO, ABB.

Starting this month, two modular UPS assembly lines at the plant in Nelamangala on the outskirts of Bengaluru will provide power-quality solutions to Indian and global customers. This additional local assembly unit will increase cost effectiveness and improve efficiencies. With the local sourcing of components, ABB's Power Protection product group improves price competitiveness while maintaining the highest quality standards.

SOLAR PROJECT

Trina Solar connects a part of its 300 MW plant to grid

Trina Solar, a global provider of photovoltaic (PV) modules, solutions and services, has successfully connected to the grid two thirds of a 300 MW ground-mounted solar project in Yunan, China.

Through an open bidding process, Trina Solar acquired a 90% stake in Yunnan Metallurgical New Energy Co., Ltd, which has a 300MW project under development in Southern Yunnan province. Once fully operational, the project will become the largest single utility-scale solar power plant in Yunnan and one of the largest in China.

Trina Solar commenced the construction phase of the project in the fourth quarter of 2014 with the deployment of its self-branded solar PV modules to the barren hills of Jianshui County. After having connected 70 MW of modules to the grid in the second quarter of this year, the company surpassed the 200 MW milestone by the end of the third quarter with additional connection of 133 MW. The electricity generated from the project is being provided to a local industrial park and to farms located in the surrounding area. The project is eligible for a 20-year benchmark on-grid tariff of 0.95 RMB/kWh based on the present feed-in-tariff programme in China.

"Despite the fact that our Yunnan project is located in a topographically challenging area, we are extremely pleased to announce that we are proceeding on schedule," said Qi Lin, Vice President and President of PV Systems Business Unit of Trina Solar.

AVOID UNPLANNED OUTAGES

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A critical substation failure may cascade into a series of problems. The result can be a massive failure of banking facilities, security systems, manufacturing plants, food refrigeration, communication networks, and traffic control systems. An electric utility involved can lose huge amounts of revenue and incur enormous costs in getting their systems up and running again.

High voltage electrical installations tend to heat up before they fail. By monitoring HV equipment continuously, even from a remote location, permanently installed thermal imaging cameras can improve the reliability and security of electric substations so that costs can be avoided.

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MANUFACTURING REPORT

1366 Tech to set up direct wafer manufacturing facility


Frank van Mierlo

1366 Technologies is all set to build a state-of-the-art, commercial solar wafer manufacturing facility in Genesee County New York, strategically located between Buffalo and Rochester, that will eventually scale to 3 GW, house 400 Direct Wafer furnaces, and produce more than 600 million high-performance silicon wafers per year – enough to power 360,000 American homes.

1366 Technologies will become the anchor tenant at the high-tech Science and Technology Advanced Manufacturing Park (STAMP), where the company will eventually create more than 1,000 new, full-time jobs in New York's Finger Lakes Region.

"Today is an exciting day, the culmination of a lot of hard work by a talented group of people. From day one, we have taken a deliberate, highly-measured path to scaling. The facility in Bedford, Massachusetts was our proving ground. New York brings us to commercial scale. The technology is ready and 1366 is squarely positioned to lead in an industry undergoing rapid global growth. We are extremely proud to become part of the Upstate New York community and are committed to the region's vibrant future," said Frank van Mierlo, CEO, 1366 Technologies.

The site selection marks the start of a phased programme to methodically scale 1366 Technologies Direct Wafer technology – a transformative manufacturing process that produces a uniformly better silicon solar wafer at half the cost – from 250 MW to 3 GW.

1366 Technologies will first construct a 250 MW facility that will produce more than 50 million standard silicon wafers per year. The facility will quickly ramp to 1 GW of production capacity and employ 300 people.

ENERGY EFFICIENCY

Energy efficiency summit facilitates industry go the green way

Energy efficiency should be the duty and way of life – said Dr Kirit Somaiya, Hon'ble Member of Parliament & Chairman, Parliament Committee on Energy, while addressing the delegates at the Inaugural Session of 14th CII Energy Efficiency Summit 2015.

While highlighting the various initiatives of Government of India in improving Energy Efficiency, he said, "We have many success stories in India and it can be shared with the world, and India should work towards attaining a global leadership position by 2022". Dr Somaiya added that the Indian industry has done very well and platforms such as Energy Efficiency Summit can be utilised for knowledge transfer and sharing of best practices.

Dr Ajay Mathur, Director General, Bureau of Energy Efficiency (BEE) highlighted the success of Perform Achieve and Trade (PAT) Scheme and the impact the scheme has created on energy sector. He added that the Indian Cement and Fertilizer industries are among the most efficient in the world, but other energy intensive sectors such as Iron & Steel, Paper need to improve their performance standard to become world's best. He mentioned that there is need for an accelerated programme or mission to promote Waste Heat Recovery in industrial sectors. He added that by accelerated energy efficiency programme in Iron and Steel sector, reduction of 20% in specific energy consumption is possible by 2030, & for paper sector it can be reduced by 50%.

BILATERAL INITIATIVES

Governments to review the CEO Forum's recommendations

The United States and India share a strong and growing commercial and economic relationship, driven by entrepreneurs and businesses in both countries. In January, President Obama and Prime Minister Modi decided to elevate the bilateral commercial and economic partnership by establishing the first-ever US-India Strategic and Commercial Dialogue (S&CD), which was held recently in Washington, DC. The S&CD is the signature, annual forum for policy discussions between the US Government and the GoI. The governments are using the S&CD vehicle to advance our shared priorities of generating economic growth, creating jobs, and strengthening the middle class. US Secretary of State John Kerry and US Secretary of Commerce Penny Pritzker co-chaired the dialogue with their Indian counterparts, Minister of External Affairs Sushma Swaraj and Minister of Commerce and Industry Nirmala Sitharaman.

The S&CD reflects the Obama Administration's commitment to strengthen the economic engagement that lies at the center of our bilateral relationship. This engagement, which includes business, education, cultural, familial and people-to-people ties, has always been at the leading edge of the US-India partnership, and continues to expand. Our bilateral trade has grown from $19 billion in 2000 to over $100 billion in 2014. US exports to India totaled $38 billion last year, supporting an estimated 181,000 U.S. jobs.

Cumulative Indian Foreign Direct Investment (FDI) in the US totaled $7.8bn in 2014; US FDI into India was $28 billion. Ongoing govt actions to facilitate trade in both directions and open new sectors to private investment will continue to accelerate economic growth and development, and increase prosperity for the citizens of both the countries.

The reconstituted and expanded CEO Forum, which has been directly linked to the S&CD, met recently. The US and Indian CEOs engaged in a substantive conversation about immediate policies that can encourage greater trade and investment, as well as the longer term path to greater strategic economic collaboration. The CEO Forum presented their recommendations to United States and Indian government officials at the S&CD and a portion of the subsequent government-to-government conversation was dedicated to reviewing the CEO Forum's recommendations. The CEO Forum offered suggestions in key areas such as business climate, smart cities and infrastructure financing, supply chain integration (including cold chain), aerospace/defense, and renewable energy among other topics.

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Littelfuse demonstrates its optimised circuit protection devices

Littelfuse, Inc., well known for circuit protection, displayed its cutting-edge circuit protection technologies optimised for the full LED lighting system during the IES Street and Area Lighting Conference held recently in Savannah, Georgia. Littelfuse presented a number of driver components, including AC fuses, varistors, TVS diodes, DC fuses, PTCs and PLED protectors. In addition to this diverse portfolio of circuit protection solutions that address a variety of LED applications from indoor and outdoor lighting to devices for LED bulb design, Littelfuse representatives highlighted two unique innovations: LSP05 and LSP10 Modules.

The award-winning LSP05 and LSP10 Modules are designed specifically to provide transient overvoltage protection for outdoor and commercial LED lighting fixtures. Constructed with Littelfuse thermally protected metal oxide varistors (TMOVs), the LSP05 (parallel) and LSP10 (series or parallel) Surge Protection Device (SPD) Modules provide robust surge current handling capability. A built-in thermal disconnect function provides additional protection from catastrophic failures and fire hazards, even under the extreme circumstances of varistor end of life or sustained overvoltage conditions.

The series-connected LSP10 is the world's first indicating surge arrestor that can handle 20,000 amp surges. The display also included a disassembled streetlight to demonstrate where and how the LSP05 and LSP10 modules can be installed.

GRC's annual meeting draws attendees from 26 countries

Nearly 1,200 attendees from 28 different countries gathered for the largest annual meeting of the global geothermal community, the 39th GRC (Geothermal Resources Council) Annual Meeting, at the Peppermill Resort Spa Casino, Reno, Nevada, USA. At the opening session, GRC Annual Meeting Chair Lisa Shevenell welcomed the attendees from 26 different countries and introduced an array of speakers from the regional, national and global energy communities.

Nevada Governor Brian Sandoval greeted the meeting saying the importance of geothermal power production in the State of Nevada is well known. The Silver State recently exceeded 30 years of geothermal power generation with 2014 production of 2,742 million net MWh. This is enough to power 247,000 Nevada households. "Congratulations to all for achieving this important and impressive milestone."

Despite the slow-down in the domestic U.S. industry the event was a success. The numbers tell the story. 829 attendees registered with the GRC for the Annual Meeting including 72 students who paid just $5. The GRC registration also included entry to the GEA Geothermal Energy Expo.

Over the four days the attendees were treated to over 135 technical presentations totaling 45 hours, bringing the latest geothermal research from around the world. On display were over 45 posters – and the winners of the prestigious 36th GRC Photo Contest were showcased in a public area of the convention centre.

ABB wins orders worth $300 million in China

World's first successfully tested converter and transformers connecting 800 kV UHVDC with 750 kV AC...

ABB has won orders worth over $300 million for critical power technologies to enable two new Ultra-High-Voltage Direct Current (UHVDC) power transmission links.

The two 800 kilovolt (kV) links will each have the capacity to transmit 8,000 megawatts (MW) of wind and thermal power from Shanxi to Nanjing and from Jiuquan to Hunan – enough electricity to meet the needs of 28 million consumers based on average national consumption. The orders were booked in the third quarter of 2015.

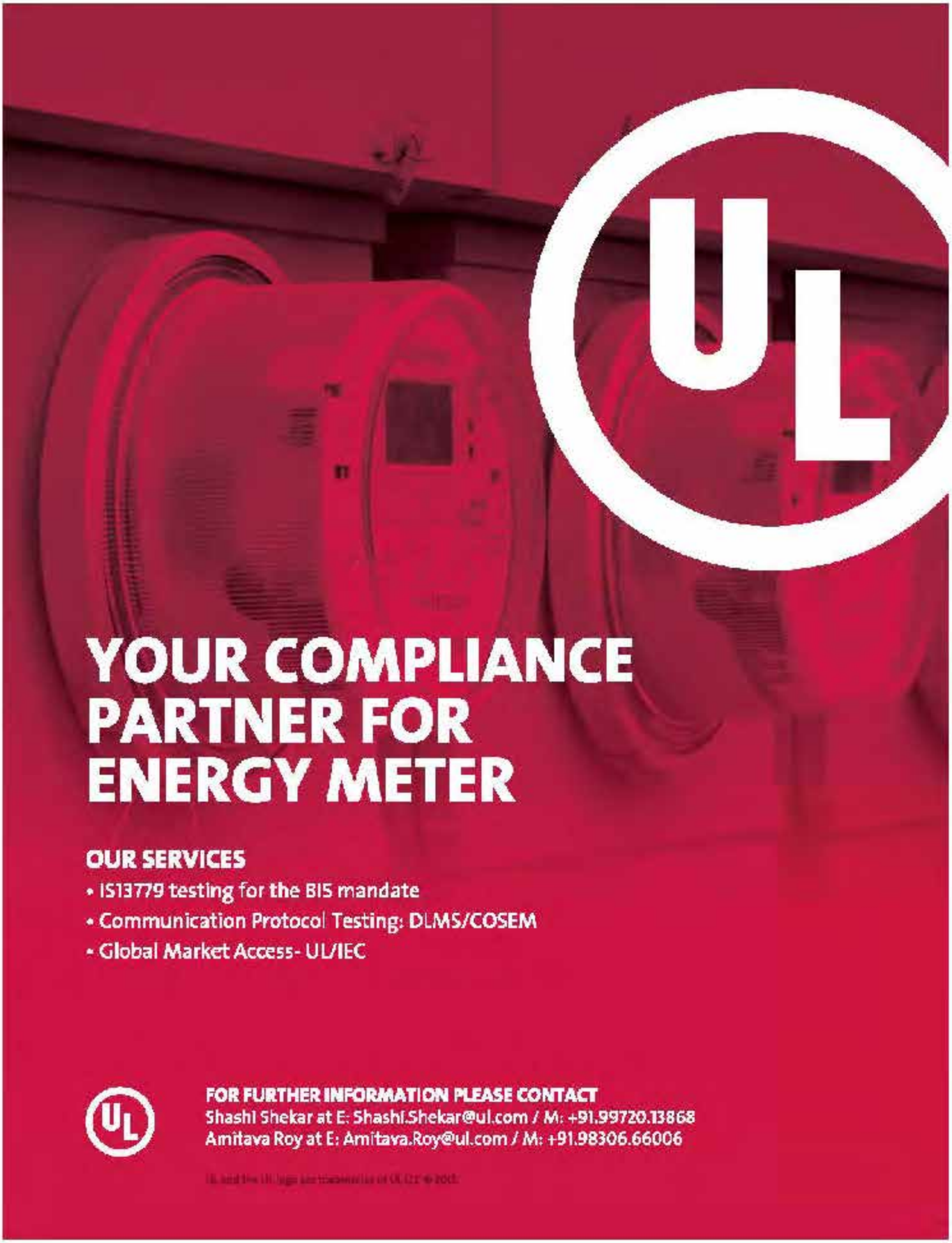
ABB will supply leading-edge HVDC converters, converter transformers and components, capacitors and filters, and high voltage circuit breakers to facilitate the efficient and reliable long distance transmission of electricity.

Converter transformers for the two projects will serve as the vital interface between the AC network and the DC links. By using 800 kV UHVDC links, the transmission losses can be reduced significantly. This application highlights the capability of HVDC technology to reinforce AC grids.

The Jiuquan to Hunan project is the world's and China's second 800 kV UHVDC to 750 kV UHV Alternating Current (AC) connection, an innovation that also enhances the efficiency and capacity of long-distance UHV electricity delivery systems.

Converter transformers connecting very high voltage AC networks (750kV) to ultrahigh voltage DC networks (800kV) are technologically challenging and earlier this year, ABB was selected to supply 800 kV UHVDC converter transformers and components to the first such connection from Lingzhou to Shaoxing.

"These projects will help integrate more renewable energy and further strengthen China's transmission grid. Technology and innovation are key differentiators for ABB and a major pillar of our Next Level strategy and ABB continues to be at the forefront of HVDC and transformer technology making projects like these feasible," said Claudio Facchin, President of ABB's Power Systems Division. In recent years, China has been focusing on developing UHVDC power transmission links to boost capacity and improve grid efficiency.



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SOLAR TECHNOLOGY

SMA Solar Technology achieves huge sales in Japan

SMA Solar Technology AG (SMA) has become the first non-local inverter supplier to surpass 1 Gigawatt of solar inverter sales in Japan. SMA opened its sales & service subsidiary in Japan in 2011 offering a full portfolio of inverters and communication products for photovoltaic installations of all sizes as well as innovative energy management systems.

"This success is contributed by excellent performance in residential, commercial and utility segments. We have established strong long term supply partnerships with leading Japanese solar power developers, EPCs and distributors. Our local sales and service team has been the engine behind this growth, providing the highest level of sales and service support to our key strategic Japanese customers," says John Susa, SMA Executive Vice President Sales Asia Pacific. The local team of SMA Japan offers customers a series of highly efficient and high-quality inverters tailored to the specific requirements of the Japanese market along with professional consulting for photovoltaic project planning. "SMA's state-of-the-art production lines in Niestetal satisfy the highest quality standards and requirements in the Japanese market and SMA has therefore developed a strong reputation for reliability and quality," explains Susa. The strong growth in the Japanese photovoltaic market for SMA is largely due to its internationally successful product portfolio. With the expansion of their central inverter product range, SMA offers flexible solutions for large photovoltaic projects and complies with globally required grid management functions. In addition, in the residential and commercial segments, SMA offers inverters that have been specially adapted for Japan and are certified by Japan Electrical Safety & Environment Technology Laboratories (JET) for sale on the Japanese market.

SWITCHGEAR SYSTEM

Eaton supports always-on power in healthcare

Power management company Eaton has released its Cooper Power series Pad-mounted Source Transfer (PST) switchgear system designed for facilities that require highly dependable power. The solution is engineered to facilitate automatic transfer of electrical loads between primary, secondary and emergency sources to support critical electrical equipment during a utility power outage. According to Eaton, compared to other transfer methods, the PST system reduces equipment footprint and profile up to 89%. With an integrated, intelligent and compact design, Eaton is helping customers support continuous uptime, while reducing time, cost and space.

"Eaton delivers an extensive portfolio of back-up power solutions to help ensure the availability of essential systems in healthcare, data centre and many other mission critical applications. With the Pad-mounted Source Transfer system incorporating proven technology, Eaton is helping support the safe and reliable transfer of power from normal to emergency sources and back again," said Rob Hardin, Product Line Manager-Underground Distribution Switchgear, Eaton.

Engineered with the powerful IST control, PST switchgear is a self-contained, compact system that is designed to provide automatic transfer between a primary source and alternate source, as well as overcurrent protection for critical medium voltage loads. Eaton's Cooper Power series PST switchgear simplifies the installation with integrated protection, transfer, system metering, event diagnostics, communications and customized logic.

STEEL MAKING

Primetals' LD (BOF) converter works in JSW's steel plant

In mid-September, a new LD (BOF) converter supplied by Primetals Technologies was started up in the Steel Melt Shop no. 2 in Vijayanagar, Toranagallu of Jindal South West Steel Ltd. (JSW Steel, India). Since then, the converter is in full production mode. It is a part of an order received in September 2014 under which Primetals Technologies will exchange a total of four LD (BOF) converters. The converters are made of high-temperature creep-resistant steel. In conjunction with a combined air and water cooling system, this will achieve a long service life. The new converters will have a larger interior volume than the previously used models. This will reduce slopping. The remaining converters will be consecutively replaced until spring 2016.

JSW Steel is the leading steel producer in India with an installed capacity of 14.3 million metric tons of steel per annum. Of this total, ten million metric tons are produced alone by the Vijayanagar steel works in Toranagallu, in the State of Karnataka. On account of the high maintenance requirement of the existing LD converters in steel works no. 2, JSW Steel decided to replace them with new converters from Primetals Technologies.

Each converter will have a tapping weight of 180 metric tons. Primetals Technologies will supply the converter vessels, including the trunnion rings and suspension systems. All the converters will be equipped with bottom-stirring systems. The converters will be constructed of high-temperature creep-resistant materials in order to limit heat-related deformations. In conjunction with a specially designed, combined air and water cooling system, this will achieve not only a long service life but also reduce maintenance requirements. Each converter will have a water-cooled cone cooling system and air cooled trunnion ring. The scope of delivery will also include two new tilting drives, two sets of new quick-change couplings for top blowing lances, and the complete basic automation (level 1) for the converters.

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Tata Power implements path-breaking technology

Tata Power has been a frontrunner in technology adoption and innovation while also setting benchmarks in sustainability. As another green milestone in the company's centenary year celebrations, two of India's first 25 MVA natural ester filled transformers were recently installed in Mumbai.

With this initiative, Tata Power has once again showcased its priority in driving sustainability by implementing path breaking green technology. Sustainability remains a core business philosophy of Tata Power, and the green transformers is one of the company's many green initiatives under its 'Be Green' campaign. Use of natural ester in transformers sets a new industry paradigm for the power sector across the country.

Pioneers of this vision, Tata Power selected Cargill's Envirotemp FR3 fluid (the most widely used natural ester fluid) & Schneider Electric (specialist in energy management & automation) for its transformers. From the safety angle, FR3 fluid provides improved fire safety and extended transformer life. It also adds additional loading capacity with a smaller footprint.

The natural esters fluids have a high fire point (360 degree celsius) and reduce risk of fires in the electrical installation. In comparison with the conventional mineral oil filled transformers, this fluid provides improved fire safety for the densely populated areas within Tata Power's service areas.

The fluid is made from a carbon neutral renewable resource, is biodegradable, non-toxic and non-hazardous in soil and water.

Speaking on this initiative, Ashok Sethi ED & COO, Tata Power, said, "Tata Power is committed towards providing greener, safer and sustainable environment while serving our consumers with uninterrupted power supply. As part of our centenary year celebrations, Tata Power reaffirms its commitment to nation building and we will continue to uphold and implement technological innovations such as green transformers. We plan to refine the design to further decrease the footprint and improve performance. This could change the landscape of the power industry in India and create a new paradigm that can be adopted successfully anywhere in the world."

GE to provide large gas turbines to Harbin

GE's high-efficiency 9HA gas turbine...

In an effort to avoid blackouts and meet the power needs of nearly 190 million people, the Punjab government in Pakistan is working to provide more affordable, reliable power as quickly as possible. To help reduce the projected five gigawatt (GW) energy shortfall, GE will provide two high-efficiency 9HA.01 gas turbines and associated equipment to Harbin Electric International Company Limited (HEI), a longtime business associate, for the new 1.1 GW Bhikki combined-cycle power plant. Harbin will handle engineering, procurement and construction of the plant.

The Bhikki plant will be able to generate the equivalent power needed to supply more than six million Pakistani homes, and is likely to be the largest, most efficient power plant in Pakistan. It is expected to enter commercial operation in 2017. This project marks the first HA orders in the Middle East and North Africa region – and the 20th and 21st worldwide. GE's 9HA is the world's largest, most efficient gas turbine. "We are committed to meeting the growing demand for power to drive industrial growth and all-round economic progress as well as to promote the welfare of our people. As part of this, we are not only investing in new plants but also strengthening public-private collaboration to ensure that advanced technologies are deployed to meet the growing demand. GE and Harbin are moving forward with an accelerated time frame to add additional power to the grid," said Ahad Khan Cheema, CEO, Quid-e-Azam Thermal Power Limited, on behalf of the government of Punjab.

L&T Construction wins power T&D orders

The Power Transmission & Distribution Business of L&T Construction has won orders worth Rs. 1376 crores in both the domestic and international markets in September 2015. In the domestic market, the Solar Business has bagged multiple orders from a reputed solar power developer for the engineering, procurement and construction of 115 MWp solar installations in the southern part of the country.

Upon completion, the total installed capacity of solar plants by the company would be 643 MWp, one of the highest executed by an Indian EPC company. The business has also received an order from West Bengal State Electricity Transmission Company Limited for engineering, procurement and construction of 132 kV double circuit transmission lines in various districts of West Bengal. In the international market, the business has made a strategic breakthrough in Malawi, Africa, by bagging an order for the construction of two 400/132 kV substations on EPC basis. Another order has been bagged in the Middle East for engineering, procurement and construction of a 220 kV substation from a reputed customer.

The Power Transmission & Distribution business is a leading EPC player in the field of T&D business offering integrated solutions and end to end services ranging from design, manufacturing, supply, installation and commissioning of transmission lines, underground cable networks (both power and control), substations, distribution networks, electrical and instrumentation works for power, process and infrastructure projects, in both domestic and international markets. On the renewable energy side, the business provides turnkey EPC services for projects on photovoltaic and concentrated solar power plants.

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FOCUS-PUNE

NEWS IN BRIEF

Sunlabob builds solar village micro-grids in rural Myanmar

Sunlabob Renewable Energy has recently finalised a contract to provide turnkey implementation of eleven solar-powered micro-grids in remote communities of Myanmar. The micro-grids will provide reliable, clean energy access at the household level in eleven villages throughout Shan State and Chin State, Myanmar. The project is under the guidance of Myanmar's Ministry of Livestock, Fisheries and Rural Development's (MLFRD) Department of Rural Development (DRD) and is funded by the Japanese International Cooperation System (JICS).

"Sunlabob is pleased to contribute to the sustainable electrification of Myanmar through the use of high-quality, international-standard solar technology," said Andy Schroeter, Sunlabob CEO. Sunlabob, which has implemented off-grid renewable energy solutions in more than 25 countries of Southeast Asia, Africa and the Pacific region, will provide material supply, design, and construction of the battery-backed solar power systems. Sunlabob engineers and technicians will also provide hands-on training for local maintenance technicians and household end-users. "All signs point to decentralised renewable energy, such as solar micro-grids, being an important ingredient to the electrification of rural communities and businesses in Myanmar for years to come," added Schroeter. Myanmar's grid-based electrification rate currently stands at approximately 30%.

NEWS IN BRIEF

Schneider Electric makes strategic investments in Singapore

Jean-Pascal Tricoire, Chairman and CEO of Schneider Electric

Schneider Electric will make significant new investments to strengthen its presence in Singapore. The company will cumulatively invest around 65 million Euros over the next few years to establish a Software Industry Solutions Centre and a Software Regional Hub, a new East Asia headquarter and a Regional Control Tower for Network Logistics, Analytics and Transportation in Singapore.

"Schneider Electric is pleased to expand its substantial operations in Singapore with new investments committed to support the country with energy management, automation and software technologies, helping make it an exemplary smart city with smart industries and smart datacenters", said Jean-Pascal Tricoire, Chairman and CEO of Schneider Electric. "Singapore is a key knowledge and innovation hub in the Asia Pacific region. By basing our Software Industry Solutions Center and Software Regional Hub in Singapore, we want to take advantage of the country's research capabilities and competitive ecosystem. We also value Singapore's strong protection of intellectual property. This is an ideal location to set up our new solutions center that will address the challenges that the cloud and data center industry faces in Asia," he added.

Supported by the Singapore Economic Development Board (EDB), the Software Industry Solutions Center will help chemicals, food and beverage, mining and metals, oil and gas, transportation, water and waste water, and utilities companies leverage Schneider Electric's market leading industrial software portfolio to enhance their productivity, improve safety and boost sustainable performance. At peak capacity, expected to be reached by 2018, the centre will employ more than 60 research scientists and engineers with deep experience in industry and technology, to develop and deliver software solutions to solve industrial companies' most critical issues. The centre will also feature a Customer Experience Center, where Schneider Electric's solutions and capabilities will be showcased.

COMMODITY

CIL holds meeting with state governments

In a bid to facilitate steady supply of coal in a fair and transparent manner to Medium and Small Scale Enterprise (MSME) sector Coal India Limited (CIL), the Maharatna PSU that spearheads the coal production in the country, held a meeting with the state governments recently at its headquarters in Kolkata. This meeting was first of its kind.

In a consumer friendly initiative CIL had invited all the state government to discuss, threadbare, the details of coal supplies to MSMEs. The idea behind was to assess the problems of medium and small consumers to find remedial measures. The objective of the meeting was to put at ease the concern of the small consumers regarding their coal requirements – and to reassure them of CIL's commitment in easing coal supplies through their respective state government nominated agency. The meeting was attended by Director (Marketing), CIL, CVO, CIL and an official from Ministry of Coal.

CIL earmarks about 8 Million Tonnes (MTs) of coal annually, sold at notified prices, to MSME sector, which constitutes brick kilns, food processing industry, lime factories, smokeless fuel plants, coke oven units and other small industries that rely on coal for their product generation. In line with the New Coal Distribution Policy of Government of India consumers in small and medium sectors having annual requirement of less than 4200 tonnes of coal – and otherwise not having any access to purchase coal or conclude FSA for coal supply with the companies, gets coal through State nominated agencies. Considering the large number of MSME consumers, Coal India's subsidiary companies enter into a bi-lateral FSAs with state government nominated agencies who in turn distribute the coal to MSME consumers as per their requirements.

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ENERGY SUPERHIGHWAY

Alstom delivers transformer for Champa-Kurukshetra project

Alstom's HVDC power transformer for the Champa project...

Alstom has manufactured and delivered India's first 800 kV High Voltage Direct Current (HVDC) power transformer for the Champa-Kurukshetra High Voltage Direct Current (UHVDC) Phase 1 link. The project will connect the power station of central India near Champa to the demand centre, in northern India at Kurukshetra, through a 1,365 km transmission line creating an 'energy superhighway' of efficient power transmission.

This is the first out of nine power transformers for the project that has been built in Alstom's largest transformer manufacturing and testing facility in India.

The transformer, measuring13m long, 5.3m high and 5.1m wide, weighs 310 tonnes. Once erected at site, it will weigh an additional 175 tonnes. It travelled over three months to cover a distance of over 2,000 km to reach the project site at Champa. The second transformer, already dispatched, is expected to reach Champa by December 2015.

Patrick Plas, Senior Vice President, Grid Power Electronics and Automation, Alstom Grid said, "Alstom is delighted to have achieved such a significant milestone for this project. These massive transformers will substantially improve grid connectivity by seamlessly transferring power across five electrical regions of India. Alstom has been a key player in HVDC for over 50 years and the company is currently executing two 800kV UHVDC bi-pole projects in India. The 800kV HVDC transformers are locally manufactured from Alstom's world class facilities and reinforce its leadership in the transformer market."

PROJECTS & CONTRACTS

S&W receives MEP contract from CIAL

Prasanna Sarambale, Group VP Business Development, Sterling and Wilson

Cochin International Airport Ltd. (CIAL) has awarded the Mechanical, Electrical and Public Health System contract for the new International Terminal at Nedumbassery in Kerala, to Sterling and Wilson Pvt. Ltd. (S&W), a part of Shapoorji Pallonji Group. CIAL is the first green field airport in the country built with Public-Private Partnership (PPP). Additionally, it is ranked as the fourth largest international airport in India in terms of passenger traffic. The sprawling New International Terminal at CIAL will spread across a built up area of 15,00,000 sq.ft.

Sterling and Wilson's scope of work under this contract will include complete electrical installations including HT and LT works, air-conditioning, fire protection, building management systems, plumbing management systems, vertical and horizontal transportation systems, along with operation and maintenance work. The project is expected to be completed by Sterling and Wilson within a period of 18 months.

Speaking on the MEP contract Prassana Sarambale, Group Vice-President–Business Development, Sterling and Wilson, said, "CIAL is one of India's busiest airports in terms of number of international passengers handled by it. Therefore, we are extremely happy that Sterling and Wilson has been entrusted with the opportunity of providing MEP solutions for Cochin International Airport's new international terminal. Having already successfully completed the electrical installations for Terminal 3- Indira Gandhi International Airport, we are confident that our astute technical knowledge and in-depth resources will ensure that the New Terminal at Cochin International Airport will have a world class feel about it." Sterling and Wilson will also assume responsibility of providing complete operation and maintenance work after the commissioning of the new international terminal.

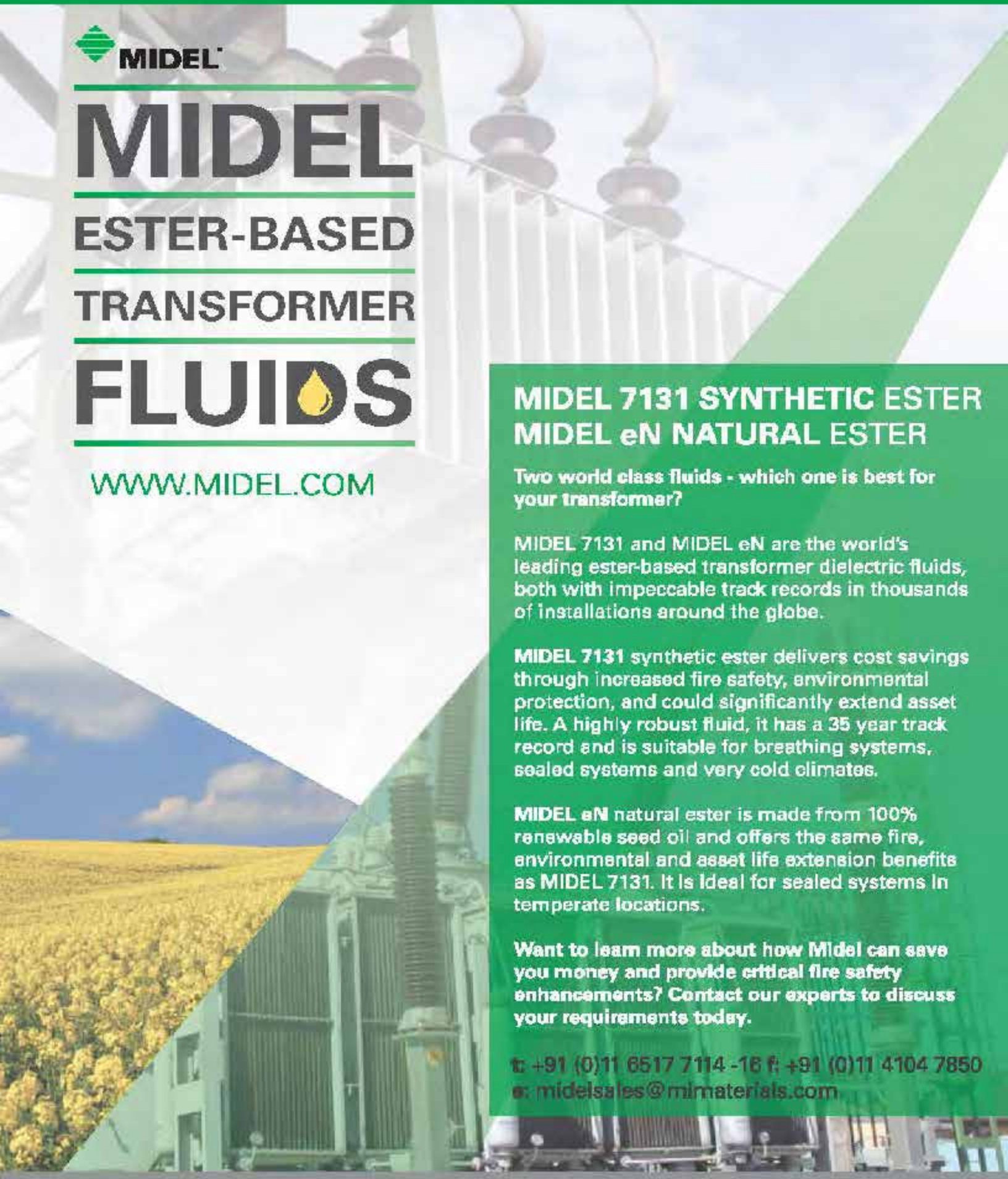
WIND POWER

Wind power's growth is driven by its competitive pricing

According to a ReportLinker review, the Global Wind Power market is accounted for $172.3 billion in 2014 with CAGR of 7.54%, and is poised to reach $308.2 billion by 2022. The wind power generation is estimated to drive the market over next decade due to increase in renewable energy. Nations across the globe are supporting the renewable energy including wind power, solar power, biomass and hydro power to reduce the carbon emissions.

Wind power's growth is increasingly driven by its competitive pricing, because it enhances energy security, price stability especially in China. China has been the main driver of the growth of the industry for the last five years. Wind Powering America (WPA) is an initiative of the United States Department of Energy (DOE) that seeks to increase the use of wind energy throughout the United States. Europe is expected to be stable, while North America is the most difficult market to predict as policy vacuums to emerge in both the U.S. and Canada. By 2020, wind power could prevent more than 1.2 billion tonnes of carbon dioxide from being emitted each year by Germany and Italy combined.

As of 2014, the wind industry in the U.S. is able to produce more power at lower cost by using taller wind turbines with longer blades, capturing the faster winds at higher elevations. This has opened up new opportunities and in Indiana, Michigan and Ohio, the price of power from wind turbines built 300 to 400 feet above the ground can now compete with conventional fossil fuels like coal.



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Innovative cooling product looks for funding

A new innovation is looking for fund to be in the market. Yes, people can now create a personalised local microclimate to enjoy a cool and relaxing environment with the help of the world's first personal air conditioner, the Evapolar.

Besides creating a cooling effect, it can humidify and purify the air for a healthy and hygienic environment. The small-size air conditioner is easy to carry, allowing a person to enjoy a personalised cooling experience everywhere where he/she goes. Evapolar has recently been launched on Indiegogo (the largest global site for fundraisers, Indiegogo helps individuals, groups and non-profits raise money online to make their ideas a reality), seeking the necessary funding for its production.

According to Eugene Dubovoy, the CEO & Co-founder of Evapolar, they are soon going to raise the necessary fund of USD 100,000. "People are appreciating Evapolar for its portability and the specially developed patented nanotechnology that makes it eco-friendly and 12 times more energy efficient in comparison to traditional air conditioners. In a few days since the launch of our Indiegogo campaign, we already have the support of more than a hundred people and have gathered thousands of dollars so far," he states. The campaign will end in 26 days, and they already have 21% funding for their project.

IRENA's report helps countries

A new report from the International Renewable Energy Agency (IRENA) is aiming to assist countries in their transition to renewable energy-based power systems. The Age of Renewable Power, was released recently on the sidelines of the Innovation for Cool Earth Forum in Tokyo. It has identified 20 measures that can be taken to support the development of national roadmaps to integrate variable renewables. It also highlights lessons learned by countries already pursuing a power system transformation.

The report finds that technology solutions to support renewable energy integration are already available, but other challenges remain. To develop a successful national strategy on power sector transformation, policy-makers must anticipate the effects this transformation will have on economic development, energy security and the environment.

To do this, the report posits, policy-makers must ensure data collection and energy planning tools are in place, examine existing flexibility options, and secure human capacity to develop and adapt technologies to local conditions.

"There is enormous growth potential for solar photovoltaics and wind power in almost all countries, but we are still at a relatively early stage in global deployment. The development of national roadmaps for power sector transformation can ensure that measures are adapted to local conditions, stakeholders are aligned at an early stage, and ambitious renewable energy targets are realised," said IRENA Director-General Adnan Z. Amin.

The report highlights the major importance of stakeholder engagement in the development of national roadmaps. For example, utilities are a central stakeholder in the power sector with vast experience in managing generation assets, power flows, and dealing with sudden events.

However, the power sector transformation will attract new stakeholders, and the role of existing stakeholders will change. The need for more distributed control systems will also introduce a new information paradigm, with impacts on data processing capabilities, data sharing, privacy laws, communication protocols, and data security measures, the report finds.

Aditya Birla Group joins hands with Abraaj Group

The Aditya Birla Group, a US$ 41 billion multinational conglomerate, has announced a partnership with The Abraaj Group (Abraaj), an investor operating in global growth markets, to build a large scale renewable energy platform focused on developing utility-scale solar power plants in India. The Aditya Birla Group will invest in the platform through Aditya Birla Nuvo Limited (ABNL) and Abraaj will invest through one of its affiliates.

ABNL has entered into a definitive Share Subscription and Shareholders Agreement (SSA) with an affiliate of Abraaj. In accordance with the SSA, subject to the customary closing conditions and subject to the requisite approvals, ABNL and the Abraaj affiliate will hold 51% and 49% of the paid up share capital respectively, in Aditya Birla Renewables Limited, currently a wholly owned subsidiary of ABNL. Aditya Birla Renewables Limited, the solar power platform, will bid for projects tendered at national and state auctions, with the intent to develop and operate utility-scale solar power plants that can provide clean and cost-effective electricity to the national grids across several key states in India.

The partnership comes at an opportune time in the growth of the Indian renewable energy sector. The demand for power in India is rising as a result of the country's growing population, rapid urbanisation and increasing economic activities.

At the same time, the Indian government has created favourable regulatory policies to foster the use of renewable energy, including setting an explicit target to achieve 100 GW of solar power capacity by 2022 – compared to the current installed capacity of approximately 4 GW.

Together, these factors create a compelling investment opportunity for the private sector, which can help meet this significant demand for renewable energy.

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MEMORANDUM OF UNDERSTANDING

MNRE, Government of Mozambique sign MoU

The Union Cabinet chaired by the Prime Minister Narendra Modi, has approved the MoU (Memorandum of Understanding) between the Ministry of New and Renewable Energy, India and Mozambique.

The MoU was signed between the Ministry of New and Renewable Energy of the Government of India and the Ministry of Mineral Resources and Energy, Government of Mozambique in New Delhi on 5th August, 2015, during the visit of Filipe Nyusi, President of Mozambique to India.

The MoU will help in strengthening bilateral cooperation between the two countries. The objective of this MoU is to establish the basis for a cooperative institutional relationship to encourage and promote technical bilateral cooperation, investment promotion and partnership on new and renewable energy issues on the basis of mutual benefit, equality and reciprocity.

The areas of cooperation will focus on development of new and renewable energy technologies in the field of conducting on-the-job and specialised training courses on renewable energy field, research & development and of technology transfer in renewable energy, including Labs; Exchange of experience on different kinds of renewable energies, focusing on solar, wind, biomass, biofuels and geothermal; Establish a bilateral private sector renewable energy platform; Scientific visits and any other mutually agreed areas.

ENERGY EFFICIENCY FINANCING

BEE, Powermin, take step in making ESCOs bankable

A view of the roundtable meeting with Banks/FIs/ESCOs...

Ministry of Power and Bureau of Energy Efficiency have constituted Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE) for providing financial institutions (Banks/NBFCs) a partial coverage of risk involved in extending loans for energy efficiency projects.

Under this programme, Energy Efficiency Services Ltd. (EESL) organised a roundtable meeting with Banks/FIs/ESCOs on 3rd October, 2015 in Mumbai. The meeting was chaired by B.N. Pandey, Additional Secretary, Ministry of Power and attended by various representatives from Banks and ESCOs. During the meeting a charter was signed between BEE and Yes Bank for empanelment of Participating Financial Institutions (PFIs) under PRGFEE, which is expected to set the tone for other Banks/NBFCs to join this league and contribute in promoting Energy Efficiency in India.

Speaking on the occasion, the Additional Secretary said that "Funds like PRGFEE and VCFEE shall help Government of India in meeting the voluntary targets set under India's Intended Nationally Determined Contribution, where India has declared a voluntary goal of reducing the emissions intensity of its GDP by 33 to 35% by 2030 from 2005 levels". Namita Vikas, Senior President and Country Head, Responsible Banking also added, "Yes Bank is glad to partner with Bureau of Energy Efficiency in making ESCOs bankable. As the MSME sector is the cradle for the government's 'Make in India' vision, strengthening and building of the sector on energy efficiency is an integral part of YES BANK's sustainability approach and we are engaging with stakeholders on all fronts to create maximum impact for climate action in India."

SOLAR ENERGY

Conergy to build a solar power plant at Thailand

Global solar power expert Conergy has signed a new contract with B.Grimm Power Limited, one of Thailand's foremost energy producers, to construct a solar power plant with an 8MWp capacity in Sa Kaeo province in support of the government's mission to have 20% of the country's energy needs supplied by renewable sources by 2036.

The 178,000-square meter solar park is one of numerous installations being developed by Conergy in partnership with private domestic power producers – and is geared to exploit the natural sunlight available and help create a sustainable renewable energy supply – that will contribute to the kingdom's future economic growth – and also reduce the use of fossil fuels, thereby preserving and enhancing the environment. The radical reduction of CO_2 emissions created in traditional fossil-fuel electricity generation is a guiding ambition.

"With abundant year-round sunshine and also the availability of highly suitable sites for solar power plants, Thailand is leading the way in ASEAN in terms of increasing its capacity to produce energy from renewable sources," said Conergy's President for Asia & ME, Alexander Lenz.

"By partnering with visionary companies such as B.Grimm Power Limited, Conergy is able to integrate its global expertise and experience into Thailand's dynamic program to focus on renewable energy and reduce the country's dependence on fossil fuels. The bold investment in renewable energy from solar sources is a long-term initiative that will continue to pay dividends for decades and help ensure a sustainable energy supply for future generations," added Lenz.

Turnkey project Kuwait

400kV, 4000A:
Substations Fintas & Sulaibiya
Project highlights:

- 18km of cables, 2500mm², 400kV, enamelled conductor
- 36 GIS terminations
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AUTOMATION & SYSTEMS

ABB to help Brazilian pulp plant increase production

ABB will supply integrated process electrification, automation and optimisation systems for Fibria's new pulp mill...

ABB will supply integrated process electrification, automation and optimisation systems for Fibria's new pulp mill in Mato Grosso do Sul, Brazil. Civil works on the 'Horizonte2' project will begin at the end of 2015, with the new plant coming online in 2017.

The Fibria unit in Três Lagoas is already today one of the world's largest pulp production plants. Once completed, the new mill will more than double the plant's capacity through the addition of 1.75 million tons of pulp production per year. The pulp produced by Fibria is used for a wide range of papers including tissue, printing and writing.

ABB is supplying an integrated electrification and automation solution that will be applied in almost all process areas – allowing for control and operation of the new mill alongside the existing one. The short-fibre eucalyptus pulp manufacturer awarded ABB the project based on technical and commercial criteria. According to Peter Terwiesch, President of ABB's Process Automation Division, ABB's combined power and automation portfolio means the company is ideally positioned to provide integrated electrification and automation solutions for process industries such as pulp and paper.

"Having a single control system for two different plants increases the productivity and effectiveness of our customers. With our integrated power and automation solutions, we are making industry more efficient and ready for the Internet of Things, Services and People, in line with our next level strategy," added Terwiesch. The project scope consists of expanding the primary substation, the gas-insulated switchgear technology, distribution transformers for the plant and power transformers for the generators, as well as low voltage switchgear, variable-speed drives, low and medium voltage motors and DCS.

Also integrated is an asset optimisation system that allows ABB to remotely monitor operations from a location thousands of kilometers away to provide data to support Fibria's maintenance engineering decisions. This will help the pulp manufacturer optimise its maintenance strategy procedures.

DISTRIBUTION

Siemens to modernise C&I systems of NTPC's plant

Siemens Ltd. – a technology powerhouse that has stood for engineering excellence, innovation, quality and reliability – together with its parent company Siemens AG, has won an order totalling approximately ₹ 183 crore from NTPC Ltd. The component of Siemens Ltd. in the order is almost ₹ 97 crore. The scope of work includes modernisation and maintenance of Controls and Instrumentation at NTPC's Dadri Power Gas Station. It'll deliver improved plant availability, quick reaction in critical situations, integrated workflows, smooth & reliable day-to-day I&C operation, ergonomic design and integration of further applications.

POWER

UDAY will lead to ₹ 1.8 lakh crore savings annually

Union Minister of State (IC) for Power, Coal and Renewable Energy, Piyush Goyal has asserted that the newly unveiled debt restructuring plan for DISCOMs, will eventually lead to a saving of ₹ 1,80,000 crore annually.

Named UDAY (Ujjwal Discom Assurance Yojana), the package involves a massive bailout plan for debt ridden Discoms, besides measures to reduce power thefts, align consumer tariff with generation cost and promote energy efficiency.

GENSET

Sterling Generators to expand its dealer network in Tamil Nadu

Sanjay Jadhav

Sterling Generators, one of the well known manufacturers of DG Sets in Asia is expanding its sales network across India. The company has started execution of its plan from Tamil Nadu. Currently Sterling Generators has more than six dealers across Tamil Nadu. It is planning to spread out to more cities increasing its dealer network to 15 by 2016. Looking at the increasing demand of DG Sets in the tier 2 and 3 cities, Sterling Generators has embarked on building a strong dealership network offering the complete range of Sterling DG sets from 10 kVA up to 3000 kVA in these cities.

Commenting on the expansion strategy being implemented by Sterling Generators in Tamil Nadu, Sanjay Jadhav, President, Sterling and Wilson Powergen Pvt Ltd., said, "We are committed to offering the best diesel generators to our customers. We already have a strong presence across the country but are looking to strengthen our reach in Tamil Nadu. We look forward to establishing a robust dealer network to reach out to discerning customers with our extensive range of diesel generators and services while continuing to serve our existing client base. We are confident that our project execution capabilities coupled with our quality and fuel efficient gensets will help us provide customers with a one stop solution to all their back-up power needs."

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AWARD

Tata Power bags award for corporate integration

On behalf of Tata Power, Chetan Tolia is receiving the award...

Tata Power has been awarded the prestigious Porter Prize for excellence in corporate integration & governance. The company was commended for its outstanding performance driven through excellence in corporate integration, superior board room performance and exploring the synergies between different business divisions and governance mechanisms.

Organised by Institute for Competitiveness, India, the Porter Prize 2015 in its fourth edition, continued its legacy of identifying the best corporates across various segments for being an inspirational force for corporates in becoming more strategic and competitive. The award was received on behalf of the organisation by Chetan Tolia, Chief Human Resource Officer, Tata Power.

Speaking on the achievement, Anil Sardana Managing Director and CEO - Tata Power, said, "This is indeed a moment of great pride for Tata Power and we are delighted to have been recognised for our good work at a national platform."

"The Porter Prize is indeed a commendable recognition, which serves as further motivation in our efforts towards being a world class organisation. The company is committed to delivering excellence across all verticals. I would like to take this opportunity to thank the Porter Prize awards team, and all our employees for their exceptional work, which enables us to take our company to greater heights each day," he added. The Porter Prize India is named after Michael E Porter, Professor at Harvard Business School and a leading thinker in the field of strategy.

TECHNOLOGY CENTRE

Regal Beloit opens its new global technology centre at Pune

Regal Beloit's new facility is the new home for over 90 engineers...

Regal Beloit has inaugurated its new global technology centre at Pune. The new Global Technology Center is located at Rajiv Gandhi Infotech Park, Hinjewadi.

This state-of-the-art facility is the new home for over 90 engineers and technicians.

The well-equipped facility supports new product development as well as engineering support and software development for Regal's power transmission customers worldwide.

J Gilebe, Chairman & Chief Executive Officer of Regal Beloit Corporation, recently inaugurated Regal's Global Technology Center at Pune. He was accompanied by John Thomas, Vice President – Asia Pacific along with Sheel Kapoor, President of Regal's India Operations. While inaugurating the facility, Gilebe said, "I'm excited to celebrate the opening of this world-class facility, which is home to so many talented engineers here in Pune. I am confident they will accomplish great things for our customers, and I look forward to their valuable contributions to Regal's success."

The Pune technology center builds on Regal's long term investment in the people and economy of India. Regal Beloit has another Global Technology Center in Hyderabad, and manufacturing operations in Faridabad and Kolkata. Together these facilities design, develop and manufacture electric motors for Regal's Climate Solutions and Commercial and Industrial Systems customers worldwide.

ORDER/CONTRACT

Alstom T&D India to improve Odisha's grid infrastructure

Overview of an AIS substation...

Alstom T&D India has been awarded contracts by Odisha Power Transmission Corporation Limited (OPTCL) worth close to €20 million (approx. INR 1403 million). The contracts include the supply of a 400/220 kV Air Insulated Substation (AIS) as well as Gas Insulated Substation (GIS) in Odisha. These substations form a part of the major drive initiated by OPTCL to improve the transmission network of the state.

The AIS will be installed at Lapanga in Odisha's northern district of Sambalpur. Alstom will manage the related civil, mechanical and electrical works to construct twelve 400 kV bays and two 220 kV bays along with the necessary electrical equipment. All equipment will be engineered & manufactured in Alstom's world class facilities in India.

Alstom will also deliver a GIS consisting of five 220 kV bays, nine 132 kV bays, substation automation and control system as well as associated civil works. The substation will be installed at Chandaka, less than 15 km from Bhubaneswar, Odisha's capital. This substation will feed the existing 132 kV load centre substations and as a result, strengthen the power supply backbone of this capital city.

Rathin Basu, Managing Director, Alstom T&D India said, "Alstom has been a regular supplier for OPPTCL, one of the largest state utilities in India. There has been an increasing focus on improving Odisha's transmission infrastructure and an emphasis on turnkey projects. As a leader in this segment, Alstom is delighted to participate in these projects and is well poised to meet the growing requirements of the customer."

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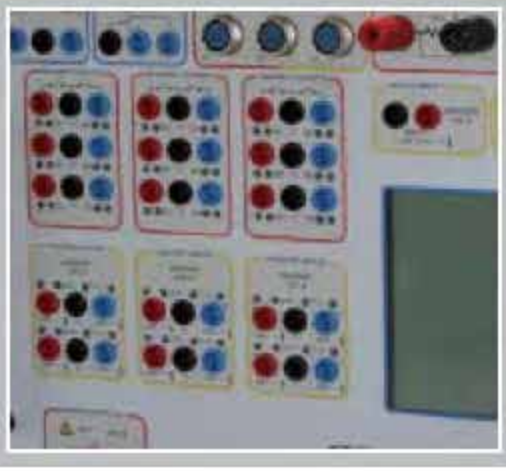

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POWER GENERATION

Floating power plant to use Alstom transformers

The Karadeniz Powership...

Alstom has signed a contract with Karadeniz Energy Group, to supply power transformers for the Turkish, Karadeniz Powership Osman Khan (KPS12) power plant. At 486 MW, the Karadeniz Powership Osman Khan will be the world's largest floating power plant. The delivery is planned to be completed by early 2016. Alstom will design, manufacture and deliver 200 MVA power transformers, inclusive of commissioning, field tests and respective spare parts. The transformers will be produced in Alstom Grid's manufacturing site in Gebze, Turkey, one of the most modern power transformer factories in the world.

"Alstom is very pleased to work with Karpowership, the world leader in floating power plants, on this Powership concept. This contract reflects the quality and the high performance of Alstom's transformers, as well as its technical expertise in this field. The ability to help countries meet short term energy demand quickly and in a cost efficient manner is an important step to providing more people access to sustainable and reliable electricity," said Tunc Tezel, Commercial Director, Alstom Grid Power Transformers.

POWER TRANSMISSION

Sterling and Wilson to construct power plants in Egypt


Bikesh Ogra

Sterling and Wilson (S&W) is aiming to construct 300 MW Solar Photo-voltaic Projects in Egypt under its Feed-In-Tariff Program for Renewable Energy initiated by Ministry of Electricity & Renewable Energy. S&W has recently opened its international office at Cairo, capital of Egypt to capitalise on the current opportunities offered by this programme and provide its customised & cost effective Solar EPC Solutions.

Having already won two Solar PV Projects of size 50 MW each, Sterling and Wilson looks forward to building another 200 MW in Egypt. It will be constructed for Consortiums of Solar Project Developers & IPPs qualified under Feed-In-Tariff programme, at Solar Parks being developed by New & Renewable Energy Authority of Egypt at Ben Ban, Aswan & Zafarana. The company is already active in Middle East, through a number of its businesses like Solar EPC, MEP & Diesel Generator. It has well established offices in Riyadh, Dubai and Qatar. It has been recently awarded Solar EPC Contract of 62.5 MWp in Jordan.

The setting up of its local office in Cairo is a testament to Sterling and Wilson's commitment of establishing itself as the numero uno Solar EPC Company in Egypt.

Speaking on venturing into Egypt and its target of 300 MW, Bikesh Ogra, President, Electrical & Solar Business of Sterling and Wilson, said, "We at Sterling and Wilson are committed to offering our customised Solar EPC Solutions to internationally renowned Solar Project Developers & IPPs including local clients. It gives us immense pleasure to be able to execute solar projects across the globe within tight timeframes and costs, which are key indicators of our project execution capabilities. We are confident of reaching our target in Egypt and are delighted that we are engaged with qualified companies, many of with whom we are already working in South Africa, Jordan, UAE, India, South East Asia, & Latin America."

TRANSFORMERS

CG to supply power transformers to PT PLN of Indonesia


Laurent Demortier

CG has bagged an order from PT PLN for manufacture and supply of power transformers, valued at USD 62 million (approx INR 410 crore). The scope of work includes design, manufacture, supply, construction and installation of these power transformers in the range of 30 to 268 MVA. They will be installed in Java, Sumatra, Kalimantan and Makassar islands of Indonesia. The project is aimed at enhancing the performance of PT PLN's transmission grid. This order reinforces the existing strong relationship between CG and PT PLN. By way of these prestigious orders, CG has consistently built its reputation as a top quality provider of turnkey products and solutions in the Indonesian market, with approx USD 93 million worth of orders already booked in the first half of the current year.

Power Transformers are very critical equipment for PT PLN considering the present power situation in Indonesia. CG products meet the stringent quality parameters of PT PLN, particularly in terms of Partial Discharge wherein, its standards far exceed the IEC standards and the Degree of Polymerization, thus ensuring long lasting, trouble-free operations. Their compact design maximise space utility and achieve optimum energy efficiency. Through the deployment of CG's power transformers, PT PLN will be able to lessen its dependence on the import of heavy equipment, while simultaneously executing a timely implementation of its transmission network strengthening programme. PT PLN with an installation base of 48 GW is the sole government-owned corporation in electricity generation, transmission and distribution in Indonesia.

CG's CEO and Managing Director Laurent Demortier said, "We are honoured to have PT PLN's continued faith in us as a partner of choice and are well positioned to support them in their network strengthening goals. The CG edge lies in providing indigenously built products and turnkey services that reflect global standards, while suiting local conditions. We look forward to being a part of many more collaborative efforts that involve building robust power transmission networks, in Indonesia and the rest of Asia."

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Netherlands Doubles Use Of Geothermal Energy

As per a 2011 report of International Energy Agency, "There is potential to achieve at least a tenfold increase in the global production of heat and electricity from geothermal energy. Heat emitted from within the earth's crust, between now and 2050." However, owing to multiple reasons, so far worldwide harnessing rate of the geothermal energy is rather slow. Under such circumstances, Netherlands has shown a good progress.

The use of geothermal heat and energy in the Netherlands is increasing continually. Although the share of these new energy sources is still very modest, the production of geothermal heat has more than doubled between 2009 and 2014, according to Statistics Netherlands (CBS).

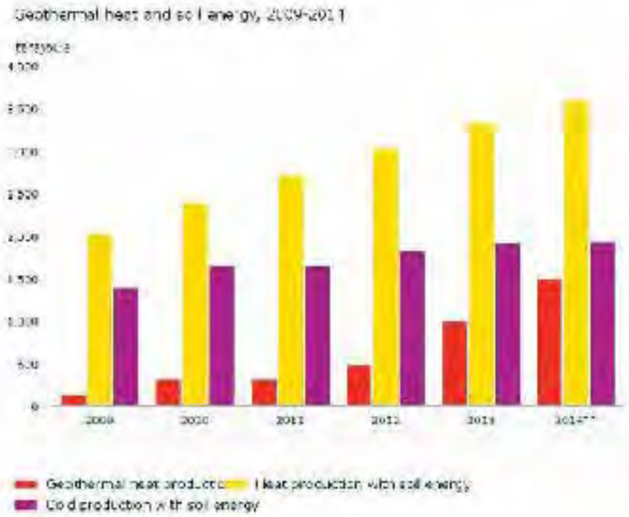
Geothermal heat accounts for 4% of renewable energy

Last year, these relatively new energy sources accounted for more than 4% of total renewable energy consumption. In turn, renewable energy accounts for less than 6% of total energy consumption in the Netherlands, so the share of geothermal heat and energy is still very modest.

Use of geothermal heat in horticulture under glass growing rapidly

Geothermal heat, also referred to as geothermal energy, is defined as the direct use of heat stored in the bowels of the earth. In the Netherlands, geothermal heat has been used since the end of

The generation of geothermal energy uses hot or cold air, which is stored in the upper layer of the soil. The use of geothermal heat and energy in the Netherlands is increasing continually...



2008 to pump up hot groundwater from deeper layers of the earth. Today, this technology is applied in ten locations.

The government has introduced the Guarantee Scheme Geothermal Heat to encourage the use of geothermal energy and reduce the risks for those engaged in this technology. The scheme partly covers the risks of unsuccessful drilling attempts.

Since 2012, geothermal heat projects also qualify for subsidy schemes. On 1st March this year, a total amount of 1.1 billion Euros in subsidies was granted to 33 projects, although it is as yet uncertain whether all these projects will in fact be realised.

Generation of geothermal energy 80% up

The generation of geothermal energy uses hot or cold air, which is stored in the upper layer of the soil, and that is often used as a combination of two things: heat extraction in winter and cold extraction in summer.

This technology was already applied in the Netherlands before geothermal heat was used. Over the past half decade, generation of heat from geothermal energy has soared by 80%.

This technology is commonly applied in large, new office buildings – and is cost-effective because in this type of non-residential buildings there is often a demand for heat and cold.

The horticultural sector also uses extensive geothermal systems to heat greenhouses. Nearly 30% of geothermal heat is used to heat greenhouse interiors.

Way To Raise Capacity Of **Micro-Supercapacitors** Discovered

Researchers have developed an electrode material that will help electrochemical capacitors produce results similar to batteries...

Micro-supercapacitors are a promising alternative to micro-batteries because of their high power and long lifetime. They have been in development for about a decade but until now they have stored considerably less energy than micro-batteries, which has limited their applications.

Now researchers in the laboratoire d'analyse et d'architecture des systèmes (LAAS-CNRS) in Toulouse and the INRS in Quebec have developed an electrode material that means electrochemical capacitors produce results similar to batteries, yet retain their particular advantages.

This work was published on September 30, 2015 in Advanced Materials. With the development of on-board electronic systems and wireless technologies, the miniaturisation of energy storage devices has become necessary. Micro-batteries are very widespread and store a large quantity of energy due to their chemical properties. However, they are affected by temperature variations and suffer from low electric power and limited lifetime (often around a few hundred charge/discharge cycles).

By contrast, micro-supercapacitors have high power and theoretically infinite lifetime but only store a low amount of energy. Micro-supercapacitors have been the subject of an increasing amount of research over the last ten years but no concrete applications have come from it. Their over energy density, i.e. the amount of energy that they can store in a given volume or surface area, has meant that they were not able to power sensors or microelectronic components.

Researchers in the Intégration de systèmes de gestion de l'énergie team at LAAS-CNRS, in collaboration with the Institut national de la recherche scientifique of Quebec, have succeeded in removing this limitation by combining the best of micro-supercapacitors and micro-batteries. They have developed an electrode material whose energy density exceeds all the systems available to date.

The electrode is made of an extremely porous gold structure into which ruthenium oxide has been inserted. It is synthesised using an electrochemical process. These capacitive materials can be used here because the components are tiny - of the order of square millimetres. The electrode was used to make a micro-supercapacitor with energy density 0.6 J/cm², which is about 1000 times greater than existing micro-supercapacitors and very similar to the energy characteristics of current Li-ion micro-batteries. With this new energy density, their long lifetime, high power and tolerance to temperature variations, these micro-supercapacitors could finally be used in wearable, intelligent, on-board microsystems.

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Measuring Specific Atoms' Move In Dielectric Materials

The work uses a technique called a pair distribution function, which allows researchers to extract information about – how atoms are arranged at extremely small length-scales based on the weak intensity X-rays diffracted from a sample...

Researchers from North Carolina State University, the National Institute of Standards and Technology (NIST), and UNSW Australia have measured the behaviour of specific atoms in dielectric materials when exposed to an electric field. The work advances our understanding of dielectric materials, which are used in a wide variety of applications – from handheld electronics to defibrillators.

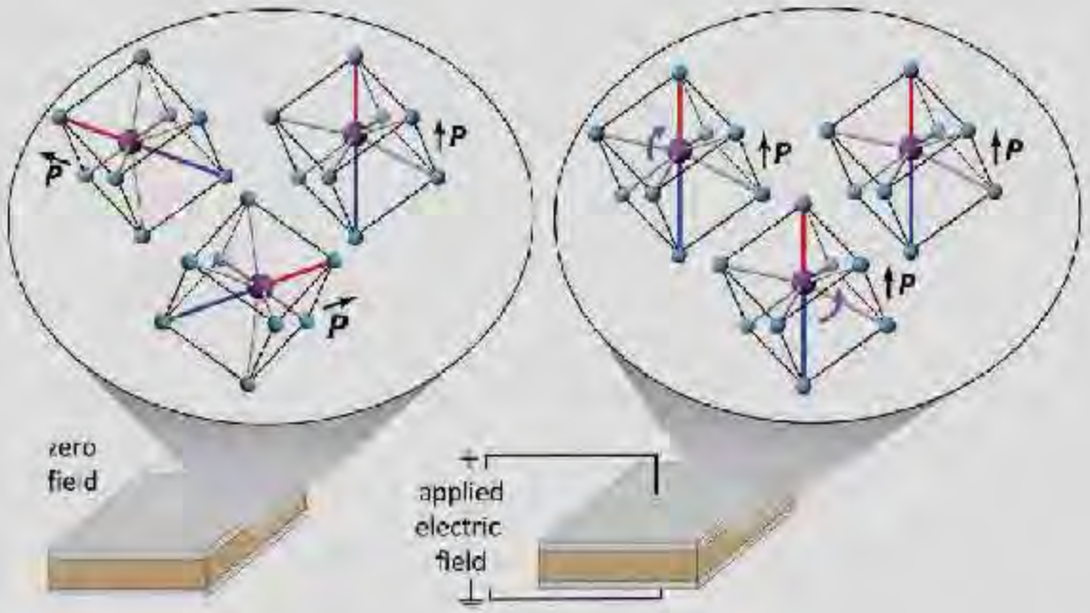
"Dielectric materials are insulators that can store and manage electric charge. But we hadn't yet directly measured how atoms move in dielectric materials in order to store that charge," says Tedi-Marie Usher, a Ph.D. candidate in materials science and engineering at NC State and lead author of a paper on the research work.

To get to the bottom of this problem, the researchers applied voltage to a dielectric material, creating an electric field. They simultaneously bombarded the material with X-rays from a synchrotron at Argonne National Laboratory's Advanced Photon Source.

When the X-rays hit the material, they scattered into a series of bright rings. Typically, to figure out the arrangement of atoms in a material, the positions and intensities of these bright rings are analysed.

However, by applying new mathematical techniques that are more sensitive to the weak (dim) scattered X-rays, the researchers could determine changes in the placement of specific atoms within the crystalline structure of the material. In other words, the researchers could see how the atoms moved relative to each other in response to the electric field.

"A good analogy would be that analysing the bright rings is like examining a skyscraper from far away and determining that each office is 500 square feet," explains Usher.



"However, by also analysing the weak X-rays scattered from the sample, we can determine that some of these are 400 square feet and others are 600 square feet, and some have the desk on the east side, and others have the desk on the north side," Lanier explains. "This is an uncommon approach because experimenters typically only evaluate the bright rings.

"What's really new here is that this technique is much more sensitive to the behaviour of select atoms, relative to their neighboring atoms, rather than looking at an average of all the atoms in a sample," says Jacob Jones, a Professor of Materials Science and Engineering at NC State and Corresponding Author of the paper.

The work uses a technique called a pair distribution function, which allows researchers to extract information about how atoms are arranged at extremely small length scales based on the weak intensity X-rays diffracted from a sample.

The researchers evaluated three different dielectric materials for this study.

"One of the interesting findings here is that each of the three dielectric materials we tested exhibited very different behaviours at the atomic level – there was no single atomic behaviour that accounted for dielectric properties across the materials," Jones says.

For example, the researchers tested a material called sodium bismuth titanate – a non-lead material that is thought to be promising for use in dielectric devices.

In the absence of an electric field, researchers knew that the bismuth ions are off center relative to neighboring atoms. But different bismuth ions would be off center in different directions.

However, when an electric field is applied, nearly all of the bismuth ions are off center in the same direction as the electric field.

"Neither of the other dielectric materials exhibited similar behaviour. One of our questions for future work is whether the bismuth behaviour we saw in sodium bismuth titanate is consistent across bismuth-based dielectrics," Usher says.

"We also want to know how dielectric materials and other complex materials, such as high entropy alloys, behave at the atomic scale when under mechanical stress," adds Professor Jacob Jones.

Waste To Energy Market To Expand At 8.1% CAGR

In 2012, the global waste to energy market was valued over US$18.4 bn and by 2019, the market is projected to be worth more than US$31.8 bn...

According to the latest research report, titled, "Waste to Energy Market - Global Industry Analysis, Size, Share, Growth, Trends and Forecast, 2013 – 2019," published by Transparency Market Research, the global waste to energy market will expand at an 8.1% CAGR during the forecast period from 2013 to 2019. In 2012, the global waste to energy market was valued over US$18.4 bn and by 2019, the market is projected to be worth more than US$31.8 bn.

The global waste to energy market is driven by the rising concern towards energy security and growing regulatory support and funding. In addition to this, factors such as the reduced greenhouse gas emission from landfills and air movement on landfills will also drive the global waste to energy market. On the other hand, the global waste to energy market will be restrained by the high initial cost associated with setting up waste to energy plants.

On the basis of technology, the global waste to energy market is divided into thermal and biological. At present, the thermal technology sector dominates the market in terms of revenue, while the biological technology sector is projected to demonstrate the fastest growth during the forecast period. In 2012, the thermal technology sector held a massive market share of 90% in the global waste to energy market. The thermal technology sector is driven by the strong demand due to increased taxes on landfills, the ability of thermal technology to minimise the amount of waste and the elevated amounts of municipal solid waste. By geography, the global waste to energy market is segmented into Asia Pacific, Europe, North America and Rest of the World (RoW). At present, Asia Pacific dominates the global waste to energy market and generates more than 40% of the total market revenue. The Asia Pacific waste to energy market is expected to witness healthy growth during the forecast period. The regional market is fuelled by rising economic development and accelerating disposable income.

Sita UK, a Suez Environnement subsidiary, has an energy from waste facility at Teesside (UK)...

At present, Spain has the highest level of sustainable waste management, while China and India have the potential to generate massive volume of wastes that can be used in waste to energy plants. The 12th Five-Year Plan of China (2006 to 2011) has also helped in the construction of many new waste to energy facilities in the region, which has further fuelled the Asia Pacific market. Furthermore, backed by the growing trend of improving the quality of life in developing regions in Asia Pacific, these countries are increasingly focusing on waste to energy practices. This will in turn fuel the overall growth of the waste to energy market.

Previously, Europe was the leading contributor in the global waste to energy market due to the incorporation of highly advanced technologies in treating solid wastes. However, the current economic stagnation and dependency on certain countries due to landfills has restricted the market, which has shown a less than impressive performance in the past few years.

Players in the global waste to energy market are projected to benefit from the ever growing population and accelerating disposable income fueling waste generation.

Some of the key players operating in the global waste to energy market are Of the Evergreen International Limited, C&C Environmental Protection Holdings, Covanta Energy Corporation, Constructions Industrielles de la Méditerranée (CNIM), Suez Environment S.A., Waste Management, Inc. and Veolia Environnement.

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Southeast Asia Risks And

he energy landscape in Southeast Asia continues to shift as rising demand, constrained domestic production and energy security concerns lead to a greater role for coal, a sharp rise in the region's dependence on oil imports and the reversal of its role as a major gas supplier to international markets.

"As Southeast Asia flourishes, it is moving to the centre of the global energy stage. Countries in the region now have much in common with IEA members. We must all work together to build more secure and sustainable energy supplies and markets, as platforms for promoting economic development," IEA Executive Director Fatih Birol said.

The World Energy Outlook Special Report on Southeast Asia (WEO Special Report) presents a central scenario in which Southeast Asia's energy demand increases by 80% in the period to 2040, though the region's per capita energy use remains well below the global average. Despite policies aimed at scaling up the deployment of renewable resources, the share of fossil fuels in the region's energy mix increases to around 80% by 2040, in stark contrast to the declining trend seen in many parts of the world.

Rising imports sharpen the focus on the economic and security aspects of energy use. By 2040 the region's net oil imports more than double to 8.7 mb/d, a level equivalent to the current oil imports of China. Southeast Asia's oil import bill surges to over $300 billion per year by 2040, compared with around $120 billion in 2014, with increases in spending in almost all countries in the region.

Indonesia supports a continued expansion of Southeast Asia's gas and coal output, but production is increasingly consumed within the region. As domestic natural gas demand outpaces indigenous production, intra-regional and intra-country trade increases, and Southeast Asia turns into a net gas importer of around 10 bcm by 2040, compared with net exports of 67 bcm in 2013.

The power sector shapes the energy outlook for Southeast Asia, as electricity demand almost triples by 2040, an increase greater than the current power output of Japan. The sector continues its shift towards coal due to its abundance and relative affordability. Although the average efficiency of Southeast Asia's coal-fired power plant fleet increases by 5 percentage points throughout the projection period, less-efficient subcritical technologies account for 50% of the region's coal power fleet in 2040, highlighting the need to accelerate the deployment of more efficient technologies in the region to reduce local pollution and slow the rise in CO_2 emissions.

The WEO Special Report, prepared in collaboration with the Economic Research

To Face Both Opportunities

Institute for ASEAN and East Asia (ERIA), analyses four key issues that will shape the future of Southeast Asia's energy system: energy investment, power grid interconnection, energy access and fossil-fuel subsidies. "The reliability and sustainability of Southeast Asia's energy system depends on investment," ERIA Director of Energy Markets and Security Keisuke Sadamori said at the release of the report in Kuala Lumpur, during the ASEAN Ministers on Energy Meeting. "To secure its energy needs, the region requires $2.5 trillion of investment in energy-supply infrastructure in the period to 2040, but for this to materialize we need to see more progress with reforms to domestic energy markets and the establishment of improved policy frameworks."

The report notes that greater integration of the region's energy markets could help catalyse development of energy resources, facilitate more efficient use of the region's resources and enhance energy security. It also highlights the significant progress achieved by the region in expanding energy access but urges increased action as 120 million people remain without access to electricity while almost 260 million lack clean cooking facilities.

The report also calls for more efforts to reduce subsidies to fossil fuels, noting that the region spent $25 billion on fossil fuel subsidies in 2014 despite reforms in Indonesia, Malaysia, Thailand and Myanmar.

The WEO Special Report also includes an in-depth focus on Malaysia that highlights the ongoing changes for country's energy sector.

Malaysia's energy demand almost doubles by 2040 with fossil fuels continuing to meet over 90% of demand throughout the period, with coal overtaking oil and gas to become the primary fuel in Malaysia's energy mix.

Renewables, aided by government policies and incentives, grow especially in the power sector where their share of generation reaches 16% by 2040. Malaysia's role in international markets shifts as it becomes increasingly dependent on imports.

DRIVING ENERGY EFFICIENCY IN DOMESTIC LIGHTING

Tata Power has launched an LED tube light programme for its residential consumers in Mumbai to encourage them to adopt energy efficient lights, and thereby save power...

In a power starved country like India, energy conservation has no alternative to save our nation economically and environmentally. Lighting consumes around 14% of the total energy generated in the country. Thus, the time calls for dropping the antiquated technologies and embracing the new ones. Under such circumstances, eventually the Indian power companies are bringing different schemes to encourage consumers to switch over to the new LED technology. Now, it is the turn of Tata Power.

India's largest integrated power company, Tata Power, has always been committed to the cause of energy conservation, and has been contributing consistently towards a brighter and greener tomorrow by undertaking several initiatives. In line with its philosophy, recently it has launched an LED tube light programme for its residential consumers in Mumbai to encourage them to adopt energy efficient lights, thereby, saving power. The programme has been initiated by Tata Power in partnership with M/s Osram India Ltd., a German MNC – and one of the two leading light manufacturers in the world.

The initiative is a part of the Demand Side Management programme to promote the use of highly efficient LED technology amongst households. Tube lights are widely used in houses. A standard 40 watt tube light can be replaced by 22 watt LED T-Ring, which will give better lumen output and have much longer life. Under this programme, each residential consumer is eligible to procure 6 LED tube light fittings at a price of Rs. 626 each, against a market price of Rs. 1325/- each. The products would be home delivered to the consumers who sign up for the scheme, and they would also get an exclusive three year warranties on the LED tubes. To avail to this scheme, consumers can register themselves online on the Tata Power website or at 24X7 call center.

Speaking on the initiative, Ashok Sethi, COO and Executive Director, Tata Power, said, "We have launched this programme after receiving an overwhelming response from the consumers on our LED bulb scheme. The importance of energy management and conservation is increasing with each passing day – and it is here that LED scheme can play a very important role. Such initiatives confirm our commitment towards energy efficiency and demand side management, both of which are integral to Tata Power's commitment to 'Sustainability'."

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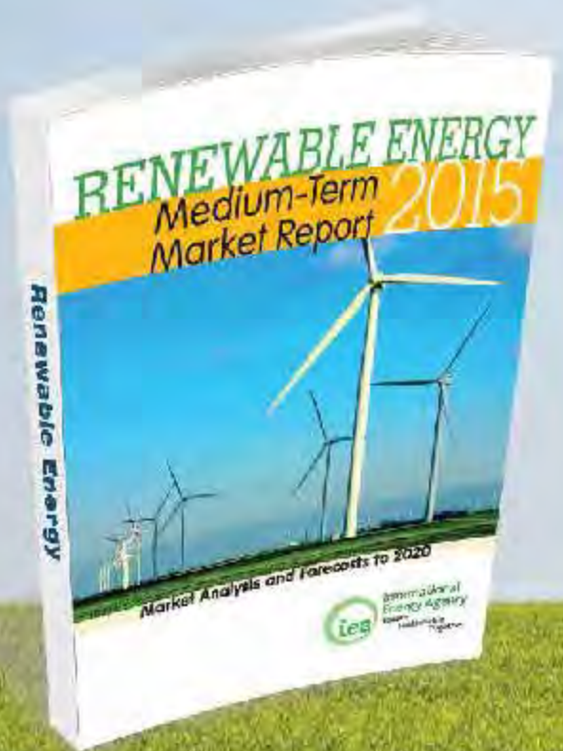
Remove The Question Marks Over Renewable

As costs fall and emerging economies drive growth, International Energy Agency's (IEA's) recent report sees major opportunities – but policy uncertainties remain...

Renewable energy will represent the largest single source of electricity growth over the next five years, driven by falling costs and aggressive expansion in emerging economies, the IEA said in an annual market report. Pointing to the great promise renewables hold for affordably mitigating climate change and enhancing energy security, the report warns governments to reduce policy uncertainties that are acting as brakes on growth deployment.

"Renewables are poised to seize the global top spot in global power supply growth, but this is hardly time for complacency," said IEA Executive Director Fatih Birol as he released the IEA's Medium-Term Renewable Energy Market Report 2015 (MTRMR) at the G20 Energy Ministers Meeting. "Governments must remove the question marks over renewables if these technologies are to achieve their full potential and put our energy system on a more secure, sustainable path," he added.

Renewable electricity additions over the next five years will top 700 gigawatts (GW) – more than today's total installed power capacity of all fossil fuels combined – and will account for almost two-thirds of net additions to global power capacity – that is, the amount of new capacity that is added



unnecessary curtailment or shedding of existing power plants. Non-hydro sources such as wind and solar photovoltaic panels (solar PV) will represent nearly half of the total global power capacity by 2050.

The report sees the share of renewable energy in global power generation rising to over 60% by 2050 from 23% in 2013 – a remarkable shift in a very limited period of time. By 2050, the amount of global electricity generation coming from renewable energy will be higher than today's combined electricity demand of China, India and Brazil.

The report says the geography of deployment will increasingly shift to emerging economies and developing countries, which will make up two thirds of the renewable electricity capacity up to 2020. China alone will account for nearly 40% of total renewable power capacity growth and requires almost one-third of new investment to 2020.

Declining costs drive growth

Renewable generation costs have continued in many parts of the world due to sustained technology progress, improved financing conditions and expansion of deployment to newer markets with better resources. Announced prices for long-term generation contracts at record levels are emerging in areas as diverse as Brazil, India, the Middle East, South Africa and the United States. As such, some countries and regions now have the potential to capture a development pathway mainly based on increasingly affordable renewable power. This is especially true in Sub-Saharan Africa.

"Affordable renewables are set to dominate the emerging power systems of the world. With good orientation, solar and wind resources, improving cost-effectiveness and policy momentum, renewables can play a critical role in supporting economic growth and energy access in sub-Saharan Africa, meeting almost two-thirds of the region's new demand needs over the next two years," Dr Birol said.

Still, the WEO-2015 highlights risks. Planning remains key to achieving sustained investment. Regulatory barriers and constraints, and inappropriate subsidies pose challenges in many emerging economies. In industrialised countries, the rapid deployment of renewables requires scaling down fossil-fired power plants putting incumbent utilities under pressure.

Wavering policy commitments to decarbonisation and diversification in response to such effects can undermine investor confidence and retroactive changes can destroy it. Consequently, global growth in the report's main case forecast trends as far as it could be and annual installations level off, falling short of what's needed to put renewables on track to meet long-term climate change objectives.

The report includes an accelerated case that assesses the impacts of enhanced policy frameworks in key countries, finding that this could boost global cumulative renewable power growth by 20% above the main case, with rising annual installations.

An improving picture for renewables can have positive ramifications for global climate change negotiations. At the same time, a clear, supportive outcome from the COP21 climate negotiations in Paris in December could create a virtuous cycle for renewable deployment by increasing long-term policy vision and predictability.

But this accelerated case requires more coherent and committed policy action. To be sure, system and grid integration will be crucial for enabling high levels of wind and solar PV.

The IEA remains at the forefront of addressing these issues, including possible impacts on electricity security. But while variability of renewables is a challenge that energy systems can learn to adapt to, variability of policies poses a far greater risk," concluded Dr Birol.

CIL PASSED THE YEAR OF ACHIEVEMENTS

Coal India Limited (CIL) witnessed several positives in FY 2014-15. In this FY; Eastern Coalfields Limited came out of BIFR and Bharat Coking Coal Limited (BCCL) was conferred the Miniratna status. Also, three new opencast mines – Magadh and Konar in Central Coalfields Limited, Makardhokra 1, Bhanegaon and Panganga in Western Coalfields Limited, and Jampali in South Eastern Coalfields Limited went operational...

Coal India Limited (CIL), the state owned coal mining behemoth, came up trumps by creating a record incremental increase in a single financial year producing 494.23 Million Tonnes (MTs) of coal in the just concluded fiscal 2014-15 registering a production growth of 8.9%.

"The increase in production in absolute terms was 37.61 Million Tonnes, which is the highest ever incremental increase in a single financial year – since the inception of the company", said Sutirtha Bhattacharya, Chairman of the flagship coal mining behemoth.

"It means, in a single year we have achieved 426% of the absolute increase of 74.36 Million Tonnes, recorded during the entire XIth Five Year Plan. The important challenge is to ramp up our production to match with the largest end sustainability added.

During the last four financial years beginning 2009-10 till 2013-14 the absolute increase in coal production was 37.18 MTs, whereas the production increase in volume terms took a quantum leap to 37.61 MTs in FY 2014-15 alone.

Raw coal off-take

Raw coal off-take during FY ending 2015 was 489.34 MTs, an increase of 17.79 MTs on a year on year comparison registering a growth of 3.8%. Target achievement in this front has been 94%. "Growth in coal off take ought to have been more", admitted Bhattacharya. One of the reasons was weak availability was not commensurate with the needs of coal companies.

Target exceeded in OBR

Referring to the positive trend in Over Burden Removal (OBR), Bhattacharya said, "We are happy about the good growth rate in Over Burden Removal. OBR is an important performance criterion as it improves the mine geometry and accesses the coal seam for future mining. It also makes mines safer to operate". CIL as a whole removed 669.00 Million Cubic Metres of overburden during 2014-15 – achieving 102% of the target registering a growth of 10.2%. This is the first ever time CIL had exceeded the target in OBR.

Improved supplies to power utilities

Coal despatches to power utilities, the major coal consuming sector of CIL's overall supplies, witnessed 0.8% growth on a year on year comparison as per the annual action plan. Despatch of coal and coal products from CIL as a whole to power utilities of the country during 2014-15 surged ahead to 384.19 MTs, up by 30.35 MTs, from that of 353.83 MTs achieved in 2013-14.

Rake loading

During 2014-15, CIL's average loading per day increased by 43 rakes. On an average 946 rakes were loaded per day during 2014-15 against 903 rakes/per day during last fiscal. The growth in average loading per day on year-on-year comparison has been 2.8%.

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Sustainable, Modern Energy For All

IREC 2015 highlighted the commitment of the South African government to diversify its energy mix, which until now had been predominantly based on coal. The growth of the renewable energy industry in South Africa, and indeed across the rest of Sub-Saharan Africa, will benefit tremendously from the exposure gained during the 2015 IREC.

At the end of the South African International Renewable Energy Conference (SAIREC), 2 000 delegates from 82 countries adopted a declaration expressing their conviction that the increased deployment of renewable energy will have a direct impact on improved global energy access, improved energy security, on mitigating greenhouse gas emissions and on climate change and sustainable economic development.

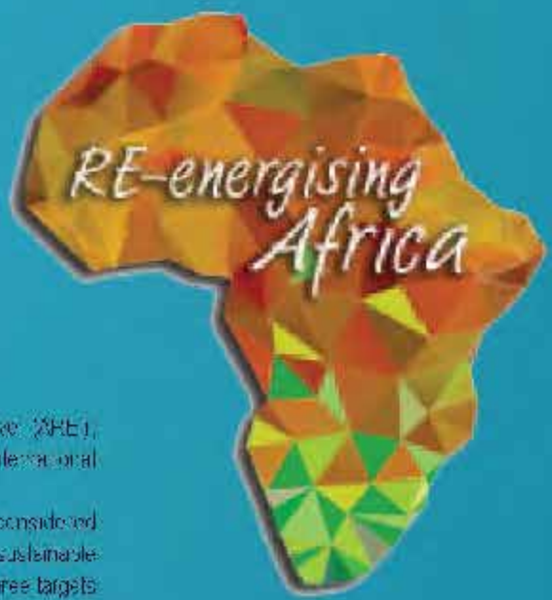
SAIREC was the sixth meeting in the series of International Renewable Energy Conferences (IREC's), building upon successful outcomes in Abu Dhabi in 2012 (AUHREC), New Delhi in 2010 (DIREC), Washington in 2009 (WIREC), Beijing in 2006 (BIREC), and in Bonn in 2004 (Renewables 2004). SAIREC 2015 was hosted by the South African Department of Energy and the South African National Energy Development Institute (SANEDI), supported by the Renewable Energy Policy Network for the 21st century (REN21).

The delegates, including cabinet ministers, government delegations, representatives from the private sector, non-governmental organisations, academia, business, industry and international organisations, who participated in the SAIREC 2015 (October 4 to 7) in Cape Town, declared to upscale and mainstream renewables in order to achieve a global energy transition.

"As of today 2.9 billion people lack access to clean forms of cooking, which needs to be addressed in order to achieve the universal access target. We note that to make universal access a reality by 2030, 1.3 billion people, out of which 621 million live in the sub-Saharan region, should be provided access to electricity," the delegates said in the declaration.

"The scale of the challenge requires that all

Participants in SAIREC recognised the importance of renewable energy in global endeavours to mitigate climate change, and the contribution renewables can make in keeping human-induced, global warming beneath the agreed two degree celsius ceiling...



approaches including grid and off-grid solutions are taken into account and adopted based on an efficiency principle. Rural and urban demands can best be met with a diverse technology mix that takes full advantage of sub-Saharan Africa's exceptional and sustainable solar, wind, geothermal, biomass, and hydropower resources," the declaration said.

The delegates declared that in order to make the global transition to renewable energy happen rapidly, the following elements are crucial: promoting transparent and effective procurement processes; advancing renewable energy locally; providing skills transfer and development; securing financial resources; conducting research and development; improving regulatory frameworks; localising supply chains and local investment; emphasising integrated planning; regionalising trade and energy resource development; conducting programmes for infrastructural development in Africa; embarking on clean energy corridor initiatives and; focusing on the African Renewable Energy Initiative (AREI); regional cooperation and also international cooperation.

Participants of SAIREC considered sustainable development goals on sustainable and modern energy for all, with its three targets on access, renewable and energy efficiency to constitute a solid guiding framework for their deliberations and future cooperation with special focus on RE-energising Africa.

Participants also recognised the importance of renewable energy in global endeavours to mitigate climate change and the contribution that renewable energies can make as a tool of choice in keeping human-induced, global warming beneath the agreed two degree celsius ceiling.

Countries will be emphasising the growing role of renewables in their national efforts to reduce emissions at the 21st Conference of the Parties under the United Nations Framework Convention on Climate Change (UNFCCC), in Paris in December.

Generating Power From Waste

The sewage treatment plant is emerging in the middle of the economic heartland of Gurgaon...

The biogas produced by the CHP plant will be used in the future for internal use in the waste water treatment plant...

A new project is coming up at Dhanwapur, where power will be generated from waste water. Then the same will be used to partially power the plant to supply 100,000 m³ of potable water daily...

In northern India's Dhanwapur, a waste water treatment facility is currently being constructed. The centerpiece of the plant are two MWM TCG 2016 V16 C gas engines, driven by biogas.

The CHP plant has a total electrical output of 1,300 kWe (2 x 800 kWe) and a total thermal output of 768 kWth each, consisting of waste heat from cooling water (230 kWth) and exhaust gases (307 kWth), depending upon the customer's exact requirement.

A promising location

Dhanwapur is a part of the major city of Gurgaon, which is considered as the industrial and business centre in the state of Haryana. Located several hundred kilometres from New Delhi, with a population of 1.5 million, Gurgaon is home to more than 250 Fortune 500 companies. In fact, the city has the third-largest per capita income in all of India.

MWM efficiency stood out

In order to improve the water supply for the workers, the city decided to build the Sewage Treatment Plan (STP) with two MWM gas gensets. The most important criteria in the selection of the engines were low running costs, unconditional reliability and high electrical efficiency. These attributes were fulfilled completely by the TCG 2016 V16 C engine type.

Thus, the CHP plant will supply some half a million households in Dhanwapur with 100,000 m³ of clean drinking water daily. With this plant, 440 MW MWM gas engines are installed of which 11% are run on biogas.

Reliable partners all over the world

From bid delivery to installation, the Indian MWM Partner M/s Green Power International Pvt. Ltd. had handed the complete turnkey configuration of the power plant system, except the associated civil construction measures.

Included in the scope of delivery are all plant components and auxiliaries associated with the gas gensets and the H_2S (hydrogen sulfide) scrubbing system for treatment of the biogas (Balance of Plant).

In addition to the installation, testing and commissioning of the complete power station and the related equipment components, Green Power concluded a long-term service agreement with the customer (for a period of six years), which, in addition to delivery of necessary spare parts, also entails operation of the plant.

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Succeeding In

Schneider Electric will take a more central role alongside thought leaders from AT&T, Cisco, General Electric, IBM and Intel in developing recommendations for industry specifications and developing frameworks to speed the adoption of industrial IoT technologies around the world...

John Tuccillo
Senior Vice President
Global Industry and
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Schneider Electric

Globe specialist in energy management and automation Schneider Electric's new branding strategy is based on building operational intelligence, which relies on optimised automation and control, advanced remote management services, advanced analytics and generation of actionable information to drive informed decision making in our homes, manufacturing facilities, data centers, buildings and cities.

The company has announced its global brand strategy that comes at a critical point of transition for the industry, in which the business and societal landscape are being transformed by urbanisation, digitisation and industrialisation. The strategy, Life Is On, is fueled by Schneider Electric's operational intelligence approach to IoT. The approach will help transform how people and organisations consume energy, better automate industrial processes and increase the quality of business decisions, while improving their lives.

The Life Is On brand strategy will help clearly show how the company is helping its customers around the world take advantage of this fundamental shift, leveraging Schneider Electric's expertise in the Operational Technology (OT) that controls our society's most important processes and connecting it to the Information Technology (IT) that we rely on to simplify our lives and make better decisions.

"We build energy management and automation technologies that ensure Life is On everywhere, for everyone and at every moment. We think access to energy is a fundamental right for everyone on our planet – and we engineer solutions to make energy safe, reliable, efficient, sustainable and connected," said Jean-Pascal Tricoire, Chairman and CEO Schneider Electric.

"We invest heavily in innovation, connecting our products and systems through the Internet of Things to our portfolio of software, making energy more distributed and connected. Our solutions serve the key markets of residential, buildings, data center and networks, energy and infrastructure and industry globally. We are committed to helping our customers succeed in this new reality by transforming their businesses and organisations into more connected enterprises – with deep, real-time,

A New Reality

Operational Intelligence," he added.

To further support this vision for IoT-powered Operational Intelligence, Schneider Electric has also announced that the company has been elected to the steering committee of the Industrial Internet Consortium (IIC). Through this appointment, Schneider Electric will take a more central role alongside thought leaders from AT&T, Cisco, General Electric, IBM and Intel in developing recommendations for industry specifications and developing frameworks to speed the adoption of industrial IoT technologies around the world.

The IoT enabled market is set to grow to $7.0 trillion annually by 2025, according to McKinsey, through IoT's ability to enable higher levels of collaboration, change the way goods are produced and influence the way we work.

John Tuccillo, Senior Vice President, Industry and Government Affairs, will represent Schneider Electric on the Industrial Internet Consortium steering committee. The Industrial Internet Consortium's Executive Director, Dr. Richard Soley, said, "The next wave of transformation in manufacturing and the arts is coming from how connectivity can yield more intelligence. This is where innovation from companies like Schneider Electric and other members come into play. Like our other members, Schneider Electric's innovation in the fields of energy and process efficiency and its range of connected products and solutions will help take IoT to the next level. Where lives, processes and whole supply chains will see significant transformation."

Schneider Electric has also entered into a collaboration with the Hong Kong University of Science and Technology Massachusetts Institute of Technology (HKUST-MIT) Research Alliance Consortium to advance IoT solutions and adoption.

IoT technologies are fundamental to Schneider Electric's focus areas in market segments such as water, oil and gas, data centres, mining, utilities, healthcare, food and beverage and smart cities, as a way to further maximise efficiency and sustainability for customers. Through partnerships like the ones with the Industrial Internet Consortium and HKUST-MIT, Schneider Electric is focused on developing new technologies and services that will drive intelligence, efficiency and connectivity to help customers meet these new and emerging challenges.

Electric Vehicle Markets Due For Takeoff In 2015

According to a recent market report by IDTechEx, three closely related new electric vehicle markets due for takeoff in 2015. They are electric motorcycles, e-assist scooters and electric three wheelers from e-rickshaws to disruptive new forms of car and car-like vehicle.

This creation of major new EV markets is occurring partly because big brands Yamaha and BMW are entering the field. Yamaha with on and off road e-motorcycles and BMW with an e-maxi scooter initially at in 2015.

Harley Davidson is getting us to respond to a first test design of e-motorcycle in 2014. In 2014, Toyota has garnered huge interest with an enclosed three wheel tilting electric motorcycle, the i-Road.

In addition, Chinese companies are already offering impressive e-maxi scooters and three wheel cars and on-line vehicles and at one third of the price. Leaders in these sectors Zero Motorcycles and Brammo are achieving increased sales and going global, and there is now a steady stream of new companies entering all these vehicles and most of them have products coming on stream in 2016-18.

BMW e- maxi scooter...

This creation of major new EV markets is occurring partly because big brands Yamaha and BMW are entering the field...

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Onshore wind and crystalline silicon photovoltaics – the two most widespread renewable technologies – have both reduced costs this year, while costs have gone up for gas-fired and coal-fired generation...

This year has brought a significant shift in the generating cost comparison between renewable energy and fossil fuels, according to detailed analysis by technology and region, published recently by Bloomberg New Energy Finance.

The research company's updated Cost of Electricity Update for the second half of 2016, based on thousands of data points related to individual deals and projects around the world, shows that onshore wind and crystalline silicon photovoltaics – the two most widespread renewable technologies – have both reduced costs this year, while costs have gone up for gas-fired and coal-fired generation.

The BNEF study shows that the global average Levelised Cost Of Electricity, or LCOE, for onshore wind nudged downwards from $85 per megawatt hour in the first half of the year to $83 in H2, while that for crystalline silicon PV solar fell from $128 to $122.

In the same period, the LCOE for coal-fired generation increased from $83 per MWh to $75 in the Americas, from $60 to $70 in Asia-Pacific, and from $82 to $100 in Europe. The LCOE for combined-cycle gas turbine generation rose from $76 to $82 in the Americas, from $85 to $95 in Asia-Pacific and from $109 to $118 in EMEA.

Seb Henbest, Head of Europe, Middle East and Africa at Bloomberg New Energy Finance, commented, "Our report shows wind and solar power continuing to get cheaper in 2016, helped by cheaper technology but also by lower finance costs. Meanwhile, coal and gas have got more expensive on the back of lower utilisation rates, and in Europe, higher carbon price assumptions following passage of the Market Stability Reserve reform."

Levelised costs take into account not just the cost of generating a megawatt MWh of electricity, but also the upfront capital and development expense, the cost of equity and debt finance and operating and maintenance fees.

Among other low carbon energy technologies, offshore wind reduced its global average LCOE from $173 per MWh to $171, but still remains significantly more expensive than wind or PV, coal or gas, while biomass incineration sees its levelised cost stay steadily at $134 per MWh. Nuclear, like coal and gas, has very different LCOE levels from one region of the world to another, but in the Americas and the Europe, Middle East and Africa region saw increases in levelised costs, to $261 and $158 per MWh respectively.

Among the country-level findings of the BNEF study are that onshore wind is now fully cost competitive with both gas-fired and coal-fired generation, once carbon costs are taken into account, in the UK and Germany. In the UK, onshore wind comes in on average at $86 per MWh in the second half of 2016, compared to $115 for combined cycle gas and $105 for coal-fired power; in Germany, onshore wind is at $60, compared to $116 for gas and $108 for coal.

In China, onshore wind is cheaper than gas-fired power, at $77 per MWh versus $119, but it is much more expensive still than coal generated electricity, at $44, while solar PV power is at $139. In the US, coal and gas are still cheaper at $36 per MWh against onshore wind at $60 and PV at $107.

Luke Mills, Analyst, Energy Economics at Bloomberg New Energy Finance, said: "Generating costs continue to vary greatly from region to region, reflecting influences such as the shale gas boom in the US, changing utilisation rates in areas of high renewables penetration, the shortage of local gas production in East Asia, carbon prices in Europe, differing regulations on nuclear power across the world, and contrasting responses to solar generation.

"But onshore wind and solar PV are both now much more competitive against the fossil-fuel generation technologies that would have seemed possible only five or 10 years ago."

Women's Participation To Increase In Top Management Of Siemens

Siemens had set a goal of increasing the share of women in its management in Germany from 10% at the end of September 2011 to 12 to 13% by 2015. This target has been reached...

Even today, globally women's participation in industry, especially at high rank positions in engineering companies is quite less. As far as hard core engineering companies are concerned, the number is even less.

Under such circumstances, Siemens AG intends to further increase the percentage of women in its top management positions. For both of the company's top two management levels in Germany the share is to be raised to 10% by the end of June 2017. For the company's Managing Board, the Siemens Supervisory Board has set the target of at least maintaining the status quo until June 30, 2017. Two women – Lisa Davis and Janina Kugel – are currently members of the seven-member Managing Board. With six female members – Bettina Haller, Nicola Leibinger-Kammüller, Güler Sabancı, Brigitte Ederer, Nathalie von Siemens and Sibylle Wankel – the Supervisory Board of Siemens AG already fulfils the statutory gender quota of 30% women.

"In recent years, Siemens has worked hard to get more women in top positions. The results are quite impressive. But we can't let up now. Particularly as a technology company, we have a long-term responsibility to increase the share of women in leadership positions. Women in top positions should be the rule rather than the exception," said Janina Kugel, Siemens' Chief Human Resources Officer.

Siemens Healthcare GmbH, a separately managed company, aims to have women in 25% of its Supervisory Board positions. This target, too, has already been achieved. Healthcare intends to boost the share of women in its top- and second-level management to five percent and 18%, respectively, by the end of June 2017.

On their own initiative, the companies listed on Germany's DAX stock market index set individual targets for increasing the percentage of women in their management positions. Every year, these companies report on their progress in status reports. Siemens has set a goal of increasing the share of women in its management in Germany from 10% at the end of September 2011 to 12 to 13% by 2015. This target has been reached. By the end of fiscal 2014, nearly 13% of the company's managers in Germany were women.

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Reliance Power appoints new Chief Executive Officer

N. Venugopala Rao

Under his leadership, all the six units of 660 MW Sasan UMPP have been successfully operational...

Reliance Power has appointed N. Venugopala Rao as its Chief Executive Officer (CEO). Rao, an MBA in Finance & Marketing, is a power sector professional with more than 34 years of experience in project development, project finance, project planning, contracts management and finance & accounts.

Before his appointment as the CEO of Reliance Power, he was the CEO of Sasan Power Ltd., a hundred percent subsidiary of the company, which has developed the Sasan Ultra Mega Power Project (Sasan UMPP), the world's largest integrated coal mine and power project with an investment of nearly ₹ 27,000 crores.

Under his leadership, all the six units of 660 MW Sasan UMPP have been successfully operational, and are delivering best-in-class operational performance in the country. Prior to this role at Sasan Power, he was the Chief Financial Officer (CFO) of Reliance Power Ltd., a part of Reliance Group.

Shekhar Basu becomes the Secretary & Chairman of AEC

Shekhar Basu

Basu was instrumental in setting up reprocessing and waste management facilities at Indira Gandhi Centre for Atomic Research in Kalpakkam...

Current director of the Bhabha Atomic Research Centre (BARC) has been appointed as the Atomic Energy Secretary and Chairman of Atomic Energy Commission (AEC). According to an order issued by the Department of Personnel and Training, Basu will continue to the post till he attains the age of 64 years, i.e., September 19, 2016.

Basu, an engineering graduate from the Veermata Jijabai Technological Institute (VJTI), Mumbai, is also the Chief Executive of the Nuclear Recycle Board (NRB). He will replace RK Sinha who will superannuate on October 23, 2015.

Basu was instrumental in setting up reprocessing and waste management facilities at Indira Gandhi Centre for Atomic Research in Kalpakkam. He is also a recipient of Padma Shri. He holds the credit for commissioning land-based Nuclear Submarine Propulsion Plant at Kalpakkam. Also, he is one of the architects of India's 80 mega watt compact Pressurised Water Reactor (PWR), which will power Arihant, the country's nuclear-powered submarine.

Abhijit Bhattacharya becomes CFO at Philips

Abhijit Bhattacharya

"I am very pleased to announce Abhijit as our new CFO..." said Frans van Houten, CEO of Royal Philips...

According to a recent announcement from Royal Philips, Abhijit Bhattacharya, who was CFO of Philips Lighting and project leader for the creation of 'lighting' as a standalone company, has succeeded Ron Wirahadiraksa as CFO of Royal Philips. Ron Wirahadiraksa has resigned from the Board of Management and the Executive Committee.

"I am very pleased to announce Abhijit as our new CFO. His extensive experience in financial and operational leadership positions at Philips and previously within NXP, together with his ability to successfully manage highly complex projects will enable him to play a key role in driving the transformation of Philips further. I am confident that Abhijit's experience, combined with the support that he will be receiving from Ron over the coming weeks will ensure a seamless transition," said Frans van Houten, CEO of Royal Philips.

Abhijit joined Philips in 1987 and has held various senior leadership roles in the company in Asia Pacific, Europe and the U.S. He chaired the team responsible for the overall planning and execution of the separation process to create two winning companies focused on the HealthTech and Lighting opportunities, reporting directly to CEO Frans van Houten. He will join Philips' Executive Committee and will be nominated for appointment to the Board of Management.

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HPCL gets a new Director for Finance

J. Ramaswamy

Ramaswamy has a wide exposure to the petroleum industry...

J Ramaswamy has assumed the charge as Director-Finance of Hindustan Petroleum Corporation Limited (HPCL), a Government of India enterprise with a Navratna Status, and a Forbes 2000 and Global Fortune 500 company. It is listed on the Bombay Stock exchange (BSE) and National Stock Exchange (NSE), India.

Ramaswamy has taken over the charge from K. V. Rao who superannuated on September 30, 2015. Being a member of the Institute of Chartered Accountants of India, he has a wide exposure to the petroleum industry spanning over 31 years in the areas of Corporate Finance, Treasury Management, Internal Audit and Marketing & Refinery Finance in Hindustan Petroleum Corporation Limited.

Prior to this promotion, Ramaswamy was the Executive Director - Corporate Finance, HPCL.

Philip Harting to chair the board of Harting Technology Group

Philip Harting

"I am very delighted, together with my sister & supported by my parents and fellow Board members, to continue my father's successful work..."

After almost 50 years in the management of the HARTING Technology Group, Dietmar Harting (Dr.-Ing. E.h.) has handed over the position of Chairman of the Board to his son Philip Harting in October 2015. Dietmar Harting nevertheless remains a member of the company group's Board as personally liable partner and will focus on matters concerning the future and new technologies.

Together with his sister Maresa Harting-Hertz, President Finance and Purchasing, Philip Harting represents the 3rd generation of the family-owned company, which was founded 70 years ago by his grandparents Wilhelm and Marie Harting in Minden. The company group has been headquartered in Espelkamp since the early 1950s.

"I am very delighted, together with my sister and supported by my parents and fellow Board members, to continue my father's successful work," says Philip Harting.

Philip Harting studied electrical engineering in Braunschweig and business administration in Cologne. In 2005, he assumed a position of responsibility at his parents' company for the first time as Managing Director Asia in Hong Kong. He has been head of the company's largest business unit 'Connectivity & Networks' since 2008.

Stanwell Corporation gets a new Non-executive Chairman

Dr. Ralph Craven

Dr Ralph has a broad experience in energy, resources, infrastructure and agri-business, having worked in these sectors for over 35 years...

Dr Ralph Craven has been appointed a non-executive Chair of Stanwell Corporation Limited recently. He is also a member of the Audit and Risk Management Committee and People and Safety Committee of the organisation.

Dr Ralph has a broad experience in energy, resources, infrastructure and agri-business, having worked in these sectors for over 35 years. His professional background encompasses electricity and gas businesses, mining, commodities trading, the management of large scale system operations at the national level – and the delivery of major infrastructure projects.

Ralph is currently a Non-executive Director and Chair of Genex Power and a Non-executive Director of Senex Energy, AusNet Services and Windlab Limited. Some of his previous roles included being a Non-executive Director and Chair of Invion Limited and Ergon Energy Corporation Limited, Non-executive Deputy Chair of Arrow Energy Limited and Non-executive Director of Mitchell Services.

He is now in his final year as a Non-executive Director of the Council Board of the International Electrotechnical Commission, having been elected to this position for two three-year terms.

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"There Has Been A Record Increase In COAL SUPPLY..."

***Indian Ministry of Coal** aims to secure availability of coal to meet the demand of various sectors of the economy in an eco-friendly, sustainable and cost effective manner. **Anil Swarup** is presently posted as **Secretary, Ministry of Coal, Government of India.** In a brief session, he talks to **P K Chatterjee** on the current developments of the coal sector.*
Excerpts...

What are the tangible benefits from bringing coal, power and renewable energy under the same ministry?

The two Ministries, Coal and Power, are interlinked. Bringing them under a single Minister has enabled seamless coordination between these two critical infrastructure Ministries and has enabled faster decision making.

What kinds of new technology are being brought into the process of coal mining to make that safer and more economic?

For opencast mining, adoption of large capacity shovel dumper units and draglines are being considered. In-pit crushing and conveying systems are also being planned for reducing the fleet of dumpers and improving the productivity wherever it is feasible.

Surface miners are being deployed on large scale as they avoid cyclic mining involving drilling and blasting. It is an environment friendly technology.

For underground mining, emphasis is laid on mass production technologies deploying continuous miners and longwall mining wherever it is found to be techno-economically feasible.

Manual loading is being replaced by mechanised loading by deploying Side Discharge Loaders (SDL) and Load Haul Dumpers (LHD) in conjunction with conveyer transportation. Man riding systems are being introduced in underground mines to improve productivity of

workers and to avoid wastage of time and energy in walking long distances to reach the work place.

All the major open cast projects are being planned with rapid loading systems for loading railway wagons. All the coal being dispatched to power sector is crushed as per the requirement of the consumers. Further, coal washeries are being set up to address the quality issues and to comply with the environment regulations.

What are your strategies to ensure smooth and sustainable supply of coal to the power plants?

There has been a record increase in coal supply by 32 million tonnes in 2014-15, which is more than the cumulative increase of 31 million tonnes during the previous four years.

During the current financial year also, the rate of growth is more than 8%. This will be sustained as mine-wise plan has been prepared and is being executed.

Apart from those, Coal India Limited (CIL) is in constant touch with various stake holders, including Railways, to ensure smoother supply of coal to the users.

To what extent are we still depending on coal import?

India imported around 200 million tonnes coal during 2014-15. This was on account of increased demand in the power sector. However, with the increase in supply of coal, the imports have already started coming down.

How will you improve the scenario?

In view of the projected supply of coal within the country, import of thermal coal will come down further in the next couple of years.

What are your steps to stabilise the coal pricing for power plants?

Coal prices have been quite stable within the country and will continue to be so in the future as well. Decisions relating to coal pricing are taken in the context of its impact on power tariff.

What will be the benefit of offloading government's stake in Coal India? Won't that affect our power sector?

There is no move to privatise CIL. However, some of stake of the Government may be offloaded in the near future. There will be no impact on power sector, if and when, such offloading happens.

What steps are you taking to improve the coal mine workers' safety and prosperity?

Coal companies have established internal safety organisations whose members regularly visit the operations for assessing the safety status – and advice the management for corrective steps, if any.

Safety audits are also being conducted through engaging experts in mines safety.

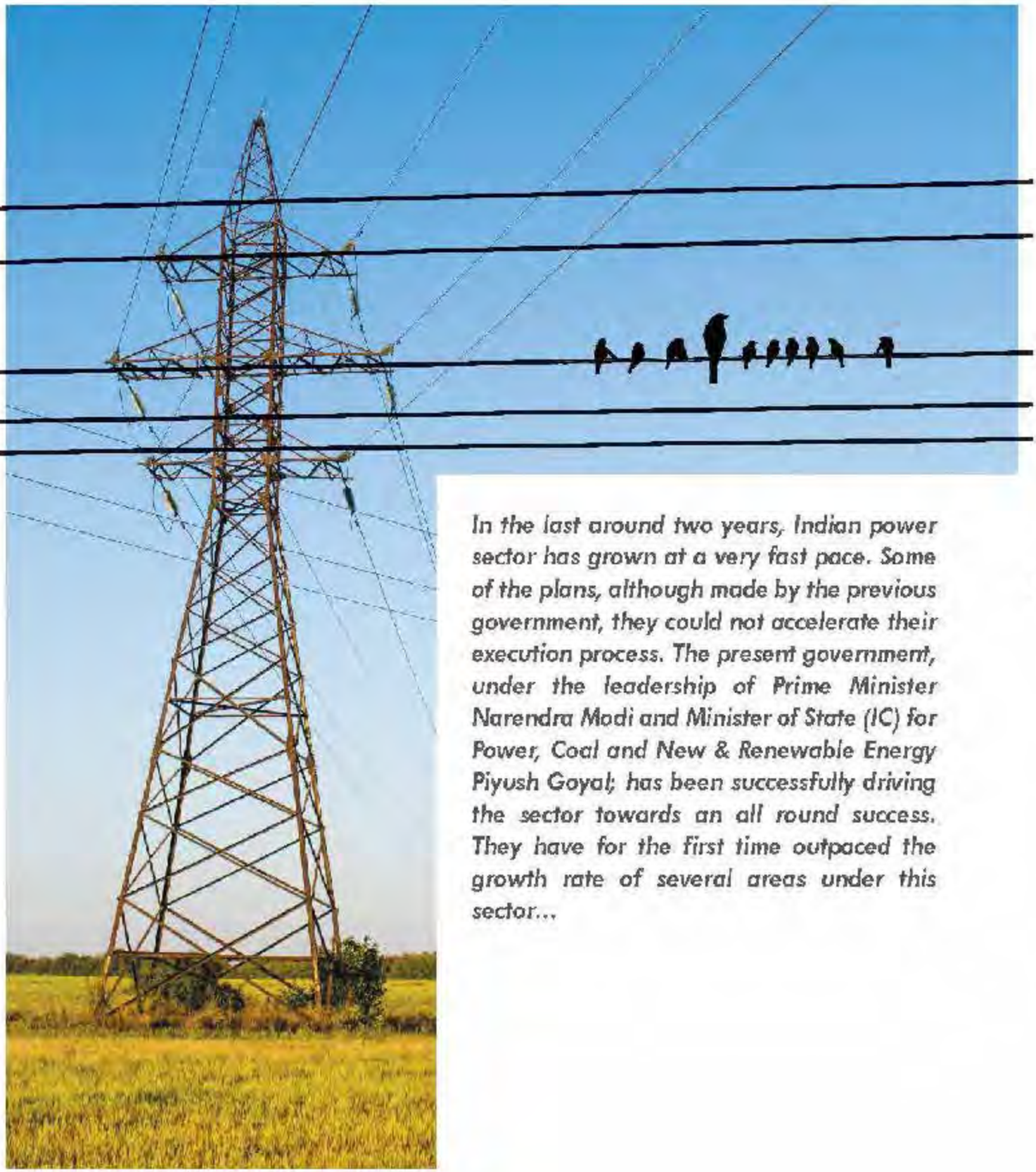
Standard operating procedures are being established to avoid unsafe practices in mines.

Through conducting of safety weeks and safety campaigns and imparting training, the awareness of safety is improved from time to time. Simulator based training is also being imparted to the operators of heavy earth moving machinery.

Risk assessment and management is the approach being adopted for reducing accidents and improving the safety of operations.

Role of Director General of Mines Safety in ensuring compliance of statutory provisions under Mines Act – and guiding supervisors and management in safety matters are also helping the industry in improving safety of mining operations.

The Standing Committee on Safety in coalmines, under the Chairmanship of Minister of Coal periodically reviews the status of safety in coalmines in the country – and issues are addressed for ensuring safety of operations and persons deployed in coal mines.



In the last around two years, Indian power sector has grown at a very fast pace. Some of the plans, although made by the previous government, they could not accelerate their execution process. The present government, under the leadership of Prime Minister Narendra Modi and Minister of State (IC) for Power, Coal and New & Renewable Energy Piyush Goyal; has been successfully driving the sector towards an all round success. They have for the first time outpaced the growth rate of several areas under this sector...

Peeping Into The Indian Power Sector

As a country full of natural resources, India has enough opportunity to harness its renewable resources for power generation. However, the Indian power scenario **(Figure 1)** clearly shows that so far we are mainly depending on fossil fuel (Coal, Gas and Diesel) burning for power generation.

The present Union Government has attached utmost priority to the development of power, as it has made a commitment to provide power to all citizens by 2019. As a result of that we have been witnessing a reversal in the power supply position **(Figure 2)** since F.Y. 2014-15 onwards.

Power Generation

Owing mainly to the 8.4% Y-O-Y growth in generation capacity, which was the highest in the last two decades; and smooth availability of coal stock in most of the thermal power plants; the Indian power sector witnessed a fairly good increase in power availability.

For the first time in the country, the annual electricity generation in 2014-15 crossed one thousand Billion Units (BUs) or one Trillion Units. The actual power generation during the F.Y. 2014-15 was 1048.433 BUs. The Compounded Annual Growth Rate (CAGR) of power generation had been around 5 to 6.8%, since 1961-62. It goes without mentioning that the biggest contribution to generation was from the coal based power stations, which recorded an annual growth rate of 12.1%. The year ended with higher power demand and large capacity addition plans.

Some of the key reforms that affected the turnaround were:

- Reallocation of coal blocks through e-auction process
- New gas pooling mechanism to be built 14,000 MW of stranded power plants
- New Ultra Mega Power Project (UMPP) policy to approach plug and play mode
- Improved focus on the T&D sector

A view of the Koldam project...

NTPC

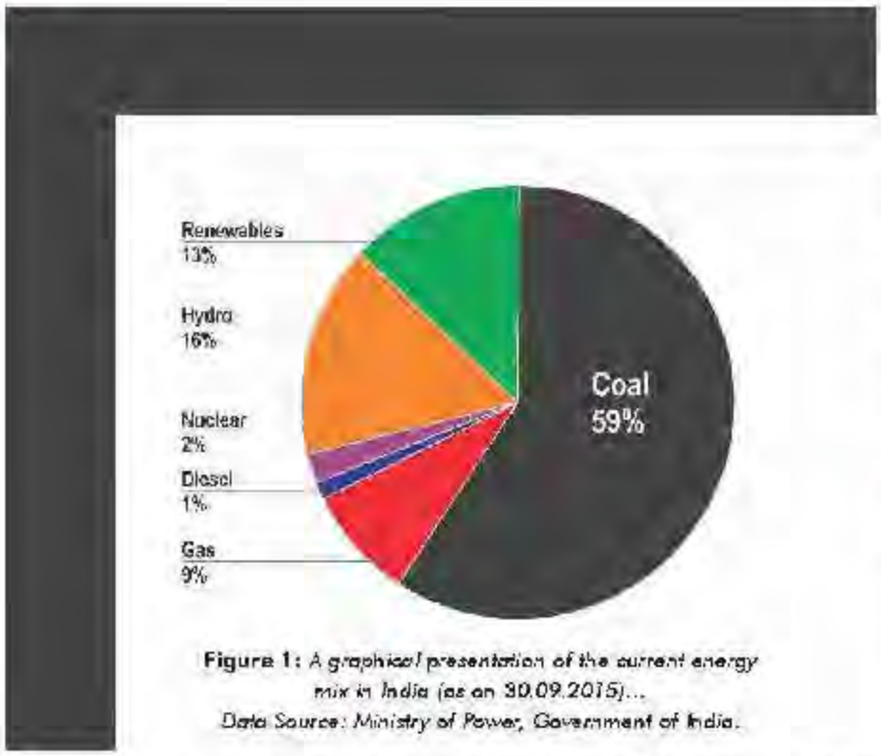


Figure 1: *A graphical presentation of the current energy mix in India (as on 30.09.2015)...*
Data Source: Ministry of Power, Government of India.

The generation capacity addition during 2014-15 was 22,563 MW against a target of 17,830 MW. This is the highest ever achievement in a single year. The capacity addition during the first three years (2012-13 to 2014-15) of 12th Five Year Plan has been 61,074 MW, which has not only exceeded the capacity addition of 54,964 MW of the entire 11th Plan (2007 to 2012) but also constitutes 38.9% of the total 12th Plan target of 88,537 Mega Watt.

Out of 22,563 MW added during the year 2014-15, contribution of thermal sector was significant i.e., 20,830 MW (92% of the total). It includes NTPC's 660 MW unit at Barh in Bihar – where the first indigenously manufactured super critical units by BHEL have been commissioned.

The year marked turn around in hydro sector with 659 MW contribution in central sector including debut NTPC's multi-megawatt unit and entry in hydro sector with Kol Dam Unit (Himachal Pradesh). NHPC and SJVNL completed their projects at Parbati III and Rampur respectively. The gas based Monarchak Power Plant of 65.4 MW, Agartala ST-II of 25.5 MW and Palatana Unit II of 363.3 MW were also commissioned during the year in Tripura – which will benefit the entire North East. Commissioning of Kudankulam Nuclear power station of 1,000 MW during the year will help all the Southern States.

Power Transmission

Mere enhancement of the generator capacity does not help in reaching power to all parts of the country as most of the power plants, especially the thermal and hydro power plants, are commissioned away from the mostly populated areas. Considering that, focus is now being put on revamping the transmission sector.

Following a number of steps taken by the government, for expediting forest clearances and intensive monitoring of critical transmission lines, 22,101 Circuit Kilometers (CKM) of transmission lines have been commissioned during the year 2014-15 against 16,440 CKM commissioned during the same period in the previous year thus having a growth of 34.40% which is the highest ever achievement in a single year.

	Energy				Peak			
Year	Requirement	Availability	Surplus(+) / Deficit(-)		Peak Demand	Peak Met	Surplus(+) / Deficit(-)	
	(MU)	(MU)	(MU)	(%)	(MW)	(MW)	(MW)	(%)
2009-10	8,30,594	7,46,644	-83,950	-10.1	1,19,166	1,04,009	-15,157	-12.7
2010-11	8,61,591	7,91,356	-70,236	-8.2	1,22,287	1,10,256	-12,031	-9.8
2011-12	9,37,199	8,57,886	-79,313	-8.5	1,30,006	1,18,191	-11,815	-9.09
2012-13	9,95,557	9,30,362	-65,195	-6.5	1,35,453	1,20,294	-15,159	-11.2
2013-14	10,02,257	9,59,829	-42,428	-4.2	1,36,618	1,30,512	-6,106	-4.5
2014-15	10,68,823	10,30,785	-38,038	-3.6	1,48,166	1,41,160	-7,006	-4.7
2015-16*	5,61,876	5,48,521	-13,355	-2.4	1,50,799	1,46,795	-4,004	-2.7

Figure 2: *The power supply position in the country during 2009-10 to 2015-16...*
**Provisional up to September, 2015, Data Source: Ministry of Power, Government of India*

This was 103% of the annual target of 20,392 CKM fixed for 2014-15. Similarly, the overall increase in the transformation capacity has been 66,054 MVA during 2014-15, which is a record achievement in a single year and constitutes 137% of the target of 47,827 MVA fixed for 2014-15.

The major inter-State transmission system (ISTS) commissioned in 2014-15 includes Raichur-Shivapur 765 kV 2nd circuit, which strengthened the synchronous interconnector

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Year	Target	Achievement	% of target	% of growth
2009-10	78[illegible]1	7[illegible]1,95[illegible]	9[illegible]7.73	6.6
2010-11	930,757	8[illegible]1,143	97.84	5.56
2011-12	955,300	976,697	102.56	0.17
2012-13	930,000	9[illegible]2,058	98.37	4.01
2013-14	975,000	967,153	99.19	0.04
2014-15	1029,000	1,048,573	102.51	8.42

Figure 3: *In 2014-15, India witnessed 8.4% YoY growth in its power generation capacity...*
Data Source: Ministry of Power, Government of India

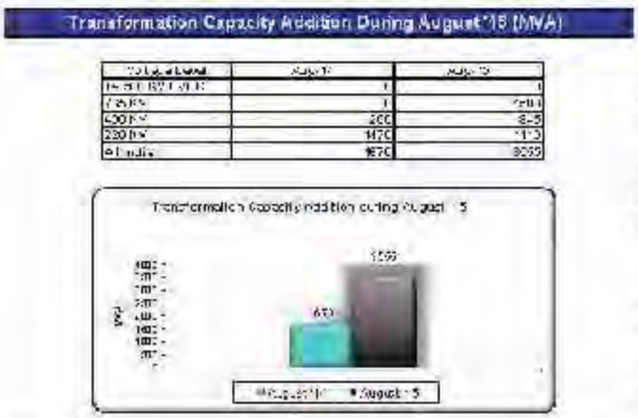

Figure 4: *Transmission lines added during August 15 (CKTms)*
Data Source: Central Electricity Authority (CEA)

of Southern Region (SR) with rest of the country – thereby facilitating reliable operation of single frequency National Grid. The commissioning of 2nd 765 kV line from Raichur to Wardha via Aurangabad during the year provides an important corridor for transfer of power from Chhattisgarh area towards load centres in Maharashtra and Chennai in Southern Region. Commissioning of Sholapur – Pune 765 kV S/C line has also facilitated improvement of power supply in Maharashtra and SR. Commissioning of Silchar – Imphal and Silchar – Bongaigaon line during the year (2014-15) will result in significant improvement in power supply to Manipur and North-east.

The huge capacity addition coupled with higher generation and improved transmission capacity has resulted in considerably reducing the electrical energy shortage from a level of 7 to 2% during the last two decades to a record low of only 0.6% during the year 2014-15 (Figure 2).

Power Grid Corporation of India Limited (POWERGRID/PGCIL), the 'Central Transmission Utility' (CTU) of the country, which is also a 'Navratna' company, is operating under the Ministry of Power. It is engaged in power transmission business with the responsibility for planning, implementation, operation and maintenance of inter-state transmission system and operation of National & Regional Power Grids. PGCIL is a stock tracked listed company, with 57.90% holding of Government of India and balance by institutional investors and public.

PGCIL owns and operates about 1,13,673 CKMs of transmission lines at HDD/±kV 400kV, 220kV and 132kV EHVAC & ±500kV HVDC levels and 187 sub-stations. Also, with the transformation capacity of about 2,40,954 MVA as on 30th September 2015, this gigantic transmission network, spreads over the length and breadth of the country. It is consistently maintained at an availability of over 98%.

Power Distribution

Distribution is the area near the 'last mile' consumers with the power, which may be deemed as a product being distributed to the point of consumption. This is the actual revenue generation point for the sector. Under the Indian constitution, power is a concurrent subject and the responsibility for distribution and supply of power in rural and urban consumers rests with the states.

Although the union government has taken various steps to improve this area, a lot still needs to be done. Especially, states are supposed to take more initiatives. As power theft prevention and appropriate metering are the two big challenges there.

Government of India provides assistance to states through various central sectors / centrally sponsored schemes for improving the distribution sector.

Integrated Power Development Scheme (IPDS): GoI has approved the scheme on 20.11.2014 with a total outlay of Rs 32,612 crore that includes a budgetary support of Rs 25,354 crore. Targets of the scheme:

- Strengthening of sub-transmission and distribution networks in the urban areas
- Metering of distribution transformers / feeders / consumers in the urban area
- IT enablement of distribution sector and strengthening of distribution network

The component of IT enablement of distribution sector and strengthening of distribution network approved in June, 2013 in the form of R-APDRP for 12th and 13th Plans got subsumed in this scheme and approved scheme outlay of Rs 44,011 crore including a budgetary support of Rs 32,767 crore carried over to the new scheme of IPDS.

Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY): GoI has also approved the scheme on 20.11.2014 with a total outlay of Rs 44,033 crore that includes a budgetary support of Rs 33,453 crore from the union government. Targets of the scheme are:

- Separation of agriculture and non-agriculture feeders
- Strengthening of sub-

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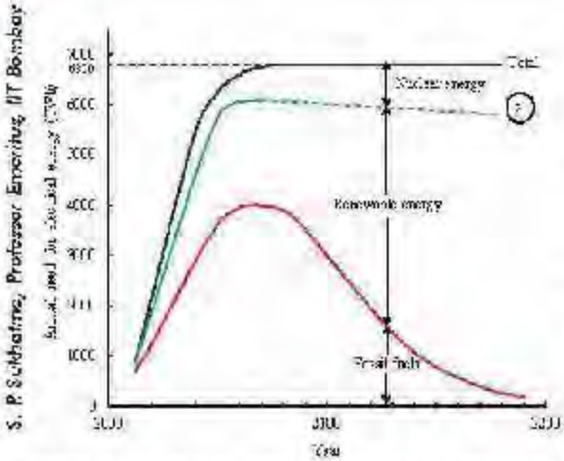

Figure 5: *Variation of India's Total Need for Electricity over the Years if Individual Need is Assumed to be 4000 kWh/year. Possible Contributions of Fossil Fuels, Renewable Energy and Nuclear Energy are also Indicated...*

transmission and distribution networks in the rural areas

- Metering of distribution transformers / feeders /consumers in the rural area
- Rural electrification

The components of rural electrification approved in August, 2010 in the form of RGGVY for 12th and 13th Plans gets subsumed in this scheme and approved scheme cost of Rs 35,276 crore including a budgetary support of Rs 55,447crore carried over to the new scheme of DDUGJY.

National Electricity Fund (NEF): To promote investment in the distribution sector, GoI had set up National Electricity Fund (Interest Subsidy Scheme) in March 2012 to provide interest subsidy on loans disbursed to the Distribution Companies (DISCOMS), both in public and private sector, to improve the distribution network for areas not covered by RGGVY and R-APDRP project areas. The projects are to be appraised and are linked to certain reform measures taken by the States and the amount of interest subsidy is linked to the progress achieved in reforms linked parameters.

Financial Restructuring Scheme: GoI has notified the scheme for Financial Restructuring of State Distribution Companies (DISCOMS) in October 2012 for achieving their financial turnaround by restructuring their short term liabilities with support through a Transitional Finance Mechanism from the Union government.

Risk Factors Associated With Coal-based Plants

Coal based power plants produce tremendous amounts of pollution, which is harmful for all living beings. According to the findings of the Centre for Science and Environment, "the coal-based power sector currently accounts for approximately 60% of particulate emissions, 45 to 60% of SO_2 emissions, 30% of NO_x emissions and more than 80% of mercury emissions."

There are currently no standards to curb emissions of SO_2, NO_x and mercury. The only standards that exist are for PM, which are quite lax compared with the global norms. However, this year MoEF&CC (Ministry of Environment, Forest & Climate Change) has published a draft notification to tighten norms for emissions of Particulate Matter (PM), SO_2, NO_x and mercury and to cut water use by coal-based thermal power plants.

STATE	PROVED	INDICATED	INFERRED	TOTAL
Total	125935	142305	33743	301984
West Bengal	13403	19022	4893	31318
Jharkhand	41077	32790	6539	80716
Bihar	0	0	160	160
Madhya Pradesh	10411	12892	2979	25679
Chhattisgarh	76652	58958	3928	139538
Uttar Pradesh	884	178	0	1062
Maharashtra	5667	3186	2110	12963
Odisha	27791	37003	8400	73070
Andhra Pradesh	9729	9670	3069	22468
Assam	465	47	3	515
Sikkim	0	58	43	101
Arunachal Pradesh	31	40	19	90
Meghalaya	99	77	47	576
Nagaland	9	0	007	016

Figure 6 : *The details of state-wise geological resources of coal... (Million tonnes), Source: Geological Survey of India*

Year	Gross Generation (M. Is)	Capacity Factor (%)	Availability Factor (%)
2015-16 (Upto Sep - 2015)	19116	77	83
2014-15	37835	82	88
2013-14	35293	89	88
2012-13	35860	90	90
2011-12	32455	79	81
2010-11	28472	71	89
2009-10	19803	61	92
2008-09	14927	60	92
2007-08	13930	64	88
2006-07	19654	68	90

Figure 7: *Nuclear Power Generation (2006-07 to 2015-16) Source: NPCIL*

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As per the Ministry of Coal, "As a result of exploration carried out up to the maximum depth of 1200 metres by the GSI, CMPDI, SCCL and MECL etc., a cumulative total of 301.56 billion tonnes of Geological Resources of Coal have so far been estimated in the country as on 1.4.2014." However, only a part of this can be used in power plants.

Looking at the long term challenge, fossil fuels will be exhausted in another 150 years. Looking at the short term challenge, fossil fuels, especially coal, highly pollute the environment.

However demand for energy will continue to grow in the country. By the middle of the next century, there will be only two types of energy nuclear energy and renewable energy (renewable energy covers different types of sources like, wind, solar, small hydro, geothermal,).

Nuclear Energy Growth Prospect in India

According to the research and consulting firm Global Data, India's cumulative installed capacity will be more than double from 272.8 Gigawatts (GW) in 2014 to 609 GW by 2025, representing a Compound Annual Growth Rate (CAGR) of 7.3%.

The company's latest report states that while coal-generated thermal power will continue to dominate, India's renewable and nuclear energy sectors are both set to record impressive growth during the forecast period (up to 2025).

According to Chiradeep Chatterjee, Senior Analyst (Power), Global Data, "India's nuclear capacity is expected to increase more than seven-fold, from 5.8 GW in 2014 to 35.2 GW by 2025, in a bid to reduce the country's reliance on coal."

He continues, "India's nuclear energy development strategy has been divided into three stages due to its limited reserves of uranium, which are already being used in existing reactors. The potential for generating power from uranium mines in India has been estimated at 10 GWe."

"However, the country has large reserves of thorium, with the result that the transition to breeder reactors that use thorium has been proposed, although this three-stage strategy" he adds.

Renewable Energy

Global Data's report also states that India's other renewable installed capacity (excluding big hydropower) is expected to be more than triple from 33.1 GW in 2014 to an estimated 125.8 GW by the end of the forecast period (2025).

Chatterjee says, "India has significant solar power potential due to its geographical location near

India's largest grid connected solar rooftop plant of 7.52 MW at Dhea Bees, Distt. Amritsar, Punjab...

Ministry of New & Renewable Energy

Programme/ Scheme wise Physical Progress in 2015-16 (During the month of September, 2015)

Sector	FY- 2015-16		Cumulative Achievements
	Target	Achievement	(as on 30.09.2015)
I. GRID-INTERACTIVE POWER (CAPACITIES IN MW)			
Wind Power	2400.00	887.80	24367.80
Solar Power	1400.00	592.35	4344.97
Small Hydro Power	250.00	91.55	4178.90
Bio-Power (Biomass & Gasification and Bagasse Cogeneration)	400.00	0.00	4419.55
Waste to Power	10.00	12.00	127.08
Total	**4460.00**	**1629.09**	**37413.70**
II. OFF-GRID/ CAPTIVE POWER (CAPACITIES IN MWEQ)			
Waste to Energy	10.00	0.50	145.51
Biomass(non-bagasse) Cogeneration	30.00	10.50	602.97
Biomass Gasifiers -Rural -Industrial	2.00 8.00	0.00 0.00	17.66 162.05
Aero-Generators/Hybrid systems	0.50	0.13	2.87
SPV Systems	30.00	46.50	260.69
Water mills/micro hydel	2.00	0.00	17.21
Total	**130.50**	**57.63**	**1219.61**
III. OTHER RENEWABLE ENERGY SYSTEMS			
Family Biogas Plants (numbers in lakh)	1.10	0.10212	4.89
Solar Water Heating – Coll. Area (million m2)	-	0.00	8.30

Figure 8: *Source: Ministry of New & Renewable Energy*

ERDA is an Autonomous Body established in 1954 by the Indian Electrical Industries and Utilities with the support of Govt. of India and Gujarat. ERDA is headed and managed by highly qualified personnel and professionals. For the last four decades, ERDA has been serving the nation as a premium professional organisation accredited by NABL, Govt. of India & approved by Intertek (ASIA). It is partnering utilities, manufacturing industries and other organisations in performance testing and evaluation of more than 100 electrical products as per BIS, IEC, UL, ASTM & TUV-PS requirements. ERDA provides services in the area of Certification Testing, Calibration, Research & Development, Residual life Assessment (RLA), Condition Monitoring, Energy Audits, Third Party Inspection (TPI) & Power Systems.

ERDA operates three site laboratories – ERDA (North) at Sonepat, ERDA (West) at Rabale & ERDA (South) at Rajahmundry to serve customers at various geographical locations of India.

Major Facilities at ERDA Include:

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- Impulse Testing Laboratory (1600kVp, 80kJ - 2 No. & 800kVp, 40kJ - 1 No.)
- Transmission & Distribution Hardware Evaluation Facilities (upto 400kV class) for Conductors, Insulators, General Hardware & Dampers
- LT & HT Cables test facility upto 66kV
- Type & Routine Test Facilities for Transformers upto 2000kVA, 33kV/433V (In-house) & upto 100MVA, 245kV at Manufacturer's end
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- Testing/Calibration facility upto 200kV, 0.1 Accuracy Class Voltage Transformers & upto 33kV, 0.2 class accuracy at site
- Type test Facilities for Energy Meters [Smart Electronic (Static), Prepaid & ABT Meters] as per IS, IEC and Calibration facilities at site and laboratory upto 0.02 class. Test Facility for DLMS - COSEM as per Indian & International Standards (Accredited by NABL).
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For more details contact: Head Business Development

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State Wise Renewable Energy Potential (In MW)								
Sl. No.	States/UTs	Wind Power	Small Hydro Power	Bio-Energy			Solar	Total
				Biomass Power	Bagasse Cogeneration	Waste to Energy		
1	Andhra Pradesh	14497	978	578	300	128	38440	54916
2	Arunachal Pradesh	236	1341	8			8650	10236
3	Assam	112	239	219		8	13760	14330
4	Bihar	144	223	619	300	72	11200	12558
5	Chhattisgarh	314	1107	236		24	10270	11951
6	Goa		7	26			900	912
7	Gujarat	35071	202	1221	350	112	35770	72726
8	Haryana	93	110	1333	350	24	4560	6470
9	Himachal Pradesh	64	2398	142		2	33840	36446
10	Jammu & Kashmir	5685	1731	73			111050	119208
11	Jharkhand	91	209	90		10	10160	10560
12	Karnataka	13593	4141	1131	450		24700	44015
13	Kerala	837	704	1044		36	6110	8736
14	Madhya Pradesh	2931	820	1364		78	61360	66953
15	Maharashtra	5961	794	1887	1250	367	64020	74500
16	Manipur	56	109	10		2	10530	10811
17	Meghalaya	82	230	31		2	5050	5108
18	Mizoram		169	1		2	9050	9261
19	Nagaland	16	197	10			7290	7513
20	Orissa	1384	295	246		22	25780	27728
21	Punjab		441	3172	300	45	2810	6768
22	Rajasthan	5050	57	1009		32	142310	148458
23	Sikkim	98	267	2			4940	5307
24	Tamil Nadu	14152	660	1070	450	161	17540	34152
25	Telangana						20410	20410
26	Tripura		47	3		2	2030	2131
27	Uttar Pradesh	1260	461	1617	1250	176	22030	27660
28	Uttarakhand	634	1708	24		5	10680	13071
29	West Bengal	22	696	396		148	6290	7222
30	Andaman & Nicobar	365	8				0	373
31	Chandigarh					6	0	6
32	Dadar & Nagar Haveli						0	0
33	Daman & Diu	4					0	4
34	Delhi					131	2050	2181
35	Lakshwadeep						0	0
36	Puducherry	120				3	0	123
37	Others					1032	760	1792
	Total	**102772**	**19749**	**17536**	**5000**	**2554**	**748990**	**898602**

Figure 9: Source: *Ministry of New & Renewable Energy*

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Minister of State (IC) for Power, Coal, New & Renewable Energy, Piyush Goyal during Signing of MOU for setting up a Joint Venture (JV) company ,for first demonstration of offshore wind power project by MNRE, NTPC, PGCIL, IREDA, PFC, PTC..., Source: Ministry of New & Renewable Energy

One MW solar plant in IIT Bombay... Source: Indian Institute of Technology Bombay

the equator, and the country has still not clear plans for future energy production from this source. One example of a planned solar power project is the multi-phase Jawaharlal Nehru National Solar Mission, Launched in 2010, it set a target of 20 GW of grid-based solar power by 2022 and 2 GW of off-grid capacity for the same year.

Renewable energy has witnessed good growth in the last few years. From the total renewable power installed capacity of 14,400 MW at the beginning of 2009, it has reached a capacity of 36,471 MW at the end of September 2015. Wind energy is continuing to dominate India's renewable energy industry, accounting for over 60% of installed capacity (22,465 MW), followed by biomass power (4,135 MW), small hydro power (3,991 MW), solar power (3,060 MW) and Urban & Industrial Waste (275 MW). In terms of electricity generation, the renewable power installed capacity is generating around 70 billion units per year.

As per MNRE's annual report 2014-15, "Renewable energy has a great capacity to usher in universal energy access. In a decentralised or standalone mode, renewable energy is an appropriate, scalable and viable solution for providing power to unelectrified or power deficient villages and hamlets. Around 1.1 million households are using solar energy to meet their lighting energy needs and almost a similar number of the households meet their cooking energy needs from biogas plants. Solar Photovoltaic (PV) power systems are being used for a variety of applications such as rural electrification, railway signaling, microwave repeaters, TV transmission and reception and for providing power to border outposts. Over 10,000 remote and inaccessible villages and hamlets have been provided with basic electricity services through distributed renewable power systems." However, we still need to do a lot as the potential is much more.

Considering that mega projects need vast technical expertise and big investments, an MOU for setting up a Joint Venture Company (JVC) towards undertaking the first Demonstration Offshore Wind Power Project in the country along the Gujarat coast has been signed on 01.10.2014 in the presence of Piyush Goyal, Union Minister of State (IC), Power, Coal and New & Renewable Energy.

The MoU was signed by the MNRE, National Institute of Wind Energy (NIWE), and Consortium of partners consisting of National Thermal Power Corporation (NTPC), Power Grid Corporation of India Ltd (PGCIL), Indian Renewable Energy Development Agency (IREDA), Power Finance Corporation (PFC), Power Trading Corporation (PTC) and Gujarat Power Corporation Ltd (GPCL). Apart from public private partnership project-based projects, there are many projects coming up, which are completely being financed, commissioned and run on private efforts. Several institutes, factories and research centres, individuals are also installing their own captive renewable energy plants. Even without subsidy from the government, this field is growing. Exact estimation of this segment is difficult. However, with the growth of the smart grid systems and microgrid systems, it will be easier to estimate the exact values of such generations.

Conclusion

According to Globe Data, despite the strong growth of the nuclear and renewable segment, thermal power will remain the dominant contributor to India's energy mix, with installed capacity forecast to almost double from 199.9 GW in 2014 to 377.6 GW by 2035.

However, owing to several negative factors like the Global Warming Potential (GWP), Ozone Depletion Potential (ODP) and Health Damage Impact Potential of the coal-fired thermal power plants, we need to completely switch over to other green technologies as soon as possible. Although, deployment of advanced technologies in coal fired power plants may help in making them cleaner and safer, they cannot completely eliminate their harmful effects.

P K Chatterjee
Editor, Electrical India

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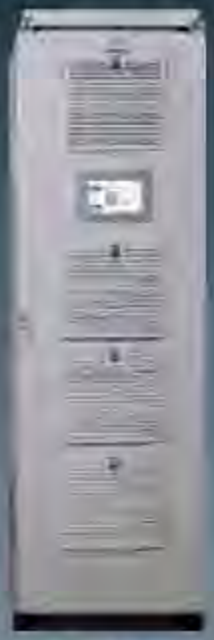

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- Independent operations of modules
- Compensation up to 50th Harmonic
- Ultra-fast response time 21 µs
- 3phase-3wire and 4 wire configuration
- Voltage range 180V ~ 460V (4 wire) and 180V ~ 528V (3 Wire)
- Best suited for fast changing harmonic distortions
- Reactive power compensation against Capacitive and Inductive load
- Balancing of loads in all phases

Applications :

- Industries having Variable Frequency Drives, Inverters UPS, furnaces such as Paper, Steel Rolling, Textile, Garment, Software Parks, Automotive, Battery Manufacturing, Continuous Process Plants and Pharmaceutical Industries etc.
- Data centers, Hotels, Hospitals, Shopping malls and Office buildings
- Solar generation farms and Wind Turbines

Special features :

- Lowest active power loss (High energy efficiency >98%)
- High harmonic attenuation factor >98%
- True 4 wire system with full capacity 4th wire
- Neutral lead compensation of 3 * I_n
- Compliant with International standards

Customer Benefit :

- Simple installation
- User friendly menu operations
- Low life cycle cost

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Interview

"Quality is not something which we strive but it is intrinsic to our ethos..."

Rishabh Instruments Pvt. Ltd., with an experience of nearly three decades is an organisation that has built its core competence in manufacturing, design and development of Test and Measuring Instruments and Industrial Control Products. In a free wheeling conversation, Deepak Thakur, CEO of the company is revealing some recent facts about his company to P K Chatterjee. Excerpts...

What are the areas where Rishabh Instruments' products have established their monopoly through its 30 years' effort?

Over the last three decades since its inception, Rishabh has built its expertise and more importantly credibility across the entire spectrum of Analog and Digital metering and instrumentation domain. The canvas covered by its products begins with very simple requirement with regards to measurement of basic electrical parameters up to high end power analytics and control including communication. This product basket covers hand held instruments as well complete panel mounting models.

Some statistics have also revealed that as of date, Rishabh is one of the largest manufacturers of analogue panel meters in the world, by volume. It makes close to about 125,000 analogue products monthly and about 30,000 digital products in a month. Added to that, it can also manufacture about 2,000 current transformers a day. This production capacity across a wide product segment, enables Rishabh to build a strong market presence in both the domestic and international markets. Its products have had exceptional response with several global stakeholders and infact some of these relationships span over decades. Unique product configurations and patented designs such as in its TMI domain enable such high reliability and high acceptance for Rishabh.

With more than half of its revenues stems from international market, Rishabh's business value chain is geared to deliver sustained value with its products and

service to International benchmarks. The philosophy adapted by Rishabh from the outset, has been that there is one Rishabh standard from design to production to service in both domestic as well as international markets. Its products are made for the world and these have been well received and appreciated by our customers all across the globe who also appreciate our core business principles and values.

How do you ensure quality of the products?

At Rishabh, quality is not something which we strive but it is intrinsic to our ethos. Quality – it is Rishabh's philosophy that rather than only operating quality programs and validating their efficacy, it has to become a 'way of life' encompassing each and every member of the team.
In Rishabh's case, quality covers all business aspects from design, development, manufacturing, marketing, selling to after sales services support – focused on ensuring value to customers consistently. Its R&D facility has been approved by the Department of Scientific and Industrial Research (DSIR) and it has a certification lab which has received approval from the National Accreditation Board for Testing and Calibration Laboratories (NABL). It further leverages expertise of its European subsidiary Lumel to gain quality insights and benchmarks in the global arena in addition to its own ongoing initiatives to keep itself abreast of international quality trends and practices.
Apart from this, Rishabh is a certified ISO 9001:2008 organization and have invested in world-class facilities to inspect our test instrumentation and manufactured products as per various standards such as IEC, DIN, IS and ANSI. While focus is on in-process prevention of quality issues, each device manufactured in the company goes through stringent testing and quality checks for which its QA lab is fully equipped with highly accurate calibration and testing equipment etc.
Rishabh also has in addition consistently focused on people and practices, over the decades, which enables it to create and sustain customer satisfaction.

What kind of technological superiority do you have?

Rishabh has manufacturing facilities in India and Poland, which are technologically at par with any world class setup. The company is equipped to cater most stringent manufacturing needs of its customers.
With its wide spectrum of products encompassing analogue meters, digital meters, multi function meters, multi meters, transducers, power supplies, relays, CTs, shunts, cam switches, Rishabh has to necessarily focus on keeping abreast with latest manufacturing techniques and practices while equal stress on process optimisation.
Rishabh customers value its end-to-end solutions from design/ development, to engineering, to manufacturing and sourcing of components, to servicing. Our in-house capabilities include plastic mould design and manufacturing, injection infrastructure for plastic parts, punch shop for metal component processing, Integrated SMT set up among other infrastructure. Reliability and robustness of the product its designs and sells, is an integral part of our offering, which it is able to deliver consistently due to the complete control across every aspect of the entire manufacturing process, which in turn reinforces the strong bond Rishabh has with its business partners and clients.
To meet varying requirements of its customers, Rishabh regularly deals with UL, CE, CSA, ANSI, ASTA, IEC, ISI, GOST certifications and compliances ensuring all requisite standards and approvals are obtained. Our operational practices are aligned to highest levels of HSE compliances and there are continuous efforts for enhance these.
Our approach to servicing requirements of the market and clients, through our in-house developed products as also designs and offerings from our technology partners. Now with acquisition in Poland, it has a further enhanced portfolio of products and technologies which supplement Rishabh's existing basket.
Rishabh initiated its in-house R&D facility development about 15 years back and since then it has developed many products, platforms and technologies with this set up.
Rishabh received two US patents in 2007 which bears testimony to the capability of this set up. A team of about 80 R&D developers is continuously working on newer developments while also upgrading existing offerings technology. This set up has enabled Rishabh moving up the value chain from analogue to digital portfolio to higher end power electronics while creating an extended portfolio in each category.

Are you developing indigenous technologies nowadays or importing those from European countries?

India is coming into the limelight as manufacturing hot spot for engineering products and the current 'MAKE IN INDIA' campaign launched recently, has only reinforced Rishabh's core conviction and thought process with regards to this principle, from its beginning. Rishabh has been serving the industry over the last 30 years wherein its manufacturing experience and expertise have played the major role.
At Rishabh, business principle followed is 'Concept to Bulk'. It has in-house 'Think Tanks' available in the organisation, which shape the concept and bring into the reality and that is where the real backward integration begins. It has a fully integrated manufacturing process as elaborated in the initial part of this discussion and this provides the organisation requisite agility and control to meet market expectations.
Since its inception, the philosophy at Rishabh has been that any product that carries the company's brand is manufactured in-house. All plastic parts and housing elements that are required for most of the meters, devices and current transformers are manufactured in house as also various metal components. In brief, for each product that we have in our portfolio, right from components to packaging and even stickers, labels and manuals – everything is done in-house. Rishabh truly lives by the principle of Make in India - and the above facts reinforce the same emphatically.

How do you manage to keep your products cost competitive?

Rishabh's state-of-the-art manufacturing facility and expertise has been its core strength in the context of ensuring cost efficiency. Over the decades, the design and engineering team has taken feedback from the market and customers, using this insight and experiences to optimise product design, component specs, material selection, manufacturing processes, testing and calibration techniques. Cost competitiveness begins with R&D process thru selection of the most efficient way of product designing. Advanced material science understanding is used appropriately as well.
Rationalisation of the bill of material and efficient adoption of newer technologies and skilled manpower are key elements of product cost competitiveness. Apart from these, one of the most important dimensions is Quality Control – which plays a vital role as it has a direct impact on product cost. Zero defects, adaptation of 5S principles and Right first time are levers to deliver the most cost competitive products while delivering unmatched quality.

How do you improve skill among your manpower?

The biggest challenge today when one is making attempts to address a growing market is talent acquisition, retention and development of skill sets. To maintain the momentum of the growth when it is happening at such a rapid pace, it demands high level of capabilities and that's why Rishabh believes in continual investment on this front.
The skill set development has been categorised across leadership skills, business capabilities, soft and technical skills. It begins at the top and reaches to the last person in the value chain. At Rishabh, the strong belief is that the biggest asset for the organisation is the highly motivated and skilled employee. Training has been also core to our values and the establishment of our 'Gurukul' learning facility at Nasik is the example of our focus towards this objective. The facility is fully equipped with the advanced presentation tools and instrumentation for skill trainers to use. Various training programs are run throughout the year and this structured calendar has proven as a rich source of knowledge building for Rishabh employees across many years.
To further meet the ongoing need for training and knowledge building, Rishabh Marketing department is constantly developing content and leveraging newer and advanced platforms like Web Based Training, live meeting, e-chat. All relevant material required by the sales team members is available via ae-Sales Tool Kit and this has been further enhanced and expanded through recent initiatives like Product Knowledge Hub (PKH).
On the manufacturing front, Rishabh has ensured through nationally recognised entities programs for measurement and improvement of efficiency, productivity and other skills of the manpower. Operation Skill Matrix have been designed for operators and classification into various categories completed, which are identified as Skilled, Semi-skilled and Critical categories respectively. Based on the type of categories, various skill improvement programs are held in the company on an ongoing basis.

Rishabh's leadership team is actively involved in an Active Management Development Program, under which inputs are provided quarterly and skills are continuously reviewed. Proactive performance management system driven by the CEO in tandem with HR ensures the process is effective.

What are the new products being planned for launching soon?

In the recent months, Rishabh has launched a new series of CAM switches with current rating up to 200A, which boasts of improved performance than the other industry front-runners in the same product category. Another innovative product successfully launched is the 3 phase CT (Current Transformer), where instead of using 3 CTs for 3 phases, only one SKU is required. Rishabh is the pioneer of this innovation in India.
Similarly, focused and continuous developments on transducers have enabled to expand its range which currently includes the dual output transducers with the recent launches of RishDucer CA/CV in the Rish Con Transducer series. In the Test and Measuring range, Rishabh has introduced the new Power Clamp with a rotating clamp jaw opening, for which it has a design patent and also added Insulation and Earth Tester in its portfolio.
Another addition is a fully programmable Signal Isolator and a new series for Programmable Relay including the Earth Leakage Relay. Robust and structured development process with complete range of in-house infrastructure and capabilities has ensured all the aforesaid developments.
This momentum at Rishabh is expected to further accelerate with even more exciting launches on the anvil which encompass upgraded Power Quality Analyzer, new Insulation Tester and Temp Controller as well as economical range of Power Supplies and improved High End Digital Multimeter with advanced communication features. At Rishabh, it is believed that its product basket enables it to enhance its strong position not only in domestic, but also in International arena, which constitutes a major portion of the company's topline.

What is your message for the power instruments' user community?

The various initiatives started by Govt. of India like Make In India Campaign, Digital India, Smart Cities etc. would boost the energy generation, distribution & energy efficiency plus conservation segments in the country. At Rishabh, it is believed that, one of the key areas, with sufficient availability of power across all users pan India, would be quality of power. Thus, in time to come, the attention of the entire power Instruments users will be drawn to power quality and its analytics. At Rishabh, there is a clear road map to address this need of the industry and it is coming up with high end devices like panel mounted Power Quality Analyzer, hand held (Portable) Power Quality Analyzer and so on. The only message Rishabh would like to give for all power instruments users is to remain aware, bring more focus on assured power quality as this will have a direct impact not only on the Instrument but also on the overall business economics.


POWER
MANAGEMENT

Interview

"The power sector has been opened to the private sector mainly to bring in additionality to the resources..."

As per India's Intended Nationally Determined Contribution (INDC) the emissions intensity of its GDP is to be reduced by 33 to 35% by 2030 from 2005 level and about 40% cumulative electric power installed capacity is to be generated from non-fossil fuel based energy resources by 2030. Under such circumstances, how is the Indian hydro power segment grooming up to share the responsibility? In a tête-à-tête, S D Dubey, Member (Power System & Hydro) Central Electricity Authority (CEA) is explaining that to P K Chatterjee. Excerpts...

Are we as a nation paying proper attention on harnessing hydropower at large scale?

Hydro Power is the clean, green and environmental friendly source of power. Among all the primary resources of energy, it is the only renewable source and has been recognised to be economical and preferred source of energy due to its inherent ability for instantaneous starting, stopping and load variation, thereby ideally suited for peaking operation and improves reliability of the power system.

Central Electricity Authority, an apex technical organisation under Ministry of Power, which is responsible for systematic and optimal development of all facets of power sector in the country has been putting in untiring efforts for development of all conventional resources of power including hydro power in an optimal environment compliant manner – more so in view of the nation's commitment towards clean and green energy production for minimising the adverse impacts on the climate.

Will we be able to achieve the target (of commissioning hydro power plants) as planned in 12th Five Year Plan?

Efforts are being made to achieve the targeted capacity addition of 10,897 MW from hydro projects during the 12th Plan. By now, 3501 MW of hydro capacity has already been added. During the balance period of the plan, another 3,245 MW is expected to be added to the grid. However, some projects with an aggregate capacity of 4 151 MW are likely to slip to the 13th Plan due to the reasons beyond the control of the developers.

What are the main causes that delay the process?

The process of implementation of hydro projects is getting delayed due to a number of issues like delay in acquisition of land for various locations of the project such as Dam, HRT, Power House, Switch yard etc., delay the commencement / progress of works. A substantial time is lost due to lack of adequate infrastructural facilities at the project site allotted to a developer by the State Govt. A large number of HE projects have been delayed due to geological surprises, environmental and forest issues, local issues including law & order problems, inter-state issues, contractual problems, financial crunch with the developer etc.

What is being done to accelerate this segment of the Indian power sector?

In order to accelerate implementation of hydro projects, efforts are being made to tackle the above mentioned issues at various levels. Regular review meetings are being taken by CEA/MOP to sort out issues with the developers. Site visits are also being conducted to monitor the progress at the site and resolution of various constraints. Project specific meetings are also being conducted for stranded projects – and the issues are referred to Inter-Ministerial Group for resolution.

What measures are being taken up to prevent cost over-run of the future projects?

Time over run is one of the major factors contributing to the cost over run, which could be due to the previously mentioned factors – or could also be due to other technical issues like geological surprises etc., which cannot be anticipated beforehand due to complex geology involved in most of the hydro projects in the young Himalayan Terrain.

However, past experience gathered from completed or ongoing projects is being used for investigation and planning of new projects to minimise such delays in future. CEA in consultation with other appraising agencies such as CWC, GSI, CSMRS, etc., have evolved a process in which these agencies are involved with the developers from the very beginning of S&I and preparation of DPR stage so that adequate investigations and studies are carried out and good quality DPR is prepared. With such an approach the issues contributing towards time and cost overrun during construction of project are expected to be minimised.

How should India attract funding in this segment?

The power sector has been opened to Private Sector mainly to bring in additionality to the resources. Subsequently, hydro policy has been announced by the Government, which has also been amended from time to time in order to provide a level playing ground to the private players. As a result, hydro projects with an aggregate capacity of about 44,000 MW have been allotted by State Govts. to private developers, which are under different stages of development. During the 12th plan 8,285 MW has been targeted to materialise through private sector that is almost double the target of the state sector.

What's your comment on complete privatisation of coming hydro-electricity generation plants?

Like any other important sector of Indian economy, there should be a proper mix of the Central/ State/ Private Sector power utilities and all sectors need to contribute for development of hydro sector. In fact, no sector should be considered as a substitute for the other instead, complementary to each other.

Do we need to launch globally open tenders for new hydropower projects (or it should be restricted to the national bidders)?

At present, the hydro projects are being allotted by the State Govts through MOU route as per the policy of State Govt's and Govt of India. Development of hydro power projects is fraught with a number of uncertainties. Broadly the problems faced by developers can be grouped in to those related to topographical, geological and hydrological aspects of the project location, to the issues of land requirement, submergence area, resettlement and rehabilitation etc. Given such uncertainties with major cost implications, it is very difficult for developers of HE projects to participate in Tariff based competitive bidding. Further, Tariff based competitive bidding is based on good quality DPR, which is considered as pre-requisite for tariff based bidding. Once the project is allotted to a developer for development, the survey and investigation and preparation of DPR is taken up by that developer – and then only the cost & tariff can be ascertained.

What is your comment on the present government's interest in this field?

As per India's Intended Nationally Determined Contribution (INDC), the emissions intensity of its GDP is to be reduced by 33 to 35% by 2030 from 2005 level and about 40% cumulative electric power installed capacity is to be generated from non-fossil fuel based energy resources by 2030. Therefore, the present government has been taking all possible steps for balanced and integrated growth of environmentally-compliant hydro projects. The government is striving for 24x7 power to the consumers at affordable prices. There has been, of late, a greater thrust on development of pumped storage hydro projects as well in view of availability of more and more infirm and off-peak energy likely in the system due to large thermal capacity additions apart from emphasis on renewable sources like solar and wind. Hydro projects with their flexible operation are required to provide grid security and stability in addition to generating green and clean power.

What would you like to communicate to the stakeholders of the Indian hydropower (large) segment?

I would like to take this opportunity to call upon all the developers that hydro power is likely to remain an essential component of our Indian power system and could contribute to the target of clean and green energy in light of availability of more and more infirm and off-peak energy in the system due to large thermal capacity additions that have already taken place apart from emphasis of the government on Renewable Energy Sources (RES), the development of hydro projects including pumped storage projects would be a desired option – and the sector is likely to yield very good returns in the long run.

APPLICATION OF CHAOS THEORY FOR POWER QUALITY IMPROVEMENT

The power quality issue is defined as any occurrence manifested in voltage, current, or frequency deviations those results in damage, upset, failure, or disoperation of end-use equipment. The history of Chaos Theory and Poincare Map are discussed here...

As it is known, energy is a basic concept in both science and engineering. One complex dynamic system that could be taken is an energy transformer. It can be divided into many subsystems, which are simpler. The nonlinear and active loads are used in many applications, such as power electronic arc furnaces and UPS and so on. These instruments improve the capacity of the control of power energy, but, at the same time, they also produce power pollution. The harmonics and reactive power components of current and voltage in three-phase system reduce the efficiency of the power system.

Traditionally, the passive filters, composed of resistors, inductors and capacitors, are used to eliminate the harmonics. With the development of power electronics, active power filters are introduced to reduce harmonic current and compensate the reactive component. Commonly, the shunt active power filters are considered as a controllable current source, which is connected in parallel with the mains. The harmonic and reactive components of the load current is drawn by the shunt active filter (SAF), so the supply current is sinusoidal with unity power factor, that is, the phases of both supply current and voltage are the same. The control objective is to make the source current of SAF equal to the harmonic and reactive power components of the load current.

The history of Chaos Theory and Poincare Map are discussed here; extensive use of power electronics devices in power system and due to which the system becomes more dynamic. So, the interest in nonlinear oscillations is growing, driven largely by developments in electronics.

Power Quality

The power quality issue is defined as any occurrence manifested in voltage, current, or frequency deviations those results in damage, upset, failure, or disoperation of end-use equipment. Almost all power quality issues are closely related with power electronics in almost every aspect of commercial, domestic, and industrial application.

Harmonics

Harmonic voltages and currents in an electric power system result due to nonlinear electric loads. Harmonic frequencies in the distribution power system are a frequent cause of power quality problems.

Harmonics in power systems result in increased heating of the equipment and conductors, missing in variable speed drives, and torque pulsations in motors. Reduction of harmonics is considered desirable

Description of Chaos

Although there is no a definite definition of chaos, its dynamical properties can be described as follows.

Chaos is an aperiodic, long-term behaviour, in a deterministic system that exhibits sensitive dependence on initial conditions. Aperiodic long-time behaviour means that trajectories in the phase portrait of a system do not settle down towards fixed points, periodic orbits, or quasi-periodic orbits. Deterministic means that the system has no random or noisy inputs or parameters. It has sensitive dependence on initial conditions.

Basic of the p-q Theory

The p-q theory is primarily based on a set of instantaneous calculation of powers in time domain. Voltage and current are sensed instantaneously which means there is no restriction on the shape of their waveform, and it can be applied to three-phase with or without a neutral wire. It is based in time domain rather than frequency domain. Thus it is valid in the steady state and also in the transient state. This shows the theory is very flexible and efficient in designing controllers for active filters and power conditioners based on power electronics devices.

Use of p-q Theory in Shunt Active Filter

The original concept of active filtering was introduced by Sasaki and Gyugyi in 1976. Now a shunt active filter can be implemented practically, and many shunt active filters are working all over the world. Their controllers detect the harmonic in real time in the form of sensing current reference, and source is power converter to synthesize the compensating current reference with high fidelity. Figure 1 illustrates the basic idea behind the shunt current compensation. It shows a source supplying power to a nonlinear load that is being compensated by a shunt active filter. Shunt active filter is actually a shunt compensator. We assume that the shunt active filter behaves as a three-phase controlled current source that can generate harmonics in phase opposition depending upon current references i_{ca}, i_{cb} and i_{cc}.

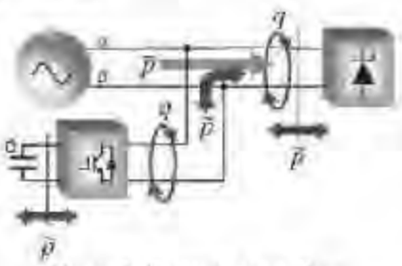

Figure 1: Optimal power flow...

The calculated real power p of the load can be separated into its average ($\bar{p}$) and oscillating ($\tilde{p}$) parts. Likewise, the load imaginary power q can be separated into its average ($\bar{q}$) and oscillating ($\tilde{q}$) parts. Then, undesired portions of the real and imaginary powers of the load that should be compensated are selected.

Modelling and Dynamic Analysis of SAF

SAF Introduction:

Basic response of passive harmonic filter and other problems have led to a power electronic solution of harmonic distortion i.e. Active Harmonic Filter a modern solution to old harmonic current problems. Nowadays, passive filters are used to cancel the switching frequency of active filters and high frequencies. Tuned filters are used besides the active filters to cancel specific frequencies and decrease the power of active filters. Active filters have been designed, improved, and commercialized in the past three decades. They are applicable to compensate current-based distortions such as current harmonics, reactive power, and neutral current. They are also used for voltage-based distortions such as voltage harmonics, voltage flickers, voltage sags and swells, and voltage unbalances and load unbalancing and neutral shifting. Moreover, unlike passive filters, they do not cause harmful resonances with the power distribution systems. Consequently, the active harmonic filter's performance is independent of the power distribution system properties.

> *Chaos is an aperiodic, long-term behaviour in a deterministic system that exhibits sensitive dependence on initial conditions...*

The shunt-connected active power filter, with a self-controlled DC bus, has a topology similar to that of a static compensator (STATCOM) used for reactive power compensation in power transmission systems. Shunt active power filters compensate load current harmonics by injecting equal but opposite harmonic compensating current. In this case the shunt active power filter operates as a current source injecting the harmonic components generated by the load but phase-shifted by 180°.

Operation of SAF

The main aim of the Active Harmonic Filter (AHF) is to compensate for the harmonics and reactive power dynamically. The AHF overcomes the drawbacks of passive filters by using the switching mode power converters to perform the harmonic current elimination.

Compensation current signals are fed to hysteresis controller or Pulse Width Modulation (PWM) converter as reference signals to generate gating signals for fast switching insulated Gate Bipolar Transistor (IGBT) inverter. The inverter generates harmonic currents required by the load through charging and discharging of capacitor. These currents are injected into the system near the load through an interfacing inductor or a coupling transformer. The performance of AHF is independent of system impedance as it compares the injected currents with reference signals and rectifies the error.

Figure 2 shows operational waveform generated by SAF. There are three topologies of AHF i) Series AHF ii) Shunt AHF and iii) Hybrid AHF. We have selected Shunt AHF (i.e., Shunt Active Filter or Current Active

Then for this study which is ideal for current harmonic compensation.

A consolidated block diagram of SAF is shown in figure 2.

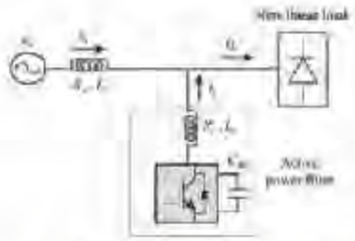

Figure 2: General block diagram of SAF...

Shunt Active filter Controller based on p-q Theory

The Distribution system we considered for research contains 3-phase source, line inductance, nonlinear load and shunt active filter as shown in Figure 3.

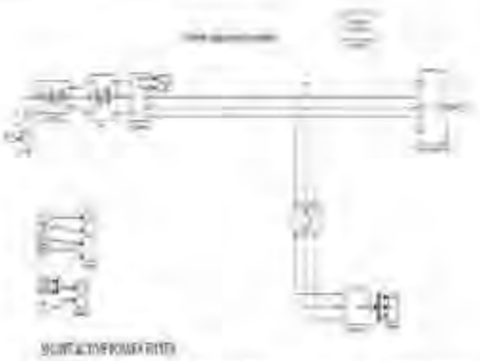

Figure 3: Distribution system SIMULINK diagram...

The S.M.U.Nk diagram of active filter controller based on the p-q Theory is shown in Figure 3. The PWM converter takes synthesizing action on compensating current. The filter control block has the job of performing signal analysis in real time to calculate the instantaneous compensatory reference current signals. Figure 4 shows the most common topology of an active filter for harmonic compensation (maximum compensation) of a specific non-linear load. It consists of a voltage source inverter with a PWM current control, here, hysteresis current control and an active filter control circuit that performs an instantaneous working control-algorithm. The shunt active filter controller works in a closed loop manner, continuously acquiring the samples of the load current and calculating the instantaneous values of the compensating current reference is for the

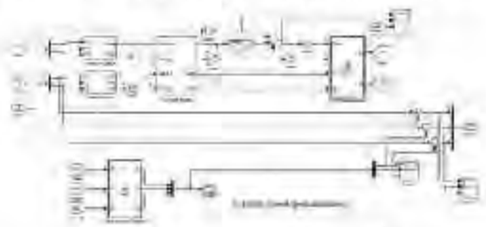

Figure 4: SIMULINK diagram for Compensation current calculation ...

PWM converter. In an ideal case, the PWM converter may be considered as a linear power amplifier, where the compensating current i_c tracks correctly its reference.

Simulation results of Shunt Active Filter

For observing the dynamic behaviour SAF we can consider many types of load, like non linear load, nonlinear plus balance resistive load, non linear plus unbalance resistive load, nonlinear load with R-L circuit etc. Here we find the result for compensation of nonlinear plus unbalance resistive load. The case is simulated to show the dynamic

Figure 5: Sinusoidal waveform of source current...

behaviour of the SAF. The SAF is switched on at 0.4 seconds with the nonlinear load only. These switching instants and the dynamic behaviour of the SAF can easily be observed.

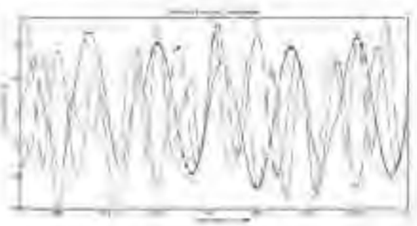

Figure 6: Injected load harmonic current waveform...

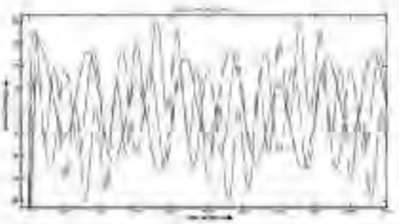

Figure 7: Injected load harmonic current waveform...

Dynamic Analysis of Shunt Active Filter

The SAF system is nonlinear, deterministic, with dimension $n \geq 3$. For existence of a chaotic behaviour it becomes necessary to check if it has an aperiodic behaviour and if it presents a sensitive dependence on initial conditions. The result presented in this section is obtained for particular case when the non linear load connected is harmonic current.

$I_L = I_{p1}[a_1 \sin(\omega t) + b_1 \sin(3\omega t) + c_1 \sin(5\omega t) + d_1 \sin(7\omega t)]$

The phase portrait of the SAF current p-q theory based control action

is depicted in Figure 9. It is not possible to know if there is a point, periodic or chaotic attractor in the phase portrait.

Figure 8: Phase Portrait of SAF..

Conclusion

The pq Theory based controller has been analysed for power quality improvement. The shunt active filter is implemented for current harmonics of the non-linear load. It is found from simulation results that pq theory along with shunt active filter improves power quality of the power system by eliminating harmonics of the non-linear load.

In next stage analysis of shunt active filter is done. Shunt active filters do not present a chaotic behaviour as long as the corresponding design parameters do not change. However, chaotic behaviour appears when the current harmonic amplitude is varied, particularly, when they become large enough. With the use of Poincare Maps to find out chaotic behaviour of shunt active filter under different load conditions.

Future Scope

Modeling and dynamic analysis of shunt active filter has been done in this thesis. It shows the chaotic behaviour of SAF (pq theory based controller) is used. The work is to be extended to implementation of Passivity-Based Control via design of passive resistors using the concept of chaos and Poincare Maps as discussed in the literature survey. Hence could be used to improve filter performance and power quality of power system. Future scope for this work is the presentation of a procedure for obtaining values for the passivity resistors by which the SAF behaves better.

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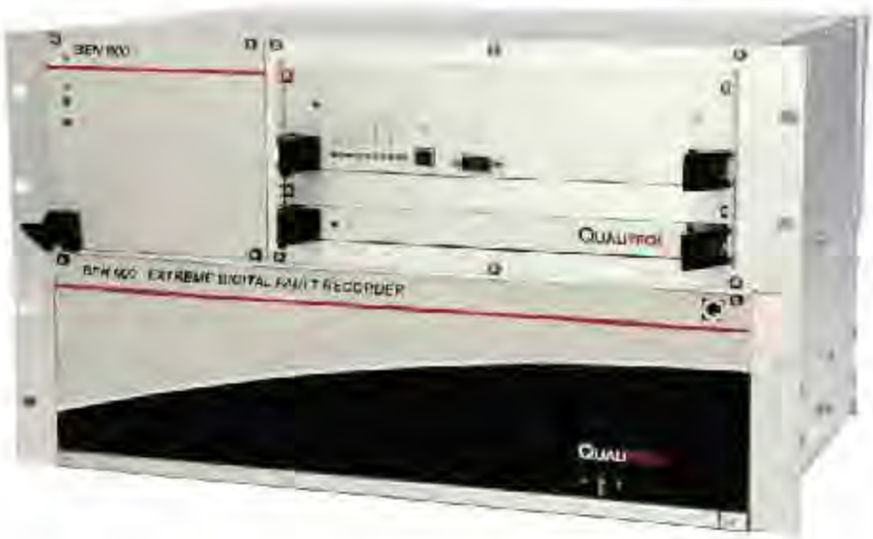
Phasor Measurement Units For Power Systems



Phasor Measurement Units (PMUs) provide real time synchronised measurements in power system with better than one microsecond synchronisation accuracy, which is obtained by Global Positioning System (GPS) signals...

Existing systems in power grid such as Energy Management System (EMS) and Supervisory Control and Data Acquisition system (SCADA) have the capability to provide only steady state view of power system with high data flow latency. In Supervisory Control and Data Acquisition system (SCADA) it was not possible to measure the phase angles of bus voltages of power system network in real time, due to technical difficulties in synchronising measurements from distant locations.

Measurements were obtained at slower rates, it was not possible to get dynamic behaviour of power system as well as timed situational awareness was not provided to the operator. Advent of Phasor Measurement Units (PMUs) alleviated this problem by synchronising voltage and current waveforms at widely dispersed locations with respect to global positioning system. PMU is superior to SCADA with respect to speed, performance and reliability.

As per definition of IEEE, PMU is defined as device that produces synchronised phasor, frequency and rate of change of frequency estimates from voltage and/or current signals and time synchronising signal. PMUs provide real time synchronised measurements in power system with better than one microsecond synchronisation accuracy which is obtained by Global Positioning System (GPS) signals. PMUs are situated in power system substations, and provide measurement of time stamped positive sequence voltages and currents of all

monitored buses and feeders. Data from various substations are collected at suitable site, and by aligning time stamps of measurements a coherent picture of the state power system is created. PMUs are time synchronised, high speed measurement units that monitor current and voltage waveforms (sinusoids) in the grid, convert them into a phasor representation through high end computation and securely transmit the same to centralised server.

PMU technology is well suited to track grid dynamics in real time, the data obtained can be used for wide area monitoring, stability monitoring, dynamic system ratings and improvements in state estimation, protection and control. It enables utilities to proactively plan energy delivery and prevent failures.

Fundamentals of PMU's

PMU technology provides phasor information (both magnitude and phase angle) in real time.

Advantage of referring phase angle to global reference time is helpful in capturing wide area snapshot of power system. Effective utilization of this technology is useful in mitigating blackouts and learning real time behaviour of power system.

A phasor is a complex number that represents both the magnitude and phase angle of the sine waves found in AC systems. The waveform can be represented by

$$x(t) = x_m \cos(\omega t + \theta)$$

$$x(t) = x_m/\sqrt{2} e^{j\theta} = \frac{x_m}{\sqrt{2}}(\cos\theta + j \sin\theta)$$

Where ω is the frequency of the signal in radians per second, and θ is the phase angle in radians. x_m is the peak amplitude of the signal. The Root Mean Square (RMS) value of the actual signal is $x_m/\sqrt{2}$.

Positive phase angles are measured in a counter clockwise direction from the real axis. Since the frequency of the sinusoidal is implicit in the phasor definition, it is clear that all

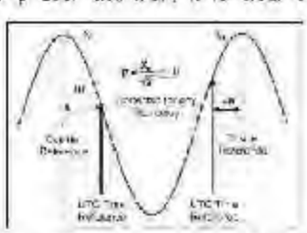


Figure 1: *Phasor representation...*

phasors which are included in a single phasor diagram must have the same frequency. Phasor representation of the sinusoidal inputs that the signal remains stationary at all times, leading to a constant phasor representation. These concepts must be modified when practical phasor measurements are to be carried out when the input signals are not constant and their frequency may be a variable.

Wide Area Measurement Systems

PMU installation is a part of wide area monitoring system network consisting of loading of PMUs throughout the electricity grid at strategic locations in order to cover the entire grid. A Phasor data concentrator at central location collects information from PMUs, and passes that to supervisory control and data acquisition system after time aligning the same.

A complete WAMS network needs rapid data transfer within frequency of sampling of phasor data samples. Phasor measurements at PMU are time stamped at each location. GPS installed at PMU location provides accurate time along with time synchronisation among different PMUs. PMU components: The main components of a PMU are data acquisition module, communication module and GPS signal receiver.

Figure 2: *Block diagram representation of PMU...*

The analog inputs to device are currents and voltages obtained from the secondary windings of the current and voltage transformers located in substation. All three phase currents and voltages are used so that positive sequence measurements can be carried out. The current and voltage signals are converted to voltages with appropriate shunts or instrument transformers to match with the requirements of the analog to digital converters.

The sampling rate chosen for the sampling process dictates the frequency response of the anti-aliasing filters. Anti aliasing filters ensure that all the analog signals have the same phase shift and attenuation, thus assuring that the phase angled differences and relative magnitudes of the different signals are unchanged.

The GPS system is used in determining the coordinates of the receiver, although for the PMUs the signal which is most important is the one pulse per second. This pulse as received by any receiver on earth is coincident with all other received pulses to within 1 microsecond.

Architecture of Wide Area Measurement Systems

In power grid, the phasor data is used from PMUs placed at different locations. WAMSs are advanced measurement technology to collect information. WAMS perform the function of obtaining, data and extracting value from the data.

Figure 3: *Integration of PMU data...*

PMUs are located at substations, and provide measurements of time-stamped positive sequence voltages and currents of all monitored buses and feeders (as well as frequency and rate of change of frequency). The measurements are stored in local data storage devices, which can be accessed from remote locations for a periodic purposes.

The local storage capacity is not necessarily limited, and the stored data belonging to an interesting power system event must be flagged for permanent storage – so that it is not overwritten when the local storage capacity is exhausted. The phasor data is also available for real time applications in a steady stream as soon as the measurements are made.

Figure 4: *WAMS architecture...*

The devices at next level of the hierarchy are commonly known as Phasor Data Concentrators. Typical function of a PDC is to gather data from several PMUs, reject bad data, align the time-stamps and create a coherent record of simultaneously recorded data from a wider part of the power system.

There are local storage facilities in the PDCs, as well as application functions, which need the PMU data available at the PDC. This can be made available by the PDCs to the local applications in real time.

Motivation for Synchronised Measurements (Synchrophasors)

When a Phasor measurement is time stamped against GPS universal time it is called synchrophasor. This allows measurements taken by PMUs in different locations or by different owners to be synchronised and time aligned, thus contributing to provide a precise, comprehensive view of an entire region or interconnection. A synchrophasor system is wide deployment of PMUs and dedicated high speed communication to access, and deliver synchronised high speed and condition data along with analytics and other advances to the dynamic security assessment and control applications. Synchrophasors enable much better inspection of grid state, and are used to trigger corrective actions to maintain reliability of the network.

Need of Synchrophasor : i) To obtain high resolution data ii) The data from different locations are not captured at precisely the same time, iii) Voltage, active power and reactive power normally do not change abruptly, unless there is a large disturbance nearby, iv) System monitoring is critical during disturbance and transients, v) To capture dynamics of the system faster synchronized data is required.

Figure 5 : *Synchronization of sample at different locations*

Synchrophasors in Indian Power Grid

Indian power grid is one of the largest power grids in the world. Operation of Indian power grid is monitored and co-ordinated through national load dispatch centre and five regional load dispatch centres and state load dispatch centres. To complement visualisation and enhance the situational awareness of large Indian power network to grid operators in control centre synchrophasor projects are deployed. Synchrophasors enable superior inspection of grid stress and are often used to trigger corrective actions to maintain reliability.

The first PMU pilot project was set up in northern region in the year 2010, wherein 4 nos. of PMUs along with GPS installed at selected 9 substations in the grid. A Phasor Data Concentrator and other associated equipment are placed at Northern Regional Load Dispatch Centre (NRLDC) located at New Delhi.

Considering the need for wide area measurement for Indian power grid, installation of PMUs on substations at 400kV level and above in the State & Central grids, all generating stations at 220kV level and above, HVDC terminals, important inter-regional connection points, inter-national connection points, etc. are being taken up. This will facilitate a Unified Real-time Dynamic State Measurements (URTDSM) towards improved system operation.

PMU application

- Post disturbance analysis
- Stability monitoring
- Thermal overload monitoring
- Power system restoration
- State estimation
- Real time control
- Adaptive protection

All the regional grids in India are interconnected, to assess the power system the angular separations over wide area are one of the key indicators. The angle, the phase angle, difference between source and sink, greater is power flow between those points. Greater phase angle differences imply large stress across the interface and large stress could move the grid closer to instability. Angular separation provides insights into the health ness of synchronous interconnection. Relative phasor angles across the system at the starting time of disturbance provide information about initial system loading conditions. It also provides indication of how system reacted to disturbance. In case of oscillations, relative phase angles can be analysed to understand the nature and shape of oscillations – and to know how different parts of system oscillate relative to each other.

Challenges in PMU implementation

- Selecting suitable location for PMU placement
- Integration of synchrophasor technology with SCADA
- Communication delays
- Low frequency oscillation monitoring
- Distorted power system waveforms makes prediction difficult
- High computational requirement
- Developing tools for in depth post facto analysis

Conclusion

PMU provide innovative solution to traditional utility problems. It also facilitates improved protection and effective control of power system networks.

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Energy Efficiency

Analysis Of A Gas Turbine Based Co-Generation Plant

Gas turbine based power plants consume sizeable quantum of primary fuel and generate significant amount of electrical energy in the country. This article describes the details of various energy efficiency improvement measures identified for implementation during energy audit of a gas turbine based co-generation plant.

A thorough study of a gas-turbine-based co-gen plant reveals some facts that may be implemented to improve the energy efficiency...

The installed capacity of electrical power generation in the country is 274.8 GW (as on 30th June 2015) and the installed capacity of gas turbine power plants is 23.06 GW (about 8.4% of total capacity).

Energy audit and performance evaluation tests were carried out on gas turbine systems and the schematic of a typical Gas Turbine (GT) based co-generation system is depicted in Figure 1.

A DG set (whose coupling gets disengaged when the speed of gas turbine is more than a certain speed) is used for the start-up purpose. Ambient air, drawn through air filter, is compressed in an axial flow air compressor and the compressed air and fuel are combusted in the Combustion Chamber (CC), and the resultant high temperature and high pressure gas is expanded across the gas turbine to generate power. Significant portion of power generated by the gas turbine (about 50%) is used to drive the axial flow air compressor and the remaining power is used to drive the GT Generator (GTG) through a gear box.

The hot flue gas exit from GT is utilised in three steps – first, to super heat the saturated steam from steam drum, second, to evaporate the hot feed water (in evaporator) from economiser and third, to pre-heat the feed water (these three heat absorption equipment forms the Heat Recovery Steam Generator (HRSG).

The superheated steam from the HRSGs goes to the HP steam header, from where the HP steam is either expanded across the Steam Turbine Generator (STG) or sent to the process for heating applications.

Performance Evaluation

Performance test was carried out on the GTGs, and the results are presented in Table 1. It is seen from the table that the operating gross efficiency of GTs # 1, 2 & 3 is in the range of 25.9-26.0% and is good. The performance parameters of HRSG and overall system are evaluated and provided in Table 2. It is seen that the overall co-generation system efficiency is 81.1 - 86.7 %. The performance of GT & HRSG # 3 is very good. The overall efficiency of GT # 1 & 2 is low since Condensate Pre-Heater (CPH) is not present and exit flue gas temperature is high. It is seen that the cost of energy and steam generation from GT & HRSG system is very much economical.

No.	Particular	Unit	GT-1	GT-2	GT-3
1	Fuel flow (Naptha)	kg/h	6062.63	6149.98	6050.7
2	Fuel pressure [at pump discharge/after control valve]	kgf/cm2	9.17/4.42	12.18/4.46	10.69/4.33
3	NCV of fuel	kcal/kg	9800.0	9800.0	9800.0
4	Total heat input to GT	Mkcal/h	59.41	60.27	59.30
5	Pressure drop across air filter	mmWc	45.72	81.28	55.00
6	Compressordischargepressure	kgf/cm2	7.37	7.20	8.75
7	Compressor discharge temp.	°C	325.0	317.0	302.0
	Performance of GTG				
8	Rating of GTG	MW	20.05	24.8	25.6
9	Energy generated during test	MWh/h	17.9	18.24	17.9
10	Load factor during the test	%	89.3	73.6	69.9
11	Auxiliary power used	MWh/h	0.453	0.453	0.453
12	Test gross heat rate of GT	kcal/kWh	3319.6	3303.4	3313.2
		kJ/kWh	13896.7	13828.0	13868.8
13	Test net heat rate of GT	kcal/kWh	3406.0	3387.4	3399.1
		kJ/kWh	14257.9	14178.8	14228.8
14	Design gross heat rate GT	kcal/kWh	3294	3391	3428
		kJ/kWh	13789	14153	14350
15	Test gross efficiency of GT	%	25.91	26.03	25.96
	Test net efficiency of GT	%	25.25	25.39	25.30
16	Design gross efficiency of GT	%	26.11	25.44	25.09

Table 1: Result of the performance test conducted on the GTs...

Energy Efficiency Improvements Identified

The various energy efficiency improvements identified in the GT power plant are described below.

- The exit flue gas temperature in HRSG # 1 &, 2 are 203 & 200°C. It is suggested to introduce CPH for HRSG # 1 & 2 also and bring down flue gas temperature up to 110-115°C. Presently, the heat absorption by DM water in CPH is from 39°C to 56°C only. This additional heat recovery system will lead to reduction of consumption of LP steam in de-aerator. The existing one metre gap between CPH and chimney can also be used to extract more heat from flue gas of all HRSGs. The capital investment may be about ₹ 2000 lakhs. The expected fuel saving is 10488.2 t / year and the payback period is 5 months.
- Steam injection system is already installed for both the GTs but not being operated now. Since the system is designed for steam injection, no harm is expected and many gas plants are successfully using it. Hence, it is suggested to restore the operation. At full load, about 1.14 t/h of steam can be injected (as per design) and the fuel saving expected is 0.8%. The annual fuel saving envisaged is 734 t.
- The chimney exit contains flue gas (about 357.8 t/h of flow/GT) with 15-16% oxygen and 355-700 ppm of CO. Oxidation catalyst can be used inside HRSG to convert CO to CO_2 and the additional heat can be produced and extracted.
- Inlet air cooling system can increase the output of GT up to 10-15% (if cooled up to 15 °C). The rating of present generator is 26.7 MVA. If load power factor is improved to, say 0.95 (from present 0.85), the same generator can take the additional 10-15% load also. Simple air washer unit is a low cost option for cooling the inlet air up to wet bulb temperature so that power generated is increased by about 5% and fuel saving is about 3%.
- On-line compressor wash system needs to be installed and employed on regular basis to reduce the dust load on the compressor blades and to achieve fuel saving.
- Presently, compressed air [about 1,100 Nm^3/h / HRSG at 7.4 bar & 35°C) is employed for atomisation of fuel in HRSGs. Since compressed air is highly energy intensive and high grade energy (generated from electrical energy), it is suggested to switch over to steam atomisation (low grade heat energy) to optimise the operating cost.
- The O_2 level in flue gas after GT is 13.7-14.1% which may be adequate for the combustion of supplementary fuel in HRSGs. It is suggested to stop the operation of augmentation air fan in

NO.	Particulars	Unit	GT # 1	GT # 2	GT # 3
I. Performance of HRSG system					
1	Main steam flow	t/h	69.9	76.8	120.0
2	Main steam pressure	bar (a)	15.6	15.4	15.9
3	Main steam temperature	°C	293.4	296.0	294.9
4	Main steam enthalpy	kcal/kg	721.9	723.4	722.5
5	Steam enthalpy at drum outlet	kcal/kg	667.4	667.4	667.9
6	Heat gain in SH	Mkcal/h	3.8	4.3	6.5
7	Drum pressure	bar (a)	16.4	16.5	16.0
8	Drum saturation temperature	°C	202.9	202.9	201.1
9	ECO outlet water temperature (assumed)	°C	185.0	185.0	185.0
10	ECO outlet water enthalpy	kcal/kg	187.6	187.7	187.7
11	Heat gain in evaporator	Mkcal/h	32.9	36.0	56.9
12	Flue gas temperature at ECO inlet	°C			213.0
13	Flue gas temperature at ECO outlet	°C	203	200	
14	ECO inlet water temperature	°C	121.3	124.7	122.7
15	ECO inlet water pressure	bar (a)	18.3	18.4	19.0
16	ECO inlet water enthalpy	kcal/kg	121.9	125.4	123.4
17	Heat gain in ECO	Mkcal/h	4.5	4.7	7.6
18	Flue gas temperature at CPH outlet	°C		156.6	
19	CPH inlet water temperature	°C		38.3	
20	De-superheating spray flow	t/h	1.4	1.7	1.46
21	Feed water flow to ECO	t/h	68.5	75.1	118.5
22	Feed water flow to CPH	t/h		91.2	
23	CPH outlet water temperature	°C		56.3	
24	CPH inlet water pressure	bar (a)		14.9	
25	CPH inlet water enthalpy	kcal/kg		38.6	
26	CPH outlet water enthalpy	kcal/kg		56.6	
27	Heat gain in CPH	Mkcal/h		1.6	
28	Total heat gain by water and steam at HRSG	Mkcal/h	41.2	45.0	72.7
29	Measured oxygen at economiser outlet	%	15.5	14.1	13.7
30	Measured CO at economiser outlet	ppm	0.0	8.3	0.0
II. Break up of heat gain in HRSG system					
31	Superheater	%	9.3	9.6	9.0
32	Evaporator	%	79.8	80.1	78.3
33	Economiser	%	10.9	10.4	10.5
34	Condensate pre-heater (CPH)	%	0.0	0.0	2.3

Table 2: Results of performance test conducted on HRSG and overall co-generation system...

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IIL Overall co-generation system					
35	Cost of Naptha	Rs./kg	50.2	50.20	50.20
36	NCV of Naptha	kcal/kg	9800	9800	9800
37	Cost of fuel gas	Rs./kg	40.8	40.8	40.8
38	NCV of fuel gas	kcal/kg	11200.0	11200.0	11200.0
39	Naptha fired for GT	kg/h	6062.6	6150.0	6050.7
40	Heat input to GT	Mkcal/h	59.41	60.27	59.30
41	Flue gas temperature at GT outlet	°C	510	533	538
42	Naptha fired for HRSG	kg/h		1548.9	2509.0
43	Fuel gas fired for HRSG	kg/h	921.74	0.0	993.5
44	Suppl. heat input (Naptha+Fuel gas) to HRSG	Mkcal/h	10.32	15.18	35.72
45	Total flue gas flow after supplementary firing	t/h	464.9	410.1	481.5
46	Total heat input to HRSG	Mkcal/h	53.5	58.9	78.8
47	% fuel cost spent to GT	%	23.23	21.89	17.05
48	% fuel cost spent to HRSG	%	76.77	78.11	82.95
49	Energy generated	MWh/h	17.90	18.24	17.90
50	Energy cost	Rs./kWh	3.95	3.70	2.99
51	Main steam flow	t/h	69.9	76.8	120.0
52	Steam cost	Rs./kg	3.34	3.14	2.10
53	Overall co-generation plant gross thermal efficiency	%	81.10	80.45	86.73

HRSG # 2 & 3 and observe for presence of CO content in the flue gas. If there is no CO content, then the operation of augmentation air fan can be discontinued.

Conclusions

The main conclusions from the study are as follows:

- Increasing the heat recovery through use of CPH (bringing down the flue gas exit temperature to 115°C) at HRSGs of GT will bring down the fuel consumption.
- Inlet air cooling and online compressor wash system will lead to fuel savings.
- Switching over to steam atomisation in HRSGs will lead to cost reduction.
- The cost of energy and steam generation from co-generation plant is significantly lower than from conventional boilers and TGs.

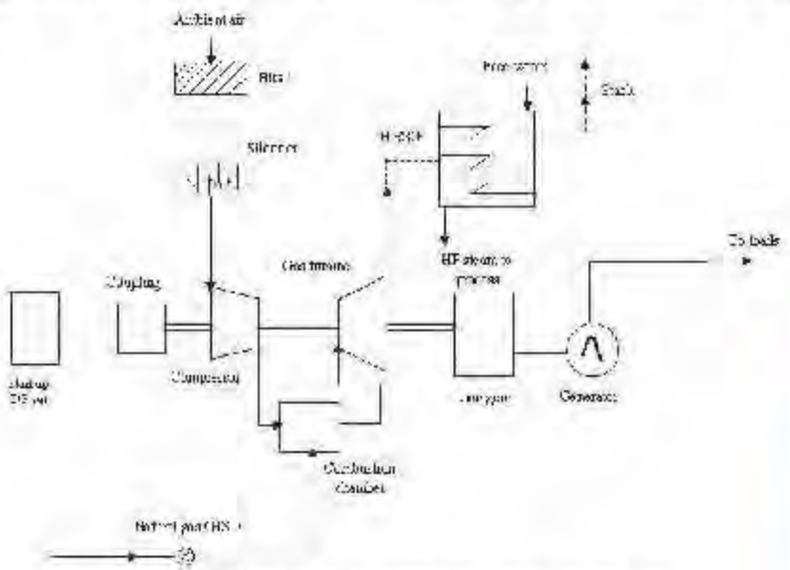

Figure 1: Schematic of the power and steam generation process from gas turbine system...

S. Jothibasu
Engineering Officer
Central Power Research Institute (CPRI)

The curious case of the shrinking, but more cost efficient transformer.

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Energy Harvesting Power Support To Wireless Sensor Networks

The most important feature of wireless sensor networks is the elimination of wires in communication. Without wiring requirements, they can be deployed in a range of remote monitoring applications where running wires is prohibitive or impossible...

Wireless Sensor Networks (WSNs) may be considered as the third wave of a revolution in wireless technology. It makes the life of humans more secure, easy and beneficial. A sensor is an electronic device used to detect or measure a physical quantity and convert it into an electronic signal. In a wireless sensor network, sensors play an important part, as sensing is one of its central roles. They sense data from various environments, process the data locally with some computation and communicate the data among the sensor nodes. The most important feature of wireless sensor networks is the elimination of wires in communication. Without wiring requirements, they can be deployed in a range of remote monitoring applications where running wires is prohibitive or impossible.

Sensor networks are formed from a collection of sensing nodes, which communicate with one another, typically through wireless channels, in order to collect spatially distributed data about their environment. Such networks have the potential to provide better quality data than single or small numbers of individual sensors in applications such as natural and built environmental monitoring, process monitoring, security and surveillance.

In order to be cost effective in many applications, the sensor nodes must be low cost and low maintenance. Sensor networks unshackled from the mains, or battery power, open the possibility for greater reliability, lower maintenance costs, improved safety, & widespread deployment. WSN systems have been varying power needs from a few microwatts of power in sleep mode to 100 milliwatts in transmit mode. Thus, these systems require a means to store energy. Batteries are the most commonly used energy-storage medium for WSNs. With new low-power WSN systems, nodes can operate for up to three years at a one-minute sample interval on four AA batteries.

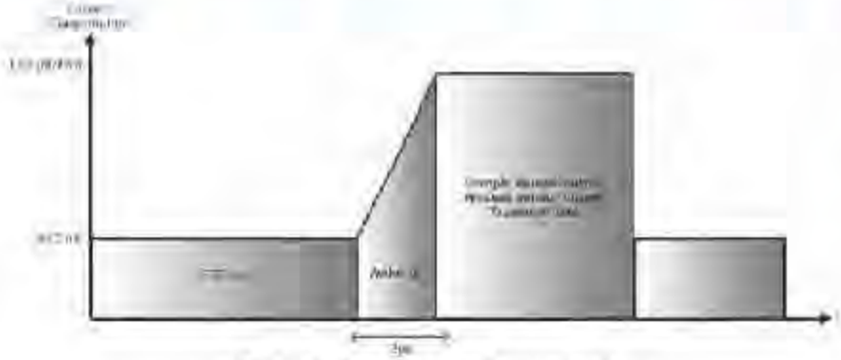

Fig 1: wireless sensor node power cycle...

Wireless sensors are ubiquitous and very flexible devices that can adapt using harvested energy. Since wireless sensor nodes are commonly placed in hard-to-reach locations, changing batteries regularly can be costly and inconvenient. It is now possible to implement wireless sensors using harvested energy because of the off-the-shelf availability of ultra-low-power, single-chip wireless microcontrollers (MCUs) capable of running control algorithms and modern communication algorithms. Power consumption can be minimised by optimising the relative amount of time spent in low-power sleep mode. Thus, most of the time wireless sensor nodes spend their time in sleep mode. The only subsystem that stays awake is the Real-Time Clock (RTC), which keeps time and wakes up the wireless sensor node to measure a sensor input.

Energy harvesting

Wireless Sensor Networks could involve billions of sensors, which are needed on variety of applications but adoption has been hindered by conventional primary batteries, which will eventually need replacing – and therefore cannot be fitted and forgotten for a long period.

While the performance of battery technology is gradually improving and the power requirements of electronics are generally dropping, these are not keeping pace with the increasing demands of many WSN applications. For this reason, there has been considerable interest in the development of systems capable of extracting useful electrical energy from existing environmental sources. Such sources include ambient light, thermal gradients, vibration & other forms of motion.

As energy storage technologies, such as super capacitors and Thin-Film Batteries (TFBs), have become more cost-effective, energy harvesting technology has become more sophisticated and efficient in recent years. These power management devices are to fully exploit the capabilities of the respective energy transducer elements and the sensor networks electronics that are ultimately powered by them. The following graph (Fig: 2) shows the power density of various energy harvesting technologies.

Energy sources suitable for scavenging

- **Solar energy harvesting**
  As an energy source for WSNs, solar cells are the most mature technology and supported by developed markets. Solar cell technology is one of the promising technologies, which are most studied and suited for various applications where availability of sun light is good. The photoelectric effect is a property of some materials to release electrons when exposed to light. These free electrons can be captured and used as a source of power for many applications. There are so many types of factors, which should be considered before using Solar Cells as an energy source like availability of bright sunlight days of sunny and cloudy days in a year, environmental conditions of deployment, power requirements etc.

  But higher manufacturing cost and relatively low efficiency of solar cells, presents considerable limitation to the use of solar cells over wide range of applications.

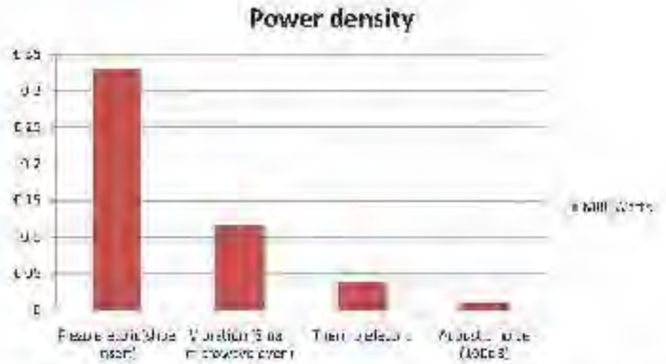

Fig: 2 The power density of various energy harvesting technologies...

- **Thermoelectric harvesting**
  Thermal gradients are one of the oldest techniques for generating electricity. A simple thermocouple is a junction of two dissimilar wires with a temperature difference between the junction and the wire ends. The thermoelectric effect is the direct conversion of thermal gradient to electric potential and vice versa. A thermoelectric generator creates a voltage when there is difference of temperature on each side (known as the Seebeck effect). Conversely, when a voltage is applied to it, it creates a temperature difference (known as the Peltier effect).The phenomena of creating electric voltage with a temperature difference and vice versa are termed as thermoelectricity.
- **Mechanical vibration**
  Mechanical vibration can be converted to electrical energy. Basically, there are three mechanisms for the conversion from mechanical vibration energy to electrical energy conversion: piezoelectric, electrostatic and electromagnetic.
- **Piezoelectric energy harvesting**
  There are certain materials that can generate an electric charge or voltage when they are under mechanical stress: this is a direct effect of piezoelectricity. Alternatively, the same materials are able to produce a mechanical deformation (or force) when an electric field is applied to them, this is inverse/ converse effect of piezoelectricity.
- **Electrostatic (Capacitive) energy harvesting**
  A capacitor broadly defined as two conductors separated by a distance that can hold opposite charges. Change in capacitance caused by change in distance or relative position between two conductors by vibration is the basic principle of capacitive energy harvesting. An electrostatic energy harvester uses the force between charges stored on electrodes to couple the mechanical energy into the electrical energy.
- **Electromagnetic Energy Harvesting**
  There is a large amount of electromagnetic energy all around us transmitted by communication devices; we just need to tap into it. Some scavenging devices can capture this energy, convert it from AC to DC, and then store it in capacitors and batteries or can be used as power source.

Challenges

Thus, in situations when there is no ambient energy from which to harvest power, the secondary power reservoir must be used to power the WSN. Of course, from a system designer's perspective, this adds a further degree of complexity since they must now take into consideration how much energy must be stored in the secondary reservoir to compensate for the lack of an ambient energy source. Just how much they will require will depend on several factors. These will include:

- The length of time the ambient energy source is absent
- The duty cycle of the WSN (that is the frequency with which a data reading and transmission has to be made)
- The size and type of a secondary reservoir super capacitor or battery)
- Is enough ambient energy available to act as both the primary energy source and have sufficient energy left over to charge up a secondary reservoir, when it is not available for some specified period?

Conclusions

In the wireless sensor networks, the use of renewable and non-renewable energy source is a promising technology with harvesting to overcome the limitation of battery source.

Although, the current harvesting technology does not provide sustained energy supply, harvesting energy from the environment offers an exciting promise for long-term WSN deployments. Energy harvesting or scavenging is possible from sources such as waste heat from industrial plants, vibrations and temperature differentials in aircrafts and automobiles, and even from human action such as walking, lifting and pressing. The self powered WSNs find their applications where battery replacements are difficult – both when the sensor nodes are not easily accessible, or because they are deeply embedded. Energy harvesting technology is now certainly ready for the prime time. By combining this technology with a wireless sensor network, both wide area and narrow field sensors can provide the data needed to detect threats more accurately and for longer periods of time across larger areas.

Although power is for free from numerous ambient energy sources, system designers and systems planners must prioritise the specific requirements of their power management systems from the onset in order to ensure efficient designs and successful long-term deployments.

Lino A Therakan
Asso.Professor, Mar Thoma Institute of Information Technology, Department of Computer Applications, (University of Kerala) Kerala

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Critical Power Solutions For Data Centres

Managing a data centre can be a significant challenge, as it needs to have high availability, extremely secure, scalable, and connected to great communications infrastructure...

Modern organisations depend on reliable access to data. They increasingly expect their data to be available from any location across a wide range of devices. Access needs to be fast, reliable, and secure. Meeting these needs has led to tremendous growth of data centres. Data centre growth is driven by increasing requirements from Banking, Financial Sector & Insurance, IT & ITES, Telecom and social media. Aggressive government policies such as National Informatics Centre (NIC), State Wide Area Network (SWAN), Common Service Centre (CSC), State Data Centre (SDC) to increase the digitalisation of records have also added to the data centre growth.

Managing a data centre can be a significant challenge, as it needs to have high availability, extremely secure, scalable, and connected to great communications infrastructure.

Infrastructure that would support future expansion for at least over a decade without major modifications is preferred. Availability of reliable power is the biggest challenge for data centre growth. Demand for continuous power supply and energy efficient products to manage the operating costs is high.

Power outages force data centres to look for alternate power sources, where diesel gensets are the most favoured option for in house power generation. On the other hand, downtime results in lost revenue and poor customer satisfaction. Hence, a data centre with higher availability is always a favoured destination for clients to have their servers.

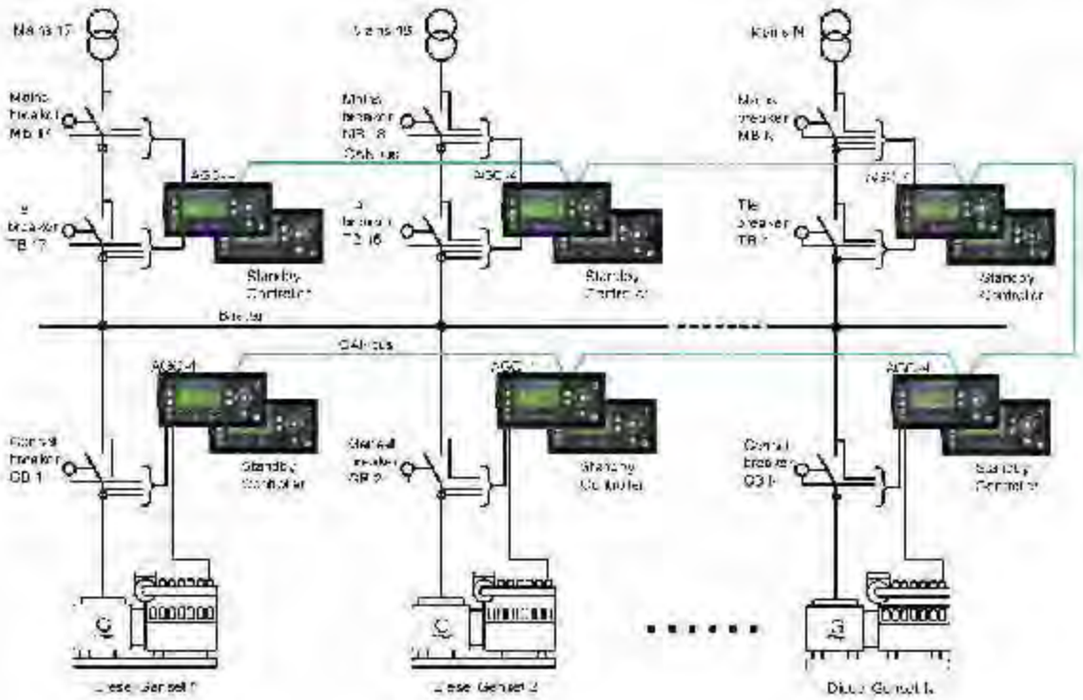
We suffice your requirements

DEIF specialises in developing emergency, standby and backup power solutions for both, captive and colocation data centres.

DEIF has a strong track record in developing emergency, standby and backup power solutions for mission-critical facilities such as data centres. DEIF's Automatic Genset Controller, AGC-4 features proven technology for a wide range of generation systems in critical power applications. Deploying DEIF's solution for your mission critical facilities will give you the crucial business edge over your competitors, and benefit you in numerous ways to elevate your data centre to Tier-4 level by reducing your maximum annual downtime.

Increased reliability and flexibility

Normally N+1 systems are used in data centres to have reserve genset. We further add to the reliability of system by providing a redundant controller so that your backup genset power has no single point of failure. In DEIF's redundant control system, two controllers operate in Hot Standby mode, with one as active controller while the other acts as a standby controller. The standby controller is connected to the active controller through



CAN bus and remains updated with the latest events and information at all times. In case of any unexpected fault in the active controller, the standby controller assumes control without any load or speed jumps during transition, thus ensuring continuous flow of power.

Fast energy backup

AGC-4 controllers are capable of synchronous starting of multiple genset using Close Before Excitation and can deliver record start-up from an impressive less than ten seconds for multiple genset in parallel, redundant control systems, or even an entire redundant power plant. Switching over the load of whole data centre quickly to backup genset is made efficient using digital voltage control. Communication between DEIF's Digital AVR and genset controllers facilitates the enhanced performance. The Digital AVR also delivers superior step load performance leading to lesser requirement of reserve power – and hence less number of online genset for a given load.

Fuel optimisation

DEIF's controllers are designed to run optimum combination of genset thus reducing fuel consumption, cutting emissions and operating cost, and increasing efficiency of your backup genset power making it greener with fast ROI.

Remote monitoring

DEIF's Advanced Graphical Interface - AGI 300 series,allows the user to view the entire system on a single screen thus facilitating convenient and effective monitoring and control of all systems or any other third party systems and critical parameters simultaneously; over one centralised IP based network from a remote location at the touch of the graphical user interface.

Scalability

Aiding your future growth and expansion plans, DEIF's controller system is fully scalable multi-master system of up to 256 genset with plant management option in one application without making major modifications in the existing project.

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Solid Insulated Switchgear

When SF6 was specified in the greenhouse gas list, the products not using SF6 were required. Then, in 2002, Toshiba developed Solid Insulated Switchgear (SIS)...

Until 1980s, Air Insulated Switchgear (AIS) had been used in almost all medium voltage substations. And due to the technological development of the insulation design, the size of the switchgear became smaller and the installation area was reduced.

But when smaller switchgear was demanded because of the rapid increase of land price, Cubicle Type Gas Insulated Switchgear (C-GIS) using SF6 gas as an insulation medium was adopted.

After COP 3 was held in Kyoto, Japan in 1997 and SF6 was specified in the greenhouse gas, the products not using SF6 were required. Then, in 2002, Toshiba developed Solid Insulated Switchgear (SIS).

SIS is designed based on the following important concepts

- **Solid Insulated:** All live parts of SIS are completely moulded in Toshiba's unique epoxy resin as an alternative insulating material to potent greenhouse SF6. It is a very environment friendly product.
- **Segregated:** Bus bars of all three phases are completely segregated from each other contributing to the minimisation of the risk of internal arc faults.
- **Surface Shielded:** All surfaces of the solid insulated parts are fully covered with a conductive layer ground to earth. This contributes to the minimisation of the of earth fault risk.

SIS has a lot of other features as given below

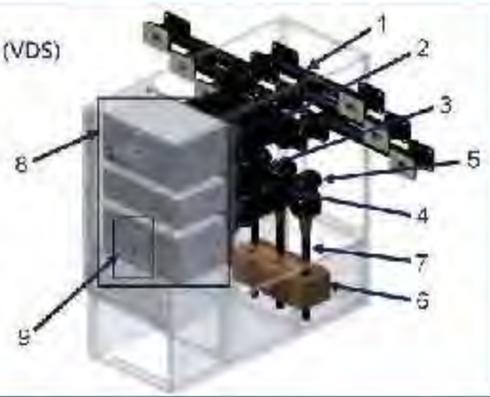
- **Compact and Light Weight:** Weight and volume of the switchgear are substantially reduced by using epoxy resin insulation compared with the conventional Toshiba's products using SF6. This leads to carrying SIS by elevators and easier equipment installation.
- **Modular Design:** Unit type solid insulated bus can make flexible arrangements. Hence, field assembly and installation of additional units can be carried out easily.
- **High Reliability:** Through complete insulation of all live parts with epoxy resin, the switchgear is protected from outside influence such as salt damage, snow damage and dust, thus promoting less maintenance and prolonged product quality.
- **Low Maintenance:** SIS structure is simpler with about 50% number of parts reduced than the conventional Toshiba's products using SF6. This significantly simplifies maintenance requirements.

Toshiba has supplied more than 1200 panels of SIS, to more than 200 customers since 2002 in Japan. It has been used in power distribution line, railway sectors, energy sectors, factories, buildings and so on.

For further information:
kosuke.sasage@toshiba-ttdi.com

Rated Voltage	Rated Current	Rated Short-time Withstand Current	Standard
36kV	1250/2000A	25/31.5kA	IEC
24/36kV	630/1250/2000A	25A	JEM/JIS/IEC
72/84kV	800/1250A	25/31.5kA	JEM/JIS/IEC

1. Busbar
2. Vacuum Disconnecting Switch (VDS)
3. Earthing Switch (ES)
4. Vacuum circuit breaker (VCB)
5. Voltage detector
6. Current transformer
7. Main cable
8. Operation mechanism for VCB, VDS and ES
9. Protection Relay (Option) (Standardized by GR series)



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Heroic Developments In Relay Testing

A complaint heard from many users was that they'd bought sophisticated – and therefore costly – test sets to gain access to just a few of the advanced options provided, but in their applications, up to 90% of the remaining functionality would never be used...

Progress is a wonderful thing but, particularly in the world of electrical technology, progress in one area can produce significant challenges in another. Recent developments in protection relays have called for almost heroic efforts from test equipment manufacturers to devise products that will test the latest relays easily, effectively and safely while retaining the versatility needed to work with older types.

There is without doubt a wide choice of protection relay test equipment on the market; indeed, many of the most popular models are made by Megger. So, it would perhaps have been understandable if the members of the company's design team had been content to rest a while on their laurels and devote their efforts to produce useful but relatively minor upgrades.

However, word reached their ears that the requirement of some users and potential users of relay test equipment were not being adequately met and that there was a pressing need for a new and innovative test set to fill a growing gap in the market.

Some users were reporting that they needed to test simple voltage and current relays but that the latest three-phase types were so intelligent that they couldn't be tricked by injecting just one phase. Others were saying that they needed to perform tests on three phase relays connected to the 230 V AC network, but that simpler test sets couldn't produce a sufficiently high output voltage.

A complaint heard from many users was that they'd bought sophisticated – and therefore costly – test sets to gain access to just a few of the advanced options provided but, in their applications, up to 90% of the remaining functionality would never be used. And an almost universal comment concerned the need to combine versatility with simplicity and safety.

Many three-phase test sets can be configured to provide higher voltages and currents for single-phase testing but this typically involves setting up a tangle of cables and connectors. Not only is this time consuming, it's all too easy to make mistakes that could endanger both the instrument and the user.

At first it seemed unlikely that it would be possible to produce a reasonably priced instrument that would address all of these issues, but the intrepid members of the protection relay test equipment design team are not easily daunted! They continued to chip away at the challenge until a practical solution started to take shape in the form of a multifunction testing "toolbox" for substation protection testing.

In developing this innovative solution, key factors the designers took into account were the need for modern distribution relay protection schemes to be tested by three-phase secondary injection and also the requirement for test sets to provide high-power, high amplitude outputs for use when carrying out single-phase tests on current and voltage transformers, and primary injection into switchgear bus bars. And, of course, they knew that changing between three-phase and single phase mode had to be fast, easy and safe.

The "toolbox" concept was fine but, as is so often the case, translating it into reality was much more of a trial. In particular, finding a convenient way of switching between three-phase and single-phase operating modes without the inconvenient tangle of wires proved, at first it was something of a headache.

Then inspiration struck – don't use flexible wires, use rigid links to make the necessary connections! At a stroke, the inconvenient cable tangle was eliminated and, after some very careful sketching and

measuring. It even proved possible to position the sockets for links in such a way that – it would be physically impossible to make the wrong connections. These simple yet novel ideas would allow convenience to be combined with safety and speed, exactly as users were requesting.

Equally innovative thinking was applied to other aspects of the instrument's design. It was provided with 3 fully isolated current channels that can be connected in series or parallel and are capable of delivering 35 A DC or AC over the range 10 to 600 Hz. The maximum capacity is a generous 250 VA and the compliance voltage is 50 V at 5 A. For single-phase testing, the three outputs connected in parallel can deliver up to 105 A for 10 seconds intermittent or 60 A continuous.

The instrument also incorporates four fully isolated voltage generators that, once again, can be connected in series or parallel. Individually, these provide up to 300 V DC or AC from 10 to 600 Hz and have a maximum capacity of 125 VA. In single phase applications, with three of the voltage generators connected in series, output voltages up to 900 V can be produced, leaving the fourth voltage generator available to power the relay. As might be expected, the frequency, amplitude and phase angle of all voltage and current sources can be independently controlled.

That's a great start, but the concept for this instrument was that it should be a multifunction engineer's 'toolbox,' so a few more tools were needed. Those ultimately provided include an analogue ammeter and an analogue voltmeter, together with facilities for measuring a wide range of parameters such as phase angle; active, reactive and apparent power; power factor; resistance; reactance and frequency.

Further versatility was built in by providing a binary output and four independently programmable binary inputs, complemented by a timer that can, if required, be used independently of the current and voltage generators. A USB port for firmware upgrades and for uploading and downloading test files were also incorporated. The design team could by now be content with the hardware specification for their new instrument, but the best hardware in the world is of little value if it's difficult to use – and this has been an all-to-common problem in the past with protection relay test systems. The team was therefore determined to ensure that the new instrument's user interface would be intuitive, simple and user friendly.

To achieve this, the interface centres on a touchscreen that provides access to a wide range of pre-configured virtual test instruments, allowing the required test function to be selected quickly and easily. The main virtual instrument provides timing tests as well as options for the manual determination of relay pick-up and drop-out points together with general facilities for generating, injecting and measuring currents and voltages.

Other virtual instruments include a CT magnetisation instrument, a pre-fault fault instrument, a ramping instrument and a sequence instrument. An impedance instrument is also provided, which allows relays to be tested directly from the impedance plane with conversion from impedance to voltages and currents carried out automatically by the test set.

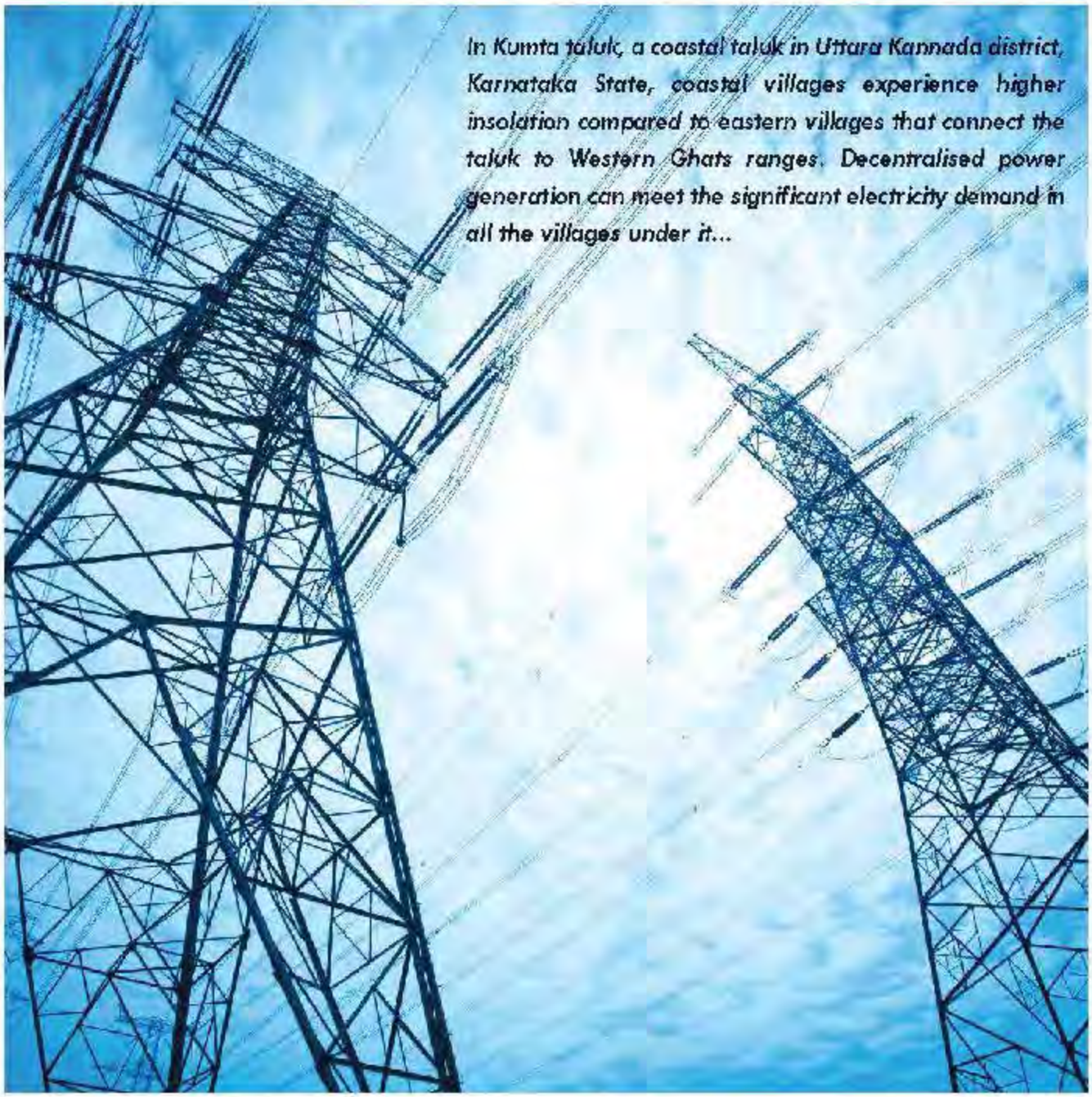
Full manual control and configuration is also supported and, in addition to the touchscreen, the instrument is provided with a large rotary knob that can be configured as required to control the current and voltage generators. Test configurations and test results are stored in internal non-volatile memory and can be readily transferred to and from a PC via the instrument's USB port.

An advanced mode that allows harmonic generation is provided. When this mode is selected, each individual voltage or current generator can be set to produce a harmonic waveform, and a second or even third layer of harmonics can be superimposed over the fundamental frequency. Will the endeavours of the Megger design team in developing the new instrument, which has been designated the SVERKER900, ultimately be successful in vanquishing the challenges of complexity, high cost and lack of versatility in protective relay testing? Only time and the market will tell for sure but initial indications are favourable.

The new instrument is already attracting attention for use in applications that include commissioning and maintenance of distribution substations and generator installations; testing of electromechanical, static and numerical protection relays; plotting current transformer excitation curves; burden measurement for CTs; polarity/direction measurement; impedance measurement; single- and three-phase injection testing in switchgear; checking SCADA annunciation and measurement values; & performing network measurements. A veritable engineer's toolbox indeed!

Niclas Wetterstrand
Business Development, Megger

Appraisal Of Centralised And Decentralised Energy Systems



In Kumta taluk, a coastal taluk in Uttara Kannada district, Karnataka State, coastal villages experience higher insolation compared to eastern villages that connect the taluk to Western Ghats ranges. Decentralised power generation can meet the significant electricity demand in all the villages under it...

Grid system based on centralized electricity generation has posed serious challenges to the environment, as well as to the economy. These systems have failed to electrify every household in the country due to technical and economical non-feasibility apart from higher transmission and distribution losses. In this context, Distributed Generation (DG) has been playing a prominent role in the regional development, as well as rural electrification where it leverages DG optimally harvesting locally available renewable energy sources and integrates with the grid. Regional Integrated Energy Plan (RIEP) based on decentralised energy systems optimises share of available resources while ensuring reliable energy supply. Spatial assessment of renewable energy sources aids in effective planning to meet the energy demand at local levels. An optimal energy plan based on renewable energy sources mitigate GHG emissions, while providing reliable energy to all citizens in rural.

Distributed Generation (DG) based on locally available, non-polluting sources of energy would play pivotal role in meeting the energy demand throughout the country. Distributed generation refers to the electric energy generation near load centres using locally available resources. Installed capacity of decentralised plants ranges from few kilowatts to megawatts. DG include various renewable energy based generating technologies such as rooftop solar PV installation, micro/pico hydro power generation, small scale wind plants, biomass gasifier, combined heat and power (CHP) plants etc. These DG systems have very minimal environmental impact and are easier to install and operate. Since the generated energy will be supplied to the local community, T&D, transmission and distribution losses will be greatly reduced. The other benefits of DG include improvement in power quality by avoiding or reduced transmission line extension costs due to generation at load centres, reduced power loss and reduction in energy price at local level while contributing to rural electrification. The centralised power systems have posed many technical challenges such as higher Transmission and Distribution (T&D) losses, frequent voltage variation, frequency variation and reliability concerns with massive environmental pollution. There are more than 24,000 villages that are not electrified even today, and many of them are in very remote places where the grid extension is economically non-feasible. The grid extension to remote location costs about INR 1 kW/km, which is economically non-viable with the present higher T&D losses. T&D losses have increased from 17.5% (in 1970-71) to 24.1% (in 2011-12) over 4 decades in spite of development in technology and use of efficient transmission conductors. Figure 1 shows the T&D losses in the country over the years. Increased T&D losses stress the transmission line and necessitate higher generation of electricity.

Grid extensions for rural electrification in remote areas are expensive and inefficient necessitating distributed generation systems. Even already electrified villages are facing the problem of unreliable power supply coupled with frequent severe voltage fluctuations. However, DGs based on locally available renewable energy sources with the lower T&D losses have proved to be economically viable and technically feasible.

Fig. 2 illustrates (Kemabonta et al. 2010) the cost approximation as the distance of the load centre and grid increases. Beyond 5 km grid expansions are economically non-viable. This necessitates onsite generation (DG) and distribution to household in remote areas to minimize the investment on infrastructure apart from Transmission & Distribution (T&D) loss of electricity. Line loss reduction with DG integration has been computed for various levels of penetration. Estimates indicate annual loss to the tune of 284 billion units (26400 GWh), on which costs minimum of INR 85 billion per year due to transmission and distribution inefficiency (Table 1). Current assessment reveals that T&D loss in India is about 24% resulting in the loss of 220 kWh/capita (per capita consumption is 917.16 kWh) of energy. Cost per unit of energy loss ranges from INR 4.62 (@ MS 2.13/kWh to INR 2220 (@ INR 7.89/kWh), depending upon the tariff for the respective state).

The necessitates deployment of DG using locally available resources to improve the efficiency of electricity transmission and distribution. India is targeting 20000 MW of solar installed capacity by 2022, in which distributed generation holds the promise. India is one of the frontiers of wind generation with installed capacity of over 21 GW after China, US, Germany and Spain. Taluk level energy assessment gives insights to explore the feasibility of distributed generation opportunities and connect un-electrified regions in the region. This also helps in integrating renewable energy resources to the existing grid, which will improve the power quality.

Study Area: Kumta, a coastal taluk in Uttara Kannada district, Karnataka State, is located between the Arabian Sea coast on the west and Sahyadri ranges (Western Ghats) on the eastern side (14.42° N & 74.4° E). Taluk spreads over 530.75 km^2 of area with population of 1,54,576 (Census 2011). Taluk is blessed with lush green forests which cover more than 66% of the geographical area and about 16% of the area is under agriculture/horticulture or plantation. Fig. 3 shows the study area with annual average solar insolation and wind speed.

Fig. 1: T & D losses in the country from 1970-71 to 2011-12

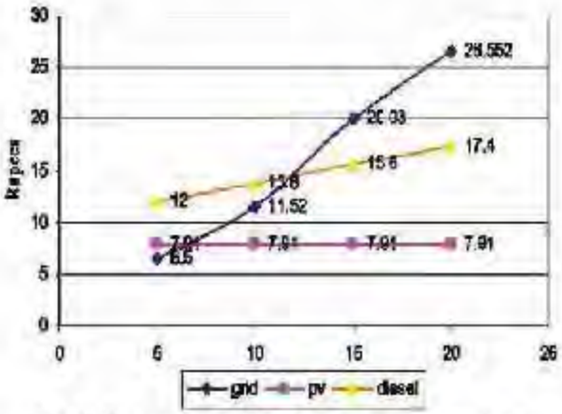
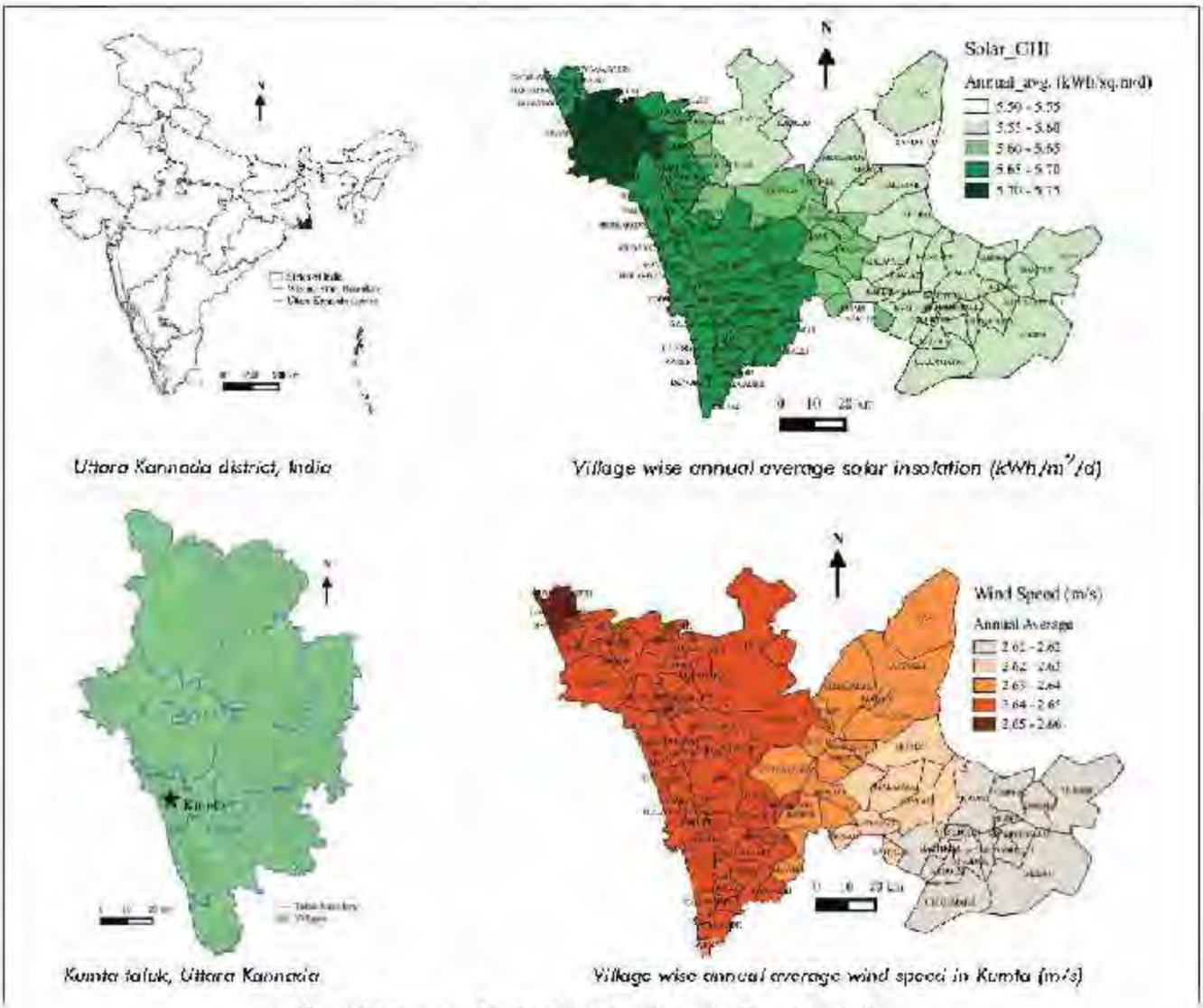


Fig. 2: Comparison of PV, diesel generator and grid electricity for rural electrification...

Spatio temporal data are used for energy potential assessment using open source GIS platform, which also gives the seasonal and geographical variability of the available energy resources. Long term data sets acquired from NASA SSE (Solar Grid) and Climate Research Unit (CRU, Wind Speed) are reliable and capture the seasonal variability, which is closely correlates with ground measurement. Taluk experiences annual solar insolation of more than 5.5 kWh/m^2/d throughout the year in all the villages. Coastal villages experience higher insolation compared to eastern villages that connect the taluk to Western Ghats ranges. However, decentralised generation can meet the significant electricity demand in all the villages. Fig. 4 shows the seasonal variability of the solar energy potential across the villages. During summer (February to May) Kumta experiences solar insolation of more than 6.6 kWh/m^2/d, which reduces to less than 5 kWh/m^2/d during Monsoon (June to August). The radial orientation also varies in these months, which will affect the electricity generation. During winter (October to January), the taluk receives insolation ranges from 5 to 5.5 kWh/m^2/d.



Uttara Kannada district, India

Village wise annual average solar insolation (kWh/m^2/d)

Kumta taluk, Uttara Kannada

Village wise annual average wind speed in Kumta (m/s)

Fig. 3: Study area – Kumtataluk, Uttara Kannada, Karnataka, India...

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Per capita electricity consumption	917 kWh
T&D losses	24%
Per capita energy loss	220 kWh
Cost of per capita energy loss	INR 462 to INR 990
Annual energy loss	2343MW
Total annual expenditure	INR 577 Crore (@ INR. 2.10/kWh)

Table 1: Expenditure due to T&D losses in India...

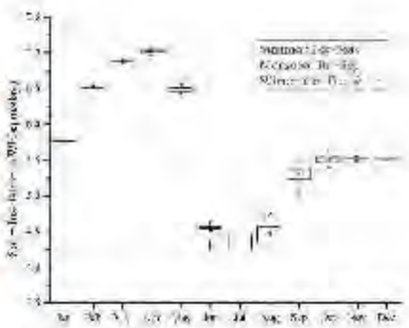

Fig. 4: Solar insolation variability...

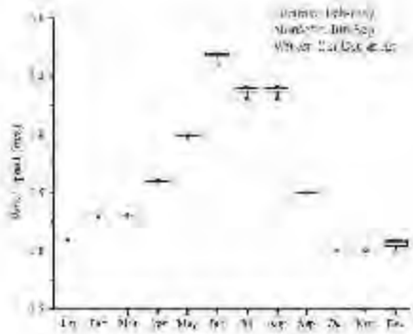

Fig. 5: Wind speed variability...

Fig. 5 gives the wind speed variability in the taluk across the months. The coastal villages experience higher wind speed of more than 2.5 m/s annually compared to the eastern villages (2.0 m/s). Though the variation in annual average wind speed is minimum, seasonal variation is higher due to the south winds during monsoon. During summer and winter, the taluk experiences lower wind speed which ranges from 2 to 3 m/s. During monsoon, it experiences speedy winds that varies from 3 to 4 m/s. Solar & wind resources supplement each other which supports hybrid energy systems in the region.

Table 2 lists Land Use and Land Cover (LULC) details of Kumta taluk. Blessed with bioenergy resources as most of the people are agriculture/horticulture, which is the primary income of livelihood. About 13% of the total geographical area is under agriculture/horticulture or contains coconut and areca plantations that generate large amount of high energy residues – such as coconut shell, bio sticks etc., which can be used in bio-gas fires. The taluk has 27.4% of evergreen forest, 12.5% semi-evergreen/moist deciduous forest, 7.3% of dry deciduous forest and 8.4% of acacia plantations which ensure the availability of plant residues with higher energy content throughout the year. These plant residues are being used for domestic purposes and sufficient quantity is available to use as a fuel for bio-gasifiers towards electricity generation.

Regional Integrated Energy Plan

Integrated energy plan essentially explores the locally available energy resources and feasible energy conversion technologies to meet the regional demand. The energy planning exercise carried out for Kumta taluk involves minimisation of annual cost function to a set of equality and inequality constraints using Linear Programming (LP) algorithm. The main objective of the energy planning is preparation of location specific decentralised energy harvesting systems for meeting the regional energy needs. It ensures least cost to the environment in the economy. Centralised energy generation and transmission cannot pay much attention to the variations in socio-economic and ecological factors of a region which influence success of any intervention. Decentralised energy planning focuses on efficient utilisation of resources, while ensuring more equitable sharing of benefits from development. The integrated energy planning mechanism takes into account all resources available and end use demand of a region. This involves that the assessment of the demand and supply, and the intervention in the energy system, which may appear desirable due to such exercises, must be at a similar geographic scale. Resource assessment done using remote sensing data with Geographic Information System (GIS) and field data computation. Regional integrated energy model based on DSM minimises the operating cost while ensuring reliable sufficient energy supply and ensures the total energy supply. The process is a constrained optimization problem where, maximum available energy from each resource and minimum energy requirement for every end use are considered as constraints. Fig. 6 illustrates the procedure adopted in the study.

The present study deals with the village wise potential assessment of renewable energy resources in Kumta taluk of Uttara Kannada district, Karnataka state. The district lies in the centre Western Ghats (WGs), which is one among 35 biodiversity hotspots in the world. District is a repository of diverse endemic flora and fauna and also receives higher solar insolation for about 300 days in a year. The coastal villages of Kumta, experiences greater wind speeds, which are high wind energy potential areas. The taluk also receives higher insolation that encourages the solar power plant installation. Spatio temporal across villages and seasonal variability of resources have been analysed to optimize the energy harvesting with best locations as well as efficient end use energy devices. Harvesting solar and wind energy ensures the availability throughout the year as wind compliments the lower solar insolation period during monsoon. Further, number of end uses and available resources are identified. Resource-less modelling is modelled where the Linear Programming (LP) is used for optimisation. Cost minimisation is also explored while meeting the total energy demand with available local resources.

System is designed to use only locally available renewable energy sources, which however have lower pollution. End use energy requirement per capita is assessed and total energy requirement per end use is computed and validated with field data. Table 3 gives the energy requirement for different end uses in the taluk.

Low temperature heating (<100°C) end uses such as water heating for bathing, agro-

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Category	Area (Ha)
Built up	1727.8
Crop and/Agriculture	5149.2
Openspace	5984.5
Coconut/Areca	2436.8
Semi-evergreen/Moist-deciduous	7370.5
Evergreen	12539.4
Scrub/Grass	15.2
Arable	2016.8
Dry deciduous	4351.5
Total	**58859.63**

Table 2: Land use land cover (LULC) details of Kuntatalak...

processing (drying of local agro products such as areca nut, coconut, cashew, pepper etc) sector has the highest share (46% GWh/annum), in the total energy requirement followed by medium temperature heating (411.7 GWh/annum) and medium power mechanical end uses (293.4 GWh/annum). The agro processing activity, which includes drying of areca nut, coconut, cashew nut, cardamom and other spices, requires lot of low temperature heat energy (60-100°C), throughout the year. Direct electricity consumption is only for lighting, fans and television in homes, commercial spaces and road lights, which consume about 37.2 GWh/annum. Table 4 shows the efficiency of the energy conversion processes to meet the end use energy requirements.

The efficiencies of various energy conversion technologies are estimated from literatures and new are computed. However, those values do not overestimate the output energy obtained by energy conversion. Table 5 gives the load factor assumed in the present energy planning process. Maximum energy availability from each resource in the taluk has been computed by converting available quantity into its corresponding energy equivalent. Abundant solar energy is available (both solar thermal and electric energy) in the taluk where the harvestable energy is about 2,060 GWh/annum. Similarly, about 570 GWh/annum of energy can be extracted from biomass and agro-wood residues in the region. Annual energy availability from all the resources in the village is given in table 6.

The wind energy harvesting depends on the swept area of the wind blades. The taluk has more than 31 km of coast line on the west, which can generate ample energy from wind resource. Depending upon end use energy requirement, micro (few watts) to small scale (few kilo watts) wind generator can be installed in the coastal villages for irrigation and electricity generation. Wind plants can also be integrated with solar or bioenergy plants, which can address the intermittency issues. Energy available from biogas and electricity is limited to 0.1 GWh / annum and 0.43 GWh / annum respectively. The optimised operating costs for meeting the end use from available resources is shown in Table 7.

Total operating cost of the model is found to be INR 32.11 crores per annum with unit cost of INR 0.22 per kWh of energy utilised. Cost of generating mechanical energy from wind resources is found higher (INR 7.8 crores), followed by solar thermal energy generation (INR 4.9 crores) and generating electricity from biogas (INR 2.43 crores). However, electric energy application for medium power mechanical end use has the lowest operating cost (INR 6945.5) where the electricity is directly obtained from grid. Total energy supplied for various end uses is about 983.5 GWh/annum from all resources. Table 8 gives the energy supply patterns from resources to different end uses.

Energy harvested from solar resource is about 290.9 GWh/annum which is used to meet the low temperature heating requirement. Wind energy resource is used for low (6.2 GWh/annum) and medium power mechanical (7.28 GWh/annum) end uses contributing about 19.09 GWh/annum. Arable biomass resource is available in the taluk, which is utilised for low (204.06 GWh/annum) and medium temperature heating (411.7 GWh/annum) and also to generate electricity (24.2 GWh/annum). Similarly, biogas is used for electricity generation (12.94 GWh/annum)

End use type	Energy required (GWh/annum)
Low temperature heating	765.0
Medium temperature heating	411.7
Low power mechanics	3.2
Medium power mechanics	293.4
Lighting, Small	37.2
Total	**983.5**

Table 3: Energy requirement for different end uses

Fig. 6: Integrated energy plan at regional levels...


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and grid electricity supply is utilised to meet the medium power mechanical end use energy requirement (20.63 GWh/annum). Model successfully simulated the resources and end use combination to generate cost effective solution with minimum operating cost. However, it can also be inferred that, taluk can meet all the energy needs from locally available resources while maintaining efficiency and minimum cost. Since the energy system utilises renewable energy sources, significant greenhouse gas emission can be avoided, which is an essential step to reduce global warming. This model will generate employment in the village level which contributes to the development of the region and energy security.

Discussion and Conclusion

Focus on the renewable energy potential with integrated energy plan highlight the availability of suitable resources to meet the demand at the taluk level. Kunta taluk receives abundant solar insolation throughout the year, which varies from 5.5 to 6.75 kWh/m²/day. Annual average insolation of the district is about 5.6 kWh/m²/day where, it experiences more than 5.6 kWh/m²/day for about 250 days. District experiences wind from west coast, which varies from 1.5 to 4 m/s where coastal villages have higher wind energy potential. Low speed wind turbines are most suitable for the region which can be used for irrigation and electricity generation. Wind energy generation systems can also be integrated with solar and biomass gasifier based generator for reliable electricity production. Village level energy potential maps give insights for distributed generation from rooftop level to installation in barren lands. Seasonal variation in the resource availability will help in understanding the dynamics and pattern of energy generation, which is a critical information for grid integration and load expansion.

Quantification of bioenergy is carried out based on availability, which shows that around 670 GWh energy is available annually. Currently, the taluk has good number of cattle and buffalo population, which can generate about 12.9 GWh of energy annually. Energy from plant and animal residues can be utilised for low and medium temperature heating and also for electricity production.

Integrated energy plan with the objective of cost minimisation is developed and validated. Optimisation results shows that, annual operating cost of the system is INR 22.1 crores and unit energy cost is about INR 0.22/kWh. The simulated model could supply 900.5 GWh/annum to meet the various end use energy requirements. System installation and commissioning could be decentralised and resources shall be harnessed depending upon the availability. Nevertheless, the work illustrates the

η_{ij}	Low temp heating	Med. temp heating	Low power mech.	Med. Power mech.	Lighting, fan etc.
Solar	0.4	0.5	-	-	0.1
Wind	-	-	0.4	0.4	0.3
Biomass	0.15	0.15	-	-	0.3
Biogas	0.65	0.6	-	-	0.35
Electricity			0.9	0.75	0.9

Table 4: Energy conversion efficiency...

kij	Low temp heating	Med. temp heating	Low power mech.	Med. power mech.	Lighting, fan, etc.
Solar	0.29	0.95			0.95
Wind	-	-	0.3	0.2	0.95
Biomass	0.29	0.95			0.95
Biogas	0.29	0.95			0.95
Electricity	-	-	0.95	0.95	0.95

Table 5: Load factor...

Resource	Energy potential (GWh/annum)
Solar	2030.6
Wind	99.44 kWh/m² of swept area
Biomass	670
Biogas	12.9
Electricity	30.5
Total	**3574.17**

Table 6: Available maximum energy potential...

Cost (INR/annum)	Low temp. heating	Med. temp. heating	Low power mech.	Med. power mech.	Lighting, fan, etc.
Solar	4949472.3	0	0	0	0
Wind	0	0	19711392.7	7375833.65	0
Biomass	1500822	449460.1	0	0	5.99E+14
Biogas	0	0	0	0	3467918.6
Electricity	0	0	0	8245.8	0
Total Cost (INR)	22.1 crores				
Unit cost (INR/kWh)	0.22				

Table 7: Optimised cost matrix of the energy model...

Energy (GWh/ annum)	Low temp. heating	Med. temp. heating	Low power mech.	Med. power mech.	Lighting, fan, etc.	Energy utilised
Solar	2509	0	0	0	0	2509
Wind	0	0	0.2	12.8	0	13.00
Biomass	334.05	411.7	0	0	24.3	670
Biogas	0	0	0	0	12.97	12.94
Electricity	0	0	0	30.53	0	30.53
End use energy supplied	486	411.7	0.2	43.4	37.2	0838

Table 8: End use energy supplied from various resources...

availability of 9035 GWh energy from locally available resources. Model implementation could significantly reduce the GHG emission while reducing the stress on central grid. It would also generate employment in the village level, which could also enable entrepreneurship opportunities. This model (Regional Integrated energy Plan: RIEP) is replicable in all alike or cluster of villages, which highlights the flexibility and strength of the approach. Integrated renewable energy planning has the potential to minimise the operating cost while exploiting sustainable, reliable and environment friendly renewable energy sources. This transforms rural India to self-reliant and self-sustained systems with energy sufficiency, which helps in realising the dream of total electrification in the country and scope for employment and education opportunities at local levels.

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Interview

"ERDA is constantly UPGRADING & OPTIMISING its resources..."

Electrical Research and Development Association (ERDA), is a cooperative research institution created by the Indian Electrical Industry and Utilities with the support of Governments of India and Gujarat. Dr M K Shah, Director, ERDA, Vadodara, in an exclusive interview with P K Chatterjee, is focusing on the capabilities, activities and status of the association. Excerpts...

What are the items included in ERDA's top priority list at present?

The critical facilities on ERDA's business plan list for the near future include setting up of a Center of Excellence in field of Renewable Energy and Smart Grid, establishment of a Learning and Skill Development Centre, setting up of a Center of Excellence for R&D in Medium Voltage Switchgears and Transformers – as well as expansion of business in our regional laboratories in Northern & Southern regions. Considering the need felt at ground level by the power sector, ERDA is creating capability and capacity to provide expertise and diagnostic services at sites.

Tell me about your test facilities in brief.

Since its establishment in 1974 and as per objectives of ERDA, Test and Evaluation Laboratories have been set up as Independent Third Party Testing and Quality Assurance Organisation, catering to a wide range of Electrical Products. ERDA's core values are Transparency, trustworthiness, fair and caring. Managing Committee, the apex managing and policy making body of ERDA meets four times during the year to ransact important policy matters. ERDA has its own Memorandum as well as Rules and Regulations for its administration and control which are approved under The Societies Registration Act, 1860 as well The Bombay Public trusts Act,1950. The managing committee consists of personnel from central, state government, PSUs, utilities and industries. ERDA has received the grant from The

Council of Scientific and Industrial Research (CSIR), Government of India, Government of Gujarat, Gujarat Electricity Board. This is again reassuring the faith of State as well as Central Government in the brand 'ERDA'.

It is dedicated to serve Utilities, PSUs and industries for the last 41 years and providing service to more than 7000 customers every year. ERDA is equipped with many sophisticated and state-of-the-art facilities at its two major Vadodara based laboratories at Makarpura and Sevi, many of them are best in class. ERDA is constantly looking at opportunities to expand its professional services to new areas with in its charter. Its facilities and capabilities are accredited, approved and certified by many leading certification agencies across the country & world, such as NABL, Intertek (ASTA), TUV, BIS, BEE, DSIR and many others.

ERDA presently caters to customer requirements covering a variety of electrical products. More than 100 products are evaluated under one roof at ERDA. It provides complete certification and evaluation of short circuit current capability up to 100kA, 575 V for low voltage products and systems. A new state of the art 10 m anechoic chamber for evaluation of immunity and susceptibility of apparatus to electromagnetic interference has been commissioned by the EMI/EMC laboratory to cater to the needs of the industry. This laboratory has been extensively used by the defence establishments of the country for EMI/EMC compliance testing as per MIL standards. With many apparatus now controlled electronically or digitally, this evaluation facility will cater to reliability assessment of apparatus to emerging needs. Further, a unique portable EMI/EMC facility is also available for on site evaluation of electrical and electronic products for EMI/EMC compliance. ERDA has Asia's largest IP test facility with payload capacity of 40 tonnes. It is also a market leader for evaluation of star rated distribution transformers and 0.2A, 0.2S accuracy class energy meters. State of the art laboratories are available for cables, and insulating and magnetic materials. ERDA also has unique facilities for calibration of in-house generated standards.

ERDA has set up regional laboratory facilities at various customer centres across India. With the facilities at ERDA (West) - Rabale, Navi Mumbai, ERDA (North) – Sonepat, and ERDA (South) - Rajahmundry, ERDA is catering to the customer base across India.

Further, ERDA has built and is operating laboratories at utility premises for evaluation of equipment and T&D hardware received at utility stores from manufacturers. These also include Kaira laboratory for UGVCL - Gujarat and MPPKVVC, Jabalpur - Madhya Pradesh.

A mobile laboratory is also available for catering to customers anywhere in the country.

ERDA is constantly looking at avenues to extend its services to new customer base across India and internationally, which is one of its prime growth strategies.

How do your calibration services help the industry?

The comprehensive range of Testing and Calibration services provided by ERDA as independent third party agency in disciplines of Electro technical, Optical, Thermal & Mechanical, enable industries to meet all their varied testing and Calibration requirements as part of quality assurance as well as product development, under one roof at our laboratory complex. Apart from saving precious time and resulting logistics for customers, the value added calibration services provided by ERDA ensure sustainable quality levels and high reliability of business operations of industries and utilities. Further, the calibration services provided by ERDA enable the industries including the MSMEs easily to obtain ISO 9000 and ISO 17025 NABL certifications.

How are you planning to make the organisation more MSME friendly?

The prime objective behind the establishment of ERDA is to serve the industries and utilities for their products development and certification. Over the last 40 years, ERDA is constantly serving the MSME segment for their testing requirements at competitive prices. Being a 'not for profit' organisation, the services of ERDA are available at affordable costs. ERDA is providing discount to its members companies along with the special discount provided to the SSI units.

One of the main objectives of ERDA is to develop and disseminate new technologies as well as to enable industrial units to optimise their product designs to meet requirements of various ISI/IEC standards. ERDA has developed more than 50 technologies, out which 35 technologies have been commercialised in the country as well as abroad (including the USA). Some of these technologies have won international, national, state & electrical industries association (IEEMA) brilliance awards.

ERDA has patented a number of technologies both in the country as well as abroad. For the purpose of supporting product development cycles of MSMEs, it has set up a sophisticated analytical centre, which is equipped with state-of-the-art simulation, modeling, and design packages that enable MSMEs and other industries to design their products in a virtual environment. Apart from saving time, the costs associated with design in a virtual environment are significantly lower than a pure prototyping-based design approach. Packages available include ANSYS & NISA FEM packages (electromagnetics, thermal, structural, & fluid) with CFX & FLUENT for CFD, RMxprt, Pexprt, Simplorer, ofurnace, and Pumplinx.

A Centre of Excellence (COE) for Rotating Machines has been set up for enabling MSMEs to carry out the entire design cycle of rotating machines under one roof i.e., simulation, virtual design, prototyping, evaluation followed by tuning of design using the evaluation results.

What kinds of training do you offer?

ERDA offers specialised training in various areas related to certification evaluation of electrical products and materials, diagnostic techniques for power plant equipment, energy auditing techniques as well as specialised topics – such as uncertainty of measurements etc. ERDA also designs and undertakes custom specific training programmes as per specific requirements of clients. Training programmes are conducted at ERDA's main laboratory complex at Vadodara as well as at clients' premises – depending on the requirement. To date, ERDA has conducted more than 300 training programmes, in which more than 7,000 engineers and scientists have participated.

How do that help the aspiring organizations?

Training programmes conducted by ERDA enable participants and participating organisations to significantly enhance their competencies in various areas of certification, testing & evaluation, condition assessment, and laboratory quality systems including uncertainty measurements. Training programmes conducted by ERDA have also enabled clients to develop new capabilities and laboratory facilities in various technical areas related to evaluation & diagnostics of power products and equipment.

Specialized energy management related seminars conducted by ERDA – at various utilities like power plants as well as at industries – have enabled the clients to optimise the operational energy efficiency of their plants. Similarly, workshops on diagnostics & RLA have enabled plants to plan for reliability centered asset management programmes for refurbishment and life extension of their critical equipment.

Tell me about your certifications and their validity in and outside the country.

ERDA is accredited and recognised by NABL (Govt. of India), Intertek (ASTA) – UK, TUV – Germany, DSIR (as R&D), BIS, BEE and many others. It is an approved nodal laboratory of BEE for the Government's standards and labeling programme for energy efficiency star rating of various equipment and appliances. The certifications of ERDA are recognised through all Intertek (ASTA), the utilities across India and in the South East Asian part of the world. The validity of the certifications is based on changes in design, materials, manufacturing process as well as government policies and requirement of utilities and customers.

What are the important technologies that you have developed within the last (say) five years?

ERDA has been carrying out R&D in five technology mission areas viz Advanced Materials, Renewables, Diagnostics, Power Systems, Smart Grid & New Products. In the last five years, ERDA has developed technologies through various Research Projects. These include Online Fault Sensor for Transformers, Silver Nano Contacts, Fault Current Limiter, Zero Halogen Flame Retardant Compound for Cables, Manual Rechargeable LED Lamp, Manual Battery Charger, Customized Health Index Tool for Transformer Asset Management, and IE4 Class Induction Motor.

What is your technology dissemination practice?

ERDA being a not for profit organisation is following the competitive bidding route for technology dissemination. The Expression of Interest is invited from potential group of technology users and competitive bids are invited for each technology.

ERDA offers the technology mainly on two types viz royalty basis and (another) on one time technology transfer fee basis. The one time technology transfer is again offered either on proprietary basis or on non-proprietary basis.

What would you like to communicate to the electrical community in the country?

I would like the electrical community to know that ERDA is constantly upgrading and optimising its resources as per the demands and requirements of our valued customers from industries, PSUs and utilities. For the last four decades, we have partnered our electrical industries and utilities to meet their requirements and needs for certification, evaluation, product development and optimisation, asset management through diagnostics & RLA, energy efficiency improvement, R&D and training.

All these services provided by ERDA are enablers of the aspirational 'Make in India' programme of the Government of India initiated by our Honourable Prime Minister. We reiterate our commitment and support to our country, in general, and the electrical industry, in particular for the success of the 'Make in India' programme through our value enhanced services of certification, evaluation, product development, R&D and training.

Some Achievements Of ERDA In 2015

- ERDA has been empanelled as an agency for carrying out energy audit and performance assessment by NTPC for three years. This empanelment will enable ERDA to grow rapidly in the area of performance efficiency assessment of thermal generating stations.
- ERDA received offer from Powerica Ltd for carrying out power quality measurement at the Point of Common Coupling (PCC), where 20 MW wind generating station of Powerica Ltd is interconnecting with 66 kV grid of GETCO.
- As part of a residual life assessment contract from GSECL, ERDA undertook detailed numerical simulation of a 210 MW BHEL KWU design turbine rotor with the objective of predicting its remnant life with respect to the degradation mechanisms of creep and low cycle fatigue.
- In order to help electrical motor manufacturers to develop indigenous technologies for IE4 class motor, ERDA had taken up an internal R&D project to develop an IE4 class motor. It has developed an IE4 class efficiency, 2.2 kW common 3ϕ squirrel cage machine, which is easy to manufacture and does not use costly permanent magnets. This development was possible through design optimisation carried out using CFD and FEA based electromagnetic analysis for stator, rotor, winding and the fan. The developed motor was tested at ERDA and found to have efficiency of 90.70%, with a power factor of 0.740 and a temperature rise of 29°C. The same motor can also be classified under dual rating of 2.2 kW IE4 and 3.7 kW IE3 in the same frame as per the test results achieved.


RENEWABLE

Condition Monitoring as an integrated component of TwinCAT 3

Scientific Automation In Wind Turbines

The degree of automation in wind turbines is increasing continuously. In addition to the actual system control, monitoring and networking play increasingly important roles. Many control suppliers that offer conventional controllers are reaching their performance limits. The solution lies in an automation system that is essentially based on a scientific approach and integrates the required measuring equipment in a standard control architecture...

Scientific Automation from Beckhoff represents a combination of high performance Industrial or Embedded PCs, the highly deterministic EtherCAT fieldbus system and intelligent software. These components are also required for automating modern wind turbines. Wind turbine manufacturers want to use the same system for control tasks, monitoring, grid synchronization and system-wide communication. Just thinking of the complex Condition Monitoring algorithms which are to be processed on the controller it becomes clear that it makes sense to use multi-core CPUs.

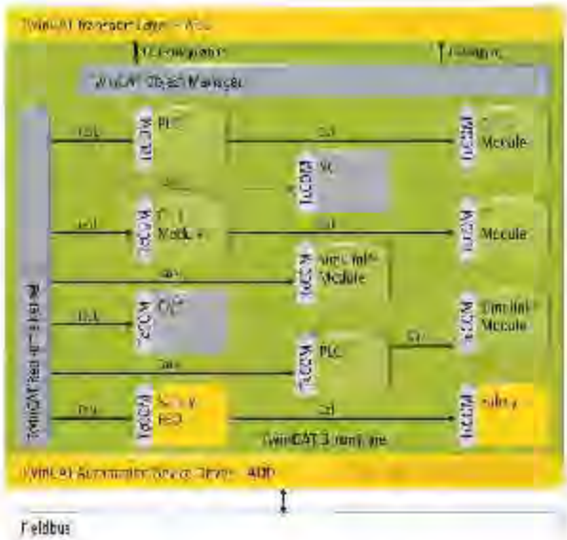
With the new CX2000 series from Beckhoff, such powerful CPUs are now available in the Embedded PC format preferred by wind turbine manufacturers. The CX2000 devices are equipped with Sandy Bridge processors from Intel. In addition to economical Sandy Bridge Celeron types, Intel Core i7 processors are available. Even the CX2020, which is equipped with a 1.6 GHz processor (dual-core), is fanless and therefore exceptionally stable because it has no rotating components.

Suitable software must be used to take full advantage of this enhanced performance. This is where TwinCAT 3 control software from Beckhoff comes in. The real-time environment of TwinCAT 3 is designed to enable almost any number of PLCs, safety PLCs and C++ classes to be executed on the same or on different CPU cores.

Condition monitoring library for TwinCAT 3

The new TwinCAT 3 Condition Monitoring library facilitates the utilisation of these options. Raw data can be logged with a fast task and processed further with a somewhat slower task. This permits measured data to be logged continuously and analysed with algorithms such as power spectrum, kurtosis, crest factor and envelope spectrum. The user doesn't have to worry about task spanning communication, which is automatically handled by the Condition Monitoring library. The results from the individual function blocks in the library are stored in a global transfer tray, a kind of memory table. From there the results can be copied to variables or processed further with the aid of other algorithms. In this way users can configure their own individual measuring and analysis chains. Particularly in the wind industry, such developments must be tested and simulated extensively because once a wind turbine has been commissioned, modifications and updates in the field would be rather time-consuming and

The real-time environment of TwinCAT 3 is designed to enable almost any number of PLCs, safety PLCs and C++ tasks to be executed on the same or on different CPU cores...



The compiled TwinCAT 3 modules can call each other during runtime, irrespective of the programming language...

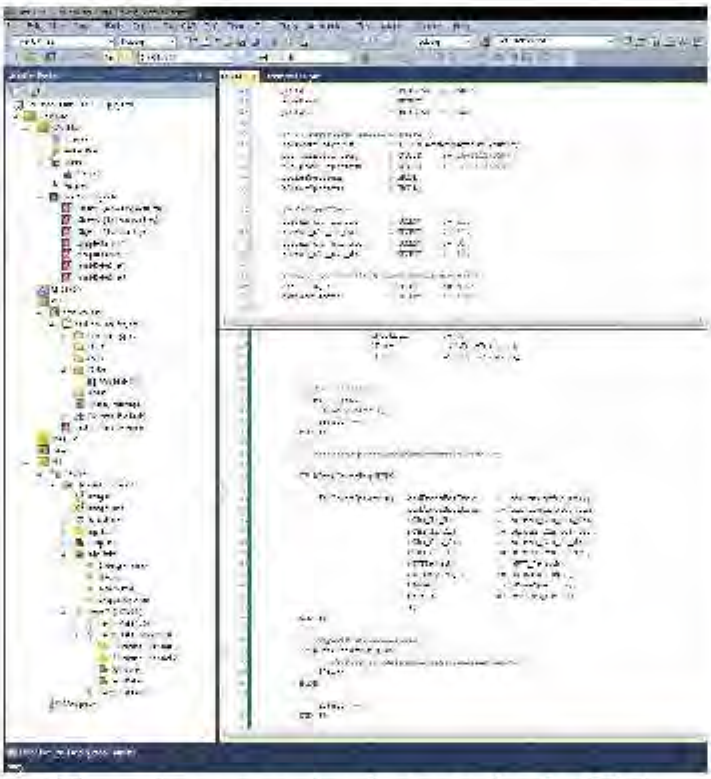
expensive. In order to save time and development costs, a Matlab/Simulink simulation of the system can be used against the original control program code in real-time, for example. In this way many problems can be detected and rectified before commissioning. No Beckhoff-specific components or other modifications of the original model are required for creating Matlab Simulink modules for the TwinCAT 3 runtime environment. The Matlab and Simulink coders generate C++ code, which is then compiled into a TwinCAT 3 module. Modules can be re-used easily through instantiation. The block diagram from Simulink can be visualised directly in TwinCAT for setting break points, for example.

In addition to TwinCAT 3 and the auxiliary Condition Monitoring and Matlab/Simulink integration packages, TwinCAT Scope enables visualisation of all relevant signals of a decentralised automation software. The TwinCAT Scope consists of two components. The View component is used for displaying signals in the form of charts. The Server component records the data on the target device. A TwinCAT 3 installation always includes a basic version of Scope. This is particularly suitable for commissioning of systems. The scope provides the user with a quick graphic overview of the machine state. Different colours enable precise reading of the measured data, even in the µs range. For large value ranges it makes sense to switch to a logarithmic display. The Scope product level enables additional functions such as long-term recording or diagnability mode for .NET visualizations. At Scope product level permit visualisation of oversampling values from EtherCAT measuring terminals.

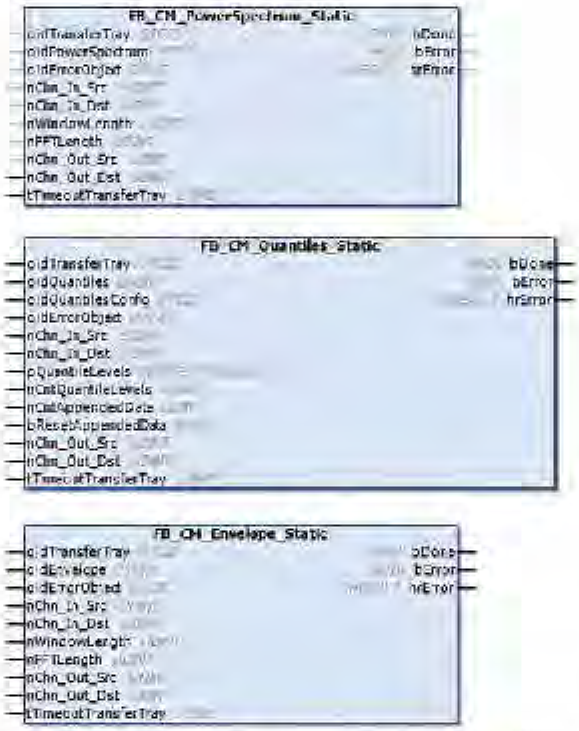
EtherCAT: high-precision measuring technology

EtherCAT as a fast real-time capable bus system rounds off the scientific automation solution from Beckhoff. EtherCAT has not only become established as a control fieldbus, but also as a measurement fieldbus. Only this Ethernet based, highly deterministic and fast fieldbus protocol enables complex applications, such as the integration of Condition Monitoring, to be realised. The functional principle of EtherCAT delivers usable data rates far in excess of 80% with full duplex fast Ethernet and bus cycle times of a few microseconds. In conjunction with the oversampling function mentioned above and buffering of values directly in the EtherCAT slave, the sampling rates can be increased far beyond the actual bus cycle. The EL3632 digital input terminal, for example, can scan signals with up to 1 million samples/second. The EL3702 EtherCAT Terminal samples analog signals of ±10 V with 16 bit resolution and up to 100 kHz. Distributed clocks in EtherCAT slaves ensure time synchronised data sampling across the network. The jitter is significantly less than 1 microsecond, usually even less than 100 nanoseconds.

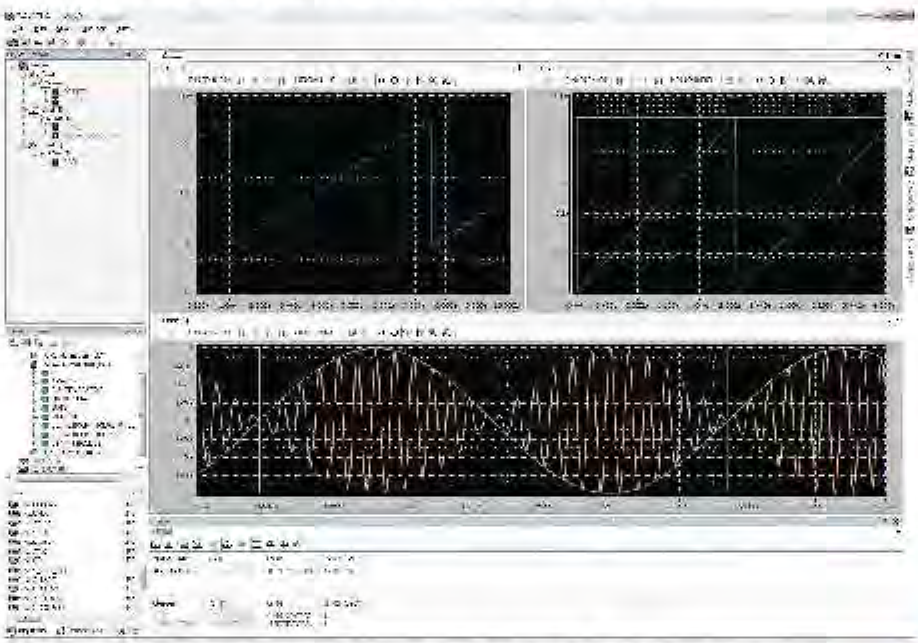
The EL3632 is also an EtherCAT oversampling terminal. This terminal is suitable for Condition Monitoring applications, in which oscillations must be sampled via accelerometer sensors or microphones. Piezo sensors (with IEPE interface (Integrated Electronics Piezo-Electric) can be connected directly to the two-channel terminal without a pre-amplifier. Due to different hardware filter stages, signal sampling frequencies between 0.06 Hz and 50 kHz are possible. The same principle of operation as in the EL3632 is used in the EL3773. The EL3773 is a power monitoring terminal that samples raw grid data, as opposed to raw oscillation data. Current and voltage can be sampled with up to 10 kHz, which makes the terminal suitable for synchronisation with other networks. The main advantage of these 12 mm wide modules is their high degree of flexibility. EtherCAT bus systems offer virtually unlimited expansion capabilities. This means that measuring applications, such as gear unit monitoring, can be implemented in new systems or retrofitted in existing systems. Thanks to the compact size of



Calling up the power spectrum function block in TwinCAT 3...



The TwinCAT Condition Monitoring library offers different function blocks for signal analysis...



Logarithmic signal analysis display with TwinCAT Scope...

the controller and the wide range of open TwinCAT interfaces, stand-alone systems are becoming increasingly popular. Such stand-alone systems are currently retrofitted in some onshore turbines for monitoring the main bearing and the gear unit based on a CX5020 Embedded PC. To this end a terminal box is equipped with five EL3632 oversampling terminals and an EL3413 power measurement terminal. CMS modems and compact hosts can give Logarithmic signal analysis display with TwinCAT Scope Pascal Dresselhaus, TwinCAT Product Management, Beckhoff be integrated as additional options. Depending on the available interface, the monitoring system can be integrated with the existing controller.

In summary, Scientific Automation enables the integration of engineering findings in the automation of wind turbines beyond the scope of conventional controllers. The power of the PC Control philosophy offers sufficient capacity to integrate numerous advanced functions beyond standard control.

High-performance CPUs, fast I/O terminals, EtherCAT communication and TwinCAT software provide the basic technologies required for this purpose.

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Pascal Dresselhaus
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ELECTRICITY FROM GARBAGE

Shadnagar facility of 6MW in Andhra Pradesh is the first operational Waste-To-Energy (WTE) plant in India. Selco has a 20 year PPA with APTRANSCO at ₹ 3.48/kWh and connects to the grid through a 33/11kV substation...

All cities anywhere have garbage disposal as a major problem. It is produced in large quantities, and has nowhere to go, except mostly in landfills. This is attracting attention of city planners lately and measures are being considered towards making the garbage disposal fruitful and productive. One of the major areas of interest is the use of garbage for energy. Wastes produced in India is of its huge... can be seen from the next table.

Total solid waste generated in urban areas: 115 Lakh Tons per day (TPD)

	TPD	% of total garbage
Waste in 6 mega cities	21,700	18.8 %
Waste in metro cities		
(1 million plus towns)	19,649	17.08 %
Waste in other class 1 cities		
(20 million plus towns)	42,569.28	37.02 %
TOTAL	**83,378.28**	**72.50 %**

If waste in class 1 cities is taken care of, 72.50% of waste is taken care of. This could be a huge achievement.

Waste generated in urban India every year

- Solid waste - 300 Million tons
- Liquid waste - 4700 Cu. Metres
- Municipal solid waste - 0.30 - 0.60 Kg / person / day
- Plus industrial waste.

Urban Local Bodies spend around ₹ 500/- to ₹ 1500/- per ton on solid waste management, out of which 80 to 70% of the amount is on collection, 20 to 30% on transportation, while hardly any fund is spent on treatment and disposal of waste. Even after segregation of waste, about 45% goes to landfills.

Most solid waste goes to landfills/water bodies, causing serious pollution with methane and CO_2. Finding new landfill sites is no solution. Permanent and eco-friendly solution lies in gainful utilization of this garbage into energy, by processing and treating the waste before final disposal. This can reduce the waste by up to 90%, and, at the same time, recover fuel gas for cooking and lighting and electricity.

Waste to energy conversion is possible in a number of ways. Refuse-Derived Fuel (RDF) facilities process the MSW prior to direct combustion. The level of pre-combustion processing varies among facilities but generally involves shredding of the MSW, and removal of metals and other bulky items. Energy from municipal waste takes care of two problems - garbage and energy needs, at the same time. There is no pollutant released or carbon emissions to speed up global warming, and waste to energy plants can be very cost efficient. Municipal solid waste pays not only in collection fees but also in the production of by-products which can be sold for a profit. Will not be out of place to mention here that landfill is banned in Germany, and entire garbage is usefully employed.

Biomass is a clean source of energy in Brazil. Over 1 million people work in production of biomass, which represents 27% of the country's energy generation. Nearly all of the biomass for power generation is based on the use of waste and residue fuels.

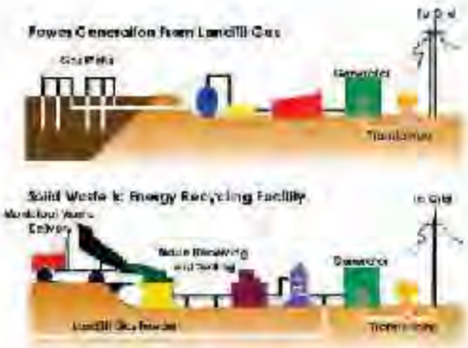
India is second in rank in the world in biomass utilisation (MNRE). Biomass can be tapped right at the landfill. When garbage

Waste to energy cycle...

decomposes, it gives off methane gas. Natural gas is made up of methane. Pipelines are put into the landfills and the methane gas is collected. It is then used in power plants to make electricity. This is called landfill gas.

Landfill gas is gathered from landfills through extraction wells placed depending on the size of the landfill. Roughly one well per acre is typical. Gas is then used to produce electricity, heat, fuels and chemical compounds.

Today, more than 900 thermal WTE plants operate around the globe. These plants treat an

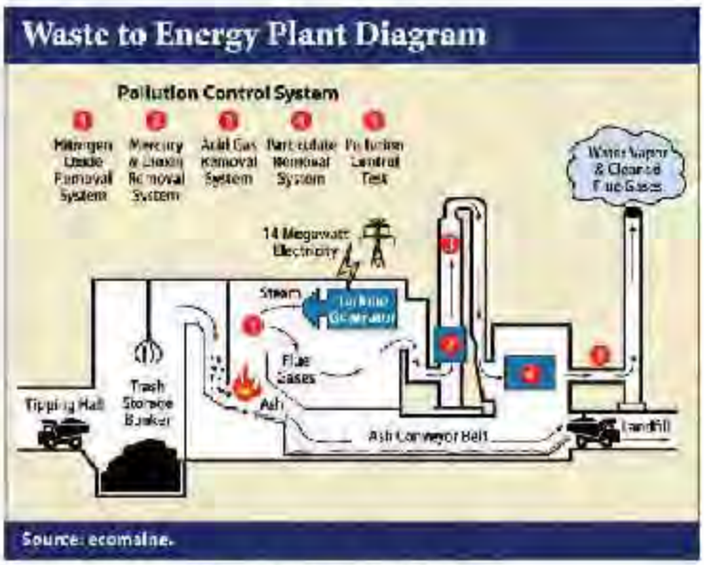


Landfill gas to energy systems...

estimated 200 million tons of Municipal Solid Waste (MSW) with an estimated output of 130 terawatt hours (TWh) of electricity. Vancouver landfill is operative since 1966, and in 2000 received 400,000 tons of MSW. The landfill serves over 600,000 residents and businesses from city and surrounding area. The landfill is part of the district's disposal system consisting of two landfills and a WTE facility that collectively serve 2,000,000 people. The project results in the recovery of approximately 500,000 G/year of energy, the total energy requirements of 8,000 to 9,000 homes, and results in a reduction of more than 280,000 tons per year CO_2 (the emissions of approximately 45,000 automobiles).

Shanmugar facility of 6MW in Andhra Pradesh is the first operational waste to energy (WTE) plant in India. Seller has a 20 year PPA with APTRANSCO at ₹ 5.40/kWh and connects to the grid through a 33/11 kV substation. The plant went commercial in Nov 2009. There are some other plants working in India for WTE conversion.

Municipal and industrial garbage incinerating plants near housing colonies in Europe are so clean that many times more dioxin is now released from home fireplaces and backyard barbecues than from such incinerators. Today's waste-to-energy plants have arrays of newly developed filters and scrubbers to capture the offending chemicals — hydrochloric acid, sulfur dioxide, nitrogen oxides, dioxins, furans and heavy metals — as well as small particulates. Timarpur Okhla Municipal Solid Waste (MSW) Management project in Delhi is the first commercial waste to energy facility in North India. This will convert one-third of the Delhi garbage into electricity.



Waste to energy plant diagram...

Thirunecramalai biogas lights up town at night...

enough to serve 6 lakh homes. The project is registered with United Nations Framework Convention on Climate Change (UNFCCC) for earning carbon credits. This is the first and largest integrated waste management project set up in the country, aiming for Zero Waste Concept. This works on an environmentally friendly process to generate clean and renewable energy. The plant is aimed at generating 16MW of power from waste. The power plant will use about a third of the daily MSW of Delhi, which stands between 8000 and 9000 tons. NDMC and MCD will be providing the waste free of cost. Similar initiatives elsewhere target to bring electricity to more than 500,000 homes with each plant.

California produces more than 60 million bone dry tons of biomass each year. Of this, five million bone dry tons is burned to make electricity. Full 60 million tons of biomass in California could make about 2,000 MW for growing population – enough energy to make electricity for about five million homes. The potential for renewable energy generation from sludge on a nationwide level is enormous. The researchers estimate that California alone generates approximately 700,000 metric tons of dried sludge every year, enough to yield 10 million kilowatt hours daily. Netherlands hosts the world's largest biomass power plant running solely on chicken waste. It converts roughly 440,000 tons of chicken manure into renewable electricity to power 90,000 homes annually. The plant has a capacity to generate more than 270 million kWh of electricity per year. The power plant also takes care of another massive problem – managing the excess of chicken waste, which if left untreated, releases methane, a very potent greenhouse gas.

Planned, designed and executed on the patented technology developed by an Indian engineer, K S. Sivaprasad from Tamil Nadu, a waste-to-energy plant in Malaysia won an international award given for best renewable energy plants in the world. The construction of power plant was taken up in Malaysia to handle 700 tons of municipal waste a day and generate 9 MW power. After meeting its consumption of 3 MW, the balance 6 MW was being supplied to the national grid. Malaysian Government then awarded him the next project to handle 1000 tons of waste per day.

Human waste to generate renewable electricity

Thames Water, U.K. has constructed plants to use human waste to generate electricity. Britain's biggest water company will save 500,000 a year using a new type of fuel – dried human waste. Cleaned up, looks just like instant coffee granules and is a highly combustible new renewable form of fuel, around 10% of electricity needs will be met by so-called poo power – enough to run around 70,000 average family homes. The facility produces approximately five tons of sewage sludge for conversion to fuel chips or flakes, produced after the sludge is heated to 180°C. The resulting flakes are burned to produce electricity.

In Thirunecramalai in Tamil Nadu, biogas from human waste produces 15,000 watts of electricity daily, enough to keep the town bright at night. The human waste from an area housing complex collects in a sump, where the methane gas produced by the sludge is used to operate a generator. Apart from electricity, the biomass utilisation produces methane for cooking and other applications, and also manure useful for farming. Overall, MSW can be a rich asset, manna rather than liability. According to MNRE estimates, there exists a potential of about 1460 MW from MSW and 225 MW from MSW and sewage.

Conclusion

Waste to energy (WTE) plants are among the most efficient ways to convert garbage to electricity. WTE plants reduce the waste volume drastically in most eco-friendly manner, at the same time reducing the necessity of landfills. Garbage is very efficiently utilised, and much needed electricity is generated, bridging the gap for electricity requirement. It is time all cities pay attention to this source for power as an economical way to tackle the city waste.

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A round table of Energy Secretaries and Utility heads

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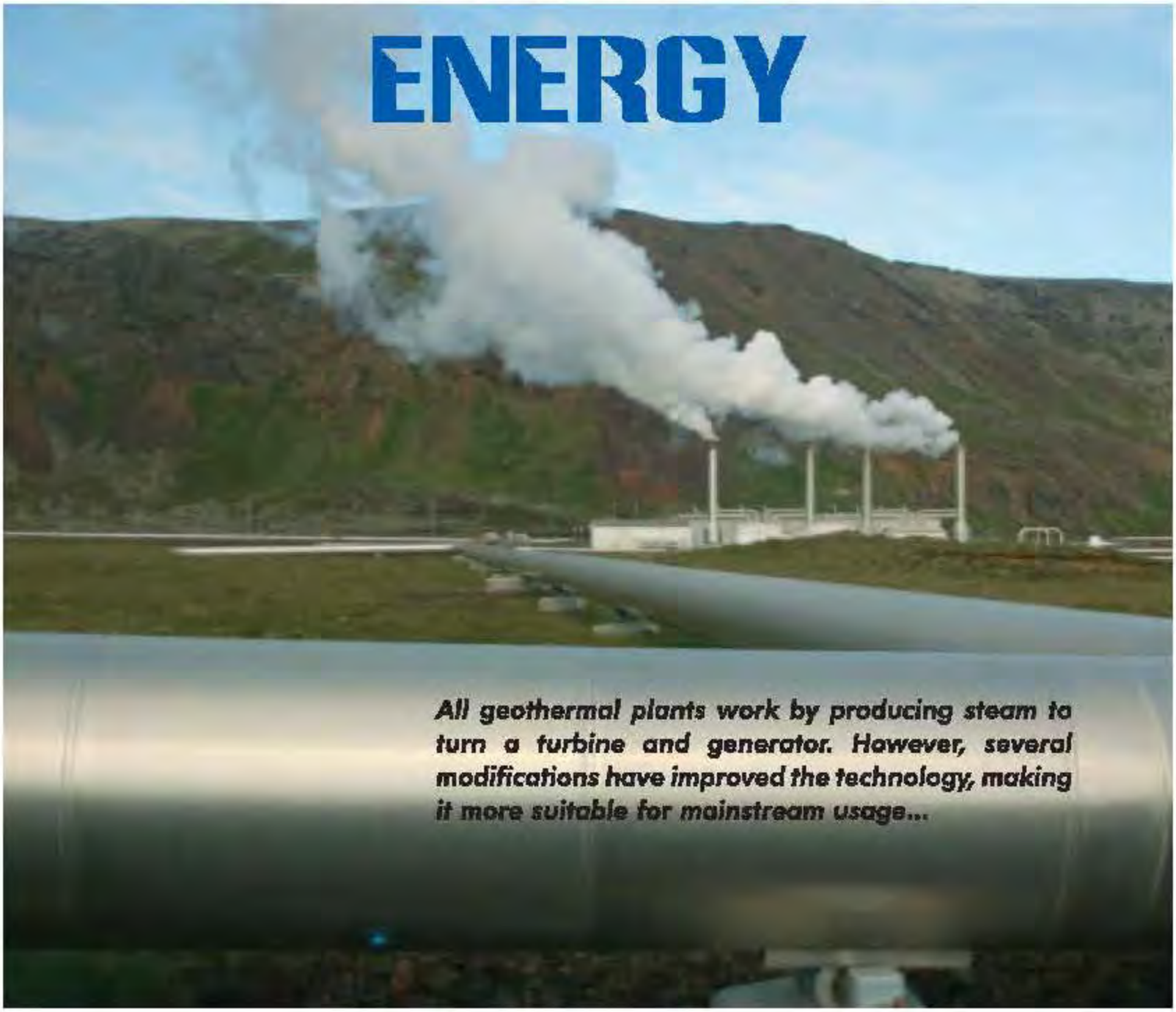


All geothermal plants work by producing steam to turn a turbine and generator. However, several modifications have improved the technology, making it more suitable for mainstream usage...

At present most of our energy demand is met by conventional fossil fuels such as coal, oil and natural gas. But these are available in limited quantities. It is estimated that we could consume all the oil in about 40 years and the natural gas soon after. However, coal is available in plenty, but its extraction is not as per demand. The other problem with fossil fuels is environmental. After combustion, they emit carbon dioxide to the atmosphere, which causes global warming. They also release many other harmful by-products that pollute the environment.

Apart from fossil fuels, we get energy from hydropower and nuclear power. But their share is less. Day-by-day, demand of energy is increasing in all the countries and there is always a shortfall. Scientists and engineers have developed some alternative sources of energy to reduce the gap between demand and availability. Geothermal energy is one of them; others being wind power, solar energy and bio-energy etc.

Geothermal Energy

Geothermal is a combination of two Greek words- geo which means 'earth' and thermos, which means 'heat'. Thus, geothermal energy is the heat energy from the earth. Where does the heat come from the earth? To know this, we have to know the creation of earth. Earth and other planets were formed from primordial clouds of hot gases. It was too hot at the time of creation. Gradually, it was cooled and the solid crust was formed. But below the earth's crust, it is still in hot liquid state. This layer of hot and molten rocks is called magma. Heat is continuously produced there, mostly from the decay of radioactive materials such as uranium. Heat flows upwards from the earth's interior. Normally the crust of the earth insulates us from the heat, but at some weaker points such as hot geyser, the heat comes to the surface of the earth.

Direct Uses of Geothermal Heat

Geothermal reservoirs of hot water can be used to provide heat directly. Direct use of geothermal energy is very old method. People in different parts of the world used hot springs for bathing, cooking food, space heating and other day-to-day heating purposes. Now, modern systems are being used for direct use where a well is drilled into a geothermal reservoir to provide a steady stream of hot water. This water is brought up through the well and with the help of mechanical systems such as pipes, heat exchanges etc., the heat is delivered directly for its intended use.

Geothermal heat can also be used for air-conditioning and refrigeration applications through a geothermal heat pump. Geothermal heat pump system consists of a ground heat exchanger, a heat pump unit and an air delivery system. This is being used directly for heating in at least 78 countries.

The most common application of geothermal energy in agriculture is in greenhouse heating, which has been developed on a large scale in many countries. The cultivation of vegetables and flowers out-of-season, or in an unnatural climate, can now draw on a widely experimented technology. Various solutions are available for achieving optimum growth conditions, based on the optimum growth temperature of each plant, the quantity of light, the CO_2 concentration in the greenhouse environment, the humidity of the soil and air, and air movement.

Exploitation of geothermal heat energy in greenhouse heating can considerably reduce their operating costs, which in some cases account for 35% of the product costs (vegetables, flowers, house-plants and tree seedlings).

Electricity Generation from Geothermal Energy

All geothermal plants work by producing steam to turn a turbine and generator. However, several modifications have improved the technology, making it more suitable for mainstream usage.

Dry Steam Power Plants

Dry steam power plants were the first type of geothermal plants. This type of geothermal power plant was named dry steam since steam is extracted from the underground reservoirs in place of hot water. Geothermal steam of at least 150°C is extracted from the reservoirs through the production wells and is sent directly to the turbine, which drives a generator to produce electricity. These plants only emit excess steam and minor amounts of gases.

Geothermal reservoirs that can be exploited by geothermal dry steam power plants are rare. The first one was constructed in Larderello, Italy, in 1904. The Geysers, 22 geothermal power plants located in California, is the only example of geothermal dry steam power plants in the United States.

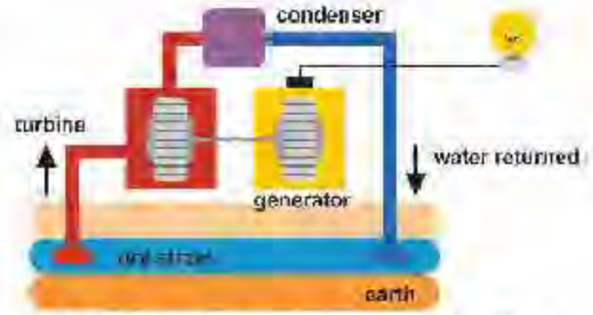


Figure 1: How a dry steam power plants works?

Flash Steam Power Plants

Flash steam power plants use water with temperatures greater than 200°C pumped at high pressures to the surface, where the pressure is suddenly dropped, causing the hot water to 'flash' into steam. The steam is then used to power a turbine and generator. Any leftover water is pumped back into the reservoir, or into a second tank where it can be flashed again to generate more steam. The only by-products of this process are excess steam and trace gases.

Flash steam is today's most common power plant type. The first geothermal power plant that used flash steam technology was the Wairakei Power station in New Zealand, which was built in 1958.

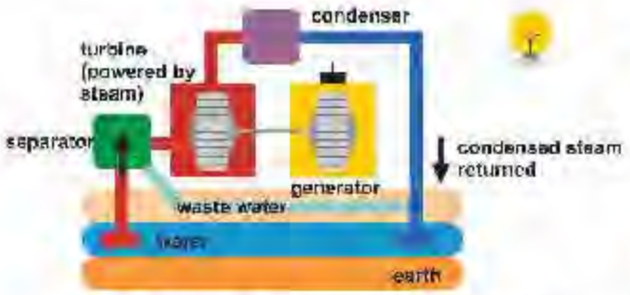


Figure 2: How a flash steam power plants works?

Binary-Cycle Power Plants

The binary cycle power plant has one major advantage over flash steam and dry steam power plants. The water-temperature can be as low as 57°C. It utilises a secondary working fluid, usually an organic fluid (typically n-pentane), that has a low boiling point and high vapour pressure at low temperatures when compared to steam. The geothermal steam or hot water yields heat to the secondary fluid through heat exchangers. As a result, the secondary fluid is heated and vapourised. The vapour drives the turbine. Then the vapour is cooled and condensed by cooling water and the cycle begins again (Fig - 3). Because the two fluids are separated during the whole process, almost nothing is emitted to the atmosphere. Since water in underground reservoirs usually has moderate temperatures, binary-cycle power plants will likely be the main geothermal technology in the future. The disadvantage of this system is that it tends to be less efficient. These power plants have a thermal efficiency rate of only 10-13%. However, geothermal binary cycle power plants enable us, through lowering temperature requirements, to harness

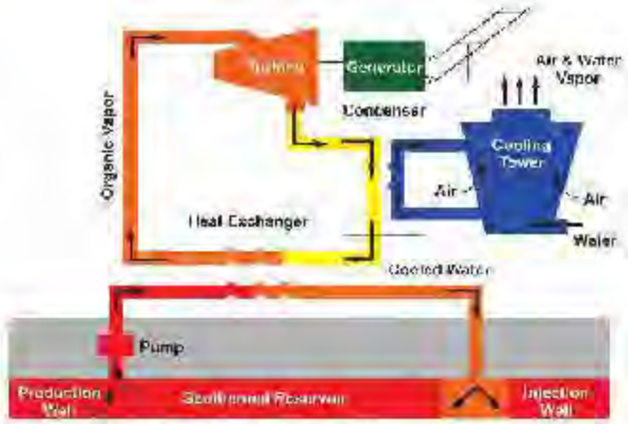


Fig. – 3 : How a binary-cycle power plant works?

geothermal energy from reservoirs that with a dry- or a flash steam power plant wouldn't be possible. First successful geothermal binary cycle project took place in Russia in 1967.

Advantages & Disadvantages of Geothermal Energy

Geothermal energy does not cause any pollution. It is a clean source of energy and it has no harmful by- products. It is inexpensive, as no fuel is required to produce energy and hence, running cost of power plant is less. Further, it can be used to produce electricity 24 hours a day (comparatively other renewable sources of energy such as solar and wind energy have limitations). Geothermal power plants are generally small and have little effect on the natural landscape or the nearby environment. Though geothermal energy has several advantages, it also has some disadvantages and limitations. If harnessed incorrectly, it can sometimes produce pollutants. Improper drilling into the earth can release hazardous minerals and gases deep inside the earth.

International Status

The worldwide use of geothermal energy is increasing. Today 11,772 MW of power is being generated in at least 24 countries from geothermal energy and in 2010; it generated 67,246 GWh of electricity. This is a rise of about 20% since 2005. By 2015, figure is expected to grow even more to 18,500 MW. The largest producer of this energy is USA that generates about 3,086 MW of electricity. The largest group of geothermal power plants in the world is located at The Geysers, a geothermal field in California of USA. The Philippines is the second highest producer, with1,904 MW of capacity online. Geothermal power makes up approximately 18% of the country's electricity generation. Also in Indonesia 5% of overall electricity generation is from geothermal energy. The installed capacity of geothermal power plant in different countries is given in Table-1.

Status of Geothermal Energy in India

Geological Survey of India has identified about 340 geothermal hot springs in the country. Most of them are in the low surface temperature range from 37°C to 80°C, which is suitable for direct heat applications. Only some are suited for power generation. The potential for power generation at these sites is about 10,000 MW. Though, India

Country	Installed capacity (MW)
USA	3389
Philippines	1848
Mexico	1017.4
Indonesia	1341
Italy	8755
Japan	537
New Zealand	842.6
Iceland	664.4
Costa Rica	207.1
El Salvador	204.4
Kenya	248.5
Russia	81.9
Nicaragua	149.5
Guatemala	48.0
China	27.0
Papua New Guinea	56
Turkey	166.6
Portugal	28.9
Total	**11772**

Table 1: Installed capacity of geothermal energy (2013)...

has been one of the earliest countries to begin geothermal projects way back in the 1970s, but at present there are no operational geothermal plants in India. The hot springs in the country are grouped into seven geothermal provinces, i.e., Himalayan, Sahara Valley, Cambay Basin, Son-Narmada –Tapi lineament belt, West Coast, Godavari Basin and Mahanadi Basin.

An experimental geothermal power plant of 5 kW capacity has been set up at Manikaran in HP. A cold storage plant has also been constructed there to utilise the geothermal energy at 90°C for preserving vegetables and fruits grown in that area. Some of the prominent places where a power plant can be established based on geothermal energy are Puga Valley and Chhumathang in Jammu and Kashmir, Manikaran in HP, Jalgaon in Maharashtra, Tapovan in Uttarakhand, Bakreshwar in WB, Tuwa in Gujarat and Tattapani in Chhattisgarh. MNRE is giving thrust on exploration and harnessing of India's geothermal energy resources.

Mayadhar Swain
Deputy General Manager
PP & EE Section, MECON Limited
Ranchi - 834 002

Moving Towards
A Cleaner Future

With an increasing demand-supply gap in energy, the government and majority of businesses are now taking crucial steps towards tapping the solar potential of the country, thereby helping achieve India's goal of becoming a country that provides energy to all...

Aided by its briskly improving economic position, India has been able to further its growth and expansion with policy based action and guidance from the government. For the advancement and progress to trickle down to the last mile, there will be a need for continuous demand in energy supply, which can power up the growth and possibly fast track it too. For the fruits of digitization as well as initiatives like e-governance to percolate to end consumers, the need arises for 24x7 power supply. The same logic also holds true for businesses, because to function unhindered and efficiently, they will need continued access to mission critical data and therefore ensuring uninterrupted energy supply is non-negotiable for their growth.

India is the world's third largest producer of electricity, generating a capacity of about 259GW. Despite this, our power demand far outstrips supply and the per capita consumption of electricity in our country is abysmally low. Consequently, India faces a power deficit situation, and hence the demand for alternative sources of energy is increasing rapidly. With an ambitious plan of generating 100GW of solar energy by 2022, the country thus represents a huge opportunity for global green-energy focused firms who are scouting to invest in the India story. What also aids their search is the reprioritisation of renewable energy sources on to the top of the national energy security agenda by the NDA led government.

Renewable and Solar Energy – The Indian Picture

With an increasing demand-supply gap in energy, the government and majority of businesses are now taking crucial steps towards tapping the solar potential of the country, thereby helping achieve India's goal of becoming a country that provides energy to all.

In this light, India looks at achieving its gargantuan (yet seemingly possible) target of 100 GW of renewable energy by 2022, the government has put in place an elaborate ecosystem to support green and renewable energy ventures. The government's announcement has already seen a majority of domestic companies capitalising and looking at adding significant green energy capacities to their prowess. This is another significant reason as to why the share of solar and renewable energy capacities is set to rise soon.

While this push will help India reduce its dependence on fossil fuels and curb pollution, India's solar push faces hurdles such as affordability and insufficient infrastructure. Speaking of affordability, assuming that there are high tax returns that will be levied on equity, the cost of generation from a solar project can be very expensive and reduce the interest of companies looking to invest in such ventures. Until now the industry has been well supported by government incentives like lower duties, tax breaks and guaranteed purchases by the state utilities. But

some companies bundle solar energy with large volumes of conventional energy, which results in a marginal rise in tariffs for the end user. This raises an important question on the affordability part. Another challenge in the quest for enhancing the solar energy production is that of inadequate infrastructure facilities, which becomes a hindrance in the adoption of solar-based technologies. With the existing transmission capacities being insufficient, we are witnessing a lot of inter-state transmission congestion, and a lot of this goes unaccounted for. This has additionally raised an important question as to whether India as a country can provide the required infrastructure for the adoption of solar energy.

Increasing Use and Benefits of Solar Energy, Products and Solutions

While India's solar push does face some grave challenges, solar energy does have some real advantages. The first one being abundance of solar energy in India. Being a tropical country, solar energy is produced on a large scale in India. India saw a 14.2% increase in solar power generation from 2013-2015.

From a business standpoint companies today are looking to go green and reduce their carbon footprint.This is why, we are already witnessing a huge surge in demand for solar inverters and UPS systems that are cost efficient and effective. The surge in deployment of such solutions is accelerating the pace of growth in the global power electronics market, a critical segment for the solar industry supply chain.An interesting point to note is, although the average price for conventional solar inverters declined by 16% last year, the power electronics industry reported significant revenue growth during the same period. This has resulted in the power electronics market catering to the solar industry growing by nearly one third year over year to about half a billion dollars in 2014.

With demand for Micro Inverters, UPS systems and power optimisers projected to be among the hottest of the lot in terms of growth, the estimated global market for these products is also set to grow 19% annually over the next four years, reaching more than $1 billion in 2019, according to a recent study by IHS Technology's PV Inverter Intelligence Service. Companies making solar panels or modules are increasingly embracing micro inverters, power optimisers and UPS solutions to differentiate themselves from competitors and expand the options they can offer their customers.This has also seen many companies including Emerson Network Power invest in central inverters and the off grid solar market in a huge way.

The Way Forward and the Future

With the government highlighting their openness for large scale PPP initiatives as well as huge solar projects, there is still an increasing need to come out with encouraging policies. Solar panels reduce the amount of electricity coming from fossil fuels, supplying business operations options of clean, renewable energy. Many business owners, from hotels to wineries to retail stores, to manufacturing units are making the decision to reduce their electricity bills by adopting the cleaner and greener option of solar energy. With major tax benefits especially carbon credits on offer, having an environment-friendly image seems a profitable business proposition too. It is safe to say that many organisations and even state governments are excited about the prospects of solar energy, which is evident from research and development conducted for solar/ green cities. A total of 60 cities/towns are proposed to be supported for development as Solar Cities during the 11th Plan period. With the country expecting an investment outlay of about $250 billion (₹ 1,52,500 crore) in the electricity and renewable energy sector by 2019, the outlook is indeed sunny (pun intended!) for India.

Dinesh Dhot
Director - Telecom / Solar Products & Solution at Emerson Network Power India

The Potential Of Sources In The

India became the world's third largest producer of electricity in the year 2013 and accounts for 4.8% of global share in electricity generation. But its per capita electricity consumption is only 746 kWh, which is lower compared to many countries, though electricity tariff is cheaper in India. Energy is the basic input in all sectors of the nation's economy, and the standard of living is directly related to per capita energy consumption. As the country is heavily populated, provision of adequate quantities and kinds of energy is a challenge to the government, and the institutions in the country engaged in tasks relating to energy supply and transport. The commercial energy inputs to the Indian economy are from conventional sources like coal, hydroelectricity and nuclear energy. The country currently has total installed capacity of thermal 70%, hydroelectric 16%, nuclear 2% and renewable 12%. For long-term sustainability, minimum utilisation of fossil fuel for energy and maximum utilisation of renewable energy are to be considered. At the same time, minimum losses during generation, transport and utilisation sector is also important.

Renewable sources and their potential for supplying electricity

Renewable energy is generally defined as energy that comes from resources, which are naturally replenished on their own. Renewable energy sources are all essentially based on the direct or indirect use of solar energy. The only exception is tidal energy, which essentially derives its power from the interaction between the earth and the moon.

Renewable energy can replace conventional fuels in the distinct areas like electricity generation, water heating, space heating, motor fuels, and rural energy services. The important renewable energy sources, which can be utilised for generating electricity in our country are as follows: (i) solar energy (direct): Solar thermal power and solar photovoltaic (PV) power, Solar energy (indirect), (ii) Hydroelectric power (large and small units); (iii) Wind energy (on land and offshore), (iv) Biomass power, (v) Wave energy, marine currents, and ocean thermal energy conversion (vi) Tidal energy.

Solar thermal power and PV power

Solar energy is utilised for direct thermal applications and for solar-electric applications. Solar thermal applications include water heating, space heating, drying, cooking etc. Generation of electricity is possible in solar thermal-electric power plants.

These plants use concentrating collectors to collect the sun's energy at high temperatures and use this energy to generate high-pressure steam. The steam in turn is used in a conventional Rankine cycle to generate electricity. India is ranked number one in terms of solar electricity production per watt installed. As on 30 March 2015, the installed grid connected solar power capacity is 3,383 MW, and India expects to install an additional 10,000 MW by 2017 and a total of 100,000 MW by 2022.

Renewable Energy Energy Sector In India

Renewable energy can replace conventional fuels in the distinct areas like electricity generation, water heating, space heating, motor fuels and rural energy services...

Photovoltaic conversions are also a direct method of utilising solar energy, which makes use of solar cells to convert solar energy directly into electrical energy. The electrical energy requirement for localised use in the remote locations all over India is estimated at about 11,000 MW – a substantial part of which is expected to come from PV systems that are not connected to the grid. These systems may be located as far as possible on rooftops, so that no land space is used. India has total installed capacity of almost 4101.65 MW grid-connected PV power systems having small capacities.

Indirect solar energy is the solar power that goes through more than one change to become in the useful form of energy. Examples of indirect solar energy are hydropower, biomass and wind energy.

Hydroelectric power

India is ranked as the 6th largest producer of hydroelectric power in the world and has great potential for hydro-electric power. Hydroelectric power projects are the largest contributors amongst renewable energy sources in our country. Apart from generating electricity, they provide water for irrigation, help in flood control and drinking water purposes.

Hydroelectric power is the generation of electric power which utilises the potential energy of water at a high level. A hydroelectric facility requires a dependable flow of water – and the water head is created by constructing a dam across the river. In a typical installation, water is fed from a reservoir through a channel or pipe into a turbine and the pressure of the flowing water on the turbine blades causes the shaft to rotate, which, in turn, is connected to an electrical generator, which converts the motion of the shaft into electrical energy.

The present installed capacity is approximately 40,561.41 MW, which is 18.36% of total electricity generation in India and small hydro power capacity is 4101MW.

India has huge hydro potential of about 84,000 MW at 60% load factor, which can be economically exploited. Almost 49 large hydropower projects are under construction in India, which will be completed by the year 2022 with a cumulative capacity of 15,006 MW.

In addition, a potential of 6,740 MW of installed capacity from small, mini and micro hydel schemes have been assessed – and pumped storage schemes with an aggregate installed capacity of 94,000 MW

have been identified. Pumped storage schemes would be helpful for meeting peak load demand and storing the surplus electricity, which can also produce power at no additional cost when rivers are flooding. India has already established nearly 6,800 MW pumped storage capacity. For small units, 5,718 sites with a total capacity of 15,384 MW have been identified all over the country.

Wind energy

India has great potential of wind energy to project as an alternate source of energy. Electricity can be generated from wind power by converting the kinetic energy in the wind into mechanical energy utilising wind turbines. The energy in the wind is utilised to turn propeller shaped blades around a rotor, which when connected to the main shaft can spin a generator to produce electricity.

The power that can be extracted theoretically from wind is proportional to the cube of its velocity and the energy generated depends on wind speed and rotor size of the turbine. Wind energy is regarded as a means of saving fuel by injecting power into an electrical grid and to run wind power plant in conjunction with a pumped storage plant. Wind power has application to rotate machinery to do physical work, such as crushing grain or pumping water and has application to desalinate water.

The estimation of the potential wind resources in India is 102,788 MW assessed at 80m Hub height. The installed capacity of wind power in India was 22,645 MW as of 30 March 2015. The target set for wind power generation capacity is 60,000 MW by the year 2022. The preliminary assessments along the 7,600 km long Indian coastline have indicated prospects of development of offshore wind power as the wind speeds offshore are usually higher and steadier.

Energy from biomass

Biomass energy has been an important alternate energy source for the countryand more than 70% of the country's population depends on biomass for energy needs. It is renewable, widely available, and free from greenhouse gases. Biomass is biological material derived from agricultural and forest resources including plant and animal manure. As an energy source, biomass can be used directly via combustion to produce heat. Indirectly, biomass can be converted into forms of bio fuel, like ethanol and methanol, to be used in engines; gaseous fuel called biogas can be obtained from biomass by anaerobic fermentation.

Biomass fuels can be most efficiently used when generating both power and heat through a combined heat and power (or cogeneration) system. A total of 269 biomass power and cogeneration projects with 2,685 MW capacity have been installed in the country for feeding power to the grid. Bagasse cogeneration projects in sugar mills have capacity aggregating to 1,686 MW. A target of 10,000 MW has set for biomass energy till 2022.

Wave energy

Wave energy is indirectly derived from solar energy and is available at the ocean surface – because of the interaction of the wind with water surface. Wave energy can be generated directly from surface waves or from pressure variations below the surface. Wave energy converters are devices, which can capture wave power for generating electricity and extract useful work like water desalination or pumping of water. India has a coastline of 7,500 km with an estimated wave energy potential of about 40,000 MW.

Tidal energy

Tides are the largest source of short-term sea-level fluctuations and caused by the combined effects of gravitational forces of sun and moon and the rotation of the earth. When the gravitational forces due to the Sun and the Moon add together, tides of maximum range called spring tides form, and when the two forces oppose each other, tides of minimum range, called neap tides, are obtained. Electrical energy can be extracted from tides in several ways by constructing a reservoir behind a barrage, and then tidal water is allowed to pass through turbines in the barrage to generate electricity.

India has a potential of 8,000 MW of tidal energy as per the estimates. Despite the huge potential, there is no progress in extracting tidal energy. Agreement is signed to implement India's first 3.75 MW mini-tidal power project in West Bengal.

Ocean Thermal Energy Conversion (OTEC)

Ocean thermal energy conversion, uses difference in ocean temperature from the surface to depths lower than 1,000 metres, to extract energy. A temperature difference of only 20°C can yield usable energy. The closed cycle and open cycle OTEC technologies are commonly used to extract thermal energy and convert it to electric power. The total OTEC potential around India is estimated as 180,000 MW considering 40% of gross power for parasitic losses. The Government of India proposed to establish a 1 MW gross OTEC plant in India, which will be the first ever MW range plant established anywhere in the world.

Geothermal energy

Geothermal energy is the thermal energy stored in the earth's interior. The steam and hot water at high temperature and pressure come naturally to the surface of the earth at some places that can be utilised for electricity generation, residential and industrial heating, greenhouses and other local uses.

According to the estimates, India has 10,600 MW potential in the geothermal energy sector but it still needs to be exploited. Union Ministry of New and Renewable Energy (MNRE) recently drafted a national policy, which intends to exploit the sector by generating 1,000 MW in phase-one by 2022.

Total installed power generation capacity (30.06.15)

The total installed power generation capacity is the sum of utility capacity, captive power capacity and other non-utilities.

Utility power: The utility electricity sector (Table-1) in India had an installed capacity of 274,817.94 MW as of end June 2015. Renewable Power plants constituted 28% of the total installed capacity and Non-Renewable Power Plants constituted the remaining 72%.

Thermal (MW)				Nuclear (MW)	Renewable(MW)			Total (MW)
Coal	Gas	Diesel	Total Thermal		Hydel	Other Renewable	Total renewable	
167,207.88	23,062.15	993.53	191,263.56	5,780.00	41,997.42	35,776.96	77,774.38	274,817.94

Table 1: Installed capacity in the utility sector in India...

Captive power: Presently India has a total installed captive power generation capacity (above 1 MW capacity) of 47,082 MW in the industries and almost 75,000 MW capacities with diesel power generation sets. In addition, there are a large number of DG sets of capacity less than 100 kVA cater to emergency power needs in all sectors such as industrial, commercial, domestic and agriculture.

Conclusion

The total demand for electricity in India is expected to cross 950,000 MW by 2030. Renewable forms of energy, especially solar, wind and hydro power, could contribute to India's energy needs. In case India has to switch from coal, oil and natural gas, it is possible that 70% of the electricity could be derived from renewable resources by 2030.

Realising the need to generate more electricity from clean energy sources, a renewable power production target of 1,75,000 MW is projected for the year 2022 by the Government of India, out of which solar power will have a share of 1,00,000 MW followed by 60,000 MW from wind energy, 10,000 MW biomass energy and 5,000 MW of small hydro projects.

Comparisons of costs per kilowatt hour of electricity produced show that newly built solar and wind plants are already considerably cheaper than new nuclear plants. In coming years solar and wind energy will compete more favourably with conventional energy generation.

India's ocean resources for energy development remain untapped as of now, though a coastline of 7,500 km can be utilised and geothermal energy sector can also supply the future energy needs.

Lekha Chandran
Associate Professor (EEE), IARE
Hyderabad

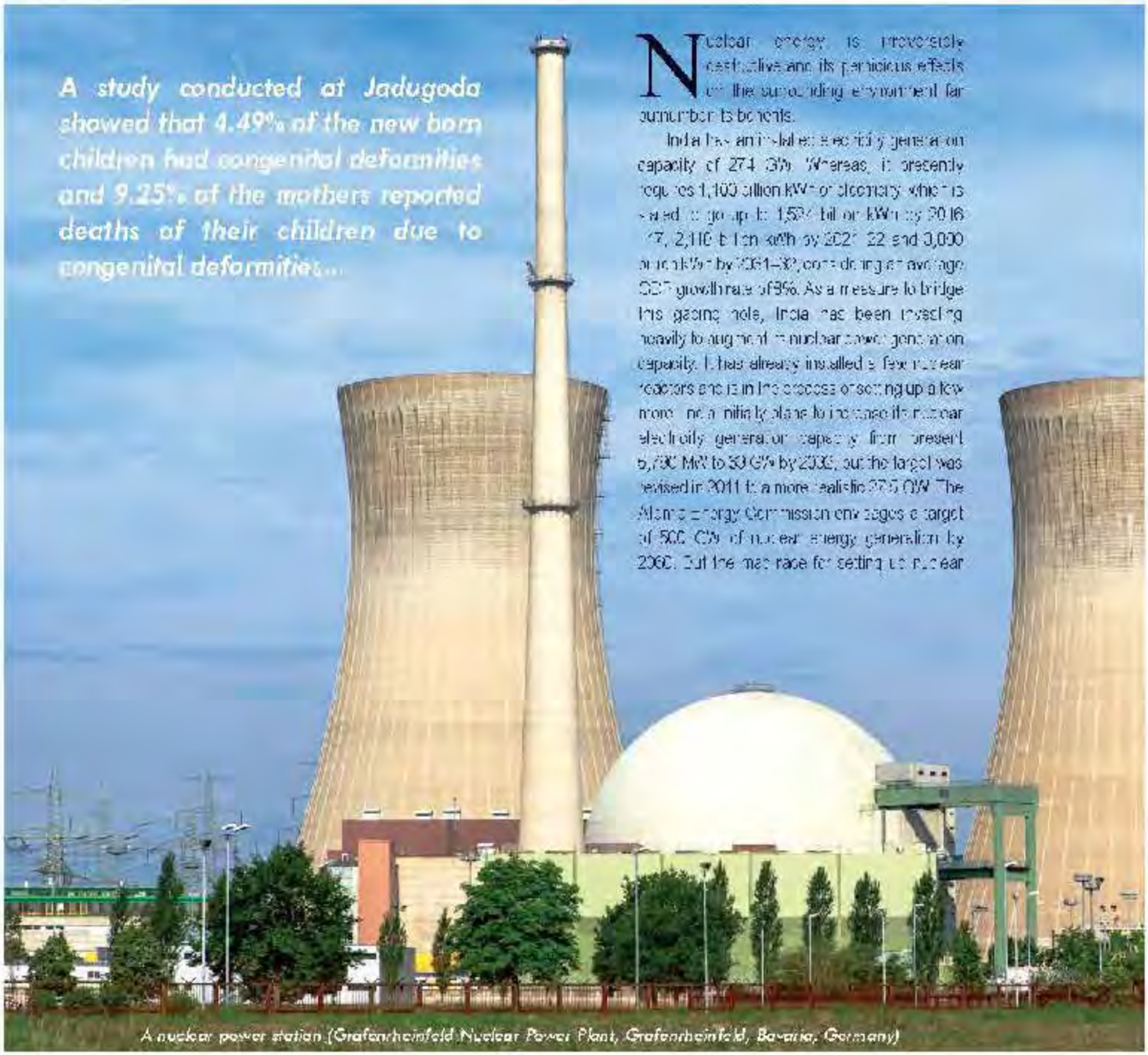
Nuclear Energy

Are We Sitting On A Ticking Bomb?

A study conducted at Jadugoda showed that 4.49% of the new born children had congenital deformities and 9.25% of the mothers reported deaths of their children due to congenital deformities...

Nuclear energy is irreversible, destructive and its pernicious effects on the surrounding environment far outnumber its benefits.

India has an installed electricity generation capacity of 274 GW. Whereas, it presently requires 1,100 billion kWh of electricity which is expected to go up to 1,590 billion kWh by 2016-17, 2,110 billion kWh by 2021-22 and 3,000 billion kWh by 2031-32, considering an average GDP growth rate of 8%. As a measure to bridge this glaring hole, India has been investing heavily to augment its nuclear power generation capacity. It has already installed a few nuclear reactors and is in the process of setting up a few more. India initially plans to increase its nuclear electricity generation capacity from present 5,780 MW to 30 GW by 2035, but the target was revised in 2011 to a more realistic 27.5 GW. The Atomic Energy Commission envisages a target of 500 GW of nuclear energy generation by 2060. But the mad race for setting up nuclear



A nuclear power station (Grafenrheinfeld Nuclear Power Plant, Grafenrheinfeld, Bavaria, Germany)

power plants, owing to their chequered past, has raised a red flag over the issue.

Although India has ambitious plans regarding nuclear energy, people residing near uranium mines and nuclear reactors are paying the price for that ambition. Usually, those working directly or indirectly in the mines and those living in the surrounding areas of mines and nuclear reactors bear the brunt of harmful radiations. Poverty and illiteracy further compounds the problems as these people usually are not aware of the harmful effects of nuclear radiation and only take notice when these effects reach alarming levels. Following is an example of Jadugoda, a small township in Jharkhand, where the Uranium Corporation of India Limited (UCIL) mines uranium and supplies it to nuclear reactors. Large scale mining in the region has led to an increase in cancer and gene mutation in the areas surrounding the mines.

Courtesy: Kornkraftwerk Grafenrheinfeld - 2013

A study conducted showed that 4.49% of the new born children had congenital deformities and 9.25% of the mothers reported deaths of their children due to congenital deformities. Moreover, 9.5% of the couples could not conceive even after three years of marriage, and 2.87% of the households attributed cancer as a cause of death in their household. An alarming 68.33% of the deaths occurred before reaching the average life expectancy age of 62 years. Apart from this, the amount of air gamma dose exceeds 1 milli Sievert (1mSv) per year in the nearby villages and 10 mSv/y around tailing ponds.

Leakage from nuclear power plants poses another threat to the ambient life and property. The most prominent example has been the Chernobyl disaster. It had, by 2005, caused 0.055 million man – Sieverts (Sv) of radiation exposure to recovery workers and evacuees and a further 25% more exposure would be received from residual radio isotopes after 2005. Incidents of thyroid cancer have increased among the young people exposed to the radiation. Apart from this, there has been an increase in the frequencies of Down's syndrome, congenital anomalies, miscarriages and pre – natal mortalities, among the people exposed.

Given the threats it poses to the people, is it still viable to go ahead with nuclear power generation?

The cost of installation of a nuclear power plant is very high, and combining it with operational cost, fuel cost, waste storage cost and cost of decommissioning, it becomes virtually untenable for developing countries to invest in the sector. The unit cost of electricity from a nuclear power plant, although initially estimated to be very low, is also steadily rising and burning a hole in the government's pocket. The expected cost of electricity from Jaitapur power plant is expected to be ₹ 9/unit in 2020 – 21 and that from Mithi Virdhi Nuclear power project is expected to be ₹ 12/unit. As compared to this, the expected cost of solar power, under National Solar Mission, is expected to be ₹ 6 to 9/unit and may fall even further due to decrease in the cost of solar PV, which can be attributed to improvement in technology.

What can be alternatives to the nuclear energy, considering the huge energy deficit that India faces and the vitality of maintaining her energy security? Renewable energy technologies, such as solar energy and wind energy, can play a major role in bridging the major gap in electricity demand and supply which India is currently staring at. National Solar Mission, started under the aegis of National Action Plan on Climate Change envisages increasing the country's grid connected solar power generation to 20,000 MW by the end of 2022.

More recently, the Prime Minister of India Narendra Modi has revised the figure and set an ambitious target of 100 GW generation of solar energy by the end of 2022. According to the Ministry of New and Renewable Energy, the wind energy potential of India is expected to be 1,02,700 MW. These renewable technologies are safe in all respects to the surrounding life and property – and are poised to become major contributors in electricity generation.

Worldwide, countries have started reducing their dependency on nuclear energy and are turning towards renewable sources of energy. Germany has decided to shut down all its nuclear reactors, while many other countries have decided not to build any new reactors. Nuclear energy, although symbolic of technical prowess of a nation, has always been at the receiving end and subjected to scrutiny from environmentalists and general public also. The government cannot afford to look the other way when it comes to safeguarding the interests of its citizens.

Although the chances of leakage from nuclear plant are low, but if it does leak, the price to be paid is quite high. It is quite evident that the road to energy security goes through renewable energy and not nuclear energy. The sooner this is accepted, the better it will be. Let us all accept this and get down to the business.

Anuj Mahajan
Environmental Engineer from Delhi College of Engineering.

Interview

"JIPT aims to produce technically trained professionals for power utilities..."

Jindal Institute of Power Technology (JIPT) is a part of US$18 billion O P Jindal Group. The institute's uniqueness lies in the fact that it provides hands-on training to its students in the group's own power plants. Dr K C Yadav, Director, JIPT, is talking to P K Chatterjee on the courses offered and teaching methods of the institute. Excerpts...

How acute is the skill gap in the fast growing Indian power sector?

Electricity reforms of Indian Power Sector have been relying upon many changes inclusive of opting to highly sophisticated process and control equipment, which need highly qualified, knowledgeable and skilled power personnel. Compulsion of fast growth adversely affected the induction training and low man / MW ratio compelled the functional heads for not sparing the working power personnel for skill advancement to cater ever the minimum training need. Fast growing Indian Power Sector is not only suffering from adequate skills but also seriously suffering from adequate process knowledge and desired attitude. This is true and known to all concerned GOs & NGOs that the large numbers of highly qualified young citizens are either not in the job or not in the proper job but it is also a fact that there's acute shortage of right persons for right job in the Government, Public and Private Sector. The Indian Power Sector is the worst sufferer of not having the rightly qualified, knowledgeable and skilled power personnel.

What are the basic activities of Jindal Institute of Power Technology (JIPT)?

Jindal Institute of Power Technology (JIPT) conducts training programmes on Power Plant Operation and Maintenance for Graduate Engineers and Power Plant Personnel of various Power Utilities.

The institute aims to produce technically trained professionals for power utilities in India and abroad, and prepares trainees to operate or undertake maintenance of power generating stations of 100 MW and above capacity.

How does the institute differ from any other engineering college?

The major advantage of the institute is that it is located within the premises of O P Jindal Super Thermal Power Plant, which allows the trainees to get regular exposure to the running power station of 4 x 250 MW & 4 X 600 MW. This facility, being unique for any institute, enhances the overall knowledge related to operation and maintenance of modern power plants.

The institute has state-of-the-art, high fidelity dynamic, full scope replica Distributed Control Systems (DCS) Simulators of 250 MW & 600 MW PF firing based and 135 MW CFBC based units to train and asses both fresh and experienced engineers.

Jindal Institute of Power Technology has excellent infrastructure facilities such as fully air-conditioned classrooms, library, computer lab, practical labs, model room and auditorium. It provides hostel accommodation in fully furnished and air-conditioned rooms, which are available inside the institute's campus. The hostel has all amenities like mess, gymnasium, both indoor and outdoor games to make living comfortable for the trainees.

What are the courses that you offer? Who are eligible to take up your programmes?

Jindal Institute of Power Technology (JIPT) offers One Year Post Graduate Programme in Thermal Power Technology for Graduate Engineers. In addition to this, we also offer various training programmes on areas of Power Plant Operation and Maintenance (including Simulator Training on 135 MW, 250 MW & 600 MW Units), which are flexible and can be modified as per the actual requirement of Power Plant Personnel.

Can you tell me about your training methodology in brief?

- Lectures & Tutorials for Description of Power Plant Processes and Equipment
- Tutorials, Talk, Group Discussions, Presentation for Absorption
- Visit of Plant Equipment and Demonstration on Model for Consolidation & Confidence of the Curriculum Contents
- Scheme Tracing for Developing Integrated Systems Engineering
- Rotation on Job Operation & Maintenance Training to Induce Desired Skills
- Simulator Training for Further Consolidation of Operational Skills
- Workshop Practices, Practical Exercises in Mechanical, Electrical & C & I Lab
- Project Work, Writing Report and its Presentation / Defense
- Surprise Test / Module Test / Midterm Appraisal / Final Assessment

How do you select lecturers, professors and other staff members related to teaching?

We select lecturers amongst the meritorious students of our own institute and senior faculty by search amongst the power professional from plant and other similar institutions. We also take faculty on deputation from our sister companies.

How does the training from JIPT help professionals in securing good jobs in India or abroad?

The Institute provides classroom teaching on various training modules related to power plant operation and maintenance. The trainees are also trained on Simulators of 135 MW, 250 MW & 600 MW. The trainees also Undergo Scheme Tracing and Rotation On - Job (Operation and Maintenance) at the 4 x 250 MW & 4 X 600 MW O P Jindal Super Thermal Power Plant.

In addition to this regular sessions on Personality Development and Communications Skills are conducted to improve the overall confidence level of the trainees.

How is the popularity of JIPT growing?

Jindal Institute of Power Technology (JIPT) is making its best efforts to persuade the maximum number of companies from Power Sector to recruit its PG Program student's and also to send their existing manpower for training on various aspects of Power Plant Operation and Maintenance including Simulators.

A good number of Power Utilities such as Adhunik Power & Natural Resources, Athena Chhattisgarh Power, Bajaj Energy, Bhushan Power & Steel, Coastal Projects, DB Power, Essar Power, Jindal India Thermal Power, Jindal Power, Jindal Steel & Power, JSW Energy, Reliance India Power (formerly, Indiabulls Power), SKS Power, Soksa Power, Vedanta and Wartsila have recruited our PG Programme student's.

Organisations like Alstom India, ACB (India), Ashlijee Power, Athena Chhattisgarh Power, DB Power, GVK Power & Infrastructure, KKM Powergen & NPTI have trained their GETs / Executives at our institute on various aspects of Operation and Maintenance of Thermal Power Plant as well as on Simulators.

What would you like to communicate to the prospective students?

It is always better to follow the path of goodness to try to achieve the greatness they aspire for. There is no substitute of punctuality, sincerity and hard work, which induce requisite knowledge, job specific skills and the healthy attitude.

There is no scarcity of opportunities for the elite people even in the crowd of billion masses, where one is required to develop the presentation skills to the extent of making others understand about his / her knowledge, skills and attitude.

Solar Power House

Electrotherm having its strong R&D background in solar inverter transformer and solar EPC solutions with its state-of-the-art manufacturing facility in Gujarat for power and various other transformers has taken the initiative to introduce its most reliable & smart substation solution to cater to solar power generation industries...

Solar Power House (SPH) is a consolidated smart solution of DC inverter circuit & AC power circuit placed together under the same roof enclosure in a thermally insulated outdoor container. The complete solution can easily be transported to a Solar Park and generate MW capacity of power in no time. Due to the extremely poor availability of resources at the remote villages where the Solar Park is usually located, the supply of sensitive instruments like power inverter and associated power protection and control instruments and their respective power & control cable connections are not only a challenge in today's world but also needs skilled about and substantial integration time. Due to this, site integration of control & instruments becomes a daunting task in solar field. Moreover, after completion of terminal connections of various instruments, each of them needs to be tested to ensure overall equipment performance.

Electrotherm has taken the initiative to introduce its most reliable & smart substation solution to cater to solar power generation industries, which help solar industries build power stations in record time. The solution is just a plug & play device and with the best in class design. These robust and high tech container solutions are easy to ship and commission at remote sites without any dependence on skilled manpower or equipment suppliers. Each AC & DC container together with associated auxiliary equipment can handle power up to 2.5 MW within a short dimension of (11000 mm) X (2900 mm) X (12,200 mm). The DC container accommodates solar inverters, string monitoring box along with seperate standalone SCADA solution.

The factory built product is completely integrated and tested in combination with DC circuit and the AC circuit before shipment, which is the biggest challenge in any solar project. It also helps reducing the integration cost at site and dependency on so many agencies. There is an added advantage attached to it, all the critical components are pre-mapped in the container solution to make it fail-safe – and accordingly Alarm and Trip circuits are designed and signals are wired up to the SCADA panels, which then send the hierarchy signal to Control SCADA server for preliminary data management and necessary proactive actions. With intelligent door devices and smart communication facility, the solar power house helps customers know about each container power output with a time axis while sitting at a remote distance.

Electrotherm selects the right design of Low Loss Solar Inverter Transformers integrated with High class HT Switch Gear – to provide a very efficient and reliable AC circuit to handle the MW power flow up to the grid in a compact and reliable manner – while controlling and monitoring the DC connection continuously to record the inverter DC power flow into the cubicle. The supporting circuit is for reliable operation of inverters backed up with battery and UPS make the customer free from arranging resources to complete the integration. Hence, the SPH is an independent and most preferred solution, which helps customers build and operate several MW capacity solar parks within the shortest possible time frame.

The biggest advantage is that all under one roof and no connection to be done at site. This is the most convenient contract solution as against conventional any substation, which involves huge cabling work at site and dependence on so many agencies.

For further information:
tinfo@electrotherm.com

STATE FOCUS

HISTORY OF KARNATAKA POWER SECTOR

Among all the existing small capacity power generation technologies, solar PV technology is the most suited technology for generating electricity on the rooftop of the existing buildings in small capacity and integrating them into the LT Distribution networks...

The main purpose of the government was making electricity available to all sections of the society at an affordable cost and overall development of the state. AEH connections, industries, village drinking water supplies, servicing of IP set connections were encouraged. The single line diagram prevailing at that time depicts the typical power system network as shown in Fig. 1.

Fig. 1: Single diagram of typical power system network...

During 1984 the deep bore well technology was brought in for supplying clean drinking water to rural population. Farmers were attracted by this technology and the farmers who were deprived of water facility for the agriculture activities in their dry lands rushed for adopting this technology. At this juncture, government of that day came to the rescue of farmers who were in need of energising the irrigation pump sets.

The central and state governments formulated a plan in order to energise IP sets in a time bound manner by fixing the quantum to be targeted in each year. In order to meet government target of energising the IP sets, technical feasibility was not strictly enforced at that time.

The underground water table reached an alarmingly low level in many areas and it was more so at Kolar, Chamarajanagar, Hassan districts etc. This matter drew the attention of the government and the government started reducing their financial support towards energisation of irrigation pumpsets. Unaffected by the government action, the farmers continued drilling more bore wells and demanded electricity for energisation of IP sets. Struggling hard to manage material needs, the power sector was forced to slowdown the energisation of IP sets. The farmers resorted to unauthorised energisation of IP sets, at this stage, resulting in shortage of energy and unreliable quality of power.

To bridge the gap between demand and supply the utilities resorted to frequent scheduled and unscheduled load shedding as shown in fig 2.

In this arrangement when the GOS in is in closed position, the output phase to neutral voltage of DTC will be around 230 volts and when the GOS is opened out for load shedding purpose the distribution transformer is completely deenergised and all category of consumers suffer from loss of power. In the process, essential loads like drinking water supply hospitals, industries and domestic loads began to suffer. Ultimately the state's economic growth slowed down and supplying energy to rural sectors during evening peak hours became a challenge.

As a first step in this regard 'in peak hour load management' rural household, non-essential 3 phase consumers i.e. IP sets, industries etc., were requested not to use power during peak loads. This did not work due to non cooperation from the consumers, compelling the power sector to cut off one phase during peak load hours to rural feeders by adopting roster GOS system at the starting point of the feeder as shown in fig 3. In this arrangement when GOS is in closed position, the output voltage all the phases will be equal to 230 volts, whereas when GOS in roster position only two phases of the LT side will have 230 volts and the other phase will be at zero potential. The existing single phase loads were re-arranged on the remaining other two phases on the LT side of the distribution transformers. This method was adopted with the expectation of great reduction in power consumption during peak load hours. However this plan worked out for some time, and over a period of time it failed as the farmers started unscrupulously using condensers to run IP sets.

Thus, power supply system was dislocated and the continuous process industries suffered severely, affecting the state economy. Finally power supply quality and reliability took a peak seat culminating in large scale failure of distribution transformers. Over loading of lines lead to snapping of conductors, sometimes resulting in electrical accidents, causing heavy loss of life and property. The T&D losses increased

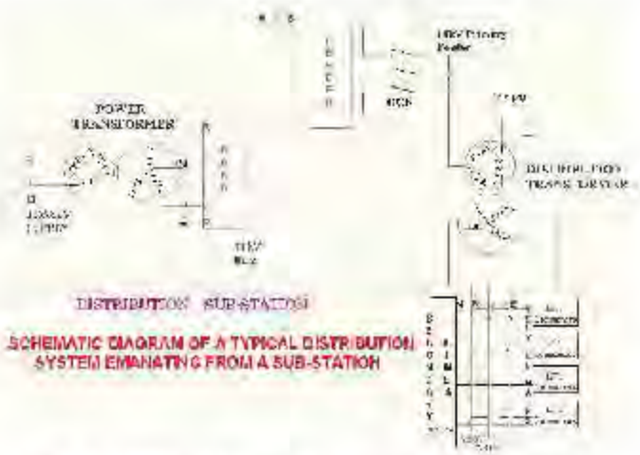


Fig. 2: Schematic diagram of distribution system network...

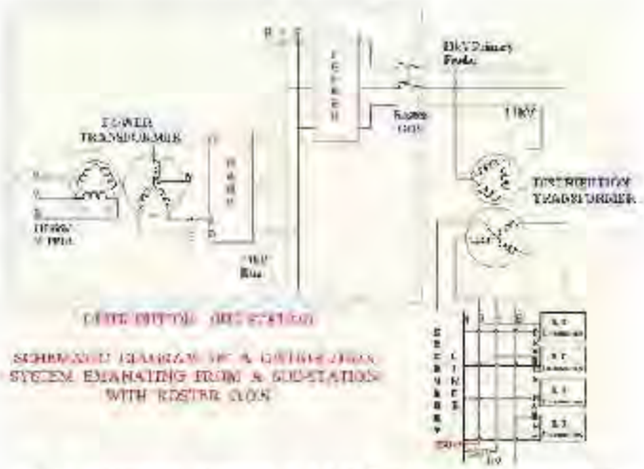


Fig. 3: Schematic diagram of a distribution system emanating from a sub-station with roster G.O.S...

abnormally and power sector jeopardy both in terms of economy and infrastructure.

Further an alternative technical solution was introduced in some selected taluks of Hassan, Kolar and Chamarajanagara districts, by way of open-delta system at the originating point of the rural feeders as shown in fig 4. In this arrangement only 2 phase supply is supplied from the 11kV side under this condition the output voltage of the distribution transformer is as shown in fig 4. In this system all the single phase loads were transferred onto one particular phase only. Farmers made this plan also to fail miserably, as they resorted to good old method of using condensers unscrupulously thereby hampering the continuity of power supply to rural households during peakhours.

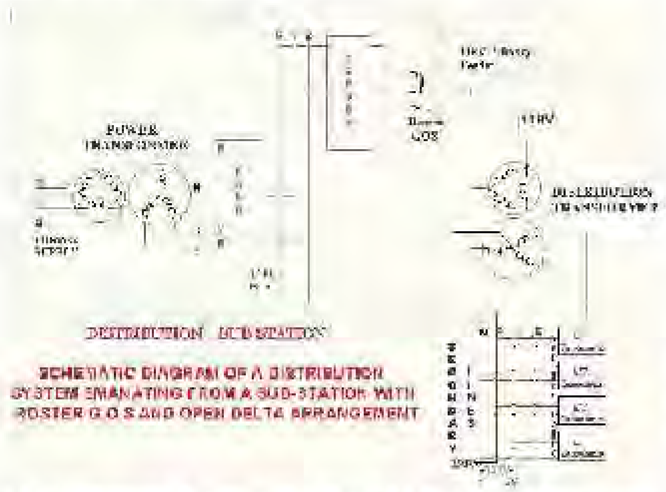


Fig. 4: schematic diagram of distribution system emanating from a sub-station with roster G.O.S and open delta arrangement...

In Hosakote and Devangi taluks, an alternative arrangement called Chanteenagothijojana was launched as a pilot project to run an additional phase and neutral conductor from the sub stations as shown in fig 5.0, for maintaining continuity of power supply to rural households by installing single phase transformers and thus depriving the IP sets of 3 phase supply. Even though this plan proved to be successful, it affected

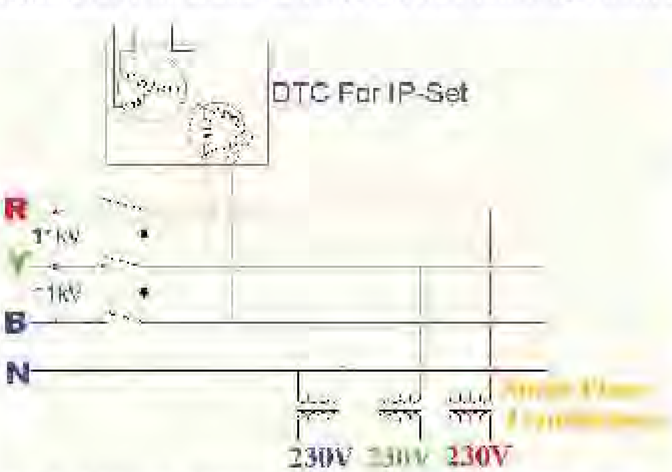


Fig. 5: Schematic diagram for extended neutral in primary line...

power supply to other essential installations such as drinking water supply schemes and industries and hence the same plan was not extended to other feeders.

Further, alternative plan of arranging continuity of power supply to non-IP loads was worked out by using Rural Load Mangement System (RLMS) scheme as shown in fig 6.0.

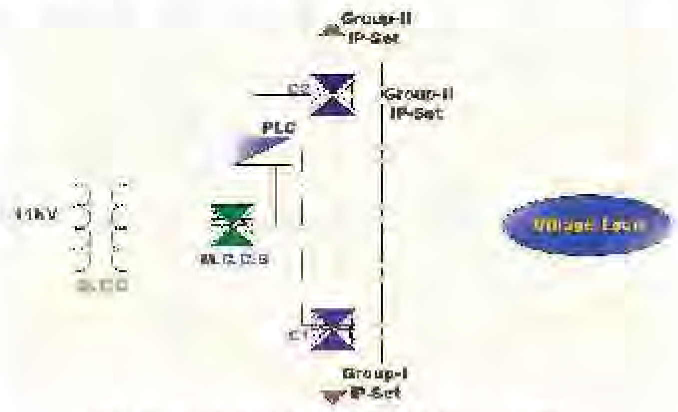


Fig. 6: Single line diagram of R.L.M using PLC...

RLMS is incorporated with fully automated preprogrammed logic controllers at distribution transformer centers of selected rural feeders in Ramanagara district. The results were as expected but did not last long as the farmers resorted to tampering and meddling PLC unit thereby rendering futility this plan also.

Fig. 7 shows a schematic diagram of extending 'Niranthara Jyothi Yojana' to rural non IP loads by separating IP loads. This scheme involves drawing of a separate exclusive feeder from substation to the village as shown in the sketch at an estimated cost of around 2140 crores in Malavalli thaluk of Mandya district and Malur taluk of Kolar district and proved to be successful. Therefore, the scheme has been extended to all parts of Karnataka.

Fig. 7: Separation of IP load from other loads...

Even though this plan proved to be successful, farmers creating legal hurdles, launching agitations, and revolted against this scheme and started hooking the Niranthara jyothi feeders by unauthorised means. All the above efforts are confined only to manage the available power in the state rather than increasing the generation. Even then situations in Karnataka have forced the utilities to purchase energy from independent power producers at higher prices of Rs. 10.00 per unit in some exigencies.

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The Government of Karnataka is attempting to construct large capacity coal and hydroelectric power plants to increase the generation capacity. However, this took a back seat due to the stiff opposition by the local people and the environmentalists citing highlighting the dangers posed to the public and ecology from those proposed power plants. Thus, with bleak solutions for meeting power demand in the state, the Karnataka government had to invest for installing a power plant in a far off state like Chhattisgarh to bring the power. Farmers are not willing to lose their fertile lands and the Karnataka Government also made a policy of acquiring only non-fertile lands for the development works. With the problem of making available land space for industries on the one hand and for installing new power plants on the other hand coupled with dwindling food production because of the parting of the land by the farmers, has pushed the planners to a corner to meet the ever increasing power demand scenario.

Particulars	Existing	Land area occupied	Infrastructure required in next 10 years	Land area requirement
Generating station capacity	193693.94 MW	193693*10 =193690 acres	7000 mw	7000*10 =70,000 acres
Number of stations	1426	1426*10 =14260 acres	500	500*10 =5000 acres
Total		193,610		75,000 acres

Table 1.22: Land area requirement for power generation...

From the above table it can be seen that for installing generating stations and receiving stations and sub stations alone, at rate of 10 acres per MW for generating stations and receiving station, 1,93,610 acres of land is utilised as on 31st March 2013. An equal amount of land has been utilised for construction of transmission lines and distribution lines. For installing additional 7000 MW generating stations and sub-stations 75,000 acres of additional land is required. An equal amount of land is required for constructing the transmission and distribution lines. Totally more than 3, 63,000 acres of land will be utilised for the infrastructure of electricity network alone in Karnataka state. Huge amount of land is also required for the development of the infrastructure for other sectors and for setting up of industries and constructing buildings. The real estate development activities around cities and towns have forced the setting up of new power plants in remote locations away from the load centres. This has resulted in increased transmission and distribution losses. These developments have resulted in shortage of land availability and the stake holders have to find new ways for supplying the electricity demand.

Present: The present energy situation in Karnataka state is plagued with constant power cuts by means of scheduled and unscheduled load shedding, much to the dissatisfaction of the public in general and industrial and commercial consumers in particular. Distribution companies are in poor financial health and have low economic viability. This alarming situation poses a serious risk not only to the future of the power industry on the whole, but the growth of the Indian economy itself. It requires a rapid yet transformational approach to move towards a secure future, and demands for strategic and integrated planning with emphasis on renewable resources and improvement of end use efficiency.

There is worldwide increase in the development and deployment of PV technology, and therefore the cost of PV modules is in the declining trend from the present cost and the present cost of PV cells is Rs 50/per Wp. There is development in metering technology, information technology and communication technology to make the optimum use of small capacity distributed generation by the distribution utilities. In addition, there is an anticipated consumer expectation of choice, transparency and quality of service. Incentive for efficiency, dynamic real time pricing and demand management will become critical in tomorrow's power grid. With the proper planning, we have to evolve a high quality, state of the art technology for T&D infrastructure development that serves us for the next several decades even as we dramatically scale up our investments. This culminated in innovating a new way of power generation to overcome the bottlenecks mentioned above and this led to go in for small capacity power generation in the rooftop areas of the existing buildings in urban areas and integrating them to the LT distribution networks.

Among all the existing small capacity power generation technologies, solar PV technology is the most suited technology for generating electricity on the rooftop of the existing buildings in small capacity and integrating them into the LT Distribution networks. The future power system with solar rooftop and other small capacity distributed generation projects will be like in schematic diagram 8.0 below.

Karnataka Solar Policy 2014-2021

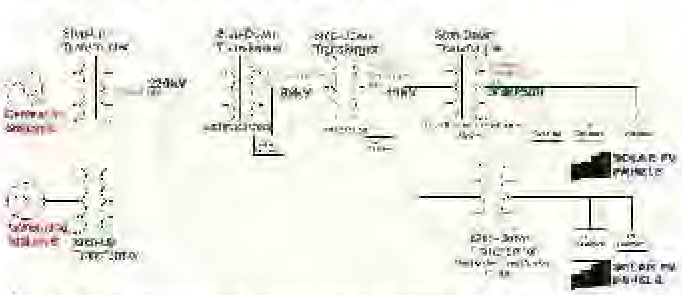


Fig. 8: Integration of small capacity rooftop PV generation...

The Karnataka Government got attracted by the policy and guidelines of Jawaharlal Nehru National Solar Mission under MNRE of GOI and notified Solar Policy 2014-2021 on 22nd may 2014 to harness the Solar resources in the state. In this policy, it is proposed to achieve minimum 1,600 MW of grid connected utility scale solar power generation projects in the state by 2021. This policy aims also at reducing scarcely available precious land by utilising the rooftop of the existing buildings for generation of electricity in small capacity by achieving minimum of 400 MW of grid connected rooftop solar generation projects in the state by 2018 at the rate of 100 MW every year from 2014-15. Installing the PV panels on the rooftop of the existing buildings for generating solar power, utilise the energy so generated for own applications locally if necessary and feed the surplus energy back into the grid. The net energy fed into the grid will be measured

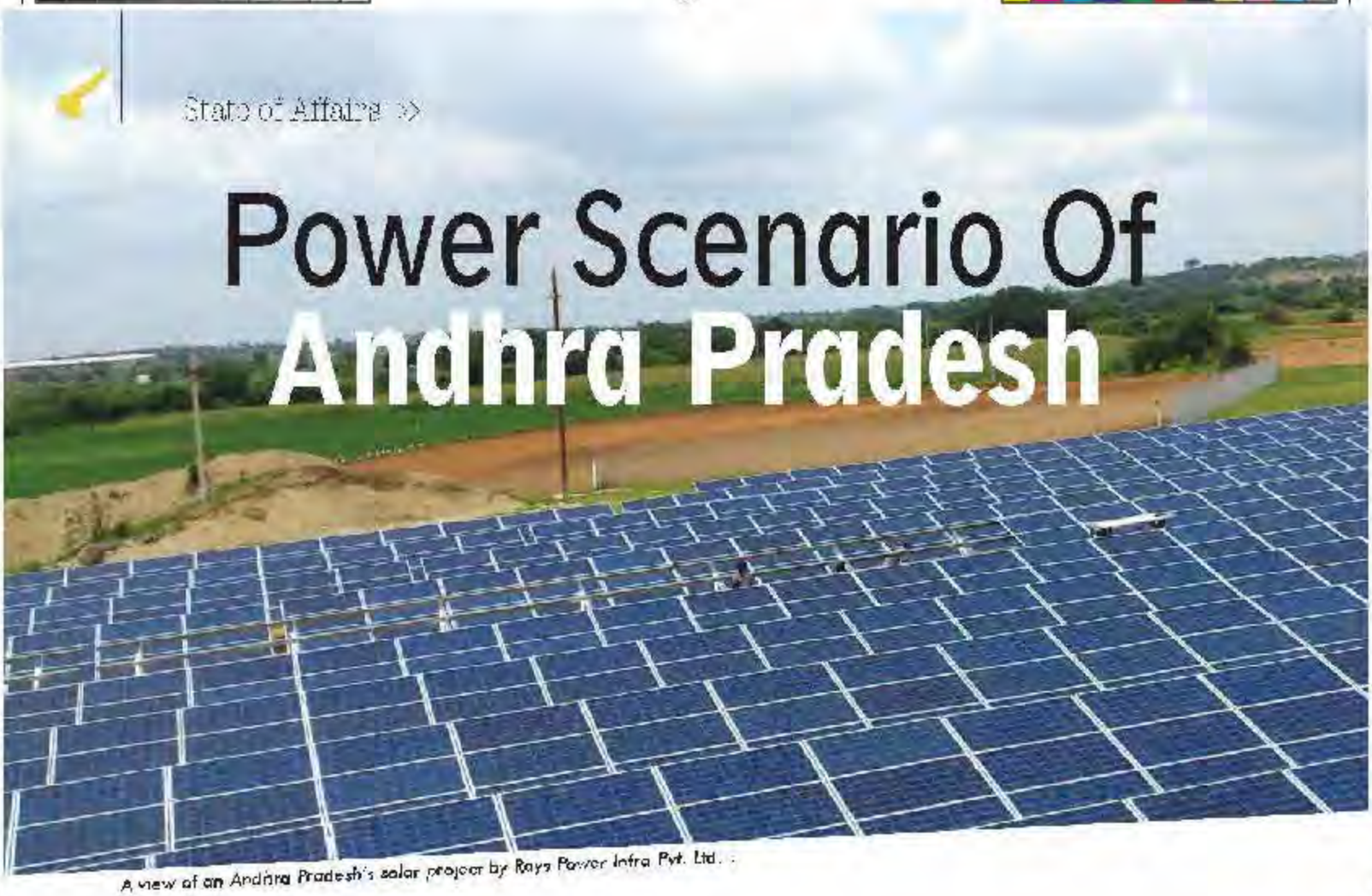
over the rest of the bi-directional meter and the concerned area distribution licensee will pay the consumer Rs 9.60 per unit and Rs 4.20 for the consumers those who have availed capital subsidy at 30% for MNRE as per the tariff order of Karnataka electricity regulatory commission dated 10th October 2013. Energy Minister D K Shivakumar, Government of Karnataka has launched the grid-connected Rooftop SPV for self-consumption with net metering that seeks to tap solar power generated by individual consumers. Under Solar Karnataka Programme it is targeted for 25,000 Solar Rooftops of 3 to 10 KWp with Net Metering with a 400 MW potential during next 5 years with a generation potential of 960 MU. If the potential is fully exploited, it will pave way for considerable reduction in the demand supply gap in the energy sector. Karnataka Government has introduced 'Surya Raitha Scheme' to encourage grid connected solar powered irrigation pump sets under small power plant on net metering basis in solar policy 2014-2021. This policy is applicable for IP sets to the extent of 5 HP capacity. The net metering mechanism shall account for the agriculture pump set consumption and the solar power injection, permitting grid support for the excess/shortfall between the generation and consumption. This programme is strongly embraced by the farmers and large numbers of proposals are being received through online.

A. The distribution licensees have issued guidelines in their websites and invited applications from interested consumers for the installation of RT-PV systems. This has given birth to lot of questions in the minds employees of distribution utilities as well as consumers. The distribution utility officials are getting ready to understand the technology, safety aspects and feasibility issues. Bangalore Electricity supply company (BESCOM) is conducting training to the officials. The consumers are calculating the installation cost, finance means, return on investment and demanding the ESCOMS authorities to act as middle management for the project in selection of installer and the maintenance guarantee of the system etc. The consumers are asking for gross metering instead of net metering, because the payback period with net metering is not satisfactory to the consumers. They are also pointing out the quantum of projects commissioned in Gujarath to an extent of around 800MW with gross metering as compared to the projects commissioned to an extent of only 14MW in Karnataka. Therefore, the progress in the installation of RTPV systems in Karnataka is very slow.

Future: There is a need to have a clear cut policy model to regulate and ensure speedy development of Solar Energy by creating a win-win situation among the stakeholders of grid connected rooftop PV systems through healthy discussions and interactions, evaluations and proper amendments to Solar policy 2014-2021.

L Somaraju
Executive Engineer (Ele)
City Works Circle, CESC, Mysore

Power Scenario Of Andhra Pradesh



A view of an Andhra Pradesh's solar project by Rays Power Infra Pvt. Ltd.

An efficient and financially healthy power sector is essential for growth and poverty alleviation. This article presents various power related aspects of Andhra Pradesh along with the future of power sector in this state of India...

The availability of reliable, quality and affordable power helps in the rapid agriculture, industrial and overall economic development of the state. The total installed utility power generation capacity is nearly 20,000 MW in the state. Only 11,400 MW is the committed power supply to the state with power purchase agreements. Rest of the capacity is exported electricity mainly to Telangana state depending on fuel availability. Significant amount of investments were made for building up generation capacity, strengthening transmission and distribution network, industrial feeder segregation, loss reduction and improving quality of power supply.

Power sector: Power sector of Andhra Pradesh is divided into four categories, namely Regulation, Generation, Transmission and Distribution as shown in figure 1.

Andhra Pradesh Electricity Regulatory Commission (APERC) deals with the electricity production and maintenance purposes new projects, and upgrades to the existing ones as well. The APGENCO also set up a Special Purpose Vehicle (SPV) named Andhra Pradesh Power Development Company Limited (APPDCL), a joint venture company of APGENCO (with 50% equity) and L AND FS (50% equity). APTRANSCO is set up for transmission of power. The erstwhile Andhra Pradesh State Electricity Board (APSEB) was unbundled into six entities to focus on the core operation of –

- Power Generation (APGENCO)
- Power Transmission (APTRANSCO)
- Distribution (APEPDCO/MS)

CRISIL had ranked AP state as No. 1 in 2003 among all the states based on the performance parameters for the power sector. Since 2004, the performance of the power sector in Andhra Pradesh did not keep up pace with development in other sectors and AP is lagging behind the other states, in

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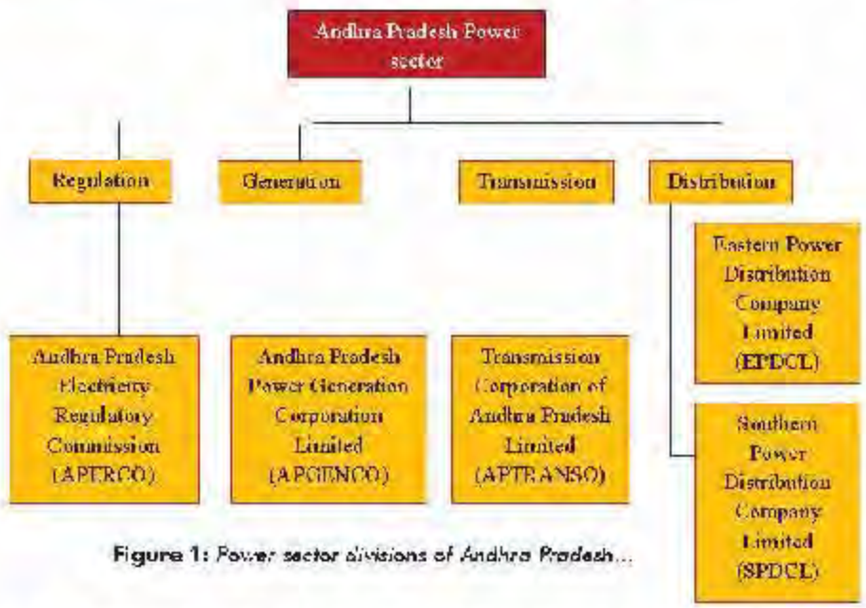

Figure 1: *Power sector divisions of Andhra Pradesh...*

terms of energy and power deficit, the policy of GoAP is to provide 24 hours power supply to all industries. However, due to power deficit, industries have suffered load shedding up to 40% of their demand (3 days a week power holiday in recent years is mainly due to of this factor increased up to four hours in Municipal Corporations, Six hours in Municipalities, eight hours in Mandals and twelve hours in villages. The State Government is providing seven hours of free power supply to the agricultural consumers. Government of India & Government of AP have taken a joint initiative to provide uninterrupted 24x7 power in the state of AP (except agriculture consumers).

This mainly includes the following.

- Reliable 24X7 supply to the consumers (except agriculture) in a phased manner within a period of three years from the date of commencement of the programme
- Increase duration of supply of electricity to agriculture consumers from seven hours per day at present to nine hours per day in a phased manner
- All unelectrified households to be provided access to electricity in a time bound manner by FY 2018-19
- Monitoring the timely commissioning of various generating plants, transmission and distribution infrastructure to meet the expected growth in demand
- To ensure reduction of AT & C losses as per the agreed loss reduction trajectory
- Overall Power Supply Improvement – to be achieved by undertaking measures such as energy mix optimisation, reduction in power operational efficiency of state generation plant(s), and optimal fuel procurement costs including sources of supply
- Financial measures including optimising investments and undertaking necessary balance sheet restructuring measures to ensure liquidity in the Utility finances
- Introduce modern technologies to monitor reliable supply like sub-station automation, providing adequate communication infrastructure, GIS, Reliability Centralised Network Analysis and Planning tools, SAP driven HRP systems, DMS (Distribution Management Systems), OMS (Outage Management System) etc.

An exercise has been carried out to assess the additional energy requirement for providing 24x7 power supply to all households in the state. An assessment of the adequacy of availability of power to the state from various sources i.e., from generating sources owned by the state – both existing and under construction, from central sector stations – both existing and under construction common projects, generating sources owned by private sector and PPAs have been made. Inter State Transmission System (ISTS), Intra State Transmission System and distribution infrastructure have been reviewed to ensure the adequacy for providing 24x7 power in the state. Works required for strengthening and

augmentation of distribution infrastructure have been identified for supplying uninterrupted power to the consumers. Central Government will supplement the efforts of the State Government through schemes which are being finalised by Ministry of Power for funding of works required for strengthening and augmentation of distribution infrastructure, feeder segregation and 100% metering. This joint initiative of Government of India and Government of Andhra Pradesh aims to enhance the satisfaction levels of the consumers, improve the quality of life of people and increase the economic activities resulting into inclusive development of the state.

Power supply scenario: The requirement of electricity i.e., both energy and peak demand are expected to increase significantly in Andhra Pradesh from the present level of 43,964 MU & 8,160 MW to 80,369 MU and 13,488 MW respectively by FY 2018-19 due to

- Natural Load Growth,
- 24x7 power supply to all consumers (except agricultural consumers),
- Increase in electrification of households
- 9 hours supply to agriculture consumers
- Additional energy requirement for upcoming capital city and associated investments
- New industrial corridors
- Inland Irrigation schemes

Present power supply position

Power is being supplied to domestic, commercial and industrial consumers along with agricultural consumers in rural areas through mixed feeders. There are 708 dedicated/express industrial feeders. Seven hours three phase power supply is being given to agricultural consumers mostly in single/two spells and supply timings are rotated every 7 days. Rural areas are given single phase domestic lighting from 6 PM to 6 AM. Three phase supply to rural areas for domestic, commercial and industrial consumers is along with agriculture supply only. As a result, most of the consumers, other than agriculture, in rural areas on mixed feeders get between 12 to 18 hours of supply every day, depending on agricultural supply spell timings. Agricultural feeders have been separated from domestic

Figure 2: *Thermal Power Plant AP...*

Particulars	Unit	FY(11-12)	FY(12-13)	FY(13-14)
Energy Deficit	%	7.0	17.8	8.9
Peak Deficit	%	14.3	20.2	17.6

Table 1: *Shows the variations in Energy and Peak deficit for past three years... Source: powermin.nic.in*

Particulars	Unit	FY(14-15)	FY(15-16)	FY(16-17)	FY(17-18)	FY(18-19)
Gross Energy Requirement (A)	MU	64,064	69,253	36,170	71,596	79,366
Energy Requirement 24hours Ag Supply (B)	MU	1,740	3,759	4,138	4,649	5,004
Total Energy Requirement (C=A+B)	MU	65,804	63,012	36,314	76,245	84,370
Energy Savings Efficiency & Conservation (D)	MU	69	399	751	1,044	1,479
Net Energy Requirement (E=C-D)	MU	65,635	62,613	35,563	75,20	82,892
Peak Demand @70% system Load Factor (F)	MW	9,220	10,211	[illegible]61	12,264	13,488

Table 2: *Summarizes the trend of Energy Requirement in AP, which is increasing in nature... Source: powermin.nic.in*

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feeders in fourteen mandals on a pilot basis during 2011.

In these mandals, domestic consumers are being extended three phase supply depending upon availability of power. However, there is a system in Andhra Pradesh, which enables single phase supply to be extended to all domestic consumers through suitable control mechanism at the substations. Depending upon availability of power, 24 hrs single phase power supply has been extended to domestic, commercial consumers & industrial consumers in rural areas. The segregation of agricultural feeders would enable extension of 24x7 reliable three phase supply to all domestic, commercial and industrial consumers.

Existing generation

Capacity allocation for Andhra Pradesh from existing and under-construction projects (Thermal & Hydel) has been considered in the proportion of 46.11% for APGENCO & IPPs and 47.89% for CGS stations and 100% for NCE projects. The total generation capacity of Andhra Pradesh as on 2nd June 2014 (on the day of formation of the new state) is 8,807 MW as per power allocation. Future generation plans for the government are shown below:

APGENCO has 3,850 MW upcoming capacities under different phases of construction & tendering, with an estimated capital outlay of ₹ 17,040 Crs.

- Krishnapatnam Stage-
  - Unit 1 – 800 MW, expected CoD by September 2014
  - Unit II – 800 MW, expected CoD by December 2014
- R [illegible] Stage IV – 600 MW to be

Power station	Operator	Location	District	Sector	Capacity (MW)
Vemagiri Combined Cycle Power Plant	GMR	Vemagiri	E. Godavari	Private	370
Spectrum Power Generation Limited	Spectrum	Kakinada	E. Godavari	Private	208
Sri Damodaram Sanjeevaiah Thermal Power Station	APPDCL	Krishnapatnam	Nellore	State	1,320
Sitharamapuram Thermal Power Station	SEPL	Krishnapatnam	Nellore	Private	600
Simhadri Super Thermal Power Plant	NTPC	Visakhapatnam	Visakhapatnam	Central	2000
Rayalaseema Thermal Power Station	APGENCO	Kadapa	Kadapa	State	1050
Pennar Power Station	PPSL	Krishnapatnam	Nellore	Private	1320
Meenakshi Thermal Power Station	MEPL	Krishnapatnam	Nellore	Private	300
Dr. Narla Tatarao TPS	APGENCO	Krishnapatnam	Krishna	State	1,760

Table 3: *Shows that super thermal power plant located at Simhadri has the highest capacity of 2000MW. this plant is under central sector and operator is NTPC... Source: en.wikipedia.org*

Power station	Operator	Location	District	Sector	Capacity (MW)
Vemagiri Combined Cycle Power Plant	GMR	Vemagiri	E. Godavari	Private	370
Sriba power plant	Sriba Industries	Chigurukota	Krishna	Private	30
Spectrum Combined Cycle Power Plant	Spectrum	Kakinada	E. Godavari	Private	208
Silk road sugar power plant	EID Parry	Kakinada	E. Godavari	Private	30
Samalkota Combined Cycle Power Plant	Reliance	Samalkota	E. Godavari	Private	2532
KVK energy power plant	KVK	Rajahmundry	E. Godavari	Private	28
Pandurangi IPP	PSPL	Amadalavalasa	Srikakulam	Private	116
262.2 Diesel Engine Power Station	Greenko	Visakhapatnam	Visakhapatnam	Private	97
Kondapalli power plant	Triveni	Gollapalem	E. Godavari	Private	3
Konaseema Combined Cycle Power Plant	Konaseema Gas Power Ltd (KGPL)	Kesavulapalem	E. Godavari	Private	445
Vemagiri Combined Cycle Power Plant	GMR	Vemagiri	E. Godavari	Private	445
GMR Rajahmundry Combined Cycle Power Plant	GMR	Vemagiri	E. Godavari	Private	768
GMR Vemagiri (Naphtha) Power Plant	GMR	Kakinada	E. Godavari	Private	237
Gautami Combined Cycle Power Plant	GMR	Peddapuram	E. Godavari	Private	464
APSEPCL Plant	APSEPCL	Vijeswaram	W. Godavari	Joint	272

Table 4: *Shows the total power capacity of gas based plants is 7545MW out of which 2620MW is generated at Samalkota Combined Cycle Power Plant owned by a private sector and operated by Reliance... Source: en.wikipedia.org*

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Power station name	Operator	Location	Sector	Unit wise Capacity	Installed Capacity MW
Upper Sileru PH	APGENCO	Visakhapatnam	State	4 x 60	240.00
TE Dam PH	APGENCO	Joint project of AP Karnataka located in Karnataka	State	4 x 9 (AP Share 28.8)	28.80
Srisailam Right Bank PH	APGENCO	Srisailam, Kurnool	State	7 x 110	770.00
Polavaram Hydro-Electric project	APGENCO	Polavaram, West Godavari district	State	12 x 80 Under Construction	
Penna Ahobilam PH	APGENCO	Somasila, Anantapur district	State	2 x 10	20.00
Nagarjuna Sagar Left pond PH	APGENCO	Nagarjuna Sagar Dam, Guntur district	State	2 x 25	50.00
Nagarjuna Sagar Right Canal PH	APGENCO	Nagarjuna Sagar Dam, Guntur district	State	3 x 50	90.00
Machkund PH	APGENCO	Joint project of AP & Odisha located in Odisha	State	3 x 17 + 3 x 23 (AP Share-64)	84.00
Lower Sileru PH	APGENCO	Y. Gollavanu	State	4 x 115	460.00
Hampi canal PH	APGENCO	Joint project of AP & Karnataka located in Karnataka	State	4 x 9 (AP Share-20)	28.80
Donkarayi PH	APGENCO	Y. Gollavanu	State	1x25	25.00
Chettipeta Mini Hydel	APGENCO	West Godavari district	State	3x2.5	1.00

Table 5: *is the list of major hydroelectric power plants in Andhra Pradesh which favour the generation of power due to ideal locations...*
Source: en.wikipedia.org

commissioned by August 2016

- Nagarjunasagar tail pond (Pyramid) hydro electric project – 60 MW to be commissioned by Oct 14
- Krishnapatnam Stage II – 800 MW, estimated Zero Date is Apr 15 & CoD Apr 18
- VTPS Stage V – 800 MW, estimated Zero Date is Apr 15 2015 & CoD Apr 19

Not considered for Energy Availability & Supply projections in FY 2014-15

Various sources of power in AP region are as follows:

Thermal power

Thermal power plants are based on the fuel coal, gas, diesel etc. Public sector undertaking NTPC, state level power generating companies and private firms are engaged in this sector for power generation. They contribute 8,630MW capacity

Name	Operator	Location	District	Sector	Unit wise Capacity (MW)	Installed Capacity (MW)
Renew Wind Mills	APGENCO	Kadiri	Anantapur	State	1x2.2	2.00
Narmada Wind farm	CLP Wind Farms (India) Private Ltd.	Nallakonda	Anantapur	Private	1x50.4	50.04
Puthlur CLP Wind farm	Westare (India) Ltd.	Puthlur	Anantapur	Private	1x20	20.00

Table 7: *Shows the state's total installed wind power capacity of 1031.4 MW...*

Name	Operator	Location	District	Sector	Unit wise Capacity (MW)	Installed Capacity (MW)
Amrutha Solar Power Plant	Amrutha Ventures	Kadiri	Anantapur district	Private	1x30	30
MEI Green Power Limited	Megha Engineering & Infrastructures Limited	Nagalapuram	Anantapur district	Private	1x50	50.00

Table 6: *shows total installed solar power capacity of 268.46 MW...*
Source: en.wikipedia.org

Gas fuel-based plants

The following are the list of presently installed combined cycle gas turbine power plants and diesel engine power plants in the state.

However, many of these power plants are not operating due to non-availability of natural gas and high cost of liquid fuels

Hydroelectric power plants

The total capacity of hydro plants is 1797.60 MW.

Solar power plant

Andhra Pradesh is blessed with good sunshine with average solar insolation of more than 5.5 kwh/sq. m/day. Especially, the scope of promoting solar power in the Rayalaseema belt is immense.

Wind power plants

The Southern region of Andhra Pradesh comprising of Anantapur, Kadapa, Kurnool and Chittoor districts have good wind power potential.

Other utility power plants

In addition to above projects, there are nearly 89.1 MW small hydro plants, bio mass co-generation and bio mass based projects, nearly 78.45 mini power plants (grid connected) and nearly 98.7 MW other (grid connected) plants based on solar/oil/ gas wells, waste heat, industrial waste, municipal waste etc in private sector.

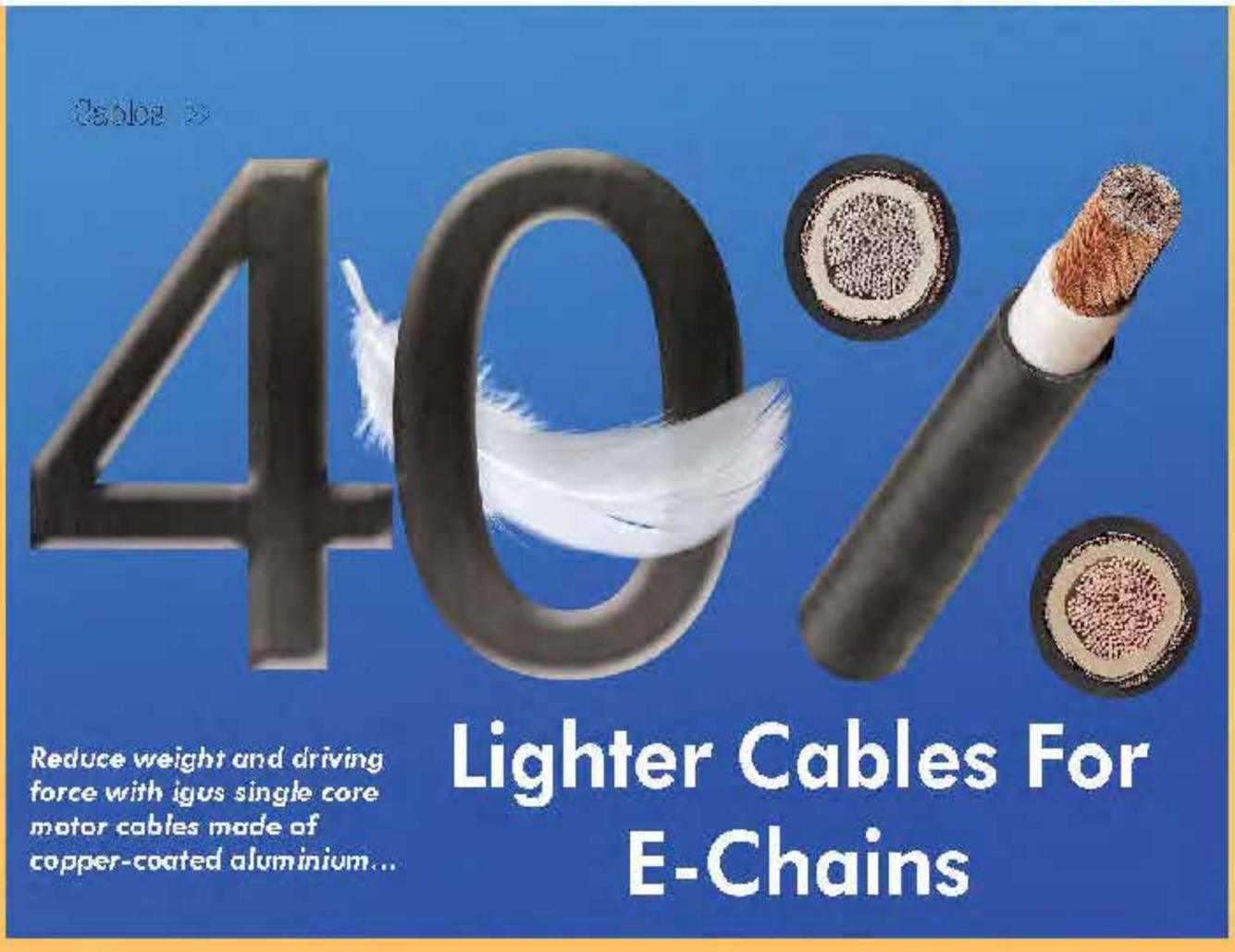
These power plants are not covering captive power capacity in various industries, which are not grid connected. In addition, there are innumerable diesel generator sets installed in the state for stand by supply and emergency power supply needs during power outages.

Conclusion

The demand for power in Andhra Pradesh has increased by eight per cent during April-August period of the current financial year. The power demand between April and August has escalated to 21,071 million units against 19,509 million units during the same period a year ago. The state maintained uninterrupted power supply to domestic, commercial and industrial sectors through regularly monitoring the load even as hydro power generation units were closed due to lack of water supply in reservoirs. To encourage energy saving, government has distributed LED bulbs for all households in district of Anantapur, Guntur, West Godavari and Srikakulam.

The government has decided to extend the scheme in the remaining nine districts of AP. Government has also replaced 170 lakh street bulbs with solar bulbs in some of the identified municipalities and Visakhapatnam Municipal Corporation. Also such measures will help in decreasing the gap between demand and supply in the coming days.

Simmi Sharma
Assistant Professor
B.P.I.T., Delhi



Reduce weight and driving force with igus single core motor cables made of copper-coated aluminium...

Lighter Cables For E-Chains

The new chainflex motor cables CF430.D and CF440 (unshielded and shielded) from igus save significant system weight for long travel applications using energy chains. In this way, the use of smaller e-chains can reduce costs and enhance both the energy efficiency and the service life of energy chain systems. As for all chainflex cables, igus offers a unique 36 month warranty for its durability.

Whether in plant construction, mechanical engineering, cranes, ships or conveyor technology, the travel distances in dynamic applications are becoming increasingly longer whilst speeds and number of movements are rising. This leads to ever increasing stress on cables that are constantly in motion. The motion plastics specialist igus has developed extremely lightweight single core motor cables for energy chains for long travels, the chainflex types CF430.D and CF440. By the use of a special stranded conductor, the cables are up to 40% lighter than standard copper cables. Depending on the cable length and cross-section, the savings potential of the new motor cables can be up to several tonnes, offering a considerable saving on required drive force.

Material combination gives numerous advantages

"The weight reduction is possible by the use of a stranded conductor made of the special material CCA," explains Rainer Ridder, Head of the chainflex cables division at igus. "Here, the cable core is made of lightweight aluminium coated with copper, known as copper-clad aluminium or CCA."

The combination of these two metals has a number of advantages. Compared to solid copper cables, the CCA cable benefits from the lower density and thus the lower weight of aluminium. When compared to a pure aluminium conductor, this one offers the big advantage that the cross contacting is ensured by the copper coating. Furthermore, the copper layer also contributes economically to the durability of the entire conductor with a stranding structure optimized for the constant bending in the energy chain.

Developed for use in e-chains

igus has created a special stranding method for its CCA lightweights and the insulation jacket material has been further enhanced for use in energy chains.

igus has already demonstrated the long service life in application in their own test lab. The chainflex CF430.D and CF440 types have already completed more than 17 million strokes without failure in continuous movement. And the installation test continues to run.

The outer jacket is made of a high-quality mix of Thermoplastic Elastomers (TPE) makes them extremely resistant to abrasion and bending, making the cables ideal for extremely high loads even at low temperatures and for outdoor use.

These cables, designed for very long travel lengths outdoors, can be ordered as shielded or unshielded options. The cables are also resistant to UV & ozone.

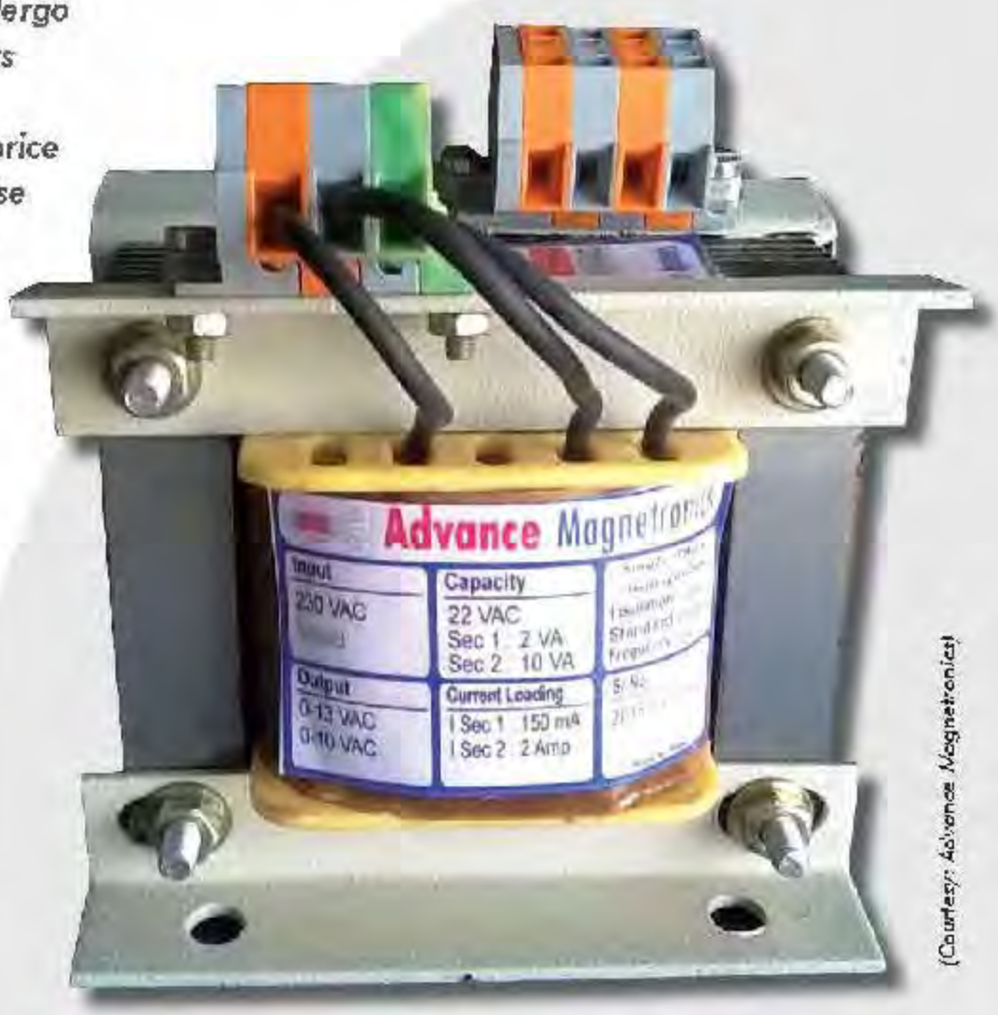
For further information:
sreejith@igus.in


ENERGY
CONSERVATION

Advance Energy Efficient Transformers Testing

Transforming Quality Power For Indian Manufactures

Before installation, a transformer needs to undergo multiple tests to ensure its long and trouble-free operation. Naturally, its price increases. Any compromise in that area may lead to untimely failure of the device...



(Courtesy: Advance Magnetronics)

Electric transformers have become a part and parcel of all modern industries, smart manufacturing industries, automation industries, textile, refrigeration, all multi national companies as well as all process industries. Without transformers one cannot imagine the growth of his/her enterprise or industry.

What is a transformer?

"A transformer is a static piece of apparatus by means of which an electric power is transformed from one AC circuit to another with the desired change in voltage and current, without any change in frequency."

Manufacturers offer wide range of sophisticated high quality industrial grade single and three phase electrical transformers. These are as follows:

- A Grade Quality having 97.69% Efficiency
- B Grade 90-95%
- C grade less than 85% Efficiency as per demand of customer at reasonable prices.

The various range of products are Single phase, Three phase, Isolation transformers, Distribution transformers, Drive isolation transformers, Auto transformers, Motor starting auto transformers, Line reactors, Heavy current transformers.

Also, there are K-factor rated transformers, low temperature rise / low electromagnetic noise emission transformers, Electrostatic shielded transformers, Special voltage transformers, and Epoxy sealed transformers and widely popular Dry-type transformers with long and trouble-free life.

Transformers are designed according to the recognized international standards such as DIN/VDE / IEC or IS. Furthermore, they fulfill all climatic, environmental and fire protection requirements.

Basic surge level, the environmental protection requirements are taken into account in the design of Cast Resin Transformers. So, a customer should be aware about the types of transformer tests necessary for application.

Tests done at factory

- Type Tests
- Routine tests
- Special Tests

Tests done at site

- Pre Commissioning Tests
- Periodic/Condition Monitoring Tests
- Emergency tests

Type test of transformers

To prove that the transformer meets customer's specifications and design expectations, the transformer has to go through different testing procedures in manufacturers premises. Some tests are carried out for confirming the basic design expectation of that transformer. These tests are done mainly in a prototype unit and not for all manufactured units. So, for the lot as a whole, type test of transformer confirms main and basic design criteria of a production lot.

Routine tests of transformers

Routine tests of transformers are mainly for confirming operational performance of an individual unit in a production lot.

Routine tests are carried out on every unit manufactured.

Special tests of transformers

Special tests of transformers are done as per customers requirements to obtain information useful to the user during operation or maintenance of the transformer.

Pre-commissioning test of transformers

In addition to these, the transformer also goes through some other tests performed on it before actual commissioning of the transformer at site. The transformer testing performed before commissioning the transformer is termed as pre-commissioning test of the transformer.

These tests are done to assess the condition of the transformer after installation – and compare the test results of all the low voltage tests with the factory test reports.

Type tests of a transformer include

- Transformer winding resistance measurement
- Transformer ratio test
- Transformer vector group test
- Measurement of impedance voltage/ short circuit impedance (principal tap) and load loss (Short circuit test)
- Measurement of no load loss and current (Open circuit test)
- Measurement of insulation resistance
- Dielectric tests of transformer
- Temperature rise test on transformer
- Tests on on-load tap-changer
- Vacuum tests on tank and radiators

Routine tests of a transformer include

- Transformer winding resistance measurement
- Transformer ratio test
- Transformer vector group test
- Measurement of impedance voltage/ short circuit impedance (principal tap) and load loss (Short circuit test)
- Measurement of no load loss and current (Open circuit test)
- Measurement of insulation resistance
- Dielectric tests of transformer

Tests on on-load tap-changer

Oil pressure test on transformer to check against leakages past joints and gaskets.

That means routine tests of transformer include all the type tests except temperature rise and vacuum tests. The oil pressure test on transformer to check against leakages past joints and gaskets is included.

Special tests of a transformer include

- Dielectric tests
- Measurement of zero-sequence impedance of three phase transformers
- Short-Circuit test
- Measurement of acoustic noise level
- Measurement of the harmonics of the no-load current
- Measurement of the power taken by the fans and oil pumps
- Tests on bought out components / accessories such as buchholz relay, temperature indicators, pressure relief devices, oil preservation systems etc.

Standard used: IS 2026, IS 11171, IS 12021

Reference standards: IS 2026-5
IEC 60076-5
IEEE Std C57.12.90 (1999),
IEEE Std C57.12.00 (2000)

Purpose: To verify the integrity for stresses primarily mechanical, developed when a short-circuit current flows through the transformer.

Tests performed for 1φ transformers

Following Routine tests are done on these transformers as per IS-2320

- Resistance test
- Insulation Resistance test (MEGGER)
- No load test
- (Open circuit Test) Short Circuit test (Full Load test)
- High Voltage test
- Temperature Rise test
- Vibration test
- Customer specific test

Conclusion

Manufacturers offer wide range of sophisticated high quality industrial grade single and three phase control transformers. If you often ask for oil-cooled transformers, obviously they suffer after a few years. So, always use energy efficient transformers.

D A Suthar
Worked as Chief Project Executive at Advance Magnetronics Emerging R&D Institute

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LEONI a global supplier of Wires, Optical Fibres Cables and Cable System as well as related services for the Automotive sector and further industries. The group of companies employs more than 70,000 people in 31 countries and generated consolidated sales of Eur 4.1 Billion in 2014.

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The Quality Connection

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Commissioning Status of Grid Connected Solar Power Projects Under JNNSM (2014-15)

Sr. No.	State/UT	Total MNRE Projects MW	State Policy MW	RPO MW	REC Scheme MW	Pvt. Initiative (Rooftop) MW	CPSUs MW	Total Commissioned Capacity (MW)
	Andhra Pradesh	94.75	87.75		250	1.62	10	335.85
2	Arunachal Pradesh	0.025						0.025
3	Chhattisgarh	4			3.1	0.5		7.6
4	Gujarat	0	873.05	60	9			920.05
5	Haryana	7.8					5	12.8
6	Jharkhand	1.5						1.5
7	Karnataka	5	40	10		3	9	67
8	Kerala	0.025						0.025
9	Madhya Pradesh	15.35	220.65		75.78		65	376.78
10	Maharashtra	47	123	36	113.75	0.15		322.9
11	Odisha	12	5		4.5	0.28	10	31.78
12	Punjab	9	39		7.52	0.25		55.77
13	Rajasthan	553.5	25	40	136			691.5
14	Tamil Nadu	15	3		93.08	2.7		104.78
15	Telangana				2	6		8
16	Uttar Pradesh	12	2			0.2	15.5	29.71
17	Uttarakhand	5						5
18	West Bengal	2.05	5			0.16		7.21
19	Andaman & Nicobar	0.1					5	5.1
20	Delhi	0.335			2.12	2.99		5.465
21	Lakshadweep	0.75						0.75
22	Puducherry	0.025						0.025
23	Chandigarh	2						2
24	Others	0.79						0.79
	TOTAL	**843.4**	**1437.79**	**136**	**523.15**	**17.83**	**119.51**	**3077.68**

Source: Ministry of New and Renewable Energy (MNRE)

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Imaging Electrical Discharges (Corona / Arcing)

When does Corona Occur?
Corona occurs when there is a partial breakdown (ionisation) of air around the HV hardware. This typically happens around sharp points on HV hardware, from badly designed or damaged components. Electrons flow from the source into the air only.

Electrical discharges (Corona, Arcing) from HV equipment gives indication regarding :

- Badly designed or installed equipment
- Damaged equipment
- Contaminated equipment, requiring washing

CoroCAM 6D
The CoroCAM 6D is a development of the CoroCAM Solar Blind UVc imaging System with an emphasis on cost reduction through innovative design.

CoroCAM 8
The CoroCAM 8 is a combined thermal IR, solar blind corona and video camera. It features a visible camera, a radiometric thermal IR camera and a solar blind UV camera.

Typical Failure which may happen due to corona or arcing :

Moisture ingress into the Bushing through a gasket, Which deteriorated due to corona discharge, caused catastrophic failure when the substation was reenergized after maintenance.

Pin Corrosion

Polymer Damage

Cracks in polymer allowed moisture penetration which resulted in a flash under Polymer Damage

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Reactive Power Cost Analysis Of Generators For Remuneration Of Reactive Power Support

Looking into the limitations of a reactive power price to be charged from the consumers based on power factor penalties, authors suggested the use of economic principles based on marginal theory...

The Independent System Operator (ISO) procures reactive power as an ancillary service from the synchronous generators and condensers to maintain security of the power system. Since cost is involved to procure reactive reserve services and to maintain the services, the service providers should be remunerated according to their reactive power supply to the system. For the recovery of the cost of reactive power, most of the utilities charge industrial consumers based on kVA demand and penalise the utilities for the poor power factor. The fixed cost recovery of reactive power is insufficient, and in the competitive markets it may not provide accurate price signals for the ancillary providers. Looking into the limitations of a reactive power price to be charged from the consumers based on power factor penalties authors suggested the use of economic principles based on marginal theory. However, the prices of reactive power based on the marginal price theory represent a small portion of the actual reactive power price. Reactive power has typical characteristics due to reactive power generation equipment and load characteristics of reactive power of loads and transmission system behaviour, therefore, it is difficult to access its cost characteristics. For the assessment of reactive power cost, many authors proposed different techniques.

The proper recovery of reactive power cost will help sustaining the ancillary service providers in the electricity markets. The cost must be calculated based on the capability limits of the generators at each operating point due to the load and power factor variations. In this article, reactive power cost characteristics have been obtained developing the reactive power capability charts at different operating points and utilising them for the cost opportunity cost.

The article presents (i) cost characteristics determination for synchronous generator based on excitability charts, and (ii) cost analysis of reactive power supported by synchronous condenser. The reactive power cost function has been obtained for reactive support at generator. These cost function can be utilised for remuneration of reactive power supplied by the synchronous generators and condensers bidding in the ancillary service markets.

Reactive Power Capability of Synchronous Generators

Synchronous generators are the major sources of reactive power generation. The generators supply reactive power meeting the base load requirements and can be operated as synchronous condenser, supplying reactive power to the system without any active power fed to the system. The reactive power supply of the generators are limited due to the armature current, field current limits and end region heating limits. These limits need to be considered during the analysis of reactive power support & the cost of reactive power calculations.

Armature current limit

Armature current is responsible for heat loss in the windings as I^2R losses and increases the temperature of the conductor. Therefore,

one of the limitations of generator rating is the maximum current that can be carried by the armature without exceeding the heating limitations. The real and reactive power supplied by the generator can be computed using the following expressions for complex power with the terminal voltage V_t and armature current, I_a.

$S = P + jQ = \dot{E}\dot{I}^*$ (1)

$P = E_f |I_a| \cos\Phi$ (2)

$Q = E_f |I_a| \sin\Phi$ (3)

The equations plotted on P-Q diagram are in the form of circle with centre on origin.

Field current limits

The field current is limited due to the heating of the windings. With terminal voltage E_t and rated armature current I_a each equal to 1 pu, the locus of the excitation current can be shown as a circle with centre on the Q axis as shown in Fig. 1. Figure also show how the active power and reactive power capability curve is varying with the armature current and the field current. The reactive power generation for a cylindrical and salient pole generator is different and the real and reactive power generated, and the maximum reactive power can be computed for cylindrical pole and salient pole generator as follows:

- For cylindrical pole rotor generator, the q-axis voltage real, and reactive power is given by,

$E_q = X_d I_f$

$$P = \frac{|E_f||V_t|}{X_d} \sin\delta$$

$$Q = \frac{|E_f||V_t|}{X_d} \cos\delta - \frac{|V_t|^2}{X_d} \quad \text{or} \quad Q = \frac{|E_f|}{X_d}\cos\delta - \frac{|V_t|^2}{X_d}$$

For maximum reactive power generation, $\delta = 0$

$$Q_{max} = \frac{|E_f||V_t|}{X_d} - \frac{|V_t|^2}{X_d} \qquad (7)$$

- Salient pole rotor synchronous generator or hydro generator. The induced voltage, the real and reactive power for salient pole generator can be obtained as

$E_q = E_t + I_a R_a + jI_a X_q$

$E_t = |E_t| + j I_d (X_q - X_d)$

$$P = \frac{|E_f||E_t|}{X_d} \sin\delta + \frac{|E_t|^2}{2}\left(\frac{1}{X_q} - \frac{1}{X_d}\right)\sin 2\delta$$

$$Q = \frac{|E_f||E_t|}{X_d}\cos\delta - \frac{|E_t|^2}{2}\left(\frac{1}{X_q} - \frac{1}{X_d}\right)\cos 2\delta - \frac{|E_t|^2}{2}\left(\frac{1}{X_q} + \frac{1}{X_d}\right)$$

For maximum reactive power generation limit $\delta = 0$

$$Q_{max} = \frac{|E_f||V_t|}{X_d} - \frac{|V_t|^2}{2}\left(\frac{1}{X_q} - \frac{1}{X_d}\right) - \frac{|V_t|^2}{2}\left(\frac{1}{X_q} + \frac{1}{X_d}\right)$$

Where,

I_f = field current, Reactive power pu, δ = load angle

Q = reactive power pu, E_t = termine voltage pu, X_s = synchronous reactance pu.

E_f = no load generator voltage p.u., X_d = effective reactance (0.2 to 0.4 X_d),

X_q = reactance pu in q-axis, X_d = reactance pu in d axis.

For cylindrical rotor synchronous generator, the synchronous resistance $X_s = X_d$ and nominal power factor is 0.9.

End region heating limits

A third limit on the machine, due to the localised heating in the end region of the armature imposes a limit on the operation of synchronous machine. The end turn leakage flux enters and leaves in the direction axial to the stator lamination. This causes eddy current to flow in the lamination and result in localised heating in the end region. In the overexcited condition it keeps the retaining ring saturated, so that leakage flux is small. However, in the underexcited region the field current is low and the retaining ring is not saturated, this causes increase in armature end leakage flux. The real and reactive power taking the end regions heating limit into account, the real and reactive power are calculated as follows:

$$P = \frac{E_f^2}{2}\left(\frac{1}{X_{ad}} + \frac{1}{X_q}\right)\cos(2\delta - \pi/2)$$

$$Q = \frac{E_f^2}{2}\left(\frac{1}{X_{ad}} + \frac{1}{X_q}\right)\sin^2(2\delta - \pi/2) - \frac{E_f^2}{2}\left(\frac{1}{X_d} - \frac{1}{X_{ad}}\right)$$

The end region heating limit is shown in green colour in Fig. 1.

Synchronous condenser mode

A synchronous condenser is a synchronous machine running without a prime mover or mechanical load. In this situation, the machine only draws the real power to meet losses only. Practically most of the machines are designed for one specific duty only, hence there are a finite limitations to the area within which any given machine may be operated successfully with about 20% to 30 % overload up to 30 minutes. When a machine is operated

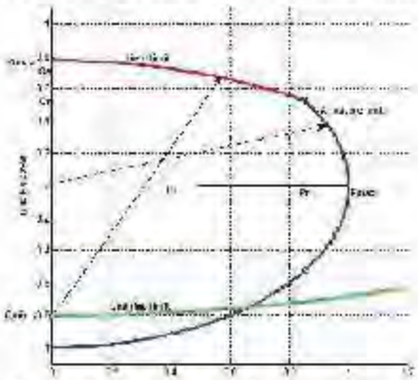


Fig. 1: Capability chart of the synchronous generator with three limits...

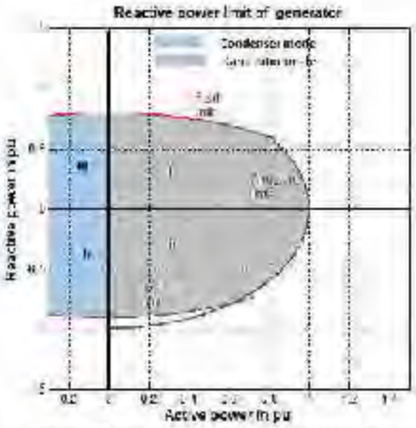


Fig. 2: Reactive power generation in generator and condenser mode...

in the condenser mode, either in overexcited or underexcited region by varying excitation current, it controls reactive power. Figure 2 show that the condenser mode region is much smaller than the generator mode region. Region (i) and (ii) supply reactive power to the system in generator and condenser mode respectively. Region (i) and (iv) absorb reactive power from the system in generator and condenser mode respectively. Negative P indicates that active power is absorbed from the grid to keep machine running in condenser mode and for supplying the losses.

Cost Model of Synchronous Generator Reactive Power Supply

To provide the more reactive power, a generator may reduce the active power and may forgo the cost of active power. This cost of forgo active power is known as the lost opportunity cost of generator. Since generator output is limited by its MVA rating, the accurate model of such opportunity cost should be derived from the generator capability curve at each operating point. If a generator produces reactive power over and above its base case values, then its cost for generating reactive power should be equal to reduced active power (VAr) cost.

The reactive power above the rated reactive power generation curve is limited by the field heating limit equation and above rated reactive power generation, the curve is limited by armature limit equation. The cost opportunity cost can be determined above the rated reactive power requirements and below the maximum limit reactive power generation from the generators. Therefore, the reduction in active power has to be calculated by the field limit equation from the current limit (4) and (5).

$$P_1 = \frac{|E_f||E_g|}{X_s}\sin\delta$$

$$Q_1 = \frac{|E_f||E_g|}{X_s}\cos\delta - \frac{|E_g|^2}{X_s}$$

$$\cos\delta = \left(Q_1 + \frac{|E_g|^2}{X_s}\right)\cdot\frac{X_s}{|E_f||E_g|} \qquad (15)$$

The real power output limited by the field current can thus be obtained as

$$P_1 = \sqrt{\left(\frac{|E_f||E_g|}{X_s}\right)^2 - \left(Q_1 + \frac{|E_g|^2}{X_s}\right)^2} \qquad (16)$$

Q will be maximum when P = 0

$$Q_{max} = \frac{|E_f||E_g|}{X_s} - \frac{|E_g|^2}{X_s} \qquad (17)$$

$$Q_{actual} = S^* \sin(\Psi) \qquad (18)$$

The change in the real power can be obtained from its rated value to any operating value as:

$$\Delta P_1 = P_{rated} - P_1 \qquad (19)$$

The cost of decrease in the real power output can be obtained using the line cost function

$$Cost(\Delta P_1) = a(\Delta P_1)^2 + b(\Delta P_1) + c \qquad (20)$$

This cost of reduced active power shall be recovered from the reactive power support obtained from the generators as

$$Cost(Q_1) = \begin{cases} 0 & \text{if } Q_1 \geq Q_{rated} \\ Cost(\Delta P_1) = Cost(P_{rated}) - Cost(P_1) & \text{if } Q_{min} \leq Q_1 \leq Q_{max} \end{cases} \qquad (21)$$

The cost of reactive power following the capability chart of the generators can thus be plotted based on the reactive power support provided by the generators. Based on the data obtained, plot the graph Q vs Cost (Q) and by using of curve fitting toolbox in MATLAB, quadratic equation can be obtained for the reactive power cost as:

$$Cost(Q) = a_q Q^2 + b_q Q + c_q \qquad (22)$$

Cost Characteristics Curves for Generators Reactive Support

The cost of real power and reactive power has been obtained for 500 MVA and 80 MVA generators. Based on the capability chart of the 500 MVA generator, the real and the reactive power outputs have been obtained and the respective cost have been obtained at each operating point within the maximum reactive power limits of the generators. The cost of the active and the reactive power for the generators are obtained and are shown in Figs. 3 to Figs. 6. As observed from the figures, the lost opportunity cost can be recovered at every operating point on the capability curve of the generator. At maximum reactive power supply point, the real power given by the generator is zero.

The reactive power cost curve obtained for 500 MVA generators is shown in Fig. 4. Up to rated active power generation the cost of reactive power is zero. Above the rated reactive power requirement, there is decrease in the real power generation and increase in the reactive power generation. Thus the lost opportunity cost has to be recovered from the reactive power cost as an and any schedule. The cost of active power at rated values and at any other operating point on the capability curves of 80 MVA generators are also shown in Fig. 5 and 6. The reactive power cost curves obtained for 80 MVA generators are shown in Fig. 7 and 8. The cost

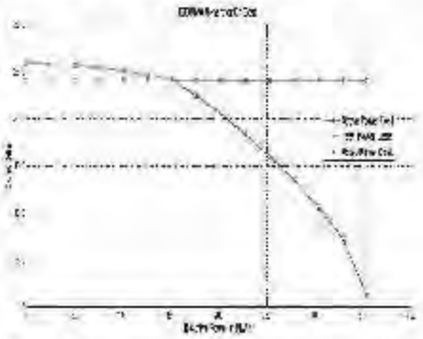


Fig. 3: Active power cost at any operating point and rated active power cost...

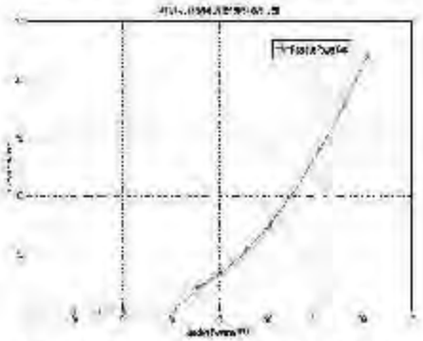


Fig. 4: 500 MVA Generator G1 Reactive power cost...

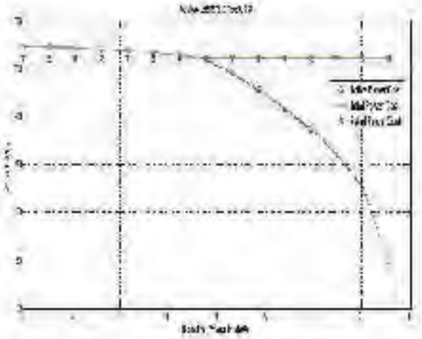


Fig. 5: Active power cost at any operating point and rated active power cost...

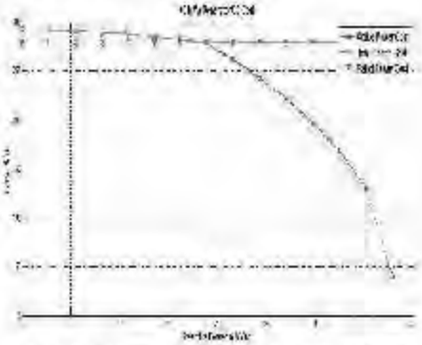


Fig. 6: Active power cost at any operating point and rated active power cost...

Generator	S (MVA)	a_q $/MW hr^2	b_q $/MWhr	c_q	Q (MVAr)
G1	500	0	0	0	Q ≤Qrated
		0.0005	8.7461	307.9502	Qrated <Q<Qmax
G3	60	0	0	0	Q ≤Qrated
		0.5180	-49.1597	1816.053	Qrated <Q<Qmax
G2	60	0	0	0	Q ≤Qrated
		0.5738	21.2959	206.1758	Qrated <Q<Qmax

Table 1: Reactive power cost coefficients...

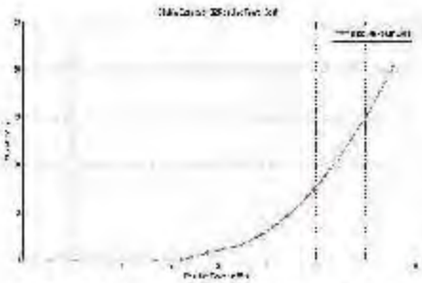


Fig. 7: 60 MVA Gen. G2 Reac. power Cost...

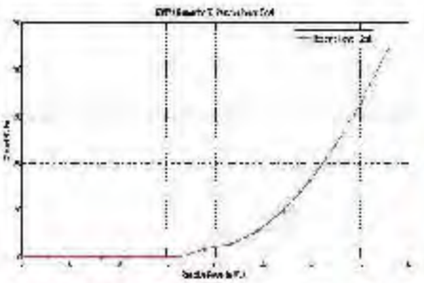


Fig. 8: 60 MVA Gen. G3 Reac. power Cost...

of reactive power at rated active power generation is zero and increases with reduction of active power above the base case. Based on the results for both the 500 MVA and 60 MVA generators, the cost characteristics for reactive power support have been obtained and the cost coefficients obtained for reactive power cost curves are given in Table 1.

Conclusion

In this article, reactive power cost functions have been obtained for the synchronous generators for their reactive support. The cost function for synchronous generators has been obtained based on their capability chart. The reactive support have been obtained for different sizes generators and using curve fit technique, quadratic cost functions have been obtained for synchronous generators. The cost of reactive power have also been obtained generator in condenser mode. These cost functions can be utilized in the ancillary service markets to remunerate the generators for their reactive power support.

Dr. Ashwani Kumar
Professor in the Department of Electrical Engineering at NIT Kurukshetra

PAWBOL: Manufacturer Of Electrotechnical Equipment

Mr. Pawel Luczak has established MALFRO-PAWBOL Distributions s.r.o. in Czech Republic with Mr. Ing. Atul Pahwa as Executive Director and M/s Flux lite Pvt. Ltd. in Bangalore, India with Mr. B I Ajwani as Business Head for India, Asia SARC & African Countries.

About Us

Pawbol Sp. z o. o. is a widely recognized manufacturer of electrical equipment in Poland and Europe. The company was founded in 1999 by Mr. Pawel Luczak who has been a solid and reliable partner in business. Years of experience and flexibility in operation guaranteed the highest quality products and customer satisfaction. Pawbol started its production in 500 sq.m. building and is gradually expanding its portfolio with new products, in response to the latest trends existing in the market. Pawbol has decided to expand its modern production plant in area of 25,000 sq.m in Zator, in the economic zone of Krakow Technology Park. It also cooperates with reliable business partners, esteemed both in Poland and abroad.

Our Strengths

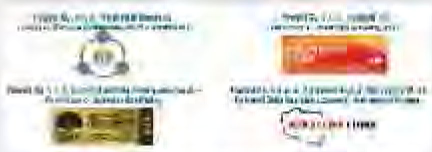
Modern Machinery | Wide Product Range | High Quality Products | Competitive Prices | Quick Response To The Needs Of Our Customers | On-time Delivery | Professional And Experienced Management Team. During the implementation of selected products, Pawbol closely cooperates with the Centre for Innovation and Technology Transfer - Technical and Humanistic University of Bielsko Biala.

Quality

We obtained our quality management system EN ISO 9001-2008 provided by DAS certification Ltd in the year 2002. The certificate covers the process of production and distribution of electrical installation products. Thanks to constant monitoring quality of PAWBOL products and services provided in terms of sales and after sales care is always the highest priority.

Awards & Achievements

Pawbol has been awarded with different prizes in the recent years from polish Gazeta Business Gazelle (2013 and 2014) and from Forbes Business Magazine - Forbes Diamond (2014 and 2015).



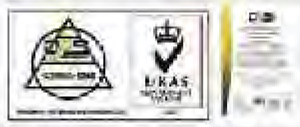
Environment-Friendly Company

"Nature Friendly Company" certificate owned by Pawbol Sp. z o. o. confirms the promotion of sustainable development of our company and environmentally friendly in which way the business is managed.

Certification is awarded by AURAEKO organization, which was founded by a Polish company Electrical and Electronic Equipment Recovery Organization in order to help all entrepreneurs introducing electronic equipment on the market. Along with AURAEKO we make sure that the equipment manufactured by us, does not threaten the environment after it had been used. Introduced electrical and electronic equipment contains many hazardous substances that after equipment utilization pose a huge threat to the environment. However, the negative consequences do not result from hazardous substances, but the wrong disposal of electronic equipment waste.

Certificates of Quality System

The main goal of Pawbol is to provide the highest standards in the production of goods, customer service and sales systems on the Polish and European. Pawbol applies a Quality Management System that complies with the requirements of EN ISO 9001:2008, which is certified by DAS Certification Ltd. Implemented in 2002, the Quality Management System complies with the requirements of EN ISO 9001:2008 contributes to the increase in the quality of services and raises the level of customer satisfaction. The certificate applies to the production and distribution of electrical installation products. Positive evaluation of the implemented system are backed by the quality certificate No. DAS 2008/25463/Q.



Cooperate with Pawbol

Due to the dynamic development of the PAWBOL brand we invite to cooperate the foreign partners interested in distributing our product range. Many years of experience and flexibility in operation have become the guarantor of the highest quality products and customer satisfaction. Our offer is addressed mainly to wholesalers and retailers.

Benefits of being our Distributor

We offer the opportunity to create products for a specific project / investment. We offer a long term warranty for our products. We are constantly expanding our product range. We offer the highest quality products, promotional materials: leaflets (in print), promotional materials (leaflets in electronic), multilingual product catalogs, substantive support of our export department.

Sales Structure

PAWBOL sells its products primarily through Electrical Wholesalers and supermarket chains (retail chain). The company Pawbol works with all purchasing groups in POLAND abroad. Our main market is EU and East European wholesalers in the electrotechnical field. We also supply to big industrial projects through different channels. ■


ELECTRICAL
PRODUCT
INDUSTRY

Interview

"We are sure our clients will evaluate the 'cost versus value' proposal offered by us..."

Kloeckner Desma Machinery Pvt. Ltd., popularly known as Desma India, offers everything for the profitable production of rubber and silicone moulded parts. Arun Mankodi, Managing Director of the company, in a one-on-one discussion with P K Chatterjee, highlights several benefits of buying their products. Excerpts...

How is Kloeckner Desma's business growing in India?

We started in India in 1996 and since then we have been growing. Thanks to support and trust of Indian rubber industry and our world class technology machines at competitive prices. Our major market since many years has been automotive, which has seen serious slow down in last 3 to 4 years. We export to neighbouring countries, and especially to electrical markets. DESMA developed special Sigma SE series and in house mould technology to cater to the ever growing demand of economic production methods for insulators. Last 2 to 3 years, our customer base in electrical application is growing exponentially, and we have plans to introduce more and more competitive products for this market.

Turnkey projects for silicone insulators, surge arrestors and cable accessories have contributed a great deal in maintaining our leading position. DESMA has supplied projects to many of the leading insulators manufacturers in India.

What are the basic differences that Desma creates in its turnkey projects?

We can claim that we are one of the very few manufacturers in the world – with manufacturing competence, facilities and know-how to offer complete solution including machine, mould and CRR under one roof. This is one main difference. We have achieved less than 5% process waste while producing 11KV and 33 KV – saving of silicone rubber per insulator makes our customers more competitive than others. Secondly, what gives big advantage to our customers is zero risk of the project success – as they get 'line-tuned machines with mould, which will start production from day one. Thirdly, as the moulds are made by us in our shop, we maintain detailed part history of the mould parts, which helps us in giving our customers spare parts quickly.

Even if some modifications are required due to design changes, which are common in developing markets like India, we are best placed to make the changes quickly. As mentioned, our project solution is designed with lowest wastage, power consumption and maximised output. Overall our client's are benefited with low total cost of ownership, and they can achieve fast ROI with German technology, reliability and fully close-loop controls as they can produce high quality insulators shot after shot for years.

How is the present government's decision to revamp the power sector with new targets helping your company?

The new government policies are encouraging new investments – as well as capacity expansions with insulator manufacturers. We have geared up our capacity too in anticipation of the surge in demand by investing in new machining centres in our mould shop.

We, however, wish the government to encourage local sourcing of end products against imported sources known for dumping. Now, on one hand 'Make in India' policy is being encouraged and on the other hand over 50 to 60% of products are being imported from China. It is also unfortunate that the age-old policy of special terms of delivery and payment for our customers is highly discriminatory providing employment to hundreds

What kind of revenue growth are you expecting in this financial year (2015-16)?

We expect to grow by over 10% year on year assuming not very positive growth prospects in automotive sector. For insulators, we expect higher growth as we feel Indian manufacturers will enter post insulators and cable accessories products, which are our areas of special expertise.

How are innovations making your company's progress easier? How are those helping your customers?

Innovation is the only key to ensure our own competitiveness and that of our clients in respective markets. We have maximum patents in rubber injection moulding technology worldwide, which shows that innovation is our backbone and our culture. We just completed 50 years in Germany this year. With so much of experience and know-how, we are definitely geared up to innovate more cost effective, reliable and sustainable technologies for making high quality insulators.

What are the new areas you are eyeing on?

We are developing tooled up solutions for cable accessories, post insulators, high voltage insulators, which are our next target applications. A new machine range is being introduced soon to take care of heavy parts in insulator industry.

What kind of effort are you putting on R&D activities?

We are developing new machine series, mould designs which are designed for specific applications and meet the challenges in all aspects. We are looking for faster cycles, easy loading and unloading of parts from mould, reducing production steps to increase output.

Save as much process waste as possible and reduce power consumption per part produced. We have been able to reduce silicone wastage from 10% to less than 5%. We have now the most power efficient machines in market.

Do you help your new customers with thorough customisation? How do you manage to do that?

We are very flexible company when it comes to customisation. We see ourselves as a solution provider rather than a machinery supplier. This makes it very important for us to know our customer and know his/her requirement – and then customise our solution for him/her specially. We have number of examples where we have developed special machines for special needs. We can react fast to customisation as we are designing, manufacturing and servicing the machines all in India, while remaining closely associated with Germany. We are in India with full facilities, which is a big plus for our clients as compared to dependence on imported machines from countries having language barriers.

How do you train your customers?

This is the biggest advantage to Indian customers. We have our service centres with qualified staff at key locations in India like Delhi, Pune, Nasik, Chennai, Hyderabad, which are physically close to our client locations. For the first time buyers, we work very closely with their teams in first few months – when they are learning the processes and machine operations. Most of the time our local engineers speak local language, which gives more comfort feeling for the operators and supervisors.

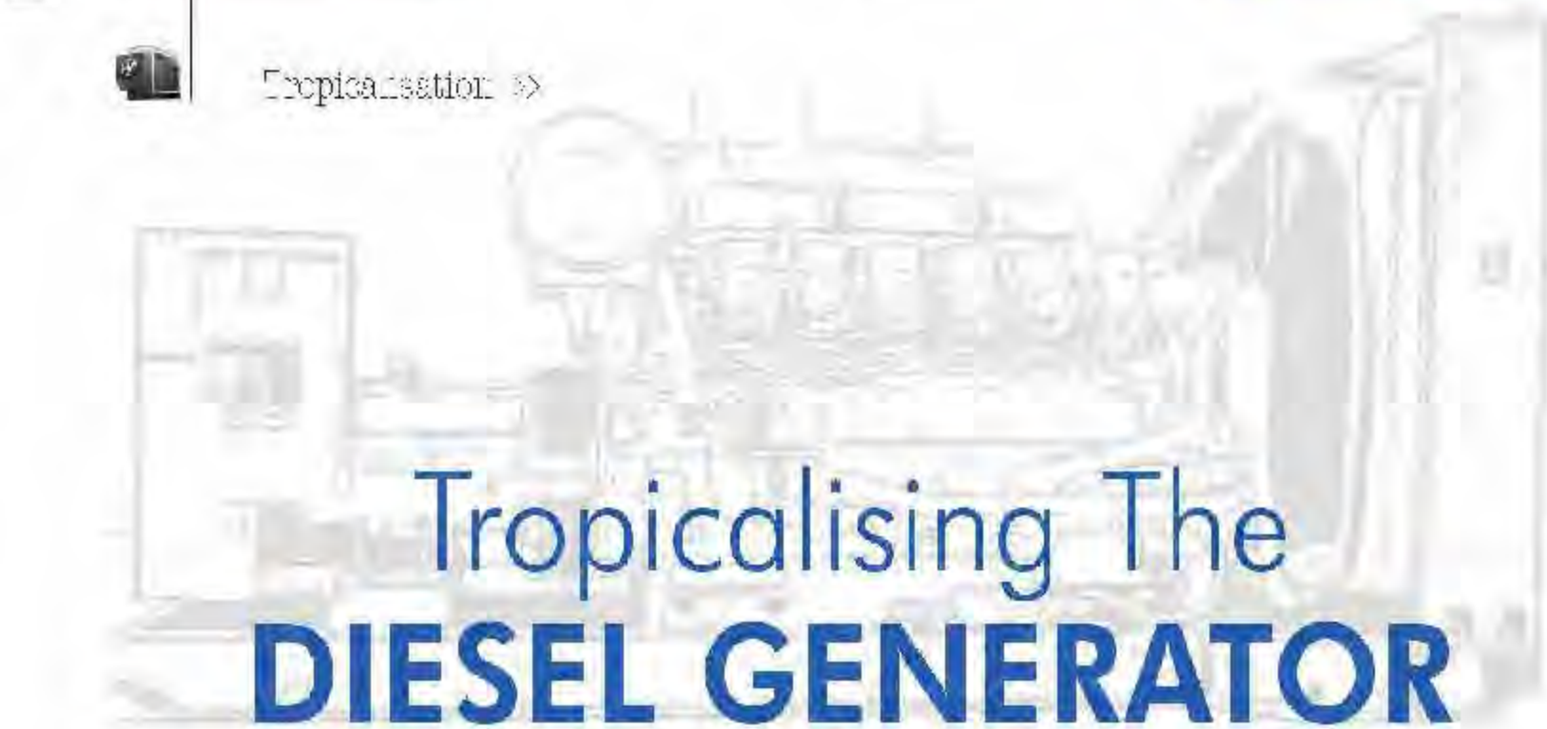
We also provide classroom and onsite training as and when required. Our clients are most welcome to call on us at our Ahmedabad works to have refresher training or have their specific queries resolved by experts face to face. This is another plus that we can offer to our clients - being in India and being with them.

What is your message to your potential customers?

We would like to assure them of the prospect in considering our equipment, which are backed by strong German technology and 50 years of experience. Our equipment will make their products most competitive. We strongly advise against falling prey to relatively small difference in prices of Asian Machine manufacturers.

Also, customers should not trust any of their agencies, claiming to have Desma expertise as 'ex Desma employees'. This is far from reality. The specs offered by some Asian manufacturers are so camouflaged that it's easy to get misled.

For example, many companies write 'Hydraulic' from a famous company Rexroth or Bosch and control from Siemens etc. These international suppliers have a very wide range – both in terms of price and technology. Just by 'naming' the extreme low-end basic specs of parts from them, they are nowhere near our state-of-the-art, power saving and user-friendly techniques. Our wide network of service and support cannot be matched. We are sure our clients will evaluate the 'cost vs value' proposal offered by us.



Tropicalising The DIESEL GENERATOR Package Utility

The industrial DG utility in India is not tropicalised till date. The existing DG packages are more suited to cold climates. Due to increase in air intake temperature from 25 to 40°C, the air fuel ratio decreases by about 5%, resulting in increase in fuel consumption in the range of 0.5 to 2% depending on engine design...

The DG set in package mod, uses the radiator fan to perform two functions namely the heat transfer and induce the engine-exhausted-hot air draft through exchanger fins. But practically, the radiator receives no air and chokes in good way daily so it is not induced – and thus reducing both its functions as heat transfer & engine ventilation, thus DG starves. So, it is suggested here to partner the radiator from the engine within the hood, provide fresh air openings to the same from the hood sidewalls and provide to the DG engine separate forced draft to the engine and as well ventilate the same separately.

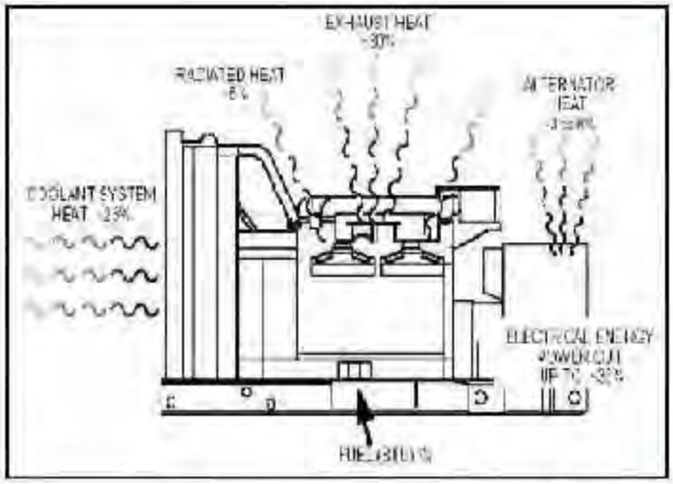
The Industry DG utility in India is not tropicalised till date. The existing DG packages are more suited to cooler climates. Increase in air intake temperature from 25°C to 40°C, the air fuel ratio decreases by about 5%, resulting in increase in fuel consumption in the range of 0.5 to 2% depending on engine design. The DG and its sub systems are put to Accelerated Ageing process due to localised heat retained inside hood.

The DG set OEM and the user industry gave priority to Units per Litre of Diesel at the package outlet. But the exhausted heat at 30% of the heat value of the input stays at the engine surroundings only due to poor air movement across the engine. That is why, the DG sets are sold as Open Terrace location gensets, but not instructed at site to put under sunshade. Already the DG is running at 35% efficiency referring to input / output values, so to sustain & improve. Listed below, are the ways to tropicalise the DG in hood.

Existing Symptoms of Inefficiency

When thermal imaging was done inside a running DG set package unit, we found the inside temperature around 10 to 15°C more than the ambient temperature surrounding the unit. Having done energy audits in many industries, we observe the trended output power and thermal imaging parameters. The symptoms like, in a running engine, when you open side doors, you will find blast of hot air trying to escape out more.

- The Sankey diagram of heat flow across the DG set shows for the given diesel input, electricity power output is only 35% whereas exhaust heat at 30% and coolant system heat at 35% is a loss only.
- But practically the exhaust and coolant losses are controlled by radiator & fan internally within the hood. This radiator and fan receive hot engine exhaust air as input and dust chokes the fins further.
- The all loads to lose L-L, due to higher than ambient air intake to DG set directly. As the thermal imaging shows, the air intake mouth reveals choked and hotter inlet temperature surroundings.



Courtesy : Cummins DG Manual / Cross ventilated DG engine / Forced Fresh air at air inlet...

How to Rectify the Same at Site

- SIMPLE SOLUTION: First, put the DG under a weatherproof umbrella shed / shelter / shade.
- Simply, open all the side doors and retrofit projected type V type NILKEN type filters with 98 mesh daily cleanable foam holder inside the package. So that no air suspended particles, dust or plant dirt wastes dictating in air not to get deposited inside the internals. This will allow more air flow across the engine and ambient air to cool the heat exchanger. This is low cost and, Acoustics and aesthetics is no an issue, this option can be implemented immediately.
- Vacuum gauge after the air intake always does not work. So, provide Magnehelic type Delta P gage, viewable from outside to condition monitor the same daily routinely and keep it clean frequently.

Re-Engineering at Site Services

- In consultation with the OEMs, Re-Engineering at Site Service Providers can take up this quick fix job. They can retrofit / relocate HX at the DG hood and will rejuvenate the DG efficiency to sustain more. After implementing the simple retrofit solutions as mentioned above, we need to further confirm.
- Provide a sliding metal sheet as barrier between the engine and the heat exchanger. This will mask the radiator face. Fresh air from ambient enough hood side panels fixed with V type pre-filters to facilitate heat transfer. Here, take care to add a thermostat in fan control circuit, so that the fan will operate to maintain optimum cooling temperature to engine. Engine hot exhaust air must not reach the HX. Here, we are trying to compartmentalise the engine and HX chambers to provide isolation.
- The HCO, the heat of compression during the combustion of diesel with excess air pressure, is the major source of heat load seen in the hood and it is better to provide adequate forced fresh air inlet to engine through Heavy Duty Fresh Air Fans to fix on side doors facing both sides of engine. Give enough Cooling to DG engine. Extend the air intake duct to rear air intake wall (alternator side) of the hood.
- Provide ventilation opening on the top area of hood where maximum exhaust air is thrown up and fix heavy duty exhaust fan horizontally as mixed roof vent. This will remove hot spot areas inside. Take care fresh air is directed to engine and facilitate the hot exhaust air out of the engine to hood roof vent.
- The diesel tank return-cooling radiator is to be fixed in the radiator counter vent. Out comes as well as to throw out hot air out of the engine. Here, the diesel temp must be at 35-40 for optimum viscosity and fuel saving. Whereas now, you go and measure your diesel tank temperature to find as 50°C +.
- The battery works for longer years at 28°C. So, put battery in the proposed HX isolated compartment.
- All these retrofits are needed to rejuvenate the DG engine hood so as to run efficiently in the long run.

Pointers to the Industry & OEM

As an industry consumer, it is not enough of this radiator-induced-air-draft to the DG set. Once the radiator chokes, very shortly the DG set sub-rates and de-rates sooner. Now, the trend here is that we have to give forced draft of air to the above either directly or indirectly for sustainable efficiency.

Thus, turbo vents have replaced the passive natural convection roof vents, in all the industry sheds. DG house is now kept positively cross ventilated. But let us now focus our attention first, within the engine hood. First we have to remove the heat that is arrested inside the DG hood for getting around 10% more DG efficiency and to sustain the DG efficiency in the long years.

Ashok S
BEE Accredited Energy Auditor
POWERON Projects, Coimbatore

Recent Trend And Technological Development In Transformer Insulation

This article gives the idea of power transformers and their insulations at various levels of voltages. It also exclusively presents the recent trends in the transformer insulation and technological development, especially like Gas insulated Transformers...

Power transformers have been used since the beginning of commercial power distribution in the late 1800s. They step-up and step-down voltages (and inversely, the magnitude of currents when power in = power out), to allow the efficient transmission of power by reducing losses caused by high currents in long conductors. The first transformers were of wood construction, air insulated and had very low current ratings. As power requirements increased, transformers were constructed with their windings contained inside sealed tanks, full of insulating oil. This general design concept allowed for better cooling and higher voltage ratings, and has remained in place for over 100 years. In the past 30 years, the use of gas as a dielectric has emerged as a safer, more environmentally friendly and less flammable alternative to oil. This article looks at Sulfur Hexafluoride (SF6) as a dielectric, current designs, reasons for implementation and the future trends of Gas Insulated Transformers (GIT).

Construction

The construction of a GIT is basically the same as an Oil Immersed Transformer (OIT), with the exception of insulating material and cooling medium.

Therefore, broad experience of OIT technology can be applied to GIT design, manufacturing and maintenance.

Features	Advantages with GIT
Non-flammability	GIT's employ SF6 gas as the insulation & cooling medium, which avoids the need for firefighting equipment, oil collection tanks and pits outside the transformer room.
Non-explosive feature	Since the rise in tank pressure for an internal fault is very small compared with the GIT tank withstand strength, the GIT tank will not explode on internal fault ensuring the safety of equipment within the substation.
Compactness	Since neither a conservator nor pressure relief arrangement is required, the height of the transformer room can be reduced. For the case of a 275kV 300MVA class application approximately 2 to 2.5 meter reduction in height can be achieved.
Excellent interface with Gas Insulated Switch gear (GIS)	The application of GIT together with GIS offers a very compact substation design as the equipment is installed in the same room. A significant cost reduction for civil construction can thus be achieved.

Features of Gas insulated transformers...

Gas Insulated Transformer

Alstom Gas Insulated Transformers at 145kV Gas-insulated switchgear (F35) at the Shuqaiq HV substation in Saudi Arabia...

Toshiba 15/150 MVA 110 KV GIT in underground substation)... (Low pressure Design 0.14 MPa-g)

Toshiba 400 MVA GIT in underground substation)... (High Pressure Design 0.43 MPa-g)

Name	SF6 gas insulated transformers			
Conforming standard	IEC60076 (1993), or ANSI C57.12.00 (1993)			
Installation site	Indoor or outdoor			
Cooling method	(1) Natural-cooled type (GNAN)			
	(2) Forced-gas-circulated, natural-air-cooled type (GFAN)			
	(3) Forced-gas-circulated, forced-air-cooled type (GFAF)			
Frequency	50 Hz or 60Hz			
Voltage and impedance	Primary	Highest voltage (kV)	Tap voltage (kV)	Standard impedance (%)
		170	187 / 181 / 175 / 169 / 163	14.0
		72.5	72.5 / 69.7 / 66.9 / 64.0	12.5
		36	36.7 / 34.6 / 33.5 / 32.4	9.0
		24	25.4 / 24.3 / 23.2 / 22.1	8.0
		12	13.2 / 12.7 / 12.2 / 11.7	8.0
	Secondary	3.6 or 7.2	-	-
Connection	Delta - Delta or Star - Delta			
Rated capacity (kVA)	1000, 1500, 2000, 3000, 4000, 5000			
	6000, 7500, 10000, 15000, 20000, 30000, 45000, 60000			
Temperature class of insulation (temperature rise limits)	Class E (Windings : 75K)			
Gas pressure in transformer tank	0.294MPa or less			

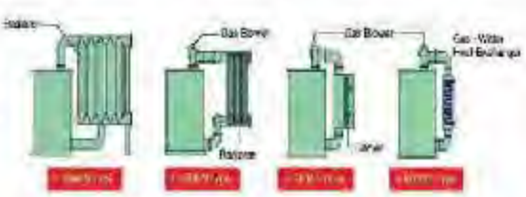
GIT - Specifications & Ratings (Courtesy: Toshiba GITs)

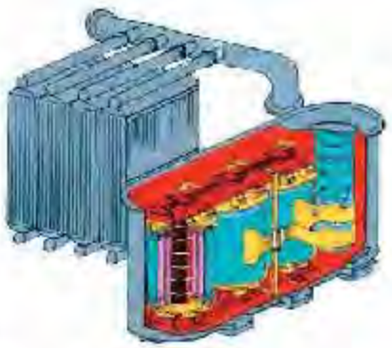
	Oil Immersed Transformers (OIT)	Gas Insulated Transformers (GIT)
1. Insulation/Cooling	Insulating Oil	SF6 gas (Pressure: 0.1 to 0.45 MPa g@20°C)
2. Solid insulation material	Oil impregnated paper, Pressboard	PET film, PI film, Aramide paper, Pressboard
3. Conservator	Necessary	Unnecessary
4. ON Load Tap Changer		
A) Diverter Switch	Arcing Switching in oil	Vacuum Interrupter
B) Tap Selector	Slide contact	Roller contact

Comparison between Oil Immersed Transformers and Gas Insulated Transformers...

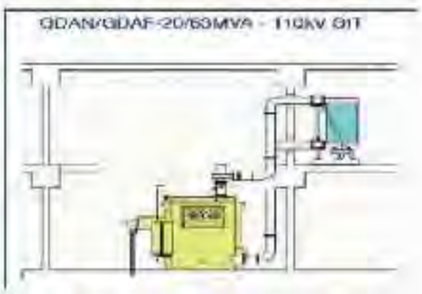
Cooling System

The concept of the external cooling design for a GIT is nearly the same as that for an OIT, for this reason various types of cooling methods can be applied.





Flexibility in Substation Design



Toshiba Gas Insulated Transformer (GIT)...

Since the head pressure of SF6 gas is negligibly low, cooling equipment can be located above the GIT level as indicated in the figure. The GIT offers excellent flexibility when locating components such as radiators or coolers.

Water Cooling System for Urban Substation

A water cooling system is widely used in large-capacity underground and/or indoor substations. The heat generated from a GIT is efficiently transferred to water-air heat exchangers by water flow. The cooling system is usually located on the top floor of the substation building.

Toshiba Gas Insulated Transformer (GIT)...

GIT - Diagnostics and Maintenance

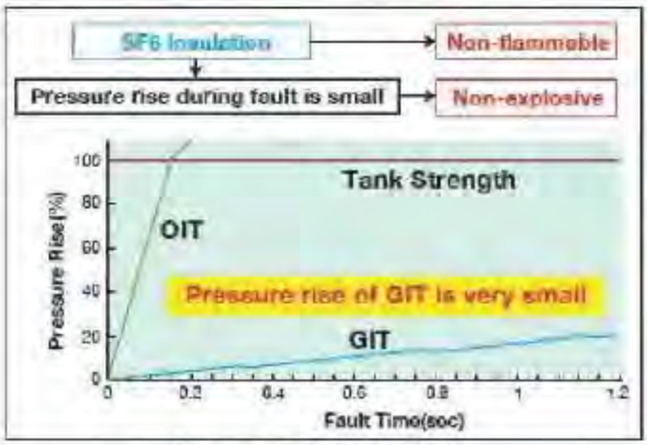
The integrity of GITs can be checked and a failure cause analysis can be made using gas chromatography. Using a simple gas sensitive tube device, GIT integrity can be confirmed at site.

GIT Interface with Other Substation Equipments

- Cable connector
- Plug-in connector interface
- Gas insulated bus bar (Direct Connection)

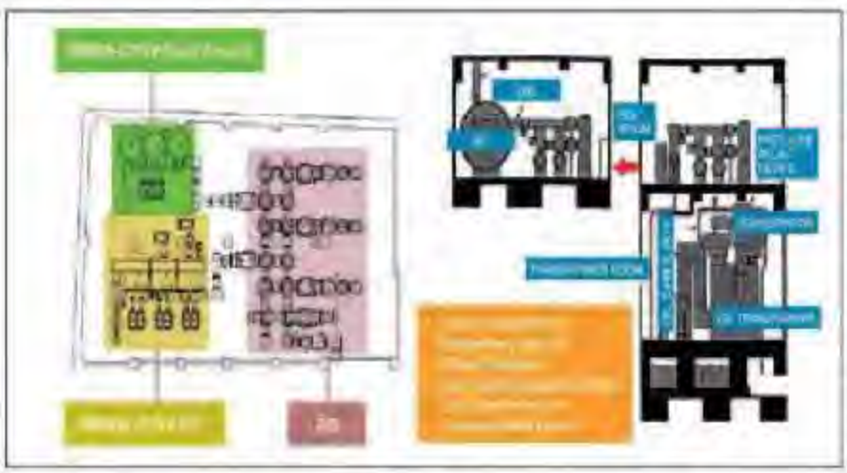
Main Applications of Gas Insulated Transformers

- GITs excel in explosion-proof safety and are widely used in underground and indoor substations in urban areas. Significant tank pressure increase does not occur during internal failures due to the gas characteristics. The risk of a tank explosion or fire incident can be completely eliminated.



Pressure rise on internal fault...

- GITs are also installed in environmentally critical areas where oil leakage is prohibited.

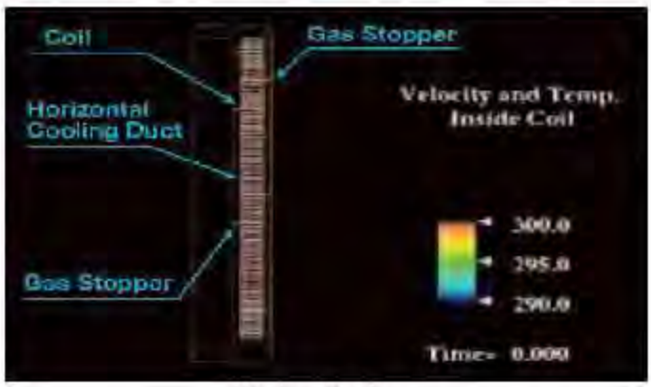


- Also, GIT can be installed without any Firewalls in between along with the Gas Insulated Substation Equipments.

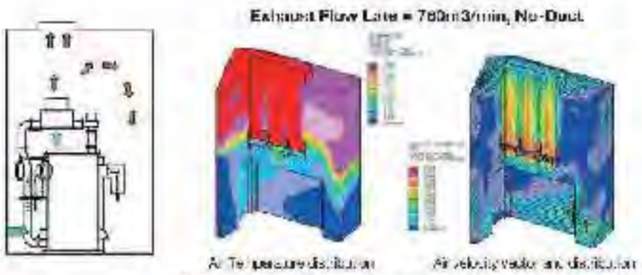
Temperature Analysis for GIT design and GIT Room Considerations

Computer Aided Engineering (CAE)

In the cooling design for the GIT winding of substation buildings, Computer Aided Engineering (CAE) methods can be applied. The calculation using CAE for the airflow inside the building and/or outside is very useful during the planning stage of the substation building.



Winding Cooling...



Transformer Room Cooling...

The calculation result used in the figure shows that the top cooler arrangement is suitable in terms of efficient substation cooling for this case. Positions of coolers can be decided.

Least considered Disadvantage of GITs

- Gas Insulated Transformers are more extensive; however, this cost difference may be made up over the life of the transformer, as maintenance is cheaper and minimum routine.
- Environmental regulations on greenhouse gases require SF6 to be handled carefully, and recycled where possible. This can create additional installation & repair costs depending on local laws.
- A GIT requires complex cooling due to SF6's low thermal conductivity, and generally the cooling system (blowers, heat exchangers, etc.) need redundancy to ensure that a small equipment failure or maintenance does not dramatically reduce the transformer rating.

Transformers in the Future

Dry type transformers are still the choice for most electricity distributors for low voltage distribution transformers where oil cannot be used. Most of the European Countries opted for GITs for Higher level of voltages. Sydney's requirements are that any transformer that is not on or below ground level (i.e., any transformer in upper level substations) is required to be oil free. Currently, Ausgrid has around 100 upper level substations with 2 or 3 dry type transformers in each. It is most likely that within the next 5 years, gas insulated distribution transformers will be used instead. Although Dry Type Transformer with SF6 have numerous advantages, transportation, handling and recycling of SF6 may become financially prohibitive.

"Octafluorocyclobutane is a possible replacement for SF6". Its molecule is made up of fluorine and carbon atoms, removing the risk of creating poisonous sulphur based gases during arcing. It is denser than SF6 and has a higher dielectric strength of 3.3 times the breakdown voltage of air (as opposed to 3.0). It is also more environmental friendly than SF6.

Conclusion

It is clear from the above mentioned points that Gas Insulated Transformers (GITs) have many benefits and will slowly replace most types of transformers in the future. It is possible that SF6 may not be used; however an equivalent gas will perform in much the same way as sulphur hexafluoride. Hence, GITs out stands with the following advantages:

- Environmental Friendly
- Explosion Free

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Interview

"Brugg Cables is very optimistic about the Indian market..."

Though Brugg Cables entered the Indian market as a permanent establishment in 2012, their installations in India date back to early 2000s, when they had the first installation at BRIGADE, Bangalore under KPTCL followed by relevant installations at NHPC, UPPTCL, Reliance, Delhi Transco, MAHAGENCO etc. Bernard Wasem, Global CEO of the company is talking to P K Chatterjee on his company's Indian business. Excerpts...

What are the very prominent global trends in the Cables & Wires market these days?

On the one hand we see more energy being consumed creating a need to expand the networks. On the other hand the trend is shifting to transmission on higher voltage levels over the existing lines. We also see rating prices due to efficiency improvements and the use of new materials.

What kind of potential do you find in the Indian Cables & Wires market at present?

In India, the industrialization process is on-going, creating the need for infrastructure development. The space constraints in the cities promote underground cables as a solution.

What is your USP (Unique Selling Proposition)?

Brugg Cables possesses over 120 years of experience. We are in private ownership with strong industrial interests making sure we have a stable long-term perspective. We use state-of-the-art technology with a highly skilled workforce. We emphasise on our own R&D organisation and our in-house High Voltage Laboratory.

Do you have any India-specific growth plan on anvil?

We opened our own Brugg Cables India legal entity in 2012 to make our local presence – and grow Brugg Cable's business. Additionally, we are partnering with a local cable manufacturer KEI for local content.

High Voltage (HV) test laboratory at Brugg Cables...

How do you ensure environment-friendliness in your manufacturing processes?

Brugg Cables holds an ISO9000 and an ISO 14000 certificate. Brugg management is committed to norms and safety standards for its employees around the world.

How do you select partners to pick up low and medium voltage accessory sets?

Since our product life-span is long, trust and confidence from customer to supplier is the key. Partnering is based on many criteria, such as experience, skills, personal relationships, product ranges and future development plans. Partnership in this industry must be based on long term and must not be changed frequently.

Please tell me a few words about your Indian business.

At present we are working at Delhi Metro, Reliance Jamnagar, Tenhansco and Tata Steel, where the installation is likely to resume in January 2016. At Tata Steel, Brugg Cables is executing a turn key project of 10.6 km 400 kV 1Ø x 630 sq mm supply including civil work, laying and installation of cables and accessories.

Our primary focus in India for cabling projects is the 400 kV market, however, for power accessories, we cater the entire range from 66 kV to 400 kV.

Brugg Cables is very optimistic about the Indian market and we foresee a bright future for the whole Brugg Group in India.

What are the products being supplied from India?

Cables, accessories and system solutions for power & data transmission and distribution.

Low, medium and high voltage cables from 1 to 500 kV with aluminium or copper conductors.

Cable System Services (Engineering, System Condition Analysis, Distributed Temperature Sensing, Partial Discharge Monitoring, Technical Training).

Cable fittings and assembly accessories from 1 to 500 kV, suitable for all connection systems.

High Voltage Laboratory for research and testing services.

Please tell me something about your global reach.

Brugg Cables has its headquarters in Brugg Switzerland with own subsidiaries in China, India, UAE, Germany, Italy, Poland and the USA. Business opportunities outside our local organisation's reach are served out of Switzerland. Brugg Cables has several manufacturing partners to be able to provide local contents upon customers' requests.

Which industrial sector tops at your clients list? What are the emerging potential fields to raise demands of your products?

Top of the list is occupied by the local utilities and EPC contractors. The segments that we are developing include alternative energies, such as wind, solar and e-mobility.

What would you like to communicate to your potential buyers in India?

Brugg Cables is a highly reliable supplier of products and services. Our engineering will provide the best solutions for your individual needs. Brugg Cables considers India as a highly attractive market and has established a presence to stay.

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The new DC fuse adapter from Phoenix Contact is an easy-to-install protective element for photovoltaic systems. Its optimised thermal behaviour prevents premature failure due to age. The fuse adapter meets all applicable international requirements, including the latest TÜV test specifications. The adapters in the SUNCLIX product family are available with high-quality IEC fuse inserts, from 6 to 30 A. They are designed for a voltage of up to 1500 V. The fuse adapter for outdoor deployment, according to Protection Class IP68 (24 h/2 m).

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The device connectors of the PRC series offer plastic circular connectors for power electronics with IP65 to IP68 protection. The multi-position power connectors are mainly used in device manufacturing. There is a particular focus on solar inverters. In addition to numerous DC and communication connectors, these devices also feature an AC connector. With the PRC series AC plug, manufacturers of PV inverters can be offered a consistent connection system. Whether AC, DC, data or signals – all solar inverter interfaces can be connected using connectors from Phoenix Contact.

For further information:
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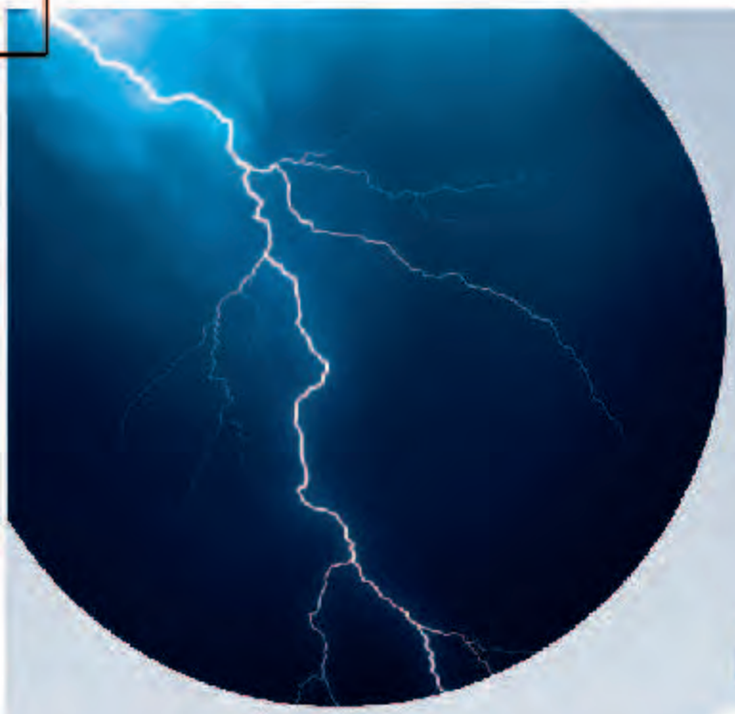

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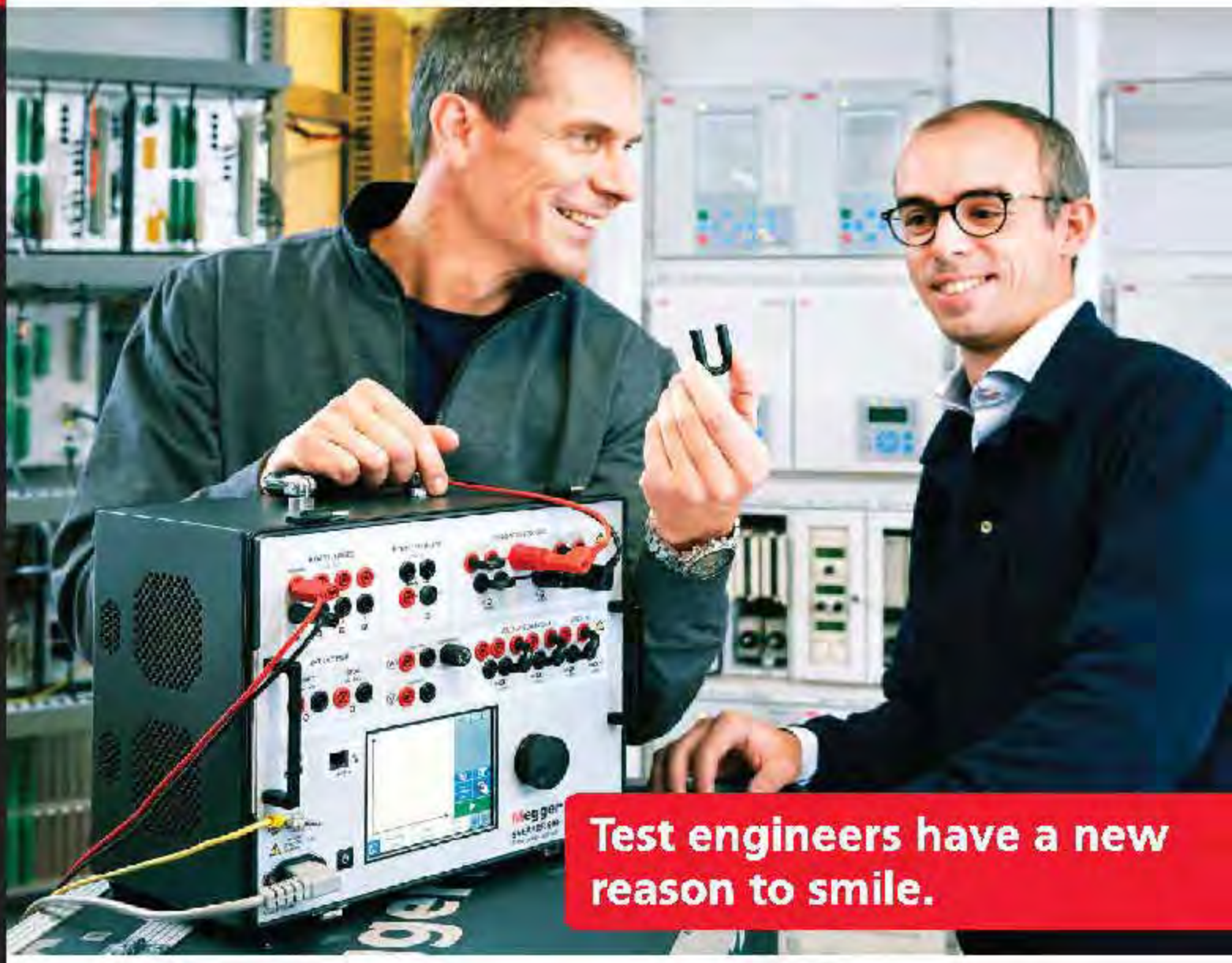

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