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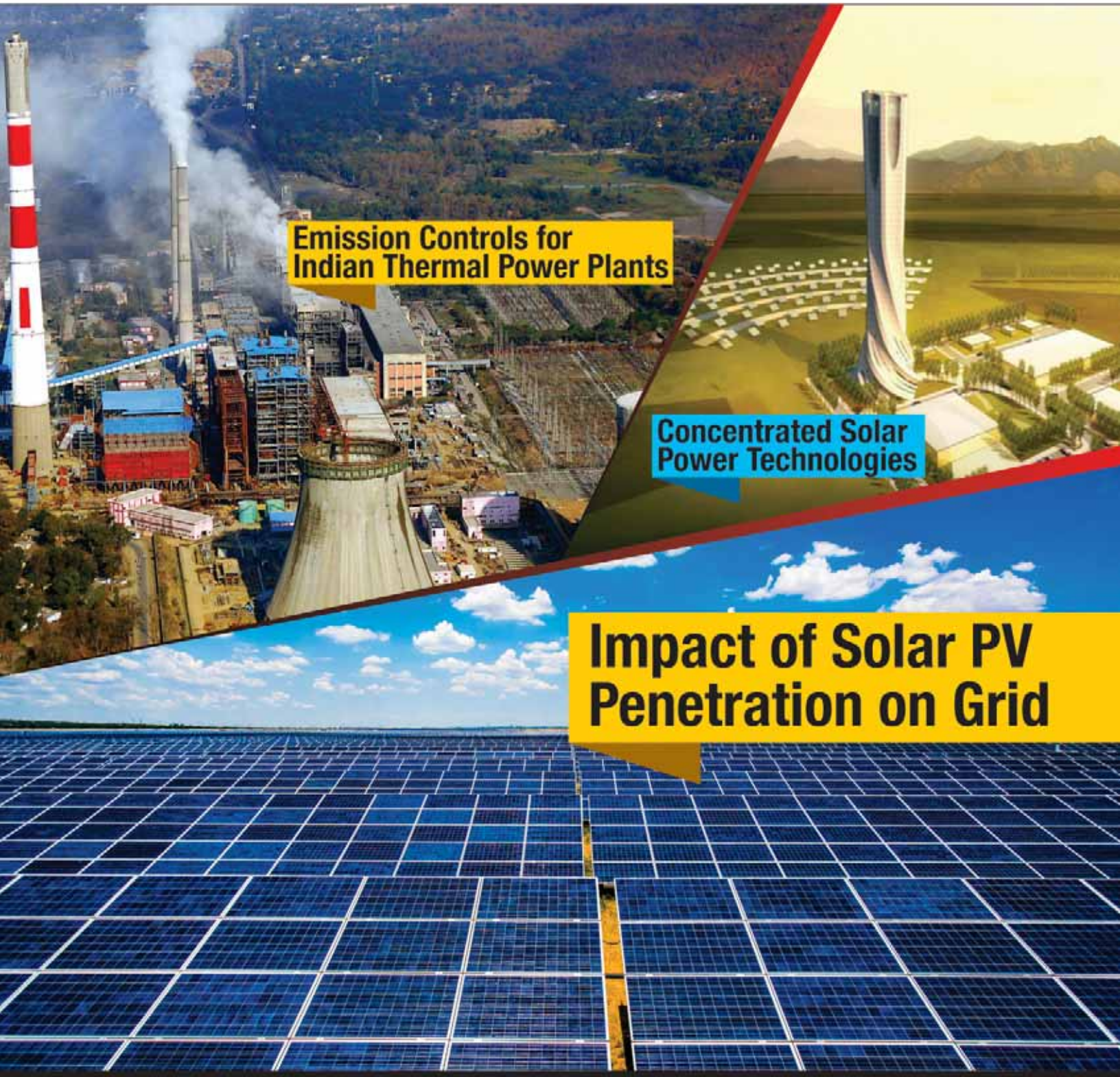

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PUBLISHER'S LETTER

Hello and welcome once again to *Electrical India*. This month's issue is focusing on solar energy. Solar sector in India has gained traction with significant attention from both Government and investors alike. As a result, the country has been witnessing roll out of policies suitable for growth of the sector, thus, attracting investments in the sector. Consequently, there is a visible improvement in India's cumulative commissioned capacity from 3,062 MW to over 10,000 MW over in just a span of two years. This does not include the over 18,000 MW of projects that are currently in the tendering or implementation phase. Against this backdrop, India is expected to reach 20 GW of installed solar capacity by the end of the present financial year (2017-18), according to a report released by the consulting firm Bridge to India (BTI) recently.

The government has set the target of generating one lakh MW of solar energy by 2022. India can expand its footprint with this shift towards solar sector, thus, claiming a large portion in the global energy sector. This will generate demand for manufacturing of solar components and hence the manufacturing capacities will definitely witness an increase. Research reveals that focusing on domestic manufacturing can save India more than $42 billion by 2030 in forex alone.

According to industry stalwarts, taking a more aggressive initiative towards enhancing the domestic solar manufacturing capacity can help in meeting the solar energy implementation target (100GW) and prepare India for the mantle of solar super power.

Moving further, the issue also covers the analytical article *Impact of Large-Scale Solar PV Penetration on Steady State Performance of The Grid*. The article *Effect of Environmental Conditions on Performance of Solar Panels* gives a glimpse of the effect of environmental conditions on performance of solar panels by visual inspections and effect of shading tree on the generating power of solar panels by thermographical technique. The case study *Overvoltage Mitigation Techniques for PV Grid* reviews the conventional techniques used to mitigate the overvoltage problem. *Emission Controls for Indian Thermal Power Plants* suggests that India has to adopt clean coal technologies to mitigate the effect of climate change and control emissions.

Hope you enjoy reading this issue as much as we in the editorial and design team have in bringing this to you. Until next time, happy reading and do send in your comments to me at miyer@charypublications.in.

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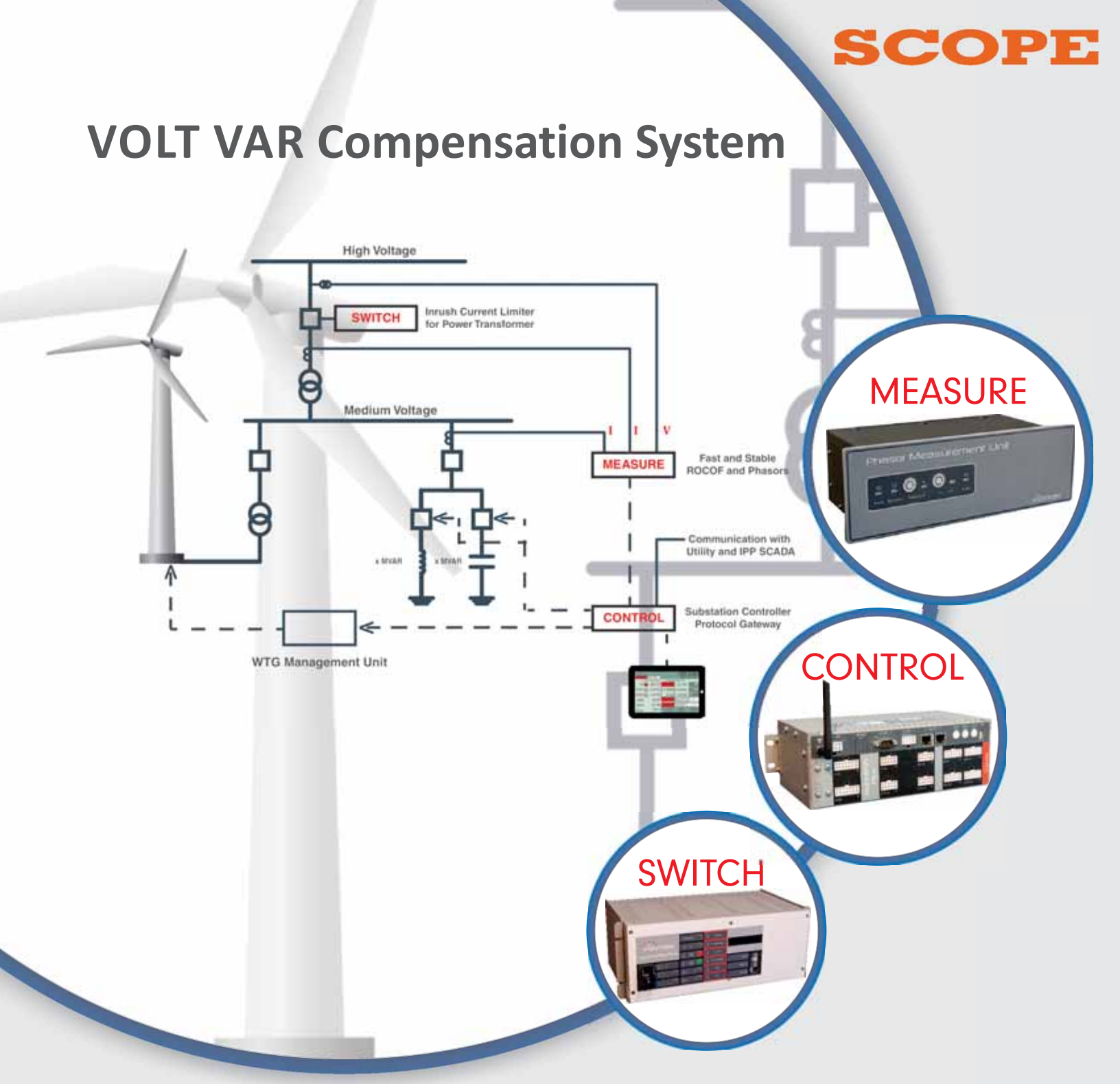

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Rahul Gupta
CEO, RaysExperts

DEPARTMENTS

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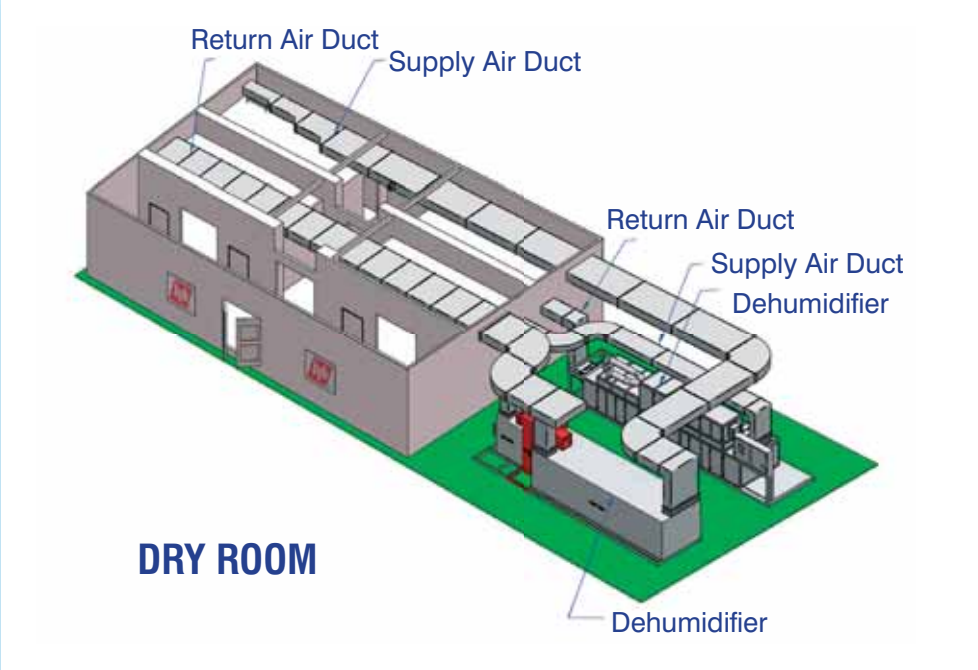

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BHEL commissions 30 MW Hydel Power Project in Mizoram

Bharat Heavy Electricals Limited (BHEL) has successfully commissioned the first unit of 2x30 MW Tuirial Hydro Electric Project (HEP) in Mizoram. Significantly, this is the first large-rating hydro power project in the state of Mizoram.

Located in Kolasib district of Mizoram, the greenfield project is being set up by the North Eastern Electric Power Corporation Limited (NEEPCO) on the river Tuirial. The second unit of the project is also in advanced stages of execution. Power generation from Tuirial HEP will result in reduction of greenhouse gas emissions and will contribute towards achieving a low carbon development path for the nation.

The order for the Electrical & Mechanical (E&M) package of two units of 30 MW each, placed on BHEL by NEEPCO, envisaged design, manufacture, supply, installation and commissioning of the complete E&M package including vertical shaft Francis Turbines & matching Generators. The equipment has been supplied by BHEL units at Bhopal, Jhansi, Rudrapur and Bengaluru and the execution of work on site has been carried out by the company's Power Sector Eastern Region.

The entire installed hydro capacity of NEEPCO of 755 MW has been supplied & commissioned by BHEL. The other hydro project of NEEPCO currently under execution by BHEL is the 4x150 MW Kameng HEP in Arunachal Pradesh.

Some of the major hydro projects commissioned for NEEPCO by BHELare the 3x135 MW Rangandi HEP in Arunachal Pradesh and 4x50 MW Kopili HEP in Assam.

EESL to procure 50 lakh Smart Meters for realisation of Smart Grids in India

Energy Efficiency Services Ltd. (EESL), under the Ministry of Power, Government of India had put out a mega tender for procurement of 50 lakh smart meters in July, which would help in reducing AT&C losses, power theft and also help in monitoring of round the clock power supply eventually leading to greater efficiency and 24X7 power for all.

A Pre-Bid Meeting was held by EESL on 22nd August 2017 for procurement of 50 lakh smart meters which elicited a stellar response from the smart meter manufacturers, system integrators and has also excited various other stakeholders including World Bank and telecom operators etc. The interest shown by the smart meter fraternity is also evident from the participation of about 100 companies in the pre-bid meeting and is a measure of the potential which smart projects have in India.

EESL will be making the entire upfront investment as well as maintain the whole infrastructure for the next ten years. This approach has made the project feasible as most of the state utilities are not in a position for such rollouts due to their financial constraints. EESL will recover its investment from the savings accruing to the DISCOMs in subsequent years.

The meters are being procured for implementation of smart grid projects in the states of Haryana and Uttar Pradesh. These meters will help these states in not only significantly reducing their AT&C losses way of increased billing efficiency, but will completely change the way in which electrical energy is presently being consumed and paid for by the ordinary consumers.

Installation of these smart meters along with its associated communication and IT infrastructure will enable the DISCOMs to obtain real time energy consumption data of each consumer for subsequent analysis and will pave the way for initiating various smart measures by DISCOMs like Time Of Day (TOD)/Time Of Use (TOU) billing, prediction and management of peak demand, providing real time energy consumption data to consumer, prepaid billing facility, remote connection and disconnection of load, accurate billing, etc. Installation of these meters will also obviate the need for the meter reader's visit to each and every consumer.

In order to make the entire project feasible and affordable, EESL has unbundled the Advanced Metering Infrastructure (AMI) project into two parts viz. procurement of smart meter and arranging the system integrator. EESL is also planning to issue the tender for selection of system integrator early next month, as second part of the AMI project.

Senior officials of Haryana and Uttar Pradesh DISCOMs were present in the pre-bid meeting along with representatives from DISCOMs of Bihar, Jharkhand and Odisha, as well as senior officials from CEA, NSGM etc.

EESL and IOCL, BPCL & HPCL sign MOUs for distribution of Energy Efficient appliances

Energy Efficiency Services Limited (EESL), under the Ministry of Power, signed a Memorandum of Understanding (MoU) with Oil Marketing Companies (OMCs) under the Ministry of Petroleum and Natural Gas (MoPNG) for distribution of energy efficient appliances under the flagship Unnat Jeevan by Affordable LEDs and appliances for All (UJALA) scheme. According to the agreement, Oil Marketing Companies-IOCL, BPCL and HPCL will take up distribution of LED Bulbs, LED Tubelights and energy efficient Fans from select retail outlets across the country. The distribution of these energy efficient appliances will be conducted in a phased manner across these select outlets. In the first phase, distribution will commence from the states of Uttar Pradesh and Maharashtra.

The MoUs were signed with Indian Oil Corporation Limited (IOCL), Hindustan Petroleum Corporation Limited (HPCL) and Bharat Petroleum Corporation Limited (BPCL) in the august presence of Piyush Goyal, Minister of State (IC) for Power, Coal, New & Renewable Energy and Mines, and Dharmendra Pradhan, Minister of State (IC) for Petroleum and Natural Gas here.

As part of the MoUs with the OMCs, EESL will make the entire upfront investment for ensuring availability of the products at the outlets and no upfront capital cost will be borne by the OMCs barring manpower and space.

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IBC SOLAR signs contract with SECI over 20 MW solar plant in India

IBC SOLAR AG, well known in photovoltaic (PV) systems and energy storage, has signed a Power Purchase Agreement (PPA) for a 20 MW AC solar plant with the Solar Energy Corporation of India (SECI). The project was part of a 270 MW AC PV tender in the state of Odisha and assigned to IBC SOLAR through a competitive auction process during 2016. The PV system is planned to be put into operation by late 2017.

IBC SOLAR has furthermore concluded negotiations about a debt finance of approximately 980 million INR for the Odisha Project with L&T Infrastructure Finance Co. Ltd., a leading Indian financial company in the infrastructure sector. This ensures the financing of the project from the construction phase. The local financing has a term of 18 years.

Shailendra Bebortha, Managing Director of IBC SOLAR Projects India Private Limited, a wholly owned subsidiary of IBC SOLAR Energy, commented, "We are pleased to announce the signing of the PPA with SECI, a company of the Government of India, and are confident to realise this project in the state of Odisha within the stipulated timeframe and according to our global quality standards. The confidence expressed by lenders in IBC SOLAR helps to further scale up our business in India."

TERI and NISE sign MoU to develop R&D on solar energy

The Energy and Resources Institute (TERI) entered into a strategic association with the National Institute of Solar Energy (NISE) to achieve common objectives related to research and development of solar energy and related equipment and technology.

TERI Director General, Dr Ajay Mathur, and NISE Director General, Dr AK Tripathi, signed the five-year memorandum of understanding at TERI. The collaboration is related to grid-connected solar rooftop PV, solar thermal power plants, energy storage systems, electric vehicles, smart grid initiatives, solar cooling etc. The organisations also intend to carry out policy and regulatory studies and capacity-building programmes dealing with grid integration, recycling and disposal of solar panels and batteries and collaborate with global research institutions to undertake research in India. Apart from this, TERI and NISE will also look into setting up a product development centre for renewable energy technologies. This centre will also focus on incubation and development of business models and consultancy in various aspects of solar energy technologies.

Speaking on the occasion, Dr Mathur said, "This partnership would open new opportunities for cooperation between the two organisations in solar energy and energy storage research, and in capacity-building programmes at the national and state levels."

Dr Tripathi said, "Technical and R&D strength of NISE and 'socio-outreach' capabilities of TERI will be jointly utilised to promote solar energy in the country, thereby achieving goals of the National Solar Mission and the INDC target of the Government of India."

THDC India Limited and IIM Kashipur signed a MoU

THDC India Limited (THDCIL) and Indian Institute of Management (IIM-Kashipur) entered in a MoU on 21.08.2017 at Kashipur to enhance the managerial skills of its executives. H. Wadhwa, Additional General Manager (HRD), THDCIL and Dr. Gautam Sinha, Director, IIM Kashipur signed the MoU in the presence of S.K. Biswas, Director (Personnel), THDCIL. Dr. (Prof.) Rakesh Uniyal and Dr. (Prof.) Badhani were also present on this occasion.

THDCIL is one of the premier power generators in the country with installed capacity of 1513 MW with commissioning of Tehri Dam & HPP (1000MW), Koteshwar HEP (400MW) and Wind Power Projects of 50MW at Patan & 63MW at Dwarka in Gujarat to its credit.

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Inox Wind signs deal for SECI-1 100 MW capacity with Adani Green Energy

Inox Wind Limited, one of India's leading wind energy solutions providers, has closed a deal for developing a 100MW wind power project for Adani Green Energy, a part of the Adani group at Kutch in the state of Gujarat. The capacity was won under the round 1 of SECI bids for wind power projects connected on the central grid. The project is scheduled to be executed over the next 6-9 months and will be executed on a turnkey basis. Inox Wind will supply, erect and commission its advanced 2MW Wind Turbine Generators (WTGs) of 120m Hub height & 113m Rotor diameter. The 113 rotor diameter WTG has one of the highest swept areas that make it ideally suited to maximise returns in low wind areas. Inox Wind's Kutch site would become one of the largest wind farms in India post execution of capacities expected to be won in future rounds of SECI & state auctions.


Kailash Tarachandani

As part of the turnkey order, Inox Wind will be responsible from development and construction to commissioning and will provide long term operations and maintenance services.

Jayant Parimal, CEO, Adani Green Energy, said, "This order positions Adani Green Energy as the leader in India's wind energy sector in the auction regime. Due to the ongoing shift in the wind power sector, we are at a juncture where clean energy resources will define our future. With the aspiration to 'Thinking Big, Doing Better', Adani Green Energy has a well articulated growth plan to increase its renewable power capacity to 10,000 MW by 2021 and contribute to the country's growth and progress. Inox Wind has been our partner of choice and we are delighted to be working with them again."

Kailash Tarachandani, Chief Executive Officer of Inox Wind Limited, said, "We are delighted with signing the deal for 100MW of SECI-1 order with India's leading IPP, Adani Green Energy, at the Kutch wind farm in Gujarat. We believe that Inox Wind would be a major beneficiary in the auction based market regime, due to its inherent cost-competitive advantage and the upcoming SECI & State auctions will begin a new phase of robust growth for the wind industry critical for reaching the 60 GW wind power capacity goal by 2022 for the country."

KOR Energy (India) installs 100 KWp Grid Tied Rooftop Solar System at DPS, Varanasi

KOR Energy (India), a Solar Power Company has successfully installed a 100 KWp Grid Tied Rooftop Solar System at Delhi Public School (DPS), Chandauli Mohansarai Bypass Road, Varanasi. The project is a part of National Solar Mission and has a power generation capacity of 1, 45,000 units of electricity every year. It empowers the green power generation and provides efficient way for schools to meet their energy needs.


Sushil Kumar Sarawgi

KOR Energy has used Polycrystalline Modules of 315Wp which is manufactured by leading PV module manufacturer Vikram Solar and solar string inverters of ABB Group to ensure maximum yield and performance consistency. The system has remote monitoring of production that offers accurate fault recognition and real time performance monitoring.

The Solar system will have an additional benefit of net metering, which will result in receiving credit in electricity bill against the excess electricity generated by the solar system especially during off peak hours and school holidays. The payback period of installed solar system can be achieved in 4 to 5 years and the performance warranty of the whole system is of 25 years that makes the solar system investment a reliable and cost effective decision.

Sushil Kumar Sarawgi, Director, KOR Energy (India), said, "We are delighted to execute this project for a school and make a contribution towards realisation of our Prime Minister's commitment towards clean and green energy, through solar power generation. We constantly look at opportunities to exploit renewable energy sources. This is yet another milestone in our quest".

"We understand that solar is the need of the hour therefore our vision is to help India go green by empowering establishments through renewable energy technologies. Rooftop Solar System installed at DPS will produce approximately 12000 units of electricity resulting in savings of Rs 85000 per month to DPS. Thus, making it cost effective," Sarawgi further added.

Vikram Solar opens its office in China at Shanghai

Vikram Solar recently revealed the opening of a new office at Yan'an W Road HongQiao, Shanghai, China. This decision has been taken with a view to accommodate growth and leverage the region's technology talent pool.

In addition to the corporate headquarters in West Bengal, and branch offices across India, the company has international offices in Germany, USA, and Singapore.


Gyanesh Chaudhary

The new office in China has been opened with the aim to provide support to the company's growth strategy, and to serve as the Logistic and Procurement hub for its business. Located at Shanghai, the office will facilitate our presence both in China and the Asia Pacific region.

Gyanesh Chaudhary, MD & CEO, Vikram Solar, said, "The decision to expand our presence into China is a step towards our business growth strategy."


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Rays Power Infra successfully commissions 9MW solar PV plant in Karnataka

Further strengthening its foothold in Karnataka, Rays Infra Power commissions yet another solar PV Plant in the state, with a total capacity of 9MW. The project was assigned by Brewer Energy Private Ltd; incorporated in July 2014, the company is involved in production, collection and distribution of electricity. Relentlessly serving under the cause of solar power in India, Rays Power started the project execution in November 2016 and commissioned it in the first week of July 2017. The project was executed on turnkey basis right from land acquisition to commissioning.

Ketan Mehta, Chief Executive Officer, Rays Power Infra said, "We have a very strong hold in Karnataka and this is the 2nd project of Rays Power Infra in the state. With 6.5 km, 66 KV of transmission lines installed, the project has been setup with a single axis tracker & fixed tilt technology and will give

a very good estimate of the comparison of generation of both. Though, we faced few challenges with the land being highly uneven, the dedicated project team adopted corrective measures and the project was commissioned within the stipulated deadline."

Spread over 60 acres of land in Pavagada Village, Tumkur District, Karnataka., this project is commissioned under Karnataka Farmer's solar scheme.

Schneider Electric India sets up 'One Schneider' office in Indore

Schneider Electric, – the global specialist in energy management and automation, revealed the opening of its new office in Indore, Madhya Pradesh. The new office will offer a single window access to the vast range of offers, to all customers and partners in the region. Centrally located, the office aims to ensure best-in-class services and an enabling atmosphere for the employees.

S Nagarajan

The Indore office inauguration is in line with the company's plan to consolidate its presence across various cities in India. The office will be led by Revanand Andhale, Regional Sales Director, supported by Debasish Banerji, G.M. Sales- (Madhya Pradesh). The new premises is located at Dhan Trident Building, Vijay Nagar, A.B Road.

S Nagarajan, President- National Sales– Schneider Electric India, said, "The opening of our new office in Indore will enable us serve the energy management requirements of customers in the state, and address the requirements from the four end markets that support the EcoStruxure strategy of the company - Building, Data Centre, Industry and Grid".

Madhya Pradesh is one of the few states in India which is power surplus. Schneider Electric believes that this could enable higher industrial growth in the state which anchors industries like automobile, hardware manufacturing, financial services, pharmaceutical, textiles, hospitals, food processing, mines, etc. The organisation has a strong distribution network through channel partners in the region.

At the inauguration, Schneider Electric Team along with the channel partners present, pledged to continue their commitment towards maintaining the coveted acclaim of Indore being the cleanest city in India and in spreading awareness about sustainable energy management.

Tata Power launches Electric Vehicle Charging infrastructure in Mumbai

Tata Power, India's well known integrated power company has been a frontrunner in technology adoption and innovation while also setting benchmarks in sustainability. As part of its commitment towards sustainability and another green milestone, the Company has installed their first Electric Vehicle charging station at Tata Power Receiving Station at Vikhroli, Mumbai.

Tata Power's aim is to build a network to make it easier for people to adopt to EVs and be future ready. Such an adoption of smart charging infrastructure will help the country achieve its ambitious plan of mass scale shift to electric vehicles by 2030. Pioneers of this vision, Tata Power has taken this initiative of providing charging stations along with Mass - Tech Controls.

Anil Sardana, CEO & MD, Tata Power, said, "We are proud and happy with the launch of Electrical Vehicle Charging stations as Tata Power continues to set a high standard in adopting sustainable practices by using innovative technology, providing customers access to energy-efficient processes. We are moving towards clean power for all and it is our endeavour to provide

best of the solutions for our country to achieve a greener tomorrow".

These chargers would facilitate electric car users to charge their cars (Battery Electric Vehicles such as the Mahindra e2o, Nissan Leaf, etc) at any time safely and conveniently. The chargers can also monitor the car battery charging status and units consumed while charging a car.

The company plans to set up charging stations at various locations in Mumbai and is already in discussions with various stakeholders.

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ABB string inverters selected for new Chilean photovoltaic projects

ABB, a pioneer and leader in the development of innovative solar power conversion technology has signed a contract to provide ABB string inverters for two new photovoltaic power plants delivered by the Solek Group in Chile, with a total output of 6MW.

The projects, which are approximately 2x 3.5 MWp each, will be equipped with TRIO-50.0-TL-OUTD three-phase string inverters. The delivery of the technology should be complete by October 2017.

The Solek Group's pilot project – the Cuz Cuz power plant near Illapel, with a total installed capacity of 3.07MW – started to deliver power into the Chilean grid at the end of last year. Thanks to a high average solar irradiance, the sun is a very attractive source of renewable energy in Chile. Photovoltaic power plants have recently become one of the main areas of investment within the power industry in this country. This trend will continue in the years to come as the ENERGIA 2050, a Chilean government program, sets the goal of increasing the share of power from renewable resources by up to 60% by 2035. Both the Amaparo del Sol and Santa Laura projects will use single-axis trackers to achieve higher output, with their business model based on the market prices of electric power, not on feed-in tarifs. Given the optimum natural conditions, high solar irradiance, stable economy and growing demand for electricity in Chile, the project is globally one of the best investments within the field of photovoltaic power.

Drax starts planning process for battery storage and gas options on site

Drax recently gave notice to the Planning Inspectorate of its intention to consult on long-term options to repower up to two coal units to gas, and build battery storage at Drax Power Station.

Plans for gas on site were announced in June and are part of an ongoing research and development project. The options could create up to 3.6GW of new gas generation capacity and 200MW of battery storage. They are subject to a positive investment decision and would need to be underpinned by a 15-year capacity market contract. The upgrade would enhance Drax Power Station's flexible and responsive capability, and make Yorkshire the home of large scale battery technology. At this early stage in the planning process these figures represent the maximum parameters of the project.

These options would, if developed, increase Drax's ability to provide the flexible generation and grid support services Britain's electricity system will need as coal and other large power stations are turned off.

Andy Koss

Today's notice to the Planning Inspectorate is a step in developing these options as part of Drax's strategy to play a vital role in changing the way energy is generated as the UK moves to a low carbon future.

Drax expects to begin consulting on these options with local communities and national stakeholders over the coming weeks.

Andy Koss, CEO of Drax Power, said, "We are at the start of the planning process but if developed these options for gas and battery storage show how Drax could upgrade our existing infrastructure to provide capacity, stability and essential grid services, as we do with biomass. This would continue to keep costs low for consumers and help to deliver Government's commitment to remove coal from the UK grid."

Siemens builds eHighway in Germany

Siemens has been commissioned by the German state of Hesse to build an overhead contact line for electrified freight transport on a ten-kilometer stretch of autobahn. The line will supply electricity for the electric drive of a hybrid truck. Siemens originally presented its innovative 'eHighway' concept in 2012. The system will be installed on the A5 federal autobahn between the Zeppelinheim/ Cargo City Süd interchange at the Frankfurt Airport and the Darmstadt/ Weiterstadt interchange.

With this field trial, the eHighway will be tested on a public highway in Germany for the first time. Siemens will be responsible for the planning, construction and, as an option, maintenance of the system. The system is being built as part of the joint project 'Electrified, innovative heavy freight transport on autobahns' (ELISA) of Germany's Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). Hessen Mobil, responsible for road and transport management in Hesse, is managing the project.

The eHighway is twice as efficient compared to internal combustion engines. That not only means cutting energy consumption in half, but also significantly reducing local air pollution. The core element of the system is an intelligent pantograph on the trucks combined with a hybrid drive system. Trucks equipped with the system operate locally emission-free with electricity from the overhead line and automatically switch to a hybrid engine on roads without overhead lines.

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igus demonstrates safe energy chain systems for new cars at the IAA

Whether in seating systems, windscreen wipers or electric sliding doors, the electrification of vehicles is steadily increasing. This is due to the new requirements on the part of the vehicle owners as well as to trends in autonomous driving and e-mobility. At the same time, the stress on electronics in vehicles, for example, is also increasing with car sharing, which means that safe and reliable energy supply must be implemented. As an expert in high-performance plastics for moving applications, igus has developed appropriate energy chain solutions that guide cables safely even in the smallest of installation spaces.

According to a Forsa survey, one in three motorists spends more than an hour in the car on a business day. The trend shows that this figure will continue to increase in the coming years due to increasing mobility. The requirements of car drivers are also growing in terms of equipment in their own vehicle. The consequence is an increasing intelligent electrification of vehicles. Whether in window lifters, windscreen wipers, tailgates and cornering lights or in seat systems and sliding doors, control systems in the centre console, displays and loudspeakers. Current trends for the future, such as autonomous driving and e-mobility, also require more and more cables, and with it the need for safe and lightweight energy supply systems.

The electronic systems in the automobile nowadays have to withstand new stresses. In the globally growing car sharing concept, for example, the door must be unlocked autonomously by means of a chip before each journey. The requirements for autonomous door systems are therefore increasing from a standard 200,000 opening and closing cycles to 500,000 cycles. The number of seat and mirror adjustments per day also increases during car sharing and stresses the energy systems. A fail-safe and long-lasting guidance of the moving cables in very small spaces is therefore required. Here, the use of energy chains from igus is optimal.

At the IAA, igus will be showing, among other things, the e-chain E2 micro in Hall 4, Stand E23. This is specially designed for minimal installation spaces and is already used in electric sliding doors. Available in various sizes for a wide range of application scenarios in the automobile, from the windshield wiper to the tailgate, the E2 micro is optimally suited to ensure energy and signal supply lines safely.

Signing ceremony for the contracts of investment in OMC Power

Mitsui & Co., (Mitsui) has entered into a strategic partnership with OMC Power Private Limited (OMC), an Indian renewable energy service company, which is one of the largest mini-grid operators in the world. To commemorate this partnership, a signing ceremony was held on August 22, 2017 in India, which was attended by Managing Officer Yoshio Kometani (Chief Operating Officer of Infrastructure Projects Business Unit) of Mitsui & Co. and the co-founders of OMC (Chairman Sushil Jiwarajka, Vice Chairman & Executive Director Rohit Chandra and Managing Director Anil Raj). By this investment in OMC, Mitsui will enhance its foray into the distributed energy business.

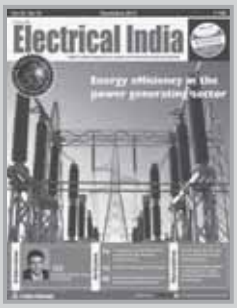
OMC generates power mainly using solar and supplies energy to rural areas via its mini-grids to anchor loads such as telecom towers, local small and medium enterprises and rural households, in areas with limited or no electricity access.

The source of energy in these areas is currently fossil fuel based, that is diesel and kerosene. OMC provides electricity to such areas with high reliability, affordable cost and with positive impact on the environment. This further contributes to reduction of CO_2 emissions and increased productivity, along with overall economic development of rural communities.

In recent years, India has experienced rapid economic growth, consequent to which the demand for electricity has been increasing. In the medium term, OMC aims to operate 1,000 mini grid based power plants (totaling to a generation capacity of 50 MW), which would deliver power to more than 1 million people. Mitsui intends to contribute to rural electrification in India through its investment in OMC as well as by joint project development with OMC, so as to capture the growth of Indian market. In additional to energy access for rural India, the strategic partnership also intends to provide value added services on the strength of availability of reliable electricity.

Mitsui & Co. Infrastructure Projects Business Unit COO Yoshio Kometani (fourth from left), Chief Representative of Mitsui & Co. in South West Asia Hiromichi Yagi (fourth from right) and OMC Chairman Sushil Jiwarajka (third from left) at the signing ceremony.

Mitsui and OMC's collaboration extends beyond India, covering Africa and other parts of Asia, where there is a strong demand for distributed energy access and rural electrification.



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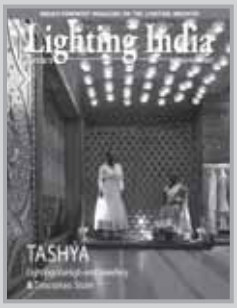

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R K Singh takes over as new Power & New Renewable Energy Minister

Raj Kumar (R K) Singh took over as new Union Minister of State (IC) in Ministries of Power & New & Renewable Energy. Piyush Goyal, New Railways Minister & former Power Minister were present to hand over the charge to Singh.


R K Singh

Singh said that there is lot of dynamism in the both Power & Renewable Energy Ministries which will be continued. He said that he would meet all standards of performance set by the predecessor and new Railway Minister, Piyush Goyal in the Ministries of Power and Renewable energy. The Country is now energy surplus and that the vision of the Ministries has been defined by his predecessor, he further added. He assured Goyal that the good work started by him will be completed and the Prime Minister's vision will be realised.

On the occasion, Goyal said he has inherited the finest team of officers in the Government of India because everybody in the Ministries and PSUs related to it is charged and emotional.

Goyal said the officials in Ministries as well as in its PSUs want to cross limitless boundaries. The PSUs are very committed. Talking about Singh, Goyal said that he has always concerned about providing electricity to all homes and under his leadership now the power & New Renewable Energy Ministries will achieve new benchmarks of performance and targets.

Schneider Electric appoints Emily Heitman to lead Energy Businesses in US & Canada

Schneider Electric, the global specialist in energy management and automation, revealed the appointment of Emily Heitman as Vice President of the Energy business in the U.S. and Canada.


Emily Heitman

As Vice President of Schneider Electric's Energy business, Heitman has profit and loss responsibility for medium voltage switchgear and energy solutions, while also developing and executing commercial strategies that drive growth and market penetration in the U.S. and Canada. Heitman joins Schneider Electric from the ABB Power Products Division where she was the Global Vice President, Marketing & Sales, Distribution Transformers. In this role, she was responsible for managing a global marketing team across 14 factories. Heitman also held product leadership and operations management roles at Cooper Industries. Heitman has a bachelor's degree in Industrial & Systems Engineering from Auburn University in Auburn, Alabama, and an MBA from Marquette University in Milwaukee. Heitman is based in Nashville, Tennessee.

Heitman will help Schneider Electric customers realise the benefits of EcoStruxure Power and the company's innovative, connected, reliable and efficient solutions, services and expertise. This will enable Schneider Electric customers to achieve top performance and reliability, while effectively controlling costs and reducing risk, transforming electrical infrastructure to respond to today's and tomorrow's needs. EcoStruxure Power improves power availability and safety in buildings by monitoring the entire network and boosting protection against shock, fire and explosion.

Technology veteran Martin Lynch joins Sunlink Executive Leadership Team

SunLink Corporation, a full-scope solar energy solutions provider, revealed the appointment of Martin Lynch as Chief Operating Officer (COO). In his new role as COO, Lynch brings more than 30 years' experience across hardware and software engineering, operations, finance, product strategy and talent development to scale and optimise SunLink's overall operations amidst the company's rapid growth and evolution into an energy solutions leader.


Martin Lynch

Prior to SunLink, Lynch was responsible for worldwide engineering program management and operations at Beamreach Solar where he oversaw silicon wafer and module manufacturing, global supply chain, quality and reliability for the $250M VC-funded commercial solar module manufacturer. Lynch previously held worldwide engineering and operations executive roles at Xicato, where he led the product strategy of integrating intelligent IoT systems and power regulation into commercial LED light modules for this manufacturer of high end LED light systems; and at 2Wire (now Arris International), a world leader in DSL gateway communications where Lynch expanded operations to meet 100 percent annual growth culminating with the sale of 2Wire for $475M. Lynch also served as VP Engineering for Maxtor's server products group where he transformed the storage product roadmap and technology for this Fortune 500 HDD manufacturer.

Lynch holds a Bachelor of Science degree in Electrical Engineering from Boston University and studied for his Master's in Business Administration at Villanova University.

BEL wins 4 PSE Excellence Awards

Bharat Electronics Limited (BEL) has been laying great emphasis on Research and Development right from the early years. It has also been able to successfully partner as production agency with many DRDO labs. From a meagre turnover of Rs 2 lakhs in 1956-57, BEL has grown manifold to record a turnover of Rs 7, 510 crore (provisional) in 2015-16.

Navratna Defence PSU BEL has won four PSE Excellence Awards 2016, instituted by the Indian Chamber of Commerce: first prize in the Maharatna & Navaratna category for Operational Performance Excellence and second prizes in the Maharatna & Navaratna category for R&D, Technology Development and Innovation, Corporate Social Responsibility & Sustainability and Corporate Governance. M M Joshi, ED (National Marketing), received the awards on behalf of BEL from T N

R Rao, former Petroleum Secretary, at the awards function held at New Delhi on September 7, 2017.

Dr. Rahul Walawalkar receives Renewable Energy India Award

Dr. Rahul Walawalkar, Executive Director of India Energy Storage Alliance (IESA) and President & M.D. of Customised Energy Solutions (India) receives the Renewable Energy India (REI) award in the category of Leading Crusader for Energy Storage Solutions at the ongoing Renewable Energy India Expo.

Dr. Rahul Walawalkar

Rahul is sixth and youngest individual to receive Jury's Award at REI. He joins a distinguished group which includes Dr. Pramod Deo, Former Chairperson, CERC (Lifetime Achievement), Piyush Goyal, Former Minister for Power and New and Renewable Energy (Transformative Leadership in RE), Dr. Upendra Tripathi, Former Secretary MNRE (RE Crusader of the year), Tulsi Tanti of Suzlon (Industry Man of the year) and Rana Kapoor of Yes Bank (Pioneer in RE Funding).IESA member companies namely Sterling & Wilson, Vikram Solar and CleanMax Solar also won REI awards in different categories.

REI awards are an initiative by UBM India to recognise and encourage industry players who strive hard to bring a sea change in India's renewable energy market with groundbreaking innovations and initiatives. These awards are conducted methodically to draw out the best in the industry, with a process driven robust approach with EY as the process advisors and a neutral jury which comprises of industry think tanks who have championed their respective domain expertise from various facets of the renewable energy sector. This award is latest recognition for Rahul and Customised Energy Solutions team.

Tohoku Electric Power awarded EEI'S 2017 International Edison Award

Tohoku Electric Power received the Edison Electric Institute's (EEI's) 2017 International Edison Award, the electric power industry's most prestigious honour. A panel of former energy company chief executives selected Tohoku Electric Power for the annual award from a group of distinguished finalists.

Tom Kuhn

Tohoku Electric Power earned the International Edison Award for its Shin-Sendai Thermal Power Station Replacement project. After a 2011 earthquake severely damaged the Shin-Sendai Thermal Power Station, the plant commenced commercial operation ahead of schedule. Additionally, the effort to rebuild has contributed to revitalisation and development in local communities affected by the earthquake. Tohoku Electric Power's work has reduced fuel costs and emissions and also has improved efficiency.

Tom Kuhn, EEI President, said, "Tohoku Electric Power's exemplary effort to rebuild the Shin-Sendai Thermal Power Station demonstrates our industry's commitment to customers and local communities throughout the world. Not only does this project reduce emissions significantly, it also created jobs that revitalised the local community."

High Voltage Cables & Accessories Market worth $40.90 bn by 2022

The global market is set to witness a significant growth due to the increasing investments in offshore wind, grid interconnections, and increase in power generation...

The high voltage cables and accessories market is expected to grow from an estimated value of USD 30.53 billion in 2017 to USD 40.90 Billion by 2022, at a CAGR of 6.02%, from 2017 to 2022. The global market is set to witness a significant growth due to the increasing investments in offshore wind, grid interconnections, and increase in power generation.

The XLPE cables segment is expected to hold the largest share of the underground high voltage cables and accessories market, by product type, during the forecast period.

XLPE (cross-linked polyethylene) cables are the most commonly used cables in underground systems. The cable technology gained a significant advancement which has enabled the use of XLPE cables over the fluid-filled cable technology. XLPE provides insulation to cables to make it withstand the electric field under rated and transient operating conditions. The XLPE cable was the largest segment in the underground cable systems market in 2016. The market in Asia Pacific is the largest market for XLPE cables segment because of the investments in the transmission and distribution sector, increasing power generation, and growth in offshore wind farms. All these factors are expected to boost the XLPE cables segment in high voltage cables and accessories market.

400 kV and above dominates high voltage cables and accessories market

The 400 kV and above segment held the largest market share under the voltage range segment in 2016. The linking of grids and transmission infrastructure between countries has resulted in the 400 kV and above segment accounting for the largest market share. These cables find applications in transmission and distribution, grid interconnection, and other energy industries.

Asia Pacific is dominant market for high voltage cables and accessories

The high voltage cables and accessories market has been analyzed with respect to five regions, namely, North America, Europe, Asia Pacific, the Middle East & Africa, and South America. Asia Pacific is the largest market for high voltage cables and accessories among other regions studied in this report. This region will continue to dominate the high voltage cables and accessories market, during the forecast period. China is the largest market for high voltage cables and accessories market in the region. Governments, private players, service providers, and cables and accessories manufacturers are also continuously trying to integrate their existing technologies and develop new ones extensively to meet the growing demand from this region. The high voltage cables and accessories markets in countries, such as India, Japan, and Malaysia are expected to grow at moderate rates.

To provide an in-depth understanding of the competitive landscape, the report includes profiles of some of the leading players in the high voltage cables and accessories market, such as, Prysmian S.p.A (Italy), Sumitomo Electric Industries, Ltd. (Japan), Nexans S.A. (France), NKT Cables Group A/S (Denmark), and General Cable Corporation (US). The leading players are trying to establish themselves in the markets in developing economies and are adopting various strategies to increase their market shares.

Impact of Solar PV Penetration on Grid

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Assistant Professor
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Ajit Kumar K
Senior Engineer
Renewable Energy Business Unit, Larsen & Toubro Construction

Renewable energy is gaining huge importance among all forms of energy resources and is being given emphasis and thrust across the globe. Climate change due to global warming and the depletion of fossil fuel reserves are two major challenges being right now faced by the planet earth. Immediate cut down in the usage of fossil fuel resources and reduction on its dependency are the need of the hour to bring down the emission of green-house gases and to secure the energy for the future. Switching to renewable energy is a promising solution for the present crisis.

The high cost of renewable energy electric conversion systems has been a main hindrance to its development till now. But in order to promote the renewable energy installations, the policies and regulations are being modified in its favor in all major countries. Also, due to the recent advancements in technology and research, the cost of renewable energy electric conversion systems has been continually decreasing with the most significant price drop being observed in solar, which is 80% over the last seven years. Solar energy (especially solar Photovoltaic (PV)) and wind energy are two major sources among the renewable energy resources which have been commercially well-established and are proven technologies for clean electricity generation. By the end of 2015, the global installed capacity of solar PV stood at 227 GW out of 785 GW of total renewable installations. The renewable energy based power generation is growing at a faster pace recently, especially, solar PV. It recorded a huge growth rate of 28% in 2015. The advancements in the field of PV panel manufacturing and the inherent advantages of solar PV over other sources and technologies have paved way for such a tremendous growth. The statistical projections indicate that the global solar PV installations will grow at even faster pace in the coming years. The situation is same in India which has set an ambitious target of 100 GW of solar power by 2022. But these renewable energy resources when implemented in large scale without any specialized controls is found to impact the

integrity, reliability and stability of the grid. Solar PV power penetration into the grid is on continuous rise and plants of order of hundreds of MW are coming up in India and at global level. The large upcoming utility scale solar plants are expected to behave similar to the conventional plants and support for managing grid stability. With such an extensive growth in the deployment of the solar PV, power system operators are expected to deal with a new set of issues due to the different nature of the generation. Hence, it is important to study and analyze the impact of the large-scale penetration of solar PV power into the grid.

In this article, the impact of large solar PV penetration on the steady state performance of the grid is discussed. The steady state bus voltages are the main parameters that are affected by the inclusion of the solar PV plants into the system. As a consequence, under-voltages or over-voltages may occur across the system, because voltages may either increase or decrease. This analysis helps in identifying the buses with high or low voltages and the buses with voltages closer to critical levels, thereby, preventive action can be taken. Hence, system reliability and stability can be improved and one can be assured that the system is operating within the permissible voltage limits. The variation in system losses, and real and reactive power loading of transmission lines at various penetration levels have also been examined.

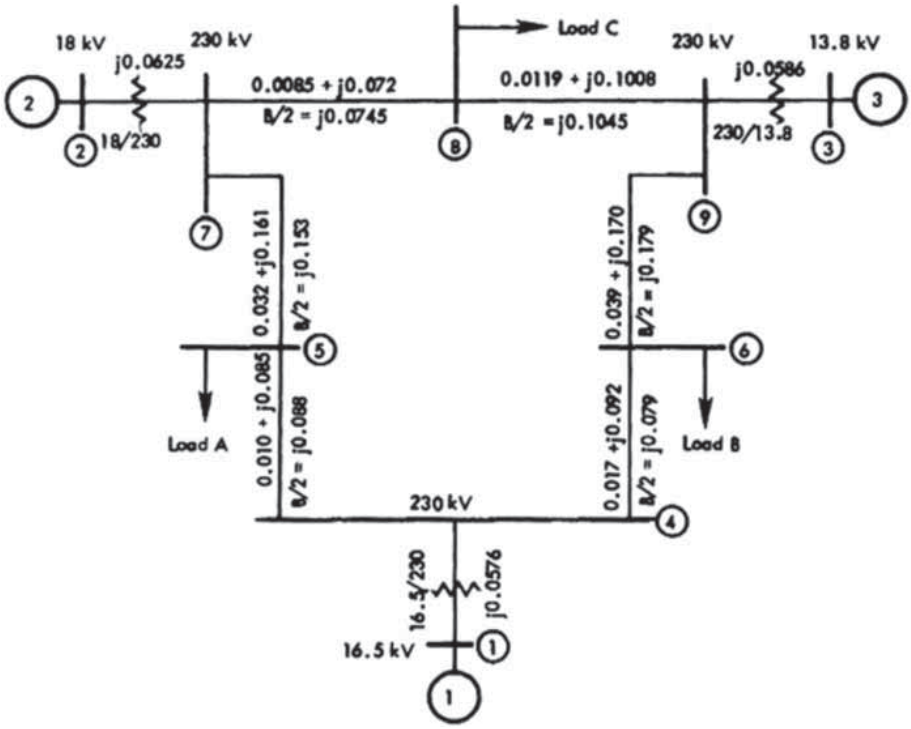

Figure 1: IEEE 9 – bus system single line diagram

IEEE 9-Bus System – Standard Bus System for Analysis

The IEEE 9-bus test system, which is also known as P.M Anderson 9-bus system, has been modelled in ETAP software. It represents a simple approximation of the Western System Coordinating Council (WSCC) system with 9 buses and 3 generators. Solar PV plant has been integrated into this system. The single-line diagram of the WSCC 9-bus system is as shown in Figure 1. The voltage levels and transmission line impedances are also indicated in the same. This test system also includes 3 two-winding transformers of 100 MVA each, 6 lines and 3 loads (135.532MVA, 94.45MVA, and 102.64 MVA). The base kV levels are 13.8 kV, 16.5 kV, 18 kV, and 230 kV.

Developing Model of Solar PV Plant Integrated to IEEE 9-Bus System in ETAP

The complete test bus system has been first constructed in ETAP. Then a model of a typical solar PV plant is developed with the help of PV array block. Many small PV panels of 200 Watt each have been combined in series and parallel

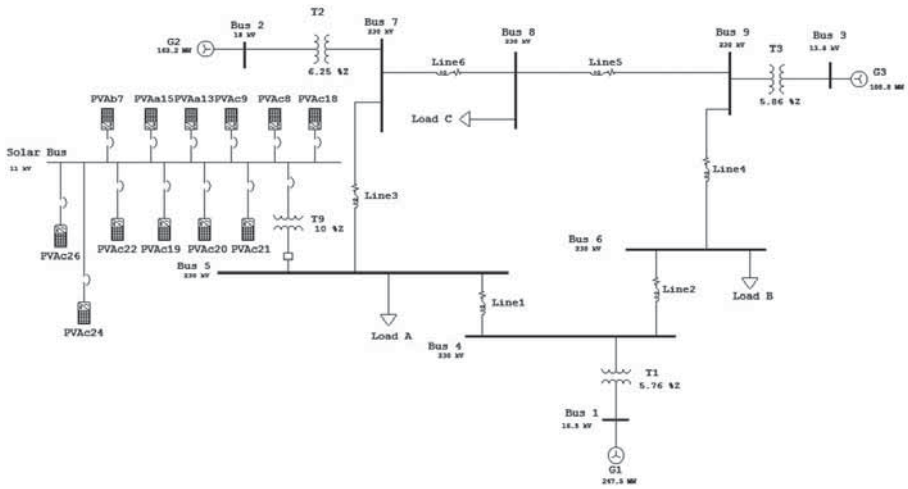

Figure 2. IEEE 9-bus system integrated with Solar PV plant

combinations to arrive at a PV array with a maximum power of 24.5 MW (MPP power) roughly and a DC bus voltage around 1000V (Vdc). Each of the PV arrays has an inverter unit with an AC rating of 11kV and 26.2 MVA roughly. Several such PV arrays have been created and pooled into a common 11kV bus called solar bus. The output of the solar bus is then given to a station transformer which steps up the 11kV generation voltage to 230kV, which would be suitable for penetration into transmission bus. Initially, this solar plant setup has been integrated into the Bus No. 5 of the IEEE 9-bus system as shown in the Figure 2.

Steady State Analysis

The IEEE 9-bus system model without solar integration has been considered as the base case with 0% solar penetration. Then solar plant has been integrated into bus-5 first as it has the largest load connected to it. The base case slack bus power (Generator G1) has been taken as reference for the calculation of solar PV penetration percentage. The power injected by solar PV plant into the grid through bus-5 is slowly increased from 0% till around 100% in steps of 10% approximately. Load flow calculation has been performed in each step and various parameters are noted. Steady state power flows in lines, bus voltages, generation details, and system losses were observed. The process is repeated with solar PV integration into other buses namely bus-8 and bus-6.

Effect of Solar PV Penetration on Steady State Voltages

Three different cases of solar PV integration namely penetration at bus-5, bus-6 and bus-8 have been considered for analysis. The bus voltages on all buses in the system have been observed. The complete bus data for all solar PV penetration levels from 0 MW till 243 MW are considered for all three cases. The bus voltages are plotted with respect to the penetration level. The bus voltages of 11kV solar bus is also indicated. Buses 1, 2 and 3 are excluded from the plot as they are constant throughout the penetration. This is because Bus 1 is modelled in swing mode and buses 2 & 3 are modelled in voltage control mode. The plots for all 3 cases are as shown in Figures. 3, 4, and 5.

As seen in plots of bus voltages, the voltage profile seemed to be improving initially as the solar penetration is increasing but it starts dropping beyond a certain percentage. Similar trend of voltage variation is observed in all three cases. The voltage starts collapsing as the solar penetration beyond a certain point causes the line drop to increase.

But the intensity of variation in voltages varied with the location of penetration. The maximum of the variation in bus voltages observed in all three cases is listed below,

- Case 1: 2.5% variation of voltage @Bus 5
- Case 2: 3.35% variation of voltage @Bus 4
- Case 3: 8.35% variation of voltage @Bus 5;

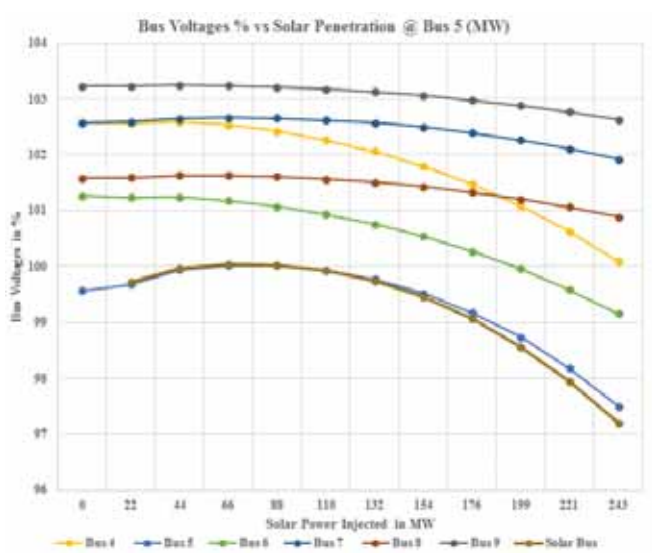

Figure 3: Plot of bus voltages at various solar penetration levels for case 1 (@ Bus-5)

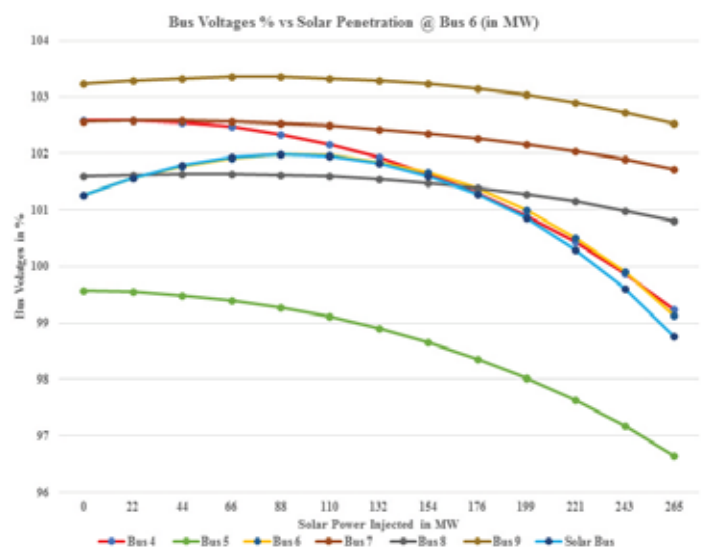

Figure 4: Plot of bus voltages at various solar penetration levels for case 2 (@ Bus-6)

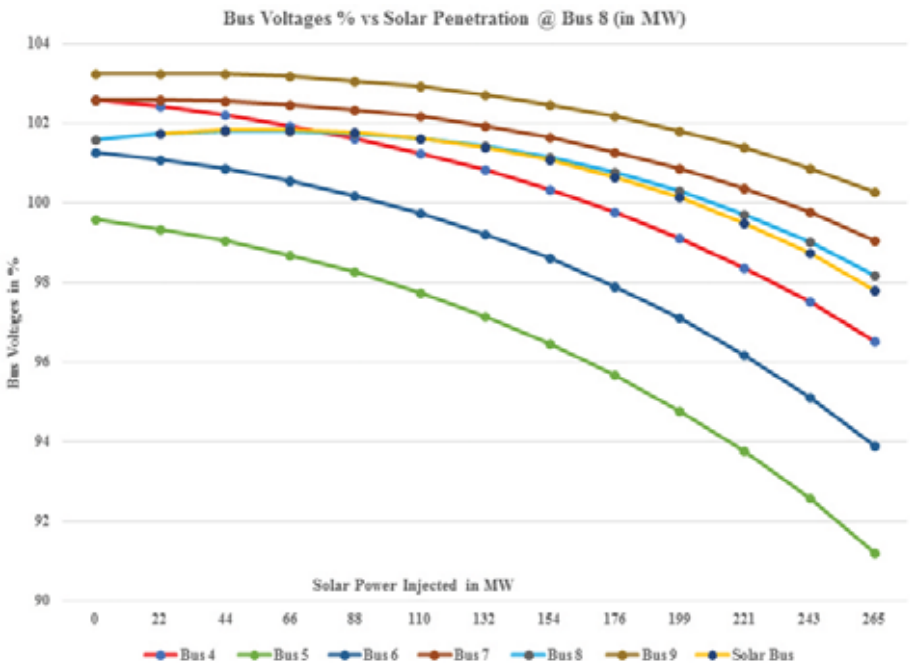

Figure 5: Plot of bus voltages at various solar penetration levels for case 3 (@ Bus-8)

The peak point of the curve also varies with the location of penetration. Hence, solar PV penetration into the system can only be allowed up to the point where the voltage profile improves. In case 1 the voltage in most of the buses seemed to be improving till about 30% and after that it collapses. In case 2 the voltage variation is little severe compared to the case 1, where in couple of buses the voltage started crashing right from the beginning. Also in this case at several instances the voltage were close to the under-voltage and over-voltage limits of the system. The case -3 was even severe with almost all bus voltages were starting to collapse right from the beginning and many voltages were close to steady state voltage limits. The variation was also severe compared to the other cases. Hence, it is seen from the study that among the three cases, PV injection at bus 5 was better as it allowed for more penetration with less severe variation in voltages.

Effect on the System Loss

The system losses in both MW (real power) and MVAR (reactive power) have been observed for all penetration levels as done for the voltages and has been plotted as shown in the Figures 6 and 7. Initially, the losses were decreasing till a point and started increasing for the penetration beyond that. In case 1 the losses were decreasing till about 20% and whereas for case 2 it was just about 10%. In case 3, the system losses were increasing right from the beginning. Similar trend was observed in case of the plot of the system losses in terms of reactive power i.e. MVAR. Optimal penetration level with respect to the system losses can be identified from the system loss profile and also the best location for penetration can also be identified from this analysis.

Effect on Transmission Line Power Flow

The real and reactive power loading of all the transmission lines existing in the network are observed and plotted for all penetration levels as shown in the Figures 8 and 9. This is observed for case 1. The variation in loading of the transmission lines was mixed with few lines experiencing increase in power and few line experiencing decrease in power. Few of the lines experienced even sign changes in the power flow causing the power reversal beyond a point. The changes in loading of line 1 is severe of all. Thus, it is very important to consider the impact of solar

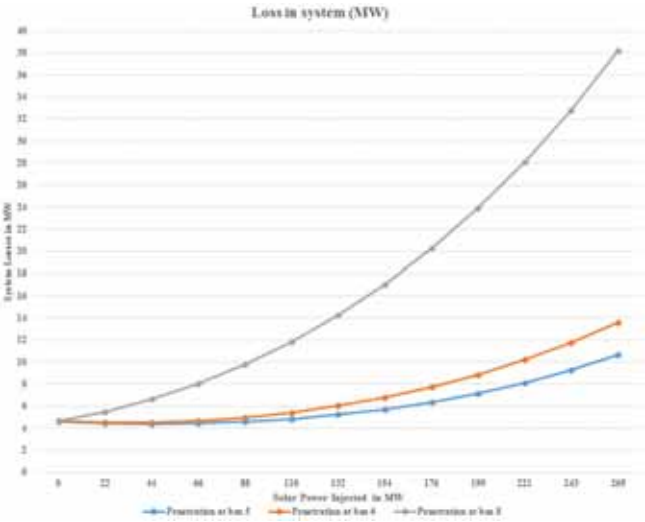

Figure 6: Plot of system losses in MW v/s solar penetration levels for injection at various bus locations

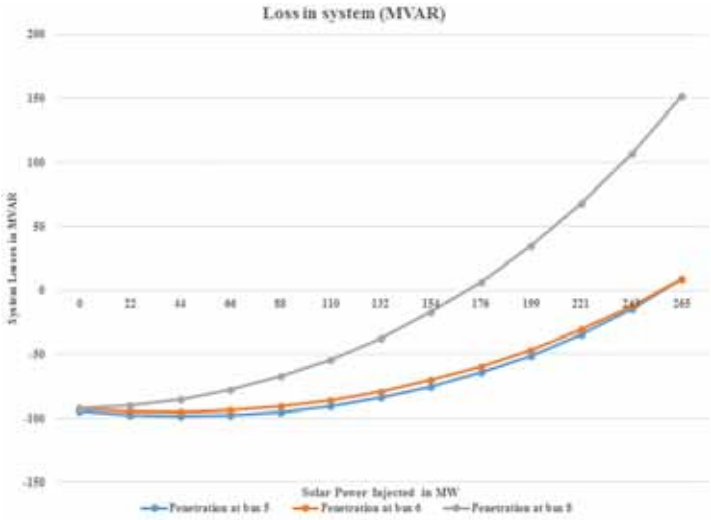

Figure 7: Plot of system losses in MVAR v/s solar penetration levels for injection at various bus locations

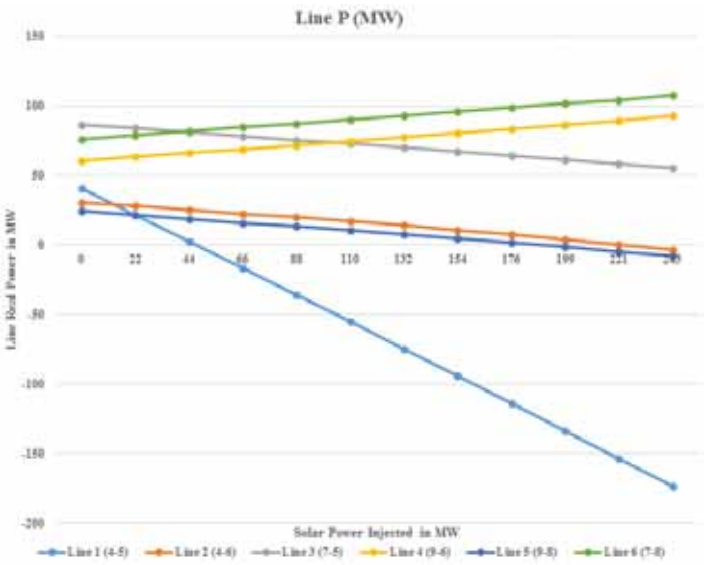

Figure 8: Plot of real power in transmission lines at various solar PV penetration levels

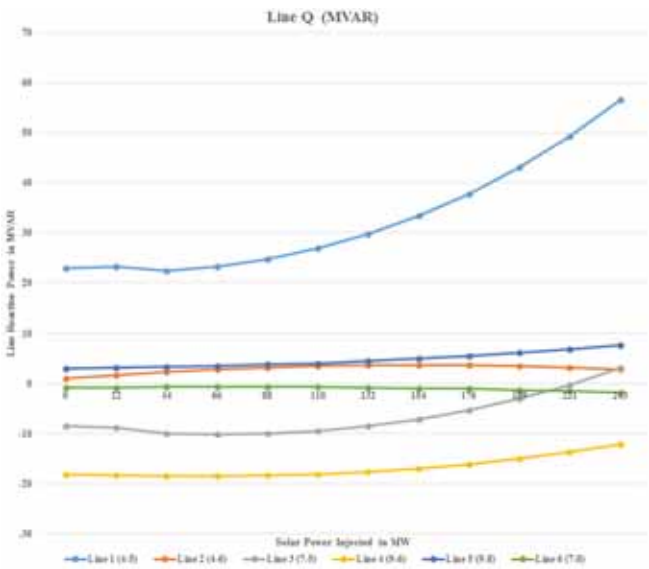

Figure 9: Plot of reactive power in transmission lines at various solar PV penetration levels

Table 1: Summary of Steady State Analysis

	Appropriate location	Maximum possible penetration
Based on bus voltage	Bus 5	66 MW
Based on system loss	Bus 5	44 MW

penetration on transmission line loading parameters while planning the network.

The summary of the case study is presented in Table 1. Increase in PV penetration can bring variations in steady state bus voltage levels and can be really critical at times and might even contribute to affecting the voltage stability of grid. Also, it might bring about severe changes into other parameters like steady state real power and reactive power loading of transmission lines and other equipment in the system and also affect the system losses. Hence, it is important in performing such a study, which will help engineers in planning the system with high penetration levels of solar PV power and in identifying the critical PV penetration levels for a given network.

Leoni Cable Manufacturing Facility at Pune

Electron beam cross linking machinery installed – superior cables for railway and solar applications

Leoni, the leading European provider of cables and cable systems to the automotive sector and other industries, has enhanced its location in Chakan/Pune, India. Today, the company inaugurated an electron beam accelerator, which allows to provide high performance cables to customers from various industries such as railway or solar.

"I am confident, that this major investment will contribute to the growth of our business in India. Thanks to the new technology, we are able to provide superior solutions for the country's rising needs with regard to the initiative 'Make in India'," states Bruno Fankhauser, member of Leoni AG's Board of Directors with responsibility for the Wire & Cable Solutions Division. India is an important country for the realisation of the company's globalisation strategy. The expansion at Pune will strengthen its leading position in the country and enable it to support India's economic development as well as generate employment opportunities both for the high skilled and well trained workforce in the Pune region.

Leoni has invested more than EUR 10 million into the expansion of its Pune location. Now, the combined production area has increased to more than 20,000 square meters and a capacity to manufacture 80,000 kilometers per year of electron beam cross linked cables, which ensure a higher degree of safety, superior performance and greater efficiency. In the e-beam process, Leoni treats its cables with extremely accelerated electrons, thus crosslinking their chemical structure. As a consequence, the cables obtain the properties of comparatively more expensive, usually more difficult to process high performance products. The e-beam process makes cables, for example, more dimensionally stable when subjected to heat, more resistant to chemicals, solvents and temperature fluctuation as well as harder and more resistant to abrasion.

Pushpendra Singh, Managing Director of Leoni Cable Solutions India Pvt Ltd comments, "This is the next phase of our evolution in India. We began to develop this market in 2010 with an engineering office and a manufacturing facility for automotive wiring systems. Since the opening of the Pune cable plant in 2013, we also have a strong foundation in the country with regard to special cables for dynamic industries like Railway, Solar, Oil & Gas etc. Leoni's new commitment will help us to further innovate and create beneficial solutions for India's economy. The Pune facility will drive synergies and economies of scale both for our domestic operations as well as exports."

Effect of Environmental Conditions on Performance of Solar Panels

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Prof D K Chaturvedi
Electrical Engineering Department, Dayalbagh Educational Institute, Agra,

This article shows a study of environmental defects generally occur in solar panels with their visualization methods. Some open environmental defects are visible by naked eye can be identified by by visual inspection. The effect of shading is one of the important factor considered in the condition monitoring of solar panels. The shading of tree on solar panels increase the temperature of solar panel surface, which is not visible in the photographs captured by normal camera. Such heat effects can be detected by thermal imaging camera easily.

The use of conventional sources of energy like wood, coal etc pollutes the environment and give rise to global warming. Sun is a renewable source of energy and is safe for the environment. Solar energy is one of the popular and efficient source of energy. It is obtained from the sun by collecting and converting the solar radiations into electrical energy. Solar energy is being utilized in several sectors like engineering, irrigation, medical etc and raising the overall efficiency of power generation. About $4\text{-}7kWh/m^2$ and $5x10^{15}kWh/m$ solar energy falls in India in a day and in a year respectively. About $3.6x10^{24}$ *Joules/year* total radiations are received by earth and environment. A solar cell is the smallest component in solar panels that changes the radiated solar energy into electrical energy.

These solar panels are installed in an open atmosphere and subjected to the environment directly. This direct contact of solar panels towards the environment develop certain defects in solar photo-voltaic panels. These defects are degradation, discoloration of solar panels, depositions effects like bird deposition, dirt and dust deposits on panel surface, shading effects, fault in solar panel components etc. Inspection of solar panels improves the health condition as well as the overall performance of solar panel and improve power generation. Thermographical techniques give best results for performance analysis of environmental conditions in terms of temperature analysis using thermal imaging camera.

Basics of Solar Cell and Panels

Solar cell is the basic element in solar photo-voltaic panel. When solar radiations fall on a solar cell, it absorbs the solar radiations and convert the absorbed solar radiations into the electrical energy. The figure 1 shows the equivalent circuit diagram of a solar cell.

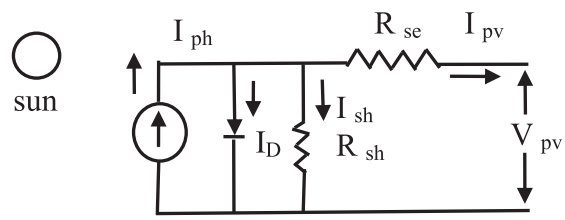

Figure 1: Equivalent circuit diagram of a solar cell

The output current $\mathbf{I_{PV}}$ of a solar cell can be written as

$$I_{pv} = Iph - I_O\left(e^{\left(\frac{V_D}{\eta V_T}\right)} - 1\right) - \left[\frac{V_{pv} + I_{pv}R_{se}}{R_{sh}}\right]$$

Where, **Vpv** is output voltage of photo-voltaic cell, **Iph** is photo-voltaic generated current/ photon current/ Insolation current/ current produced by Incident light, $\mathbf{I_0}$ is diode reverse saturation current/ leakage current of

diode, I_D is diode current/ Shockley diode equation, V_D is voltage drop across diode, Rse is series resistance, Rsh is shunt resistance, V_T is thermal voltage and is equal to (KT/q), K is Boltzmann constant, T is cell's operating temperature in kelvin, q is charge of an electron, η is Ideality factor of diode/ panel quality factor. The solar panels may be different types depending upon the photo-voltaic technologies used. These photo-voltaic technologies may be divided into the two types namely Crystalline silicon type and Thin film type. The Crystalline Silicon PV cells can be Mono-Crystalline and Poly-Crystalline PV Cells. Thin film PV cell consists of Cd Te (Cadmium Telluride), CIGS (Copper Indium Gallium Selenide), and a-Si (Amorphous Silicon). The fig. 2 shows a complete diagram of 72 cell Mono crystalline solar photo-voltaic module.

Figure 2: Monocrystalline solar photo-voltaic module

Method of Thermography

Infrared radiations were first discovered in 1800 by Frederick William Herschel, a German Astronomer. A thermal camera can detect the energy emitted as heat from any object, whose temperature is above absolute zero (-273°C). Thermography is a technique of converting infrared radiations into thermal images known as thermogram. It uses a thermal camera which captures thermal images without making a physical contact to the object. These thermal images known as thermograms, are the colourful patterns of the object representing the temperature.

Effect of Environmental Conditions on Solar Panels

Solar panels remain directly in contact with open environmental conditions, therefore, defects emerging in solar panels cause heat, affect solar power generation and reduces life of component. Some of these defects are visible by naked eye but some are not visible by naked eye. The visual effects of solar panel include corrosion of panel frame, degradation defects (cracking of the encapsulant surface, yellowing, browning of cells, delamination of cells, discolouration of cells etc), open circuit, short circuit, debridging, bubble and ruptures at back of solar panels. The effect of shadow of tree leaves, shadow of building, deposition of snow, dirt, dust, soil etc are not visible by naked eye but are one of the reason for other problems like hotspots, reduction in power generation in the solar panels. Today solar photo-voltaic systems are used in various fields like military field, medical/health care, civil, mechanical and aerospace infrastructure, electrical etc which need a continuous inspection against these defects in order to work in satisfactory and reliable manner.

The table 1 gives the description of visually identified degradation

Table 1: Visually identified environmental defects in solar panels

Components of solar panel	Defects in solar panel	Possible reasons	Effect of defects
Frame	Corrosion of frame and interconnect, deframing	Subject to open atmospheric effects(moisture, dust, detachment of sealing and adhesive between frame and panel parts.	Risk electric shock, reduced expected life
Glass surface	Cracking of transparent glass, soil deposition on panel glass surface	Mishandling, lack in maintenance, dusty and soily environment	Degradation of ARC (discoloration, delamination), corrosion of cells, possibility of electric shock, reduced power generation
EVA encapsulant	Yellowing	Degradation of adhesive material between glass and cell due to high temperature, UV and water exposure	Change in transmittance of light falling on solar cell cause reduction in power generation
Solar cells and bus bars	Discoloration (blue from purple), burn marks in bus bars	Poor EVA quality, high temperature, oxidation of ARC, heating of module parts to show burn mark	Reduction in energy generation due to less absorption of solar irradiance by discolored cell, discolor encapsulant by burn marks
Backsheet of solar module surface	Bubbles, rupture, chalking of back sheet	Release heat dissipation of cells from back surface at high temp., transportation or heating due to temp., due to thermal degradation and poor quality material of back sheet	Reduce life of cell, formation of hotspots, reduce performance of heated portion, less reduction in generated power, moister and risk of electrical shock
Junction box	Corrosion	Moisture due to loose sealing contact	Reduce life of junction box components
Table terms: ARC (Anti-reflective coating), EVA (Ethylene vinyl acetate)			

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defects found in various components in solar photo-voltaic panels. The table 1 systematically explains the common defects of various component in solar photo-voltaic panel, with possible reasons and their effects. First, it explains corrosion of frame, de-framing and defects arise during interconnecting of frame. Then problems due to glass surface are discussed like cracking of glass surface, soil deposition and its visual effects like discolouration of EVA etc. After then problems in EVA encapsulatant are discussed like yellowing with possible reasons and effect. Discoloration and burn marks of solar cells and bus bars is also being focused. Next the defects of back sheet of solar module like bubbles, ruptures are also explained. Finally, the defects occurring in the junction box of solar panel are also discussed.

Work to Study Condition of Solar Panels in Environmental Conditions

The experimental work performed to study the condition of solar panels in practical environmental conditions include two sections. First Section was to identify the environmental defects in solar panels using visual inspection i.e., the defects clearly visible by naked eye. The visual inspection involve physical identification of the environmental defects and capturing the normal camera photographs. The Second Section involves effect of shading of tree on solar panels power generation using a thermal imaging camera. Electrical measurements for power generation under no shade and under shade of tree are also done.

A. Visual Identification of Environmental Defects in Solar Panels

The visually inspected defects in solar panels are shown from fig. 3(a) to fig. 3(b). Fig. 10(b).

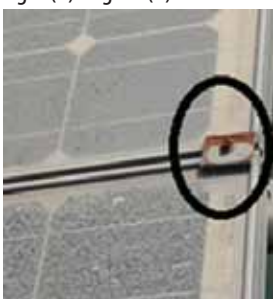

Figure 3(a): Corrosion on the interconnecting joints of solar modules

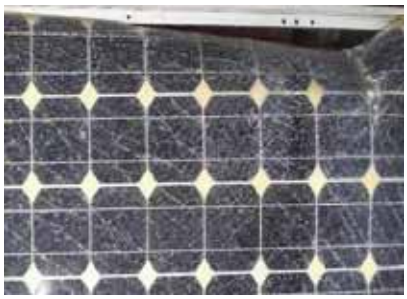

Figure 3(b): Deframing of solar module

Figure 4(a): Crack on a small part of glass surface

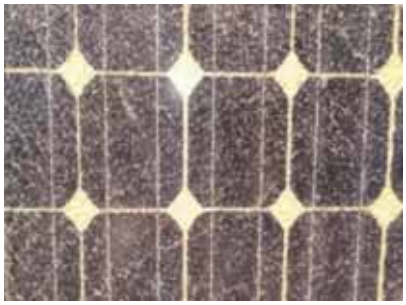

Figure 4(b): Cracking of the complete glass

Figure 4(c): Soil deposition on the solar module surface

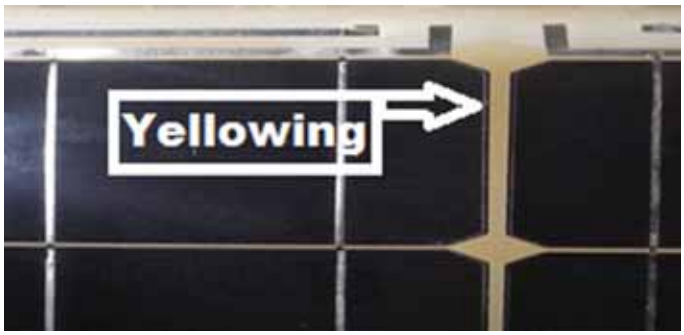

Figure 5: Yellowing of solar panel surface

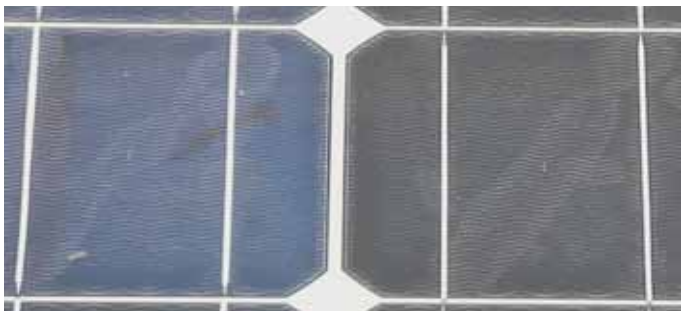

Figure 6: Discoloration of solar cell

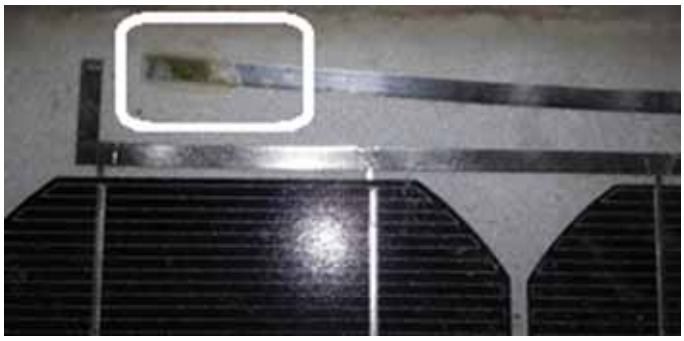

Figure 7: Burn marks on the bus bars

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Figure 8(a): Bubbles on the back sheet of solar module surface

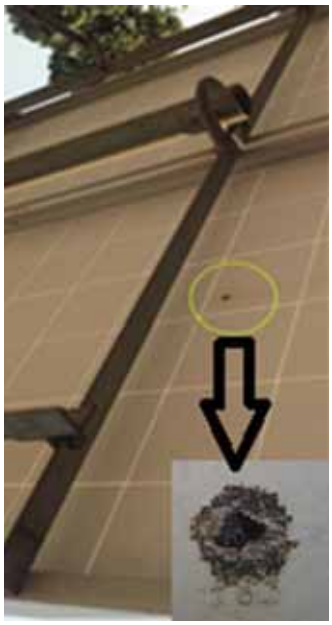

Figure 8(b): Rupture on the back of solar module surface

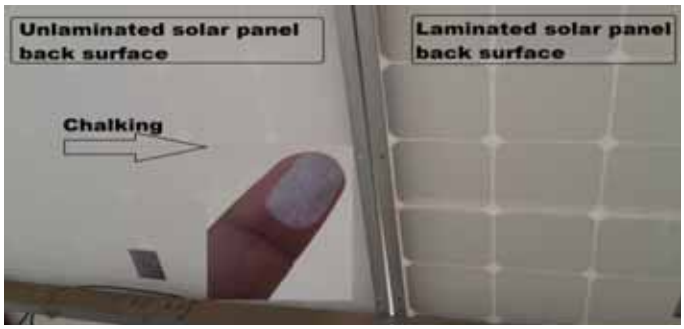

Figure 9: Chalking at back surface of unlaminated solar panel

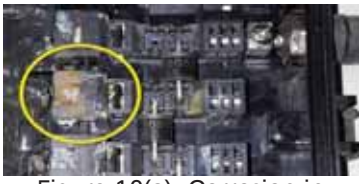

Figure 10(a): Corrosion in junction box

Figure 10(b): Moisture over the cover of junction box

The Fig 3(a) shows the corrosion on the joints used for connecting one solar module to another. Fig 3(b) shows deframing of solar panel frame. Deframing can occur due to ageing effect when solar panels are exposed to open atmospheric conditions.

Cracks of glass surface can affect the solar cell as well as bus bars. The glass surface defects are shown in the fig 4(a) and fig 4(b). The effect of a small crack at glass surface on solar cell can be seen in fig 4(a). The fig 4(b) shows the cracking of the complete glass surface. The soil deposition on solar panel surface can also be visualized easily. The fig 4(c) represents a heavy soil deposits on the solar module surface.

Yellowing is a common problem in solar panels. The Fig 5 shows yellowing of the panels due to the degradation of EVA (ethylene vinyl acetate).

The discoloration of solar cell is also one of the mostly occurred problem in solar panels. It is basically due to high temperature and oxidation of ARC (anti-reflective coating). The color of the solar cell changes from purple to blue. The change in color of solar cell allows to fall less amount of solar irradiance on solar cell, as a result less amount of energy is generated. Fig 6 shows the discoloration of the solar cell. The color of the left solar cell became less blue than the right solar cell which is dark blue.

When the temperature of a particular part becomes very high, then the hot area produce burn masks. Such burn masks on the bus bars can be seen in fig 7. It can affect the life of encapsulant if neglected or even not treated with a proper care.

There may be visual defects at the back sheet of solar modules. As the module back sheet allows to dissipate the heat of the solar cells, there may be a possibility of the emergence of bubbles. It occurs when some gases are released during the chemical reaction of encapsulant and creating an air chamber. The temperature of cell above the bubble becomes high because of less dissipation of heat. Rupture is an another defect exists in back sheet of solar module surface. It can be due to high temperature, mishandling of modules during transportation. Both bubbles as well as rupture affect the generation of power by a small amount. Fig 8(a) shows two bubbles on the back sheet of solar module surface and fig 8(b) shows a rupture on the back of solar module surface.

Generally, the back sheet of solar panels are laminated to get good finish, durability and safety against any other degradation defects. When the quality of back sheet material is poor or the back surface is rough, deposition of chalking is observed. Chalking is a white powder at the back sheet of solar panels commonly occurs due to thermal degradation or poor quality materials used at the back sheet of solar panels. It fails back sheet insulation and cause electrical shock also. The fig 9 shows two solar panels with unlaminated and laminated back surface along with chalking observed from unlaminated back surface. There may be corrosion in the junction box, situated at the back surface of solar module. The main reason of the corrosion of the junction box is the moisture. If the closing cover of the junction box is not fixed tightly then there are chances of corrosion. Fig 10(a) and fig 10(b) shows the photograph of the corrosion present in the junction box components and moisture on the outer cover of junction box. The corrosion may lead to reduce the life of the junction box components.

Effect of Shading on Solar Panels using Thermal Imaging Camera

Shading of tree, bird deposits, cement deposits, soiling are some of the environmental factors which cause reduction in power generation from solar panels in heat form. The heating of solar panels due to shade is not be visualized by naked human eye and can damage the affected area. Therefore, thermographical techniques are like thermography is used.

Effect of shading of tree: When shade of tree falls on solar panels, the solar cells under shade attain less solar irradiance as compared to unshaded solar cells therefore unshaded solar cells act as a load and draw power instead of supplying. This causes formation of hotspots on shaded areas of solar panel surface and release heat. The temperature of hotspot area becomes more which may damage the solar cell. The second important issue is regarding loss of power which is wasted during shading of solar cell. A lot of generated power is radiated in heat form when hotspots are formed during shading effect.

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- RS-RT worm gearboxes: 28 to 150 mm centres. One stage worm, helical/worm and double worm.
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- RN parallel shaft gearboxes: 180 to 3300 Nm. Two and three stages.
- RO-RV bevel/helical gearboxes: 180 to 3300 Nm. Three stages.
- RG precision planetary gearboxes: 10 to 230 Nm. One and two stages.
- VR dry friction speed variators: IEC63 to IEC90 1 to 5 stepless speed range, 300 to 1500 rpm.
- VS planetary speed variators: IEC71 to IEC112 1 to 5 stepless speed range, 200 to 1000 rpm.

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The measurements were performed on 25.04.17 at the roof of a library building in faculty of engineering of Dayalbagh Educational Institute Campus over which solar array was installed with facing towards south. The library building is surrounded by trees in plenty on eastern side and few on western side, there was a building on north side. The table 2 shows detailed configuration of complete solar array consisting of four strings of solar panels.

Table 2: Configuration of solar array

No. of Strings (S1, S2, S3, S4)	No. of Solar Modules
String 1(a+b+c)	6+6+6=18
String 2	18
String 3	18
String 4	18
Solar Array (4 strings connected together)	72

The shade of tree falls on solar panels after 2.00 pm, so two cases were formed:

Case 1: Thermal method with no shade of tree on solar panels

Case 2: Thermal method with shade of tree on solar panels

For case 1, the measurements were performed at 10.30 am when there was no shade on solar panel surface. Normal camera photographs and thermal images were captured along with other thermal and electrical parameters. For case 2, measurements were performed after 2.30 pm when shade of tree covers almost half portions of solar panel string 1, string 2 and string 3. String 4 is free from shade. Therefore, solar irradiance of string 1 and string 2 is low as compared to string 3 and string 4. Normal camera photographs and thermal images were captured with electrical parameters. The fig. 11(a) to fig. 11(h) and fig. 12(a) to fig. 12(h) show normal camera photographs and thermal images of solar panels for two cases considered above. The thermal images show areas of heating with maximum temperature, minimum temperatures on scale.

Case 1: Thermal images with no shade of tree for string 1, 2, 3, 4 respectively


Fig. 11(a)


Fig. 11(b)


Fig. 11(c)


Fig. 11(d)


Fig. 11(e)

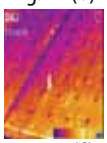
Fig. 11(f)


Fig. 11(g)

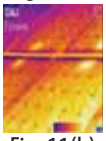
Fig. 11(h)

Case 2: Thermal images with shade of tree for string 1, 2, 3, 4 respectively


Fig. 12(a)


Fig. 12(b)


Fig. 12(c)


Fig. 12(d)


Fig. 12(e)


Fig. 12(f)


Fig. 12(g)


Fig. 12(h)

Fig. 11(a) to fig. 11(h) shows normally captured photographs for string1, 2, 3, 4 respectively under no shade of tree, fig 12(a) to 12(h) show normally captured photographs for string1, 2, 3, 4 respectively under shade of tree.

The fig 11(a), fig 11(b), fig 11(c), fig 11(d) are the normal photographs of string 1, string 2, string 3, string 4 respectively under no shade of tree i.e., for case 1. The fig 12(e), fig 12(f), fig 12(g), fig 12(h) are the corresponding thermal images showing high temperature represented by bright color. The fig 12(a), fig 12(b), fig 12(c), fig 12(d) are the normal photographs of string 1, string 2, string 3, string 4 respectively under shade of tree i.e., for case 2. The fig 12(e), fig 12(f), fig 12(g), fig 12(h) are the corresponding thermal images showing low temperature represented by dark color with hotspots clearly visible.

Electrical measurements for shading effect of tree

To study the effects of shade of tree on solar panels more precisely the corresponding electrical parameters were measured along with thermal measurements, which include output current, output voltage and output power of complete solar array. Table 3 shows electrical parameters for case 1 and case 2.

Table 3 Electrical parameters under no shade and under shade of tree for solar array

Parameters		Case 1: With no shade on solar panels	Case 2: With shade on solar panels
Date & Time		25.04.17, 10.30 am	25.04.17, 02.30 pm
I_{Output} (A)		16.24	3.76
V_{Output} (V)		440	497
P_{Output} (kw)		7.14	1.86
$T_{Ambient}$ (°C)		35	39
Solar string operating Temp (°C)	T1	45	40
	T2	46	41
	T3	48	40
	T4	47	40
Solar Irradiance (W/m2)	I1	161	74.8
	I2	151.3	84.6
	I3	158.5	117.4
	I4	163.2	116.8
Humidity (%)		25	25
Pressure (K Pa)		100.8	100.6
Wind speed (m/s)		NW 4.6	W 5.7
UV		9	8
Visibility (km)		6	6
Shade status		No shade on solar panels	Shade of tree on solar panels
Hot spots observed		No	Yes
Weather status (dry/ wet/rain)		Clear sky	Cloudy sky

Table 3 shows that the output current as well as output power of solar photo-voltaic array reduces as solar panels come under the shade of tree. It also shows individual temperature, solar irradiance of solar strings with

atmospheric parameters. Hotspts were noticed for solar cells which are shaded by tree showing loss of generated solar power in heat form

The fig 13 and fig 14 show the bar chart for operating temperatures, solar irradiance for four string with no shade of tree and with shade of tree respectively.

The fig 15 shows bar chart of the output current and output power of solar array with no shade of tree and with shade of tree respectively showing reduction in output current and output power of solar array due to shading effect of tree.

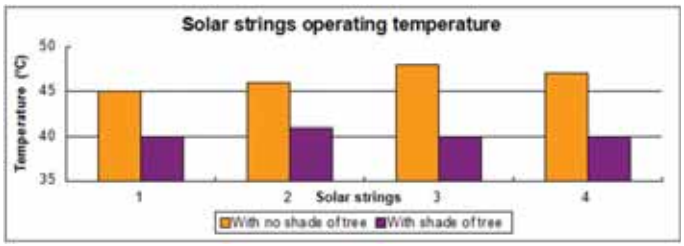

Figure 13: Operating temperatures of four solar strings with no shade of tree and with shade of tree

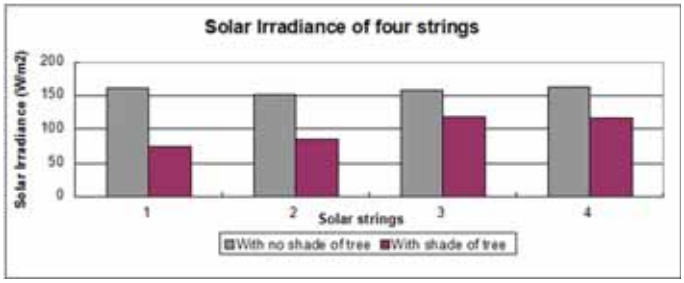

Figure 14: Solar irradiance of four solar strings with no shade of tree and with shade of tree

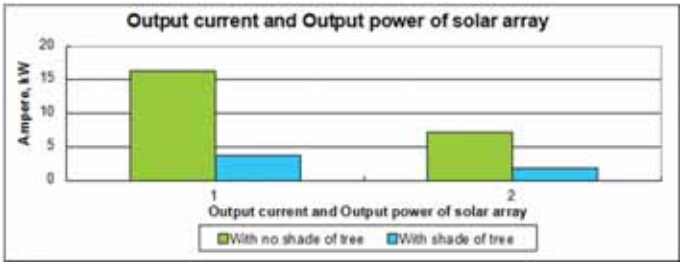

Figure 15: Output current and output power of solar array with no shade of tree and with shade of tree

Conclusion

This paper shows a study of environmental defects generally occur in solar panels with their visualization methods. Some open environmental defects are visible by naked eye can be identified by visual inspection. The effect of shading is one of the important factor considered in the condition monitoring of solar panels. The shading of tree on solar panels increase the temperature of solar panel surface, which is not visible in the photographs captured by normal camera. Such heat effects can be detected by thermal imaging camera easily. The shading of tree on solar panels affect the power generation of solar panels, therefore, thermal analysis of solar panels with no shading and with shading is also included by formulating two cases. So a comparison is obtained between case 1 and case 2 with the help of normally captured photographs and thermal images to show how shadow of tree affects the generating power of solar panels. The bar charts shown in fig 13 and fig 14 represent variation of operating temperature, variation of solar irradiance for solar panel strings 1, string 2, string 3 and string 4 respectively. The shading of tree give rise to hotspots and causes heat and reduction of generated power as shown in fig. 15.

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"Govt is the keystone for success of solar industry in India"

Leveraging over 450 Megawats (MW) of consulting portfolio experience, RaysExperts has been an active player in the solar industry and has emerged as a leader. Due to shortage of non-renewable sources of energy, solar energy sector of India has been growing rapidly since past few years, mainly due to government initiatives, informs **Rahul Gupta, CEO, RaysExperts in an interaction with Electrical India...**

Can you please take us through the journey of RaysExperts?

RaysExperts began its journey from hostel rooms of IIT Roorkee as a consultancy service. I was in final year studying civil engineering at IIT Roorkee. After deciding officially to constitute a private limited company as Rays Power Experts Private Limited, I envisioned setting up a 5MW solar power plant at young age of 22. This was a humble start to what will become Poster Company of Indian solar dream.

Architecting the concept of India's first Private Solar Park, RaysExperts established its first solar park in Kolayat village of Bikaner district in Rajasthan. Within a span of just six years, the company has become one of the emerging solar companies of India. RaysExperts has been ranked in the top 10 solar companies of India by Bridge to India in Ground Mounted EPC, Ground Mounted Open Access, Rooftop Project, Rooftop EPC categories. Today, RaysExperts has established more than 230MWs of solar plants across India. RaysExperts has developed more than 600 acres of private solar farms. Their clientele includes both government and private sector.

What are the services catering to the solar sector offered by the company?

RaysExperts serves to both ground mounted and rooftop segments offering services. Key segments are:

- EPC Services
- End-to-End Solar Project Development
- O&M Services
- Rooftop Solar

The government has set the target of generating one lakh MW of solar power by 2022. What kind of opportunities will it generate for the Indian solar sector?

India is ranked number one in terms of solar electricity production per watt installed. Due to shortage of non-renewable sources of energy, solar energy sector of India has been growing rapidly since past few years, mainly due to government initiatives. India took a long jump in solar sector; six years back India was at 10MW installed capacity. Now, it is more than 8,000 MW. This rapid growth is expected to continue in the future. This will generate ample opportunities:

- The solar sector will expand itself by 10,000 times in just 12 years. From 10 MW in 2010 to 100,000 MW in 2022
- Massive employment generation across all income segments
- Huge growth for localized businesses dealing in equipment, hardware, machinery etc
- Huge growth potential for service providers like welders, pilers, fencers, security agencies, contractors etc across India
- Biggest ever opportunity for finance sector to grow by leaps as USD 100 bn would be needed to reach 100 GW. This will also add up in the national GDP

With this target, what kind of potential do you envisage for your company?

We have always seen the growth of Indian Solar & RaysExperts in parallel frames. With this mammoth target, opportunities to become leader of the sector are ample. With the right approach towards the ever changing scenario of falling tariffs, falling panel prices & rising competition, it is a tough task.

We hope to become the largest solar company in India with an aim to become the most widely respected practitioner of solar industry. We have a solid foundation, a thrilling momentum and we hope to fire it up.

What are the challenges faced during setup of a solar park? How do you manage financial closure for the project?

When we set out to set up our first solar park, the challenges were like a big mountain. There was practically nothing to begin with. No practical knowhow, no land, no skilled labor and biggest of all - no investment. We travelled to Rajasthan in scorching heat to find land. After a few attempts, we ended up convincing local people of Kolayat to give up their land on sale or lease.

On a parallel front, the hunt for investor was progressing. We had a consultancy background which became RaysExperts. One of leads worked and the investment was arranged. While the construction was going on, we even faced opposition from the local unions & sarpanchs for not employing labor from the local villages.

The supply of materials was also a big issue. Our first solar park was set up in Bikaner. At that time in 2011, there was no readily available infrastructure in Bikaner to set up solar parks. We had to depend on Delhi market for the supply of materials, equipment and service providers.

Acquiring land for solar park is the biggest bottleneck. How do you tackle this issue?

A business is successful because all involved stakeholders enjoy its success. It is true that despite being such a large country, acquiring land for harnessing solar power is tough.

At RaysExperts, we have constantly worked on innovating financial models around buying or leasing land enabling us to effectively source land directly from its owners. As of today, RaysExperts has around 500 acres of land acquired in different parts of the country.

We have also used technology around defined process sets to optimize the time taken to make a land pocket solar ready and makes installation process faster and efficient.

What are the projects under implementation? What is the target for this fiscal?

There are many projects under implementation right now. We are a technology driven company and thus, we always need to improve ourselves. Apart from setting up new solar plants in Haryana, Madhya Pradesh & South India, we have also scaled up the rooftop business last year.

> India is ranked number one in terms of solar electricity production per watt installed. Due to shortage of non-renewable sources of energy, solar energy sector of India has been growing rapidly since past few years, mainly due to government initiatives.

During the year 2016-17, we were ranked 5th largest Project Developer in OA category and 7th largest in the Rooftop category in India installing a total of more than 100 MW. This fiscal, we aim to add a total of 200 MW combined capacity in Rays Solar Parks, Outside Solar Parks, Captive & Rooftop Projects.

What is impact of WTO ruling against India's domestic content requirement (DCR) on the sector?

The impact of this ruling came as a threat to India's local solar panel manufacturers. Some countries were able to sell panels in India at a lower than domestic price, solar imports of India surged to top 90% of the total imports. This resulted in falling solar prices and cost of panel fell by 40% in just three quarters. This leads to lower than ever solar tariffs (Rs 2.44/Unit) which in return caused a down wave in the Indian solar industry.

The events that followed after the ruling came against India's DCR lead to a hesitated mindset of investors and project developers. If you do the maths, such low tarrifs will drastically reduce the profitability of solar projects which can lead to thinner profits and cutting corner practices. The bright side is that this has forced entire industry to innovate and coming up with magically different business models to keep up with the constantly evolving market dynamics.

The Government has up-scaled the target of renewable energy capacity to 175 GW by the year 2022 which includes 100 GW from solar, 60 GW from wind, 10 GW from bio-power and 5 GW from small hydro-power. Going ahead, can India become a renewable energy hub?

India is already a renewable energy hub since decades being the first country to setup the Ministry of Non-Conventional Energy sources. Other countries look up to us for making their policy frameworks.

> Looking at Indian GDP growth alongside solar industry growth: Currently, India imports 90% of its solar panels from China / Malayasia. So much imports of solar panels is harmful for local industries as well as national GDP.

India is ranked number one in terms of solar electricity production per watt installed; Number one market in Asia for solar off-grid products; All the major rivers in the country are dammed and are producing power. Considering India has one of the most complex river systems in the world, we are already doing great. Though there are areas where we lack too like ethanol blending, electric cars etc, there is a lot of positive hope for the future.

With acute participation from people of India and effective regulation by the Government of India, we can become world's largest renewables based economy.

What are your expectations from the government for this sector?

Stating that government is the keystone for the success of solar industry in India will be an understatement. Government is the ideator, incubator and influencer of the solar dream.

For fact, during early 1980s, India became the first country in the world to officially set up a department of Non-Conventional Energy under the Ministry of Energy which later became Ministry of Renewable Energy in 1992.

Government has pushed the bar by introducing a formal framework of policies, incentives and regulations in the industry. But to meet the target of 100GW by 2022, a lot more needs to be done at a lot faster speed. We can broadly classify expectations from government under following heads:

- Strict implementation of policies & introduction of penalties for non-compliance of regulations. It will allow for a steady foundation for the solar industries to thrive.
- Looking at Indian GDP growth alongside solar industry growth: Currently, India imports 90% of its solar panels from China or Malayasia. So much imports of solar panels is harmful for local industries as well as national GDP.
- Enabling *Make in India* in solar by pumping finance infrastructure: As of today, India's largest solar manufacturer has the capacity of producing 300 MW in a year which is seven times less than the top Chinese solar panel manufacturer.
- Long term, politically agnostic policies: Government has to understand that changing leadership shouldn't affect the growth of Solar.

Finance Infrastructure: Solar financing is still a big problem to solve. Without the support of the government, this problem can never be solved.

ABB to acquire GE Industrial Solutions

Shaping leadership in electrification...

ABB announced the acquisition of GE Industrial Solutions, GE's global electrification solutions business. GE Industrial Solutions has deep customer relationships in more than 100 countries and an established installed base with strong roots in North America, ABB's biggest market. ABB will acquire GE Industrial Solutions for $2.6 billion; the transaction will be operationally accretive in year one. ABB expects to realize approximately USD 200 million of annual cost synergies in year five, which will be key in bringing GE Industrial Solutions to peer performance. As part of the transaction and overall value creation, ABB and GE have agreed to establish a long-term, strategic supply relationship for GE Industrial Solutions products and ABB products that GE sources today.

"With GE Industrial Solutions, we strengthen our Number 2 position in electrification globally and expand our access to the attractive North American market," said ABB CEO Ulrich Spiesshofer. "This combination brings together two global businesses with a broad complement of electrical protection and distribution assets," said John Flannery, CEO, GE.

GE Industrial Solutions will be integrated into ABB's Electrification Products (EP) division, resulting in a unique global portfolio and very comprehensive offering for North American and global customers. They will benefit from ABB's innovative technologies and the ABB AbilityTM digital offering coupled with GE Industrial Solutions' complementary solutions and market access. Included in the acquisition is a long-term right to use the GE brand. ABB will retain the GE Industrial Solutions management team and build upon its experienced sales force. After closing, this transaction will have an initial dampening effect to EP's operational EBITA margin. Tarak Mehta, President of ABB's EP division, said, "This acquisition strengthens our position as partner of choice for electrification globally and in North America. We look forward to working with GE Solutions' and ABB's customers and partners to create new opportunities in this attractive core market for our division. We have a clear integration plan to realize the synergies of this combination."

Honeycomb System as a Strain Relief for Cables

igus introduces another world first: Universal strain relief saves engineering and assembly time

World first: The new honeycomb-shaped strain relief keeps cables and hoses safe and sound in motion. As a vertical or horizontal version, it can be used universally and assembled in just a few seconds.
(Source: igus GmbH)

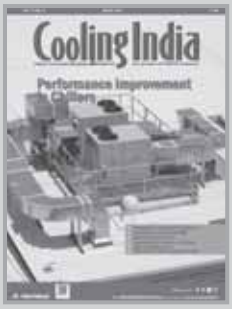
Cable tiewraps play a predominant role in strain relief today. Every individual cable is fixed to an e-chain, which is often a job consuming a lot of time and space. Cable tiewraps are used quickly and can often only be used once. The company igus revolutionises the strain relief in the e-chain with the bionically inspired honeycomb system. This saves the designer's engineering and assembly time.

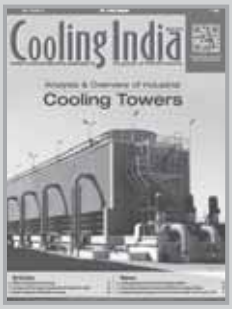
The motion plastics specialist igus has now developed a unique strain relief system with a honeycomb structure for its energy supply systems. Cables and hoses can simply and gently be pressed into the honeycomb. It is then closed, whereby the outer walls of the honeycomb cavities are pushed gently but extremely tightly around the cables. In this way, the structure simply adapts to the cable diameters. The honeycomb can be mounted in seconds; in comparison to the often used cable tiewraps or other strain relief solutions, the user saves about 80 percent assembly time. The new system saves space and protects the cables in the e-chain. It is also much more flexible, as the system is easy to open, to insert new cables or to replace them.

The universal strain relief system is available in two versions. The horizontal strain relief CFU.H can be installed in layers. It allows the insertion of different cables in one layer. It is screwed from above in front of the mounting bracket and can also be used for long travels at the fixed end. The vertical version CFU.V can be simply hooked on in front of the mounting bracket. Different cables are simply inserted into the vertical rows. The system is tightly closed with a clip lock and thus protects the cables reliably against mechanical stress. The two versions of the new strain relief are available for the e-chain series E4.1L from summer this year.

New strain relief and separators make the E4.1L the fastest harnessed e-chain

The new honeycomb system is part of an innovation campaign for an even faster and simpler harnessing of e-chains. With the E4.1L, igus offers the most easy-to-fill e-chain on the market. Thanks to the innovative separator system, which was also presented by igus at the 2017 Hannover Messe, a custom interior separation of the energy chain is made still easier for the customer. Furthermore, the new strain relief gives the designer the freedom to insert the cables into the E4.1L precisely as and when he wants it in his own design process – and also the possibility to change this filling again without complication.





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'Smart LED' venture iBahn launched

Aims to be a `5,000 million company in 6 years

Rajeev Chopra, former Philips India CEO and former Global CEO, Business Group Home, Philips Lighting BV, has announced the launch of a Smart LED Lighting venture - iBahn Illumination. The company has been formed along with the core leadership team that includes Arjun Shahani, Kunal Chaudhuri, and Sudeshna Mukhopadhyay. A brainchild of the team that pioneered LED Lighting in India, iBahn, which has raised its first institutional round of funding from Sequoia India, aims to disrupt the market with its brand of 'Smart LED Lights,' Svarochi.

Announcing the launch, Rajeev Chopra, Co-Founder & CEO, iBahn Illumination said, "Our aim is to disrupt the market by offering a range of smart LEDs based on Bluetooth Mesh technology, which will enable users to control the intensity and colour of their lights through our easy to use smartphone app. We believe the 'Smart LED' market is likely to be a `40,000 m ($600m) market by 2022. Our brand 'Svarochi' will offer innovative products that are high on functionality, easy to use, locally relevant and affordable."

Speaking on the market scenario, Arjun Shahani, Co-Founder & COO, iBahn Illumination, said, "We envision that Smart LED Home Lights in India will replace 'standard' LEDs in the next 10 years. We are looking to leverage the team's track record in execution and driving innovation at affordable costs to revolutionize the market, and have greater adoption of Smart LEDs in India."

Abhay Pandey, Managing Director, Sequoia Capital India Advisors, said "Smart LEDs are the next frontier in lighting solutions. iBahn has identified a massive opportunity that exists in the LED Lighting market today and created a product that is easy to use and very locally relevant. Sequoia India is excited about partnering with this team in a high potential market."

'Svarochi' is a Sanskrit word which means "brilliant appearance" and "own ray". Svarochi Smart Lights aspire to make spaces beautiful creating the perfect lighting effect for every room and every occasion using your Smartphone. All aspects of the product, right from the software to design and technology are conceptualized, developed and manufactured in India. Aiming to become a `5,000 million company in six years, iBahn will roll out its offerings pan India in a phased manner.

iBahn will be launching a series of 'Lamps' and 'Downlighters' this month, with more to follow. These lights can be controlled through their app that will be available on Android and iOS.

Anand's Farmers opt for Solar Energy

The Agro Solar project, conducted by Anand Krishi University, Gujarat in collaboration with Gujarat Industrial Power Company Limited (GIPCL), will produce 1 MW Solar PVC on 1.5 hectare area of Anand district...

With the completion of electricity requirement from the solar panel, there will be a new option for farmers in Anand.

Now, it is not surprising if the solar panels are seen along with agricultural crops standing in farms. Farmers will farm different crops with solar panels on the farm. With the completion of the requirement of electricity, 50% of the irrigation water will be saved in agriculture and the new option of income for the farmers.

The Agro Solar project, conducted by Anand Krishi University, Gujarat in collaboration with Gujarat Industrial Power Company Limited (GIPCL), will produce 1 MW Solar PVC on 1.5 hectare area of Anand district. The impact of solar generation on the growth of various crops vis-a-vis crops grown on open land is being examined.

With the problem of solar power being solved, 50% of pistachial water will be saved. Under the Agro-Solar Project, the distance of the solar panel between 10 meters and the two panels surrounding the distance is 25 mm, 150 mm and 250 mm. A 5% stake in the farm has been cultivated in solar panels and 95% of the area. As compared to the crops grown in the solar panels, the growth of agricultural crop, development and production capacity is compared to the open land. Anand farmers will harvest different crops along with solar panels on the farm.

In Aamar village at Gujarat the solar panels are undergoing testing of various crops and production capacity.

With the completion of electricity requirement from the solar panel, there will be a new option for farmers. Solar panels will get compensation by selling electricity produced from the panel.

In the kharif season, crops like millet, maize, pigeon pea, moong, soybean, groundnut, cotton and pigeon, winter wheat, rayadas, coriander, spinach, fenugreek and chilly and bhindra were harvested. One hundred percent drip irrigation system has been used in agriculture. In addition, the water used to clear the solar panels is used in agriculture for not being wasted. This experiment is planned to take different crops every year. Especially, in shade more value added crops will be given priority. Apart from this, farmers will be able to get compensation by selling electricity generated from the solar panels in a failure situation.

In Aamar village at Gujarat the solar panels are undergoing testing of various crops and production capacity. A 5% stake in the farm has been cultivated in solar panels and 95% of the area is for agriculture purpose. Agro Solar Project by Anand Krishi University will show new direction to India.

Paresh R Modha
EE Department,
ADIT, New
Vidyangar, Anand

Saubhagya Scheme to Stimulate Energy Demand: ICRA

The Government of India (GoI) has launched the 'Saubhagya Scheme' with an objective of providing household electrification, especially, in rural areas. According to ICRA, the scheme having a projected outlay of Rs 160 billion is a positive for the power sector as the implementation is likely to improve the energy demand; besides it is likely to benefit for the capital goods industry, especially, players in the distribution segment.

Sabyasachi Majumdar, Senior Vice President & Group Head, ICRA Ratings, says, "The launch of Saubhagya scheme shows a thrust on rural electrification. If implemented in a time-bound manner, this is likely to result in a boost in energy demand, apart from improving the quality of life for rural households. Nonetheless, the demand growth from the relatively high tariff industrial and commercial segments will remain critical for the overall demand growth and viability of discoms."

"While the energy demand growth in 5M FY2018 has shown some improvement (an increase of 5.4% on yoy basis), a sustained demand recovery still remains to be seen."

The 'Saubhagya Scheme' has a planned outlay of Rs 160 billion (of which around Rs 120 billion will be provided as budgetary support by the central government) as contribution required towards electricity connections for all rural and urban households currently without any access to power (estimated to be above 40 million).

The scheme outlay is estimated to be funded by 60% GoI grant, 10% by respective states and 30% through loans (for special category states it is 85%, 5% and 10% respectively). The Rural Electrification Corporation Limited (REC) is the nodal agency for the operationalisation of the scheme throughout the country.

Overvoltage Mitigation Techniques for PV Grid

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In this case study, the authors have reviewed the conventional techniques used to mitigate the overvoltage problem and observe that they have several disadvantages. So, it is suggested a novel technique that relies on a minor modification made to the secondary windings of the distribution transformer: an extra tapping is pulled out from each of the secondary windings into a separate PV junction box which is the modified Point of Common Coupling (PCC)...

In order to achieve the goal of mainstreaming Photovoltaic (PV) systems in the rural environment, one of the main technical issues to be resolved is grid interconnection. Of the problems encountered in such an environment, 'overvoltage' is the top priority. Overvoltage incidents are more likely to occur on rural grid, in which, generally, the line impedance is higher and the load is relatively low. Many of the constraints, including overvoltage can be eliminated when infrastructure and other facilities are upgraded by designing the grid configurations and distribution capacities to meet future capacity growth. In addition, the following characteristics are identified as key recommendations for the future grid systems free of constraints on PV grid interconnections.

- Integrated system management using ICT (Information and Communication Technology)
- Extension of distribution capacities
- Development and widespread use of storage technologies or integration of either grid load control or building load control with PV generation output.
- Provision of power quality that fits the corresponding application

Impact of PV Grid Interconnections

Over the past century, the standard electric power distribution model has been to generate power at large-scale power plants and distribute power to customers via power transmission lines. Power distribution infrastructure has also been designed with this model in mind. In recent years, however, we have been witnessing the appearance of many small-scale power plants on power networks as distributed power sources — such as photovoltaic power, wind power, and various types of co-generation power — gain traction. One side effect of this multiplication of power sources has been to make network electricity flow patterns much more complex, which in turn requires more sophisticated power regulation technologies than have been employed in the past.

Another concern with PV and other renewable energy forms is that they are intermittent power sources with substantial output fluctuations. As more of these power sources are interconnected with power grids, various risks come into view, such as lower electric power quality and stability.

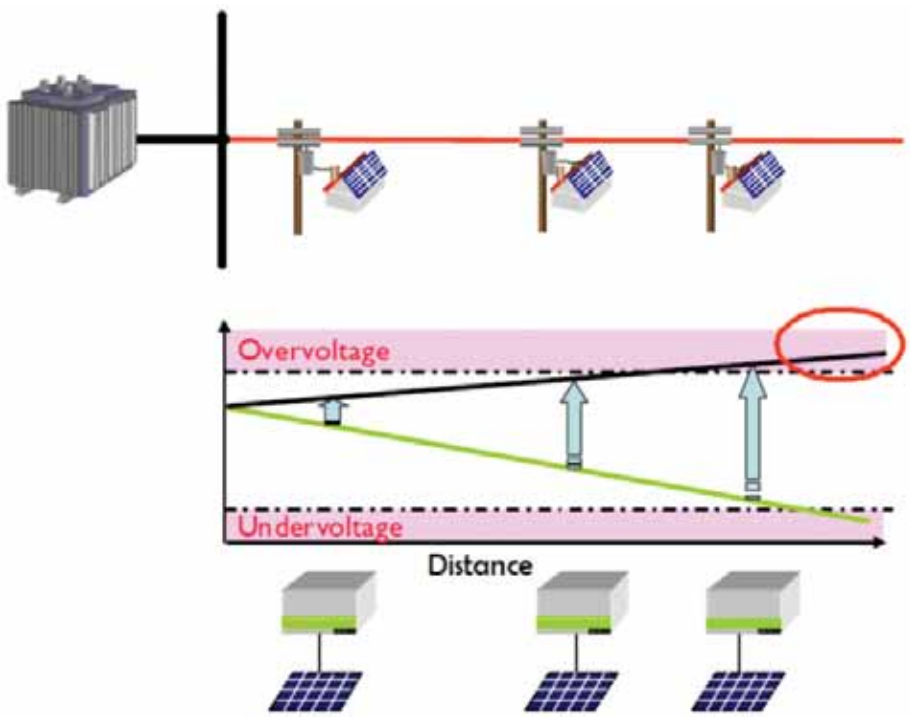


Figure 1. Conceptual diagram of Over-voltage

AC power quality is a general term for indices that describe the impact on customer-device operation due to deviations from prescribed tolerances in the sinusoidal voltage's amplitude, frequency, phase, and waveform. Various schemes have been proposed of parameters to evaluate the quality of electric power. Europe created the power quality standard EN 50160 in 1994 (revised in 1999), and the United States set out the IEEE Standard 1159 on electric power quality in 1995. The International Electrotechnical Commission (IEC) worked on establishing measurement methods for AC power quality parameters in conjunction with the global trend to deregulate the power industry. It set forth these methods in the IEC 61000-4-303 standard in 2003.

In this paper, we focus on voltage amplitude (overvoltage and undervoltage). For a voltage amplitude problem, it is required to arrive at a solution that can be implemented with minimal disturbance to the existing infrastructure. Overvoltage can be a nuisance that causes frequent inverter tripping. Hence, it is necessary to identify the root cause of the over-voltages and find not just potential but practical solutions to this problem.

The problem of overvoltage was being faced by the Dhundi Saur Urja Udpadak Sahakari Mandali (DSUUSM), a solar pump co-operative at Dhundi village in Kheda district of Gujarat. This co-operative was formed to sell surplus power produced in their farms to the electricity grid. We studied the problem of overvoltage and have arrived at a novel and elegant solution that addresses their problem.

Basics on Overvoltage/ Undervoltage

Just as running water flows from a higher pressure point to a lower pressure point, electricity current flows from a higher voltage point to a lower voltage point. The water pressure and flow weakens as water is consumed along the way. In a similar fashion, the voltage of electricity decreases as it is consumed. Thus, the line voltage decreases relative to the distance from the voltage source, as well as the types of loads encountered (see Figure 1).

On the other hand, when the power generated by PV is more than the energy consumed at the point of use, the surplus electricity will flow back to the grid. In this case, the electric current flow reverses direction and the voltage rises as it goes to the end. This is not a significant issue in an urban grid, which can be characterized as a strong network with low grid impedance, and limited PV capacity. However, as PV penetration increases or when a large number of PV systems are installed on a rural grid with higher impedance, the voltage could exceed the upper limit. This issue is called overvoltage (see Figure 1).

Voltage must be kept in a certain range as designated by laws, standards, or guidelines, which vary from region to region for purposes of appliances and machinery to operate properly. In order to control the voltage within the range, utility companies apply various technology counter measures.

One way is to control the line voltage to some extent by reducing the sending voltage from the distribution transformer; however, this may cause undervoltage of neighbouring lines connected to the same transformer with little backward flow, since it is difficult to independently control sending voltage from the same bank (see Figure 2).

Both overvoltage and undervoltage would have a negative impact on stable operation of the

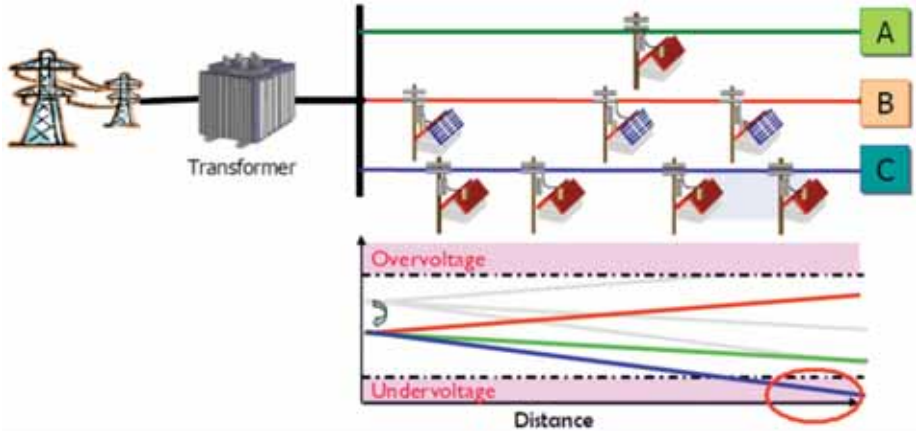


Figure 2. Undervoltage problem

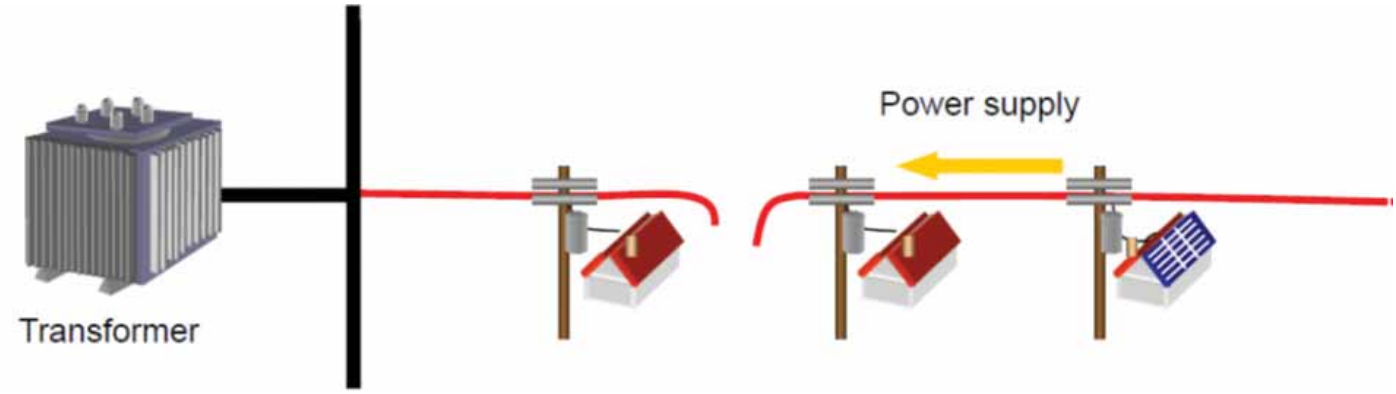


Figure 3. Unintended Islanding Operation

supply-side devices including generators and transformers. Additionally, there would also be an impact on the demand-side equipment. Overvoltage might damage or shorten the lifetime, while undervoltage could constrict the normal performance of electric equipment.

In Japan, Power Conditioning Systems (PCS) for PV systems are designed to control the voltage rise so as not to exceed the limit. Overvoltage can be completely prevented with this technology. However, a disadvantage is that the PV power output is dumped to control the voltage, leading to lower efficiency of the PV system. This can also lead to unfairness among users since the PV output at the end of the line tends to be restricted with higher priority. When investments are based on the PV production such as a feed-in tariff, the grid operation will affect the investment. Since the Japanese solution is both inefficient and unfair, it is not suitable for a democratic country such as India. Thus, overvoltage and undervoltage can be one of the biggest barriers to mass distribution of PV systems.

Instantaneous Voltage Change and Islanding

When faults such as lightning occurs on the grid network, the voltage around the fault point drops until the protective relay detects the fault and isolates the fault from the main grid by means of breakers. This is the typical case for instantaneous voltage change. The duration of the voltage drop is dependent on the operational time of protective relays and breakers.

Unlike other distributed generation sources, PV systems have little impact on instantaneous voltage change since fluctuations in the power output are relatively slow and the grid interconnection processes are appropriately controlled by power conditioners. One possibility for instantaneous voltage change occurrence by a PV system is simultaneous disconnection of PV systems by an unintended islanding function in the inverter that is too sensitive and the PV dropping off line.

The term islanding has historically been used to describe the undesirable event of a grid-connected PV generator failing to disconnect during a grid outage. However, as grid-connected PV systems have emerged to provide the dual purpose of acting as stand-alone generators during a grid outage, the term has been refined to intentional and unintentional islanding.

Unintended islanding is an electrical phenomenon in which PV systems within a certain network continue to supply power to the load even after the network is disconnected from the main grid for some reason (e.g., electrical problem). When a network is disconnected from the main grid, the PV systems in the network are designed to detect the abnormal power quality in voltage, frequency and grid impedance and to disconnect from the network immediately. However, if the power generated from the PV systems and that consumed in the load are by chance identical, the PV systems might not be able to detect the unintended islanding and will continue to supply power. It should be noted that there is little impact from unintended islanding since the possibility of unintended islanding operation is quite low.

Islanding operation can only be possible when the following three conditions happen simultaneously.

1. The power supply from the main grid stops for some reasons,
2. The power generated from the PV systems accidentally matches load
3. Islanding protection functions in the PCS failed to detect the islanding conditions

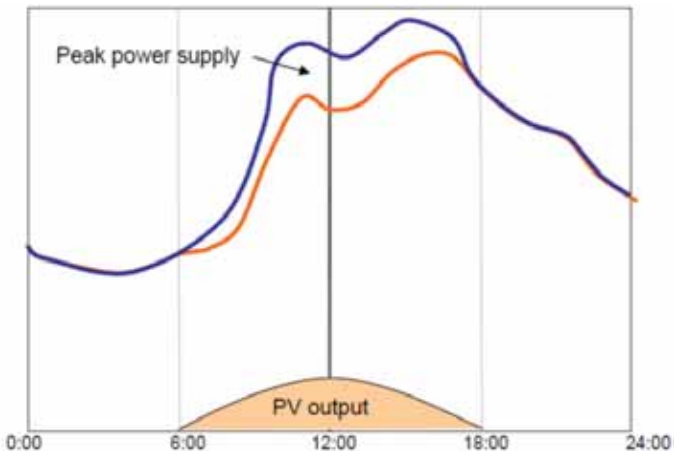


Figure 4. Peak Power Supply - 1

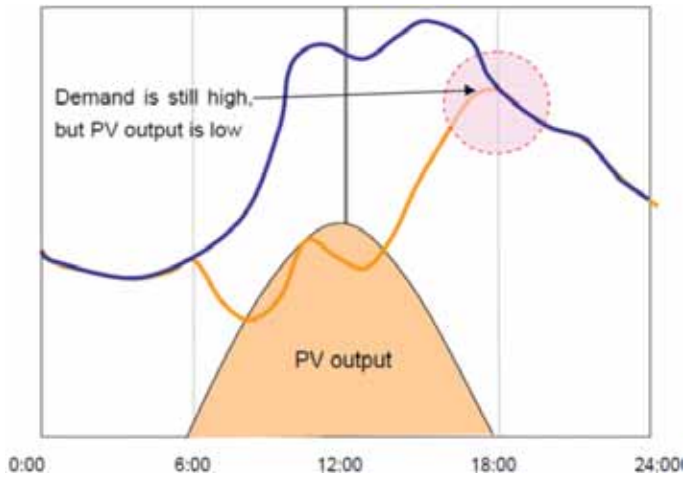


Figure 5. Peak Power Supply – 2

According to the IEA PVPS Task 5 report, the possibility of unintended islanding operation that continues for more than five seconds in a distribution line is 8.3×10^{-10} to 8.3×10^{-11} / year.

Currently, advanced unintended islanding detection schemes are available that minimize the risk of simultaneous disconnection of PV systems. Europe and the US are also considering change of timings for the PV system to drop off to have a slight (a fraction of the power frequency cycle) delay.

Voltage Imbalance, Harmonics, DC Offset, Frequency Fluctuation etc.

The other conditions for abnormal voltages could be – (a) Voltage Imbalance - when each phase voltage is different in a three phase system, (b) Harmonics - when voltages having an integer multiple of the fundamental frequency generated by the power electronics technologies distort the grid voltage waveform. DC offset, frequency fluctuations, etc., can also result in abnormal voltages, but these abnormalities are beyond the scope of the current paper.

Peak Power Supply Effect of a PV System

Generally, electricity demand increases during the day time and decreases during the night time, although it is heavily dependent on regional conditions. Since PV systems generate electricity in the daytime they can contribute to supplying the peak load. Especially, for countries with a relatively hotter climate, PV is expected to offset the increase in cooling demand during the summer (Figure 4). Large office buildings in urban areas have to cool year-round due to heat loads from both people and electronic equipment. On the other hand, it is not easy to quantitatively assess the effect of peak power supply by PV systems. For example, PV systems cannot supply electricity in the evening when the demand remains relatively high in many countries; therefore, the effect is limited (Figure 5). It is also pointed out that solar energy is an intermittent energy source that requires a back-up generation plant to some extent in order to ensure supply security.

The peak power supply effect of a PV system can be significantly enhanced through coupling with a small-scale energy storage system such as batteries (peak-shifting). If the system stores power during times of high PV output and discharges the power when it is needed, the power supplied from the grid during peak hours would be reduced. Also, in large buildings with cooling loads, the energy controller of the cooling equipment can be interfaced with the operation of the PV to effectively use the thermal mass storage of the building to support the intermittency.

The imbalance between power supply and demand leads to fluctuation of grid frequency or voltage, which could cause equipment damage on the

Table 1. Counter measures that can be taken if poor Power Quality is observed.

Abnormalities	Countermeasures		
	Grid Side	Demand Side	PV Side
Overvoltage / Undervoltage	LDC (Line voltage drop Compensator), Shunt capacitor, Shunt reactor, SVR (Step voltage regulator) Electric storage devices	Shunt capacitor Shunt reactor Electric storage devices	Voltage control by Power Conditioner Systems (PCS) Electric storage devices
Instantaneous Voltage Change (Sags / Swells)	TVR SVC STATCOM Electric storage devices	DVR Electric storage devices	Electric storage devices
Unintended islanding Protection	Electric storage devices Protective devices Transfer trip equipment	Electric storage devices Protective devices	Electric storage devices Advanced PCS (Power Conditioner Systems)

demand side. However, electricity demand (load) changes every minute. In order to efficiently respond to the changes, utility companies generally classify and operate power plants independently. Example classifications are: base load power for constant output, middle load power for changing load and peak load power for peak demand.

Peak-power generators do not usually operate during off-peak hours. Therefore, the capacity factor for power plants is relatively low and the cost is high. To reduce the need, and therefore the cost, for peak-power generators, utilities strive to reduce the peak demand through demand-side management programs. Utilities also price electricity higher during peak periods with time-of-use and demand-rate tariffs. Consequently, utilities benefit from reduced peak demand via supply of PV power, and the PV owner benefits as well. Moreover, if the PV owner is on a demand rate or time-of-use rate, the PV electricity is displacing higher-priced electricity, and the benefit of energy cost savings is greater.

Counter Measures

It describes various counter measures that can be taken if deterioration in power quality is observed (see Table 1).

Some of the equipment used to counter overvoltages are:

i. Line Voltage drop Compensator (LDC)
ii. Phase modifying equipment, such as Static Capacitor and Shunt Reactor
iii. Step Voltage Regulator (SVR) or Transformer with on-load tap changer.
iv. Thyristor Voltage Regulator (TVR)
v. Static VAr Compensator (SVC)
vi. STATic synchronous COMpensator (STATCOM)
vii. Dynamic Voltage Restorer (DVR) using Storage Devices
viii. Power Conditioning System (PCS) with function to suppress rise in grid voltage
ix. Passive Filter or LC Filter
x. Active Filter
xi. Sodium-sulphur (NaS) Battery
xii. Unintended islanding detection system (Passive system)
xiii. Unintended islanding detection system (Active system)
xiv. Transfer trip equipment – signals from transformer directly to device via communication lines
xv. OLTC fitted transformers
xvi. Batteries or Super-Capacitors Energy Storage

Unfortunately, many of the counter measures listed above have their own disadvantages. Thyristor Voltage Regulator (TVR) has disadvantage of long term reliability when installed on a pole. Cost is a bottleneck in Static VAr Compensator (SVC) technology and Static Synchronous Compensator (STATCOM). Line voltage Drop Compensator (LDC) has a problem of overvoltage suppression. Step Voltage Regulator (SVR) has disadvantage of low response time.

Tap changer has limitations in switching time. The main problem associated with On Load Tap Changer (OLTC) fitted transformers is the communication infrastructure cost associated with this kind of procedure. Test results show that in order to implement a cost effective approach we need to minimize tap operations, voltage profile issues monitoring should be only located at the end of the feeder and the ideal cycle length should be 30 minutes, thereby, causing

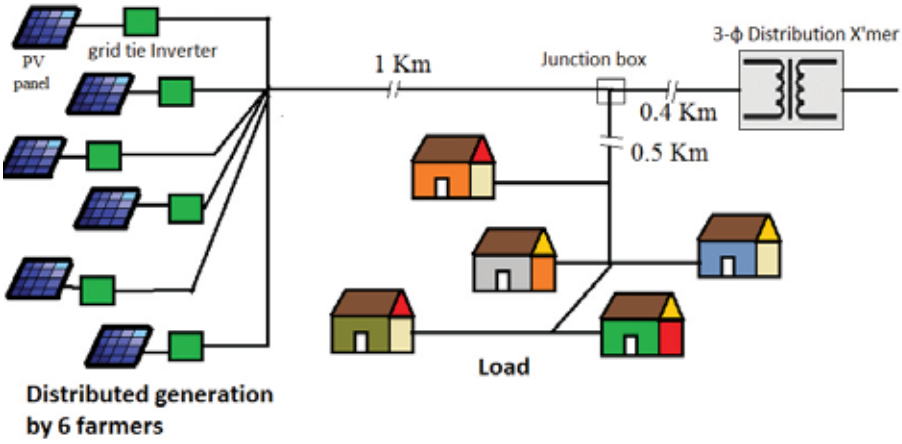


Figure 6: Line diagram of Dhundi village

less impact in the OLTC usage.

Energy storage devices such as NaS batteries or super-capacitors are very expensive making their choice uneconomical. Moreover, the interruptible characteristic of renewable energy has a detrimental effect on battery life due to stress.

Case Study

We studied the problem of overvoltage being faced by the farmers of the solar pump co-operative at Dhundi village, in the Anand District of Gujarat. This co-operative was formed by bringing together six vegetable farmers in Dhundi village (see Figure 6). The solar pumps were connected to the power grid of the local electric utility – Madhya Gujarat Vij Company Limited (MGVCL), and a 25 year power purchase agreement was signed allowing the farmers to sell back the surplus energy at a rate of `4.63 per kWh equivalent of solar energy.

The current installed capacity of the Dhundi solar co-operative is 56.4 kW, which is estimated to generate nearly 85,000 kWh units of energy annually, if 300 sunny days and 5 units per kW are assumed. The six farmer members would use 40,000 units to irrigate seven acres of farmland and the balance 45,000 units would be injected into the grid to fetch over `2 lakh in revenue from the sale to MGVCL. The problem of overvoltage is causing the grid tie invertors to trip, thereby, causing a substantial loss in this revenue. Hence, in this paper we suggest an elegant solution to the overvoltage problem to minimize the loss of revenue to the farmers.

Observations during Field Visit

We visited a solar pump house of one of the six members of the co-operative on a cloudy day. The PV installation comprised of a group of six large swivel type PV panel mounts each of which was rated for 250 We at an output voltage of 144 Volts. There were six mounts; the connection of which were in series, hence, the total output from the PV panels to the solar pump house was 864 Volts and 7 Amps, representing a total of 6 kWe of solar generation from this single farmland. There are six such members with different capacities and the total installed capacity of all the members of the solar co-operative is 56.4 kWe.

The following observations were taken when the Grid-Tie inverters were connected to the solar panels instead of the pump. The output of the inverter was observed to vary from 2.30kWe to 2.41 kWe, which was less in comparison to its rated capacity (6.0kWe) due to cloud cover.

The voltage readings were taken before and after connection of the Grid Tie Inverter to the PV grid. In the meter room that housed the individual meters and the net meter, the voltage readings recorded are as shown in Table 2. It can be observed that there is, on an average, a 3.5 Volt increase in each of the three phases when the inverter is connected.

Table 2. Grid Voltage before and after connecting the Grid Tie Inverter

Condition	Grid Voltage (Volts)		
	R Phase	Y Phase	B Phase
Inverter Disconnected	257.1	247.1	250.2
Inverter Connected	260.6	251.3	253.1
Difference	3.5	4.2	2.9

We also observed rains (a mild shower) and the PV output dropped. Table 3 gives the power output and the corresponding current in each of the three phases from the grid-tie inverter during the rains.

Table 3. Readings of phase currents before and during rains

Condition	Current (Amps)			Power (Watts)
	R Phase	Y Phase	B Phase	
Cloud Cover	4.01	3.94	3.94	2303
Rains	1.13	1.15	1.02	668

It may be noted that the meter room is a central one that contained all the six individual meters from the six farmer members of the co-operative. This means that the generation of all the PV installations gets accumulated in this meter room.

The central meter room also has a common main Net meter from which a separate cable emerged that ran as an overhead cable all the way to a junction box or PCC (Point of Common Coupling) located about one kilometer away from the meter room. In this junction box, the PV grid output gets fed (injected) into the utility (MGVCL) grid.

Table 4. Readings taken on utility's distribution transformer station

Parameter	R Phase	Y Phase	B Phase
Voltage (Volts)	262.6	260.7	260.4
Current (Amps)	35.2	20.7	8.0

About 400 meters further down from the junction box (see Figure 6), we

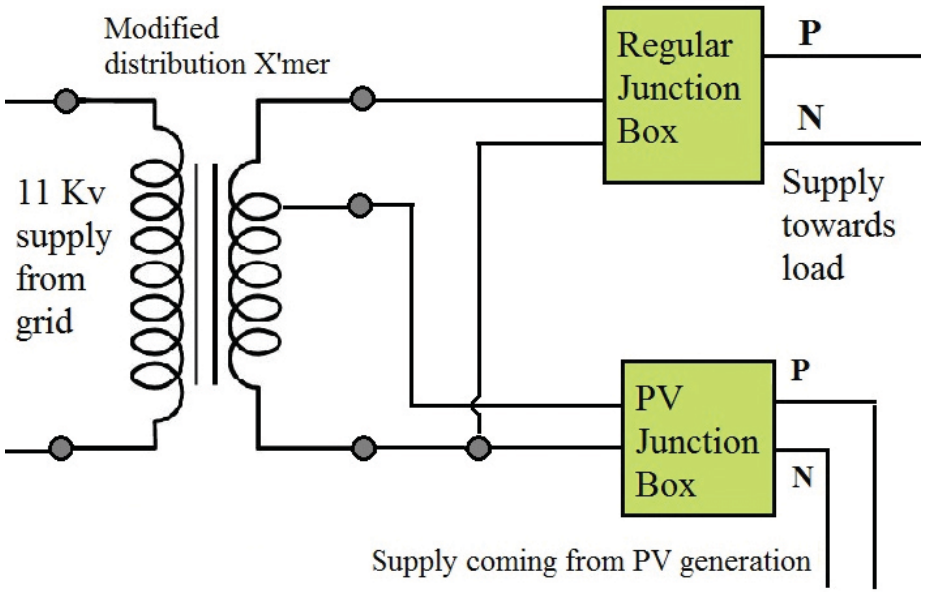


Figure 7: Modifications proposed for Dhundi village

located the utility's (MGVCL) distribution transformer which was positioned close to the pump house and overhead tank that fed water to the village. This single distribution transformer of 100 kVA capacity fed electric power to the whole of Dhundi village. The readings taken on the transformer meter are as shown in Table 4.

From the distribution transformer meter readings, we can observe that the transformer output voltage is about 5 to 12 volts higher than the voltages observed at the farm when the PV generation was off. This indicates that the impedance (essentially resistance) of the long rural lines (length greater than one kilometre) is high.

Though we were unable to take readings at the distribution station while the PV generation is ON, it is clear that the voltage at the transformer output would increase further. When all the PV sources are simultaneously injecting into the PV grid, the voltage at the grid tie inverter points would easily exceed 270 Volts which is the limiting value beyond which the Grid tie inverters are designed to trip.

In Dhundi, we observe all the conditions present that can promote overvoltages, namely:

i. Integration of generation (PV) in a rural grid
ii. Reverse power flow, and
iii. Rural area far away from the substation transformer.

Hence, the frequent tripping of grid tie inverters comes as no surprise.

Proposed Overvoltage Mitigation Technique for Dhundi

In counter measures section, we have described various overvoltage mitigation techniques that would help to mitigate overvoltage, however, each of them have disadvantages that make them less attractive. In this section, we propose a solution that would suit the Dhundi rural installation. The constraints for Dhundi arise since PV installation was already complete; the proposed technique should not disturb the installation in a major way. The cost of the proposed technique is also of significance and it is desirable to have a least cost solution. Due to the urgency, the time required to implement the solution at Dhundi should also be minimum.

Proposal : Transformer with a Secondary Tapping

Unlike the techniques given in counter measures section, here we propose a novel technique that, not only satisfies all the above constraints, but also requires only a minor modification to the distribution transformer.

The transformer used in Dhundi is over-rated at 100 kVA to account for future addition in PV generation capacity. This 3 phase distribution transformer is like any other used in the Indian distribution system. It is a simple step down with three numbers of 11 kV input (primary) windings in a delta configuration and three numbers of 240 V output per phase secondary windings in a star configuration.

Though India now is expected to conform to the international regulations that suggest 230 Volts instead of 240 Volts, the lower voltage is

seldom observed in a grid surplus Indian state since the utility revenues would fall. The rural LT lines also extend over long distances, and hence with the high line resistances, it is inappropriate to suggest to the Indian utilities that they lower down the output voltage of the transformer secondary.

Hence, the minimum changes that we recommend in our proposal are as follows (see Figure 7):

1. **Get a Tapping out from each of the Transformer Secondary Windings**: While keeping the number of turns of the primary and secondary the same, a minor change would take out a tapping from the secondary after 90% of the turns have been wound. Hence, when the nominal voltage at the secondary of a loaded transformer is 240 Volts, the voltage at this tap would be 216 Volts.

   Since our transformer is lightly loaded, when the voltage across the secondary is 260 Volts, the voltage at the tap would be 234 Volts.
2. **Shift the PV injection point**: On the secondary side of the modified transformer we would now observe two junction boxes (see Figure 7). The 260 Volts (Nominal rated: 240 V) secondary output winding gets terminated in the regular junction box that is feeding the Dhundi village load. On the other hand, the 234 Volts (Nominal rated: 216 V) secondary output winding would be terminated in the PV junction box (see Figure 7). This means that for Dhundi village, the PV grid cables need to be extended further by another 400 meters to this new PV junction box from where the PV power would get injected into the utility grid system (also see Figure 6).

With the above changes, the Dhundi village would not be facing an undervoltage problem in the evening or night when the PV generation is OFF and the load is heavy. At the same time, during the day, when PV generation is maximum, the grid tie invertor would not face the problem of tripping since it feeds into a secondary tapping that carries a lower voltage.

We consider this proposal as the most elegant, since the changes are minimal, and so is the cost. This proposal is best suited for Dhundi, as the co-operative has already invested in laying a separate PV grid till the feed junction point or the Point of Common Coupling (PCC) that is located close to the transformer center. Under the proposed modifications, the new PV Junction box becomes the PCC and hence the PV grid needs to be extended further by 400 meters (see Figure 6 and Figure 7).

Conclusions

Worldwide, side by side with distributed renewable integration, we observe the power system to be evolving into a smarter and more efficient grid. However, till such a time that our Indian villages become equipped with such grids that are smart enough to mitigate the overvoltage problem with ease; we need elegant solutions that can be implemented with minimal changes to the existing infrastructure.

In this paper, we have reviewed the conventional techniques used to mitigate the overvoltage problem and observe that they have several disadvantages. Hence, we have suggested a novel technique that relies on a minor modification made to the secondary windings of the distribution transformer: an extra tapping is pulled out from each of the secondary windings into a separate PV junction box which is the modified Point of Common Coupling (PCC). The PV output is connected to this PCC / PV junction box. The load connections and the rest of the distribution system remain unaltered. Since it is minor modification that will help promote PV on a large scale, we hope to see this modification implemented in all the distribution transformers that are manufactured in India in the near future.

Co-authored by Final Year Undergraduate Students of BE (Electrical) at Birla Vishwakarma Mahavidyalaya Engineering College, Anand, Gujarat.

Nivea Chauhan

Harsh Bhatt

Payal Bhadresa

Akash Sent

Green DEIF World: Words Supported with Actions

A DEIF solution is a greener choice because it means optimised operation: life extensions and other advanced technologies make our customers' assets more valuable and operationally more efficient. DEIF solutions being cost-effective balance your economy and conserve the environment as they are highly efficient...

Climate change effects world over have resulted in transition of focus from using black to green energy solutions. Not only so, people also want to introduce a mix of green in their existing portfolio with multiple green energy sources.

Central to DEIF's vision is to be the preferred global supplier of green, safe and reliable energy control solutions, we at DEIF are committed to actively engaging in and supporting sustainable environmental policy by developing and supplying cleantech products and intelligent power management. Our goal is to help make the world a little greener every time we implement a DEIF solution. Reflecting the accelerating switch of the worldwide energy system towards more renewable and sustainable energy practices, DEIF's progressive strategies and product development focus intensely on wind power, hybrid solar, hydropower and biogas.

Aiming to also act in an ethically responsible way across all business segments, including conventional power generation, all DEIF products and solutions are developed in accordance with DEIF's green vision. DEIF develops energy efficient products and solutions that reduce fuel consumption, maintenance intervals, thus, cutting harmful emissions and costs. As a means to combat climate change, conserve natural resources and meet the challenges of global population growth, we are continuously looking for ways to increase the performance and efficiency of our partners' installations. 20% of DEIF's more than 500 highly skilled employees work in R&D in our pursuit of excellence, consistently mapping new ways in power control technology.

A DEIF solution is a greener choice because it means optimised operation: life extensions and other advanced technologies make our customers' assets more valuable and operationally more efficient. DEIF solutions being cost-effective balance your economy and conserve the environment as they are highly efficient.

Extracting more out of the Sun

DEIF's Automatic Sustainable Controller (ASC) is a solution that provides integrated solution for systems with utility, diesel and solar power source. The system provides an interface between the diesel/gas genset and solar, with or without presence of utility power - a solution that enables you to share the load between solar PV cell and diesel/gas genset with maximum solar penetration, thus, resulting in maximised savings even during utility failure. Using solar for the additional period of the year can make that period also further green and help maximize the project's overall return on investment. DEIF's solar solution will thus prove to be a boon to India's evolving solar sector.

Capturing the Wind

Needless to say that in DEIF's Wind Power Technology division every product sold is contributing to a greener world. We do not only contribute – we also optimise. Thus, the control systems of DEIF Wind Power Technology are constantly subject to optimisation of the energy generated by the wind turbines.

Flexible and reliable control solutions being our strength, we deliver everything from complete turnkey solutions to individual components.

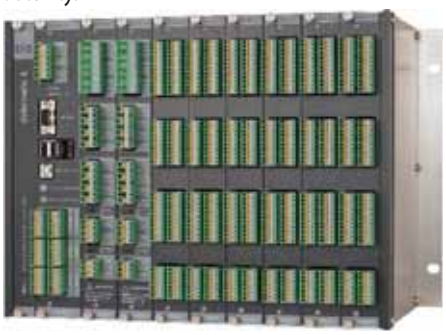
At DEIF, we continuously strive to improve the performance of the wind turbines and make necessary upgrades to the application and embedded software. As a customer you also benefit by receiving free software updates in future as well.

DEIF's wind turbine control systems are not only suitable for new installations but also can be used for retrofitting existing wind turbines to give you numerous key benefits.

Harnessing Hydro Power

Hydroelectric power plants are installed to capture energy from the flowing water and turned into electricity. Delomatic 4 (DM-4) Hydro-controlled plants offer fully automated control for stable optimised operation and require less maintenance and fewer man hours. Compatible with all types of turbines, the Delomatic 4 Hydro is flexible and easy to adapt

with simple parameter settings. Critical functions such as speed governing, generator protections and synchronising are fully integrated with password-protected features for maximum security.



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

Making the most out of waste gas

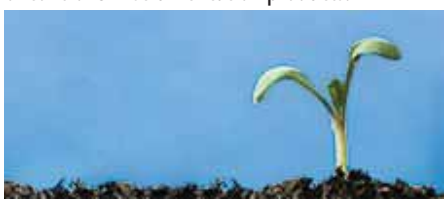
Regardless if your gas is bio, natural, landfill or other, our control solutions will enable you to convert it into energy. Irrespective of size of your application, type and make of your gas engine or turbine, DEIF's standard controllers are extremely flexible and will accommodate most of your needs. But, we are also happy to develop completely unique solutions designed exclusively for your specific application. Our product DM 400 Gas is suitable for total engine control and protection whereas Automatic Genset Controller – AGC-4 Gas is suitable for power management and CHP applications. Installing DEIF solution gives benefits through increased operational availability of the system and enhanced cost saving by not having to pay to dispose the waste.

Transforming Black to Green

Equipped with features and functionalities such as fuel optimisation, load dependent start/stop, asynchronous load sharing, DEIF's Automatic Genset Controller – AGC-4 is the most comprehensive and flexible power management and protection unit in the diesel segment. The innovative solution gives you a critical market advantage that ultimately helps you produce more green power at the lowest possible cost.

Internally Green

DEIF A/S is ISO 14001:2004 certified for Environmental Management Systems. DEIF A/S also has been approved by Lloyd's Register Quality Assurance with the environmental scope as 'The environmental aspects in relation to the processes, facilities and buildings for administration, development and manufacturing of control & instrumentation products.'



The green focus at DEIF is not only related to product solutions but also to our internal processes as well. Internally, we focus on carbon-neutral heating and cooling; the DEIF Group's headquarters in Skive, Denmark, features advanced green energy system includes a carbon neutral Aqua Thermal Storage System: storing groundwater at constant temperatures in underground wells, the system heats and cools the buildings and has an indefinite lifespan.

Our CHP plant cuts emissions – a micro CHP plant generating power for DEIF's buildings, naturally, equipped with DEIF controllers, helps keep our CO_2 emissions low.

DEIF wants to prevent pollution & reduce negative environmental impact by encouraging all employees to have a high environmental awareness in every relevant decision taken in the company, especially, in our processes and production. We want to have a common green mind-set.

DEIF A/S is part of the CO_2 neutral website initiative. The carbon emissions from both the website and users of the site are offset through the building of new renewable energy sources, various CO_2 reducing projects, and through purchasing certified CO_2 offsets cleared by relevant government institutions and bodies.

The DEIF website is hosted on Hostnordics servers. As part of Hostnordics green IT strategy to minimise power consumption to take pressure off the environment. DEIF's printed marketing material is carbon compensated according to ClimateCalc (Cert. no. CC-000033/DK). The paper used for printing is FSC certified (Forest Stewardship Council) implying that the paper comes from well managed forests that provide environmental, social and economic benefits. The printed matter also carries NORDIC ECOLABEL stamp that evaluates a product's impact on the environment throughout the whole lifecycle.

We at DEIF have done our part in all aspects of product lifecycle, now it's your turn to make a commitment towards green energy and safe environment. DEIF can help you achieve your green energy goals.

For more details, contact
india@deif.in

Emission Controls for Indian Thermal Power Plants

Prof Mayadhar Swain
Director, School of Electrical Engineering,
KIIT University, Bhubaneswar

Thermal power plants are the most common sources for generation of electricity. These plants also pollute the environment mostly. They emit many harmful gases to the atmosphere apart from fly ash, which itself has many harmful health effects. The Ministry of Environment, Forest & Climate Change has notified the revised standards for coal-based Thermal Power Plants in the country, with the primary aim of minimizing pollution.

In the world, installed capacity of thermal power plant is about 65% of the total capacity from all sources. In India, this is 68%. As on February 2017, total installed capacity in India is 315426 MW and that of thermal power plant is 215215 MW (refer Table - 1).

In spite of emissions of many harmful substances from coal fired plants, we depend on mostly for electricity. It is because these have some strategic advantages over other sources. The main advantage is that its fuel coal is available in plenty in many countries. In our county, the coal will last for another hundred years. India is the world's third largest coal producing country and the fourth largest coal importer. The cost of generation of electricity from coal is cheaper than other sources. Further, its technology is well-established and it takes three to four years for installation from concept to commissioning.

The most crucial reason is that there is no alternate source to quantitatively substitute thermal power at present. The other conventional sources of power are hydroelectric and nuclear power. In India, the share of hydroelectric power has come down from more than 50% at the time of independence to 14% now due to resettlement and rehabilitation and other problems. Similarly, share of nuclear power is not improving due to several reasons. Although, installation of wind power and solar power is rapidly progressing, it will take some years to fully depend on them.

Due to these reasons, thermal power has become favorite to planners, although it comes with significant costs to environment and human health.

Thermal Power Plant Emissions

The water runoff from coal washeries carries pollution loads of heavy metals that contaminate ground water, river and lakes, thus, affecting aquatic flora and fauna. Fly ash residues and pollutants settle on soil contaminating lands and are especially harmful to agriculture.

Generally, Indian coals have lower calorific value and ash content is more (up to 40%). The typical characteristics of Indian coal used for power generation are given in Table 2.

Table 1: Installed capacity of electricity generation from different sources (as on 28.02.2017)

Source	Installed Capacity (MW)	% of Total capacity
Coal	189047.88	59.93
Gas	25329.38	8.03
Diesel	837.63	0.27
Nuclear	5780.00	1.83
Hydro	44413.43	14.08
Renewable	50018.00	15.86
Total	315426.32	100.00

Source: Central Electricity Authority

Table 2: Typical Characteristics of Indian Coal

Property	Value
Ash content	25 - 55 %
Moisture content	4 - 7 %
Sulphur content	0.2 - 1 %
Gross Calorific Value	3100 - 5100 kcal/kg
Volatic matter content	20 - 30 %

Combustion of coal in coal fired power plants releases emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter (PM), carbon monoxide (CO), and volatile organic compounds (VOCs) into the atmosphere through stacks (chimneys). The PM in the flue gas also contains high concentrations of heavy metals such as arsenic, lead, cadmium, mercury, copper and zinc. Chronic and acute exposure to these pollutants has health impacts that include respiratory illnesses, compromised immune systems, cardiovascular conditions, cancer and even premature death. The people living nearby the plants are severely affected. While the impact of the emissions is felt within 200 km of the power plants, under windy conditions the influence can be tracked to distances as far as 400 km from the source region. Another pollutant is carbon dioxide which is a greenhouse gas and is considered as the main source for global warming.

Environmental Regulation

Some measures have been taken to reduce the effects of pollutants from coal fired power plants. Limits have been fixed for the amount of different emissions. The emission standards for thermal power plants in India are being enforced based on Environment (Protection) Act, 1986 of Government of India and its amendments from time to time. Earlier, only emission standard for particulate matter had been specified and this was also lagging to those implemented in China, Australia, the United States of America and the European Union.

Ministry of Environment, Forest and Climate Change has announced in December 2015 stringent emission standards for different emissions from different industries (refer Table 3). Thermal power plants are categorized into three categories, namely those:- (i) Installed before 31st December, 2003 (ii) Installed after 2003 upto 31st December, 2016 and (iii) Installed after 1st January, 2017.

Nearly two-thirds of India's installed coal-based capacity is made up of plants commissioned after 2003 and all of them will now have to be upgraded to the new requirements for NOx, SO_2 and PM emissions. The remaining third, primarily older plants commissioned before 2003, will have to at least upgrade their PM control systems.

Emission Control Measures

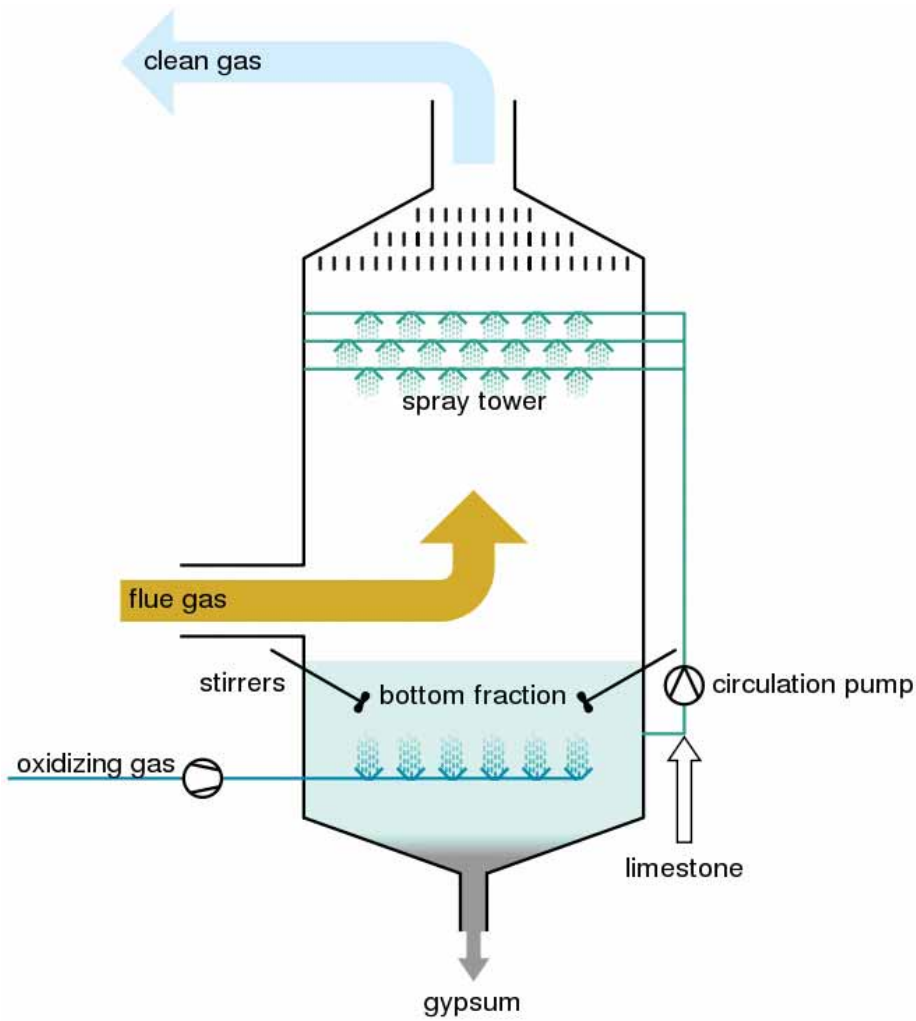
Flue gas Desulphurization

Flue Gas Desulphurization (FGD) system is installed to remove SO_2 from flue gas. It reduces the emission of SO_2 to the atmosphere upto 97%.

However, FGD is not installed for most of the power plants in India as it increases the cost of power generation. Further, it was felt not required for low sulphur Indian coal while considering SO_2 emission form individual stack. At the end of 2015, around 24 Indian thermal power plants, mostly, using imported higher sulphur coal had installed FGD system. Now, all

Table 3: Emission Standards for Thermal Power Plants

Date of installation	Parameters	Standards
Before 31st December 2003	Particulate Matter	100 mg/Nm^3
	Sulphur Dioxide	600 mg/Nm^3 (units smaller than 500 MW capacity units) 200 mg/Nm^3 (units having capacity of 500 MW and above)
	Oxides of Nitrogen	600 mg/Nm^3
	Mercury	Nil (units smaller than 500 MW capacity units) 0.03 mg/Nm^3 (units having capacity of 500 MW and above)
After 31st December 2003	Particulate Matter	50 mg/Nm^3
	Sulphur Dioxide	200 mg/Nm^3 (units having capacity of 500 MW and above)
	Oxides of Nitrogen	300/Nm^3
	Mercury	0.03 mg/Nm^3 (units having capacity of 500 MW and above)
Installed after 1st January 2017	Particulate Matter	30 mg/Nm^3
	Sulphur Dioxide	100 mg/Nm^3
	Oxides of Nitrogen	100 mg/Nm^3
	Mercury	0.03 mg/Nm^3



Flue Gas Desulphurization Scheme

new and many older coal-fired plants will have to install FGD system. The most common technologies for this are wet scrubbing using slurry as absorbent, usually lime or limestone and sea water scrubbing.

For control of SO_2 and PM, the height of stack has been specified. The more the height of the stack the more area the emission spreads which dilutes the effect. Stack height for different capacity of power plant is given in Table 4.

Coal Beneficiation

Coal beneficiation is the process of removing impurities from coal. This is done by washing the coal with water. Coal is first broken down into specified sizes and washing / cleaning methods are then used for various sizes. Coarse coal is handled by dry separation in air jigs or hydraulic jigs, where cyclones and concentrators are used for medium-size coal. Coal fines are separated by floatation or agglomeration. It reduces emissions of ash and sulphur dioxides when the coal is burnt. Coal washing / drying can reduce CO_2 emission by as much as 5%.

Ministry of Environment & Forests, vide notification no. GSR 560(E) & 378(E) dated September 19, 1997 and June 30, 1998 respectively made mandatory use of beneficiated / blended coal containing ash not more than 34 per cent on annual average basis for power plants located beyond 1000 km from pit head and power plants located in critically polluted areas, urban areas and ecologically sensitive areas.

Coal Blending

Indian coal has higher ash content. So, in many cases, it is blended with imported coals having high calorific value and lower ash content. This method reduces overall cost and improves combustion performance.

Efficiency Improvement at Existing Power Plants

There is scope for efficiency improvement at existing power plants, where achieving thermal efficiencies upto 40% could reduce CO_2 emissions by as much as 22%. This can be done by equipment upgrading and the systematic performance monitoring and diagnostic testing of boilers, turbines, condensers and auxiliary equipment. Effective electrostatic precipitators can remove 99% of the fly ash and PM from the gas. Flue gas desulphurization system should be installed.

Super-critical Boiler

The emission of carbon dioxide and other substances depends on the efficiency of the power plant. The average efficiency of conventional thermal power plant using sub-critical technology lies between 25% and 35%. The more efficient the plant, the fewer amounts are emissions. Substantial improvements in generation efficiency can be achieved through the use of more efficient super-critical and ultra super-critical technologies. Efficiency of power plant with super-critical technology lies between 37% and 44% and that of ultra super-critical technology lies between 45% and 60%.

Fluidized Bed Combustion

Fluidized Bed Combustion (FBC) is well established method of burning low-grade coals, biomass and other waste fuels. It produces less NOx and SO2 than a conventional coal based power plant and is also more efficient.

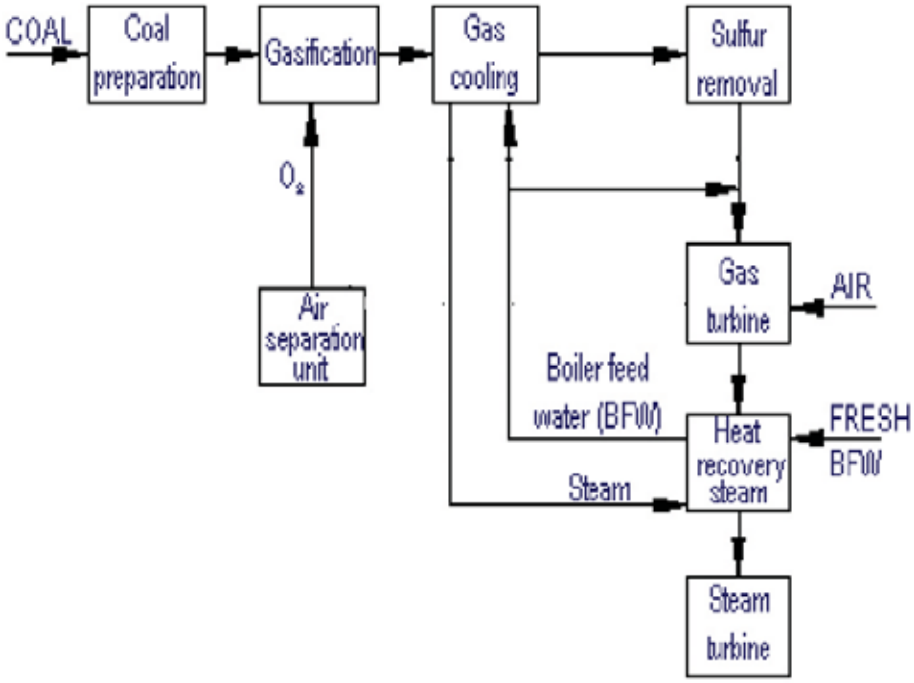
Integrated Gasification

Table 4: Stack Height Requirement for Coal Fired Power Plants

Capacity	Stack height (meter)
Less than 210 MW	H= 14 (Q) 0.3, where Q is emission rate of SO2 in kg/hr, and H= Stack height in meters
210MW to less than 500 MW	200
500 MW & above	275 (+ space provision for flue gas desulphurization systems in future)

Combined Cycle Power Plant

Integrated Gasification Combined Cycle (IGCC) power plant consists of a gasifier incorporated into a combined cycle system including coal fired steam power generation and gas turbine based power generation. Typically, the gas turbine produces 65% of the power and the steam turbine produces the remaining 35% power. Coal is partially oxidized in the gasifier producing syn gas (mixture of CO, CO_2 & H_2). This is called coal gasification. This gas is fed to the combustor as fuel. This is a technology which offers a practical means of utilizing poor quality coal efficiently while at the same time meeting clean environment requirements. In this case, efficiency of the order of 45% to 50% is achieved. This is a very new technology with only a few plants operating in USA and Europe. The technology is also very complex and highly costly.



(Basic structures of IGCC)

Carbon Capture & Storage (CCS)

Carbon capture and storage is an approach to mitigate the contribution of fossil fuel emissions to global warming based on capturing carbon dioxide from large point sources such as thermal power plants. The carbon dioxide can then be permanently stored away from the atmosphere. The carbon dioxide can be separated from the flue gases by chemical absorption processes. CCS applied to a modern large thermal power plant can reduce carbon dioxide emissions to the atmosphere by approximately 80-90% compared to plant without CCS.

Conclusion

India has little option but to invest in coal, because it is cheap and domestically available. In 2016, coal generated roughly 80% of the country's electricity. Currently, known coal reserves about 250 billion tonnes are expected to last another 100 years. But India has to adopt clean coal technologies to mitigate the effect of climate change and control emissions. At present coal beneficiation is being done in India .Also in all the large power plants of unit size of 660 MW and above, super-critical boilers are being used. It not only reduces emissions, but they also produce power far more economically. Now time has come for India to adopt CCS and IGCC technologies to reduce emissions to the atmosphere. Of course, the technologies are new and their implements may increase the electricity tariff. But for the larger interest of the environment, we may have to bear it.

In a report, 'Transitions in Indian Energy Sector - Macro Level Analysis of Demand and Supply Side Options', The Energy and Resources institute (TERI) indicates that current installed capacity and the capacity under construction would be able to meet demand till about 2026, keeping India power sufficient. The report estimates that no new investments are likely to be made in coal-based power generation in the years prior to that. It further estimates that beyond 2023-24, new power generation capacity could be all renewable.

Concentrated Solar Power Technologies

Anupam Sharma
Sr Project Associate, Department of Mechanical Engineering, Indian Institute of Technology, Kanpur

The future power plants with concentrated solar power (CSP) technologies utilize the heat of the Sun to produce steam, which drives a turbine to produce electrical Power

To meet projected future demand, Concentrated Solar Power Technologies provide electricity on demand and also have the ability to store energy to an extent, can help utilities avoid the costs of building new power plants by making electricity more valuable to the grid.

Concentrated Solar Power

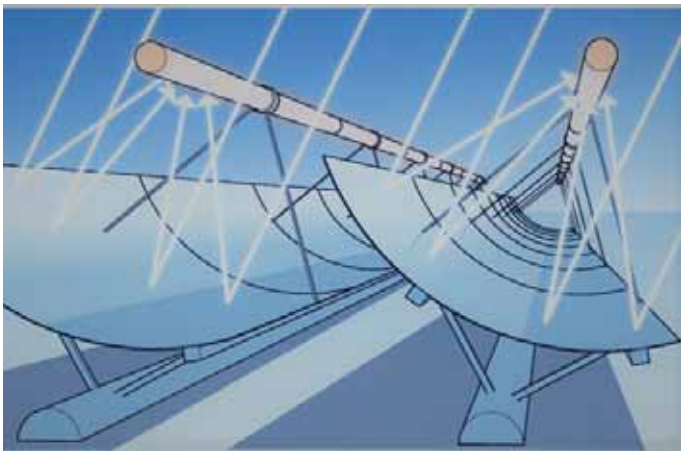
Concentrated solar power is a broad collection of technologies that includes parabolic trough, linear fresnel reflector, power tower and dish engine respectively.

Concentrated Solar Power System utilizes combinaton of mirror or lenses as reflectors to concentrate direct beam component of solar radiation onto a receiver that consist of heat transfer fluid (such as water, oil or molten salts) to transfer heat collected by constantly tracking the sun in the solar field to the power block, where steam is generated with very high temperature and pressure to drive a turbine that produce electricity.

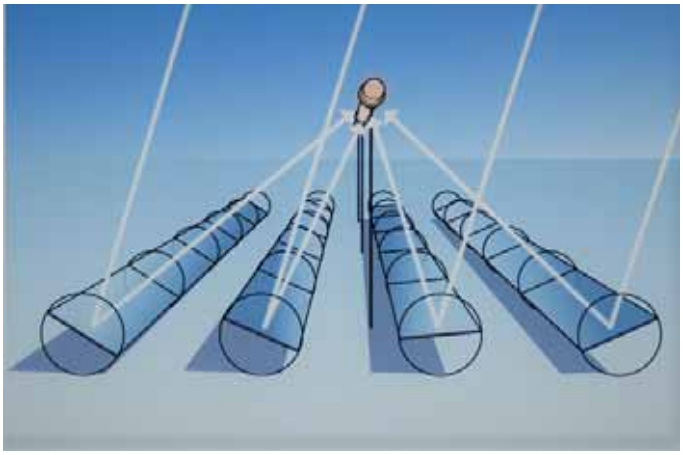
Concentrated Solar Power Initiatives in India

World's largest Concentrated Solar Power Plant by Linear Fresnel Reflector Technology is in India.

In India, availability of direct beam solar



Parabolic Trough



(Line Focusing Type) Linear Fresnel Reflector

Power Tower

(Point Focusing Type) Dish Engine

Figure 1: Concentrated Solar Power technologies

Concentrated Solar Power from Electricity Generation Point of View

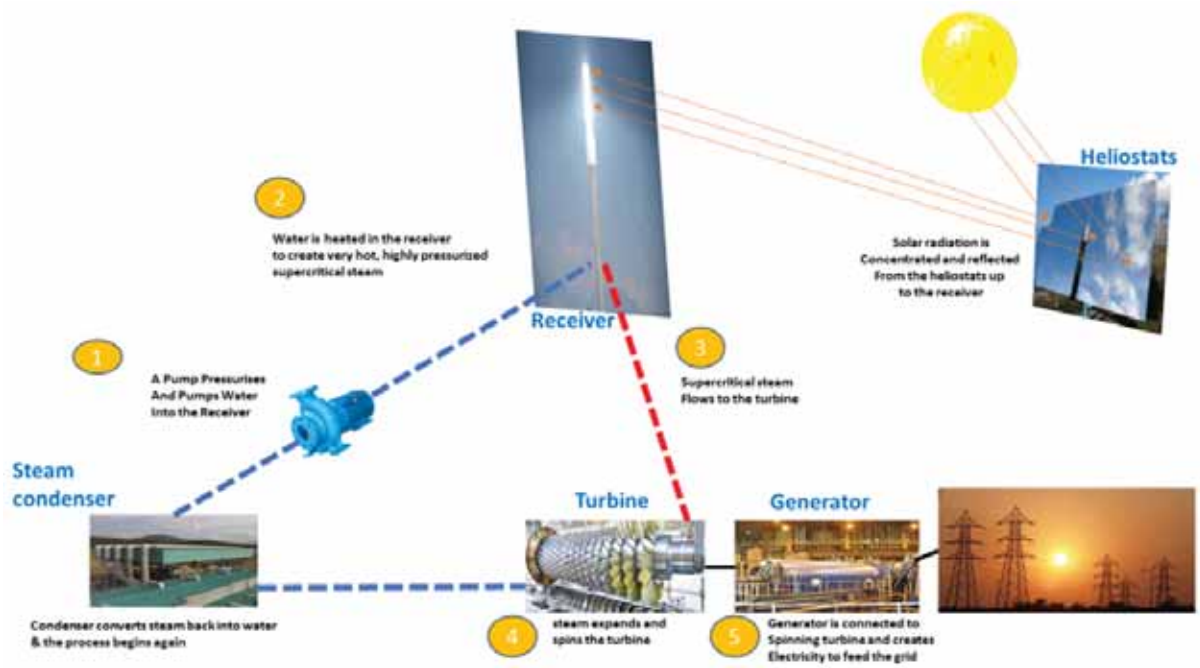


Figure 2: Power generation through Concentrated Solar Power Technologies

Table 1: Performance data for various Concentrated Solar Power technologies

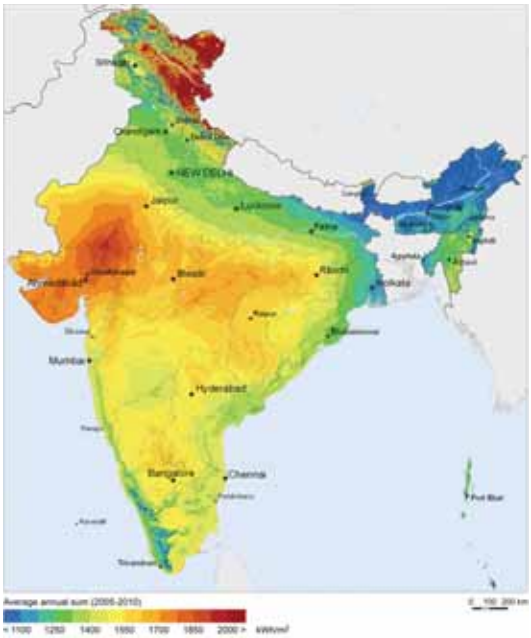
	Parabolic Trough	Linear Fresnel	Power Tower	Dish Engine
Typical capacity (MW)	10-300	10-200	10-200	0.01-0.025
Operating temperature (oC)	350-550	390	250-565	550-750
Receiver Type	Movable	Fixed	Fixed	Movable
Concentration	70-80 Suns	>60 Suns	>1000 Suns	>1300 Suns
Steam Rankine Cycle	Superheated	Saturated	Superheated	Stirling
*Annual Solar to Electricity Efficiency (net) %	11-16	13	7-20	12-25
Thermal Energy Storage with Molten Salt	Commercially available	Possible, But not Proven	Commercially available	Possible, But not Proven
Application Type	On - Grid	On-Grid	On-Grid	On-Grid/ Off- Grid
Key Technology Provider	Abengoa Solar, Seimens, SolarMillennium, Sener Group, Acciona, NextEra, ACS, SAMCA etc.	Novatec Solar, Areva	Abengoa Solar, eSolar, BrightSource, Energy, Torresol, SolarReserve,	Tessera Solar

*Annual Solar to Electricity Efficiency (%) is the ratio of Net Power Generation to Direct Beam Component of Solar Radiation.

Table 2: Present Status of Concentrated Solar Power Plants in India

Project Name	Location	Technology	Turbine Net Capacity	Status
National Solar Thermal Power Facility	Gurgaon (Haryana)	Parabolic Trough	1.0 MW	Operational
Dhursar	Dhursar (Rajasthan)	Linear Fresnel Reflector	125.0 MW	Operational
Godawari Solar	Nokh (Rajasthan)	Parabolic Trough	50.0 MW	Operational
Megha Solar Plant	Anantapur (Andhra Pradesh)	Parabolic Trough	50.0 MW	Operational
ACME Solar Tower	Bikaner (Rajasthan)	Power Tower	2.5 MW	Operational
KVK Energy Solar	Askandra (Rajasthan)	Parabolic Trough	100.0 MW	Under Construction
Diwakar	Askandra (Rajasthan)	Parabolic Trough	100.0 MW	Under Construction
Abhijeet Solar	Phalodi (Rajasthan)	Parabolic Trough	50.0 MW	Under Construction
Gujarat Solar One	Kutch (Gujarat)	Parabolic Trough	25.0 MW	Under Construction
Dadri ISCC Plant	Dadri (Uttar Pradesh)	Linear Fresnel Reflector	14.0 MW	Under Construction

Figure 3: Direct Beam Solar Radiation across India



radiation is good enough especially in Rajasthan and Gujarat to develop concentrated solar power plants. The Ministry of New and Renewable Energy is planning to develop 175GW of power from renewable energy sources under Jawaharlal Nehru National Solar Mission. Solar Energy Corporation of India Ltd has launched solar guidelines, which is an initiative under Indo-German Energy Programme. To cater to India's rising industrial heating needs, the Ministry of New and Renewable Energy has collaborated with United Nations Development Programme to enable greater use of concentrated solar heat. National Institute of Solar Energy, an autonomous institute under Ministry of New and Renewable Energy Govt of India, has set up state-of-the-art solar thermal technologies for different end use applications such as power generation, air-conditioning, space heating, cooking, cold storage, process heat desalination, hot water etc.

Conclusion

Concentrated solar power is heating up India's solar thermal market under National Solar Mission with improved ground solar radiation data provided by Centre for Wind Energy technology, Chennai. Thus, concentrated solar power can play an essential role in achieving secure and diversified energy future for India by providing supplemental electricity during times of peak usage and ensuring grid stability.

Forthcoming Events At A Glance

National

9th Nuclear Energy Conclave
Venue: Hotel le Meridien, New Delhi
Date: 27 October 2017
Website: www.indiaenergyforum.org

Intersolar India 2017
Venue: Bombay Exhibition Centre, Mumbai
Date: 05-07 December 2017
Website: www.intersolar.in

Global Re-invest 2017
Venue: Greater Noida
Date: 7-9 December 2017
Website: https://re-invest.in/

ELECRAMA
Venue: India Expo Mart, Greater Noida, NCR, India
Date: 10-14 March 2018
Website: http://ieema.org/events/

International

14th SOLAR Bangladesh 2017 International Expo
Venue: International Convention City, Bashundhara, Dhaka, Bangladesh
Date: 26-28 October 2017
Website: http://cems-solarexpo.com/

Solar Power New York
Venue: New York Marriott at The Brooklyn BridgeNew York, NY
Date: 11-12 December 2017
Website: http://events.solar/newyork/

POWER-GEN & DistribuTECH Africa
Venue: Sandton Convention Centre, Johannesburg, South Africa
Date: 19-20 July 2018
Website: http://www.wire-southeastasia.com/

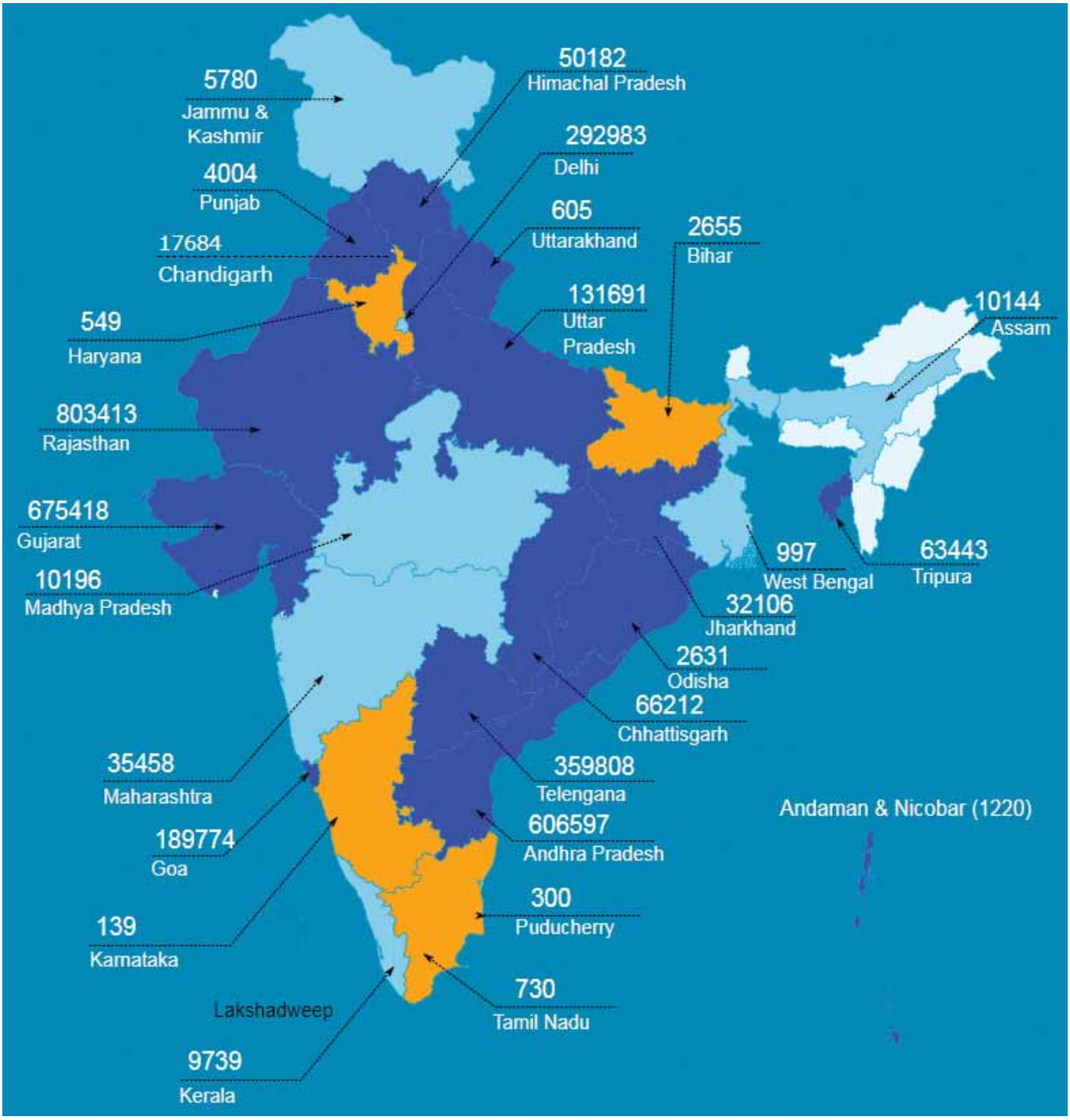
POWER-GEN
Venue: Orange County Convention Center
Date: 4-5 December 2018
Website: www.power-gen.com

Total Streetlight Completed 3,374,458

As on 24.09.2017

0.385 kWh	1299166.33 kWh	1078.31 tCO2	118.11 MW
Average energy savings per light per day	Average Energy Savings per day	GHG Emissions Reductions	Avoided Capacity

State Level Projects ■ **Individual ULB Level Projects** ■ **Institutional Projects** ■ **Project under discussions** □



Source: EESL

Witnessing Record-Breaking Visitor Count

Twelfth International Wire & Cable Trade Fair for Southeast Asia held at Bangkok Trade & Exhibition Centre (BITEC) showcased an impressive line-up of machinery, innovative products and solutions from the synergistic sectors of wire, cable, and tube....

Kobchai Sungsitthisawad, Deputy Permanent Secretary, Ministry of Industry inaugurating Wire and Tube Southeast Asia 2017 at Bangkok Trade & Exhibition Centre

Wire and Tube Southeast Asia 2017 – the 12th International Wire and Cable Trade Fair for Southeast Asia and the 11th International Tube and Pipe Trade Fair for Southeast Asia came to a successful close on 21 September 2017.

Together, the synergistic, co-located trade fairs unveiled an all-encompassing exhibit range that was presented by 400 leading industry names from 30 countries – of which 95% came from outside Thailand, as well as national pavilions and country groups Austria, China, Germany, Italy, Taiwan, UK and USA. Testament to the trade fairs' standing as the region's definitive sourcing and procurement platform for the industry, wire and Tube Southeast Asia 2017 recorded attendance of 8,458 trade visitors from 50 countries, with 39% coming from overseas, including visiting delegations from Vietnam, India, Japan, Thailand and Malaysia. This year's overall visitorship showed a healthy increase of close to 20% as compared to 2015, with local demand manifested by 65 local group visits from Bangkok Cable, Phelps Dodge International, Thai Wire Products, Thai Yazaki Electric Wire, The Siam Industrial Wire, among others.

In tapping into growth opportunities in Asia, companies need the right ecosystem and framework. Citing Kobchai Sungsitthisawad, Deputy Permanent Secretary, Ministry of Industry at the Opening Ceremony of wire and Tube Southeast Asia 2017, he shared that "the timely staging of exhibitions like wire and Tube Southeast Asia, thus bring forth new ideas, facilitate business deals and transactions and provide an environment for ideas and creative solutions to propagate, paving the way for product manufacturers, raw material suppliers, components and equipment manufacturers and technology innovators to gain their foothold in Thailand and the region."

Reiterating wire and Tube Southeast Asia's standing as a business-promoting forum were the sentiments gathered from visitors at the show grounds. For Ir Chang Yew Cheong, Vice President of The Electrical and Electronics Association of Malaysia, he shared that the trade fair brought a great opportunity for wire companies and manufacturers to be exposed to the latest range of products and technologies available in the market, and he will be bringing home the knowledge gained to his association members and the industry. His thoughts resonated with Naohiro Une, President of Daishin Industrial Co, who commented that he was glad to be able to see new technologies coming into Thailand at the exhibition.

Beyond the strong corroboration by international industry partners towards the trade fairs' dynamic line-up, the three full on days of action was augmented by concurrently held conference, seminar and technical presentations. Led by field experts and participating exhibitors, the concurrent events met with overwhelming response and were well-attended by over 300 trade attendees.

Online Feedback

Good Informative Discussion

Article: Smart Transient Free Switching of Switchgears
Author: Er K K Murty
Issue: May 2017

The article is good informative discussion on the inrush current phenomenon. The article has shed light on a basic duty of a 'Controlled Switching Device' in back to back switching of a shunt capacitor banks. The transients developed are very high in nature and are very injurious to the circuit breaker used for this duty. A case study, highlighting the need for implementing such device for back to back switching of shunt capacitor banks is also described in the article.

– Senthil Kumar

Differentiate Between Faulty Conditions & Normal Operating

Article: Superconducting Fault Current Limiters-Application and Effects in Power System
Author: Avinash Babu K M and Prof (Dr) Vinayak N Shet
Issue: November 2014

The article discusses superconducting fault current limiter technology that is a very much cost effective, clean, safe, reliable method of fault current limiting. Many researches are going on this topic. It has a very good future scope. In recent decades, all our systems will be of superconducting technology. It is one of the contributing components of smart grid technology. Only the limitation they are facing is that they cannot use for high voltages. Research studies are going on to overcome this difficulty.

Protective relays should be able to differentiate between faulty conditions and normal operating conditions and function only for the specific protection for which they are designed, without operating for any normal and short term acceptable abnormal events for which they are not intended to act and provide protection.

– P Kishore

Informative Article

Article: Protection System of a Grid-Connected PV System
Author: Dr Sasmita Behera, Dr Bibhuti Pati
Issue: April 2017

The article presents a case study of protection system of a Grid-connected PV power plant. The function and the ANSI codes for different relays have been discussed for a Line- In- Line- Out (LILO) arrangement and the protection standards in Indian scenario has been briefed in the case study. The multifunctional relays used with their advantages have been discussed. But it can be seen that with such interconnection at distribution level successful utilisation of capacity is possible only when reliability of feeder is high and synchronisation is maintained.

The case study is very good and informative.

– Srinivasulu B

FLIR CM83/CM85: True RMS Power Clamps

The FLIR CM83 and CM85 are industrial-grade power clamp meters engineered with advanced power analysis and variable frequency drive (VFD) filtering functions to meet the needs of electrical troubleshooters.

The CM83 and CM85 meters offer additional features including Bluetooth technology to connect compatible mobile devices for remote viewing and sharing, and METERLiNK technology, to wirelessly embed electrical readings into radiometric infrared images on compatible FLIR thermal cameras.

- VFD Mode provides superior accuracy for working on VFD-controlled equipment
- Advanced power efficiency and harmonics measurements for system level performance analysis
- True RMS voltage and current plus non-contact voltage detector
- Powerful LED lamps assist with clamping and are bright enough to serve as a primary work light
- 2 meter drop tested with lifetime warranty

For further information, Email: flirindia@flir.com.hk

Fluke T6: Electrical Testers with FieldSense Technology

Troubleshooting electrical systems can be time-consuming and potentially dangerous because it requires access to metallic contact points. The new Fluke T6 Electrical Testers with FieldSense Technology make troubleshooting safer and more efficient by allowing electricians to take simultaneous voltage and current measurements — not just detection — without test leads.

The T6 testers now make it possible to take reliable true-rms measurements in crowded junction boxes or along conductors with inaccessible end points, saving time, minimizing potential errors, and greatly reducing the possibility of arc flash.

With the Fluke T6-600 and T6-1000 testers, electricians can:

- Be safer: Measure voltage up to 1000 V through the open fork without test leads or exposed conductors
- Be faster: With no need to open panels or remove wire nuts, electricians can speed through troubleshooting
- Be more efficient: Simultaneously measure and display voltage and current on the T6-1000. The T6-1000 also measures resistance up to 100.0 kΩ

- Be everywhere: With the widest open fork in the industry, the T6 testers measure 4/0 wires up with current up to 200 A

At the heart of the T6 testers is the new Fluke FieldSense Technology. It enables the testers to give simultaneous, reliable voltage and current readings, not just simple go/no-go voltage detection.

The rugged testers are 1000 V CAT III, 600 V CAT IV safety rated (600V CAT III for the T6-600 model) and feature an easy to read display with a backlight.

For further information: www.fluke.com/india

CBS ArcSafe introduces RSA-186 for Westinghouse Type ADM disconnect switch

CBS ArcSafe, a well known manufacturer of remote racking and switching solutions for low- and medium-voltage switchgear, introduces its remote switch actuator (RSA) for the Westinghouse Type ADM disconnect switch. The lightweight, portable CBS ArcSafe RSA-186 allows technicians to remotely close or trip the Westinghouse load-break switch from a safe distance of up to 300 feet, well outside the arc-flash boundary.

Installation and operation do not require any modifications to the existing electrical equipment. The RSA-186 is compatible with Type ADM disconnect switches. Typical applications include use as a disconnect switch in AC-power systems up to 5500 V, with or without fuses. When compared to other arc-flash mitigation alternatives, the RSA-186 is a cost-effective solution for keeping operators safe.

Optional features include radio remote with a range of up to 300 feet, 24 V DC LED light, wireless video camera system with LCD monitor, and rugged protective case assembly. All RSA units are portable, fast, and easy to set up; offer mechanical and/or electrical safety protection; are adjustable to fit unique electrical equipment configurations; reduce the requirements for personal protection equipment; and help customers with NFPA 70E arc-flash safety compliance.

For further information: www.cbsarcsafe.com

True RMS Clamp Meter

Model KM-086 is a new AC True RMS Clamp Meter introduced by 'KUSAM-MECO', an ISO 9001-2008 certified company. It has Three Phase Rotation indications, backlight function, MAX/MIN/AVG Recording mode (Auto ranging). It has a unique AmpTip function, not available in any other instrument in the market.

This feature allows users to keep the current carrying conductor at the top end of the clamp meter & get accurate measurements whereas in other meters, the current carrying conductor has to be at the centre of the clamp to get the best accuracy. KM 086 also has VFD-V & Hz function specially designed for variable frequency drives. It can measure TRMS 1000A AC Current upto400Hz frequency, TRMS AC voltage 1000V upto 400Hz frequency, DC1000Volts, Capacitance upto2500 µF, Frequency, Continuity, Temperature upto 400°C /752°F. It can measure DCµA current & has a special feature of Noncontact EF detection. It has Crest peak-RMS hold & data hold facility.

It has highest safety levels having transient protection upto 8 KV lighting surge and meets the requirements for CAT III 1000V & CAT IV 600V AC & DC. It meets E. M. C. requirements and Double insulation per UL/IEC/EN61010-1 Ed. 3. 0, IEC/EN61010-2-033 Ed. 1. 0, CAN/CSA C22. 2 No. 61010-1Ed. 3. 0, IEC/EN61010-2-032 Ed. 3. 0 &IEC/EN61010-031 Ed. 1. 1. It has a fire retarded casing.

The conductor size is upto 51mm dia. It is supplies with Soft Carrying Pouch, Operating Manual, Test lead set, Bkp60 banana plug K-type thermocouple, Alligator Clip set, BKB32 banana plug to type-K socket plug adaptor (for optional purchase).

For further information: www.kusamelectrical.com

GE's Resilient Power Supply for Industrial Applications

Utilising its expertise in the power segment, GE's industrial solutions has introduced its new power supplies specifically designed for general purpose industrial applications—its resilient 3000. The 3,000-watt (W) power supplies are engineered to provide the high reliability and ruggedness needed in today's demanding industrial segment in a simple, cost-effective solution.

The user-friendly design of the Resilient 3000 (officially known as GE's EP3000AC48IN) eases the implementation process for all users—regardless of experience level or design sophistication—enabling a broad range of users to deploy and operate the units in their unique applications. While the modules are designed with simplicity in mind, they also maintain the performance, efficiency and ability to offer robust communications that users require. The power supply's rugged design, which includes a conformal-coated interior circuit board to protect against dust and high humidity, and an oversized fan that enables the unit to operate in extreme temperatures make it an ideal fit for demanding industrial applications. Additionally, the Resilient 3000's robust design can withstand poor grid conditions and line surges, allowing for global deployment in a wide range of industrial applications.

The single-phase Resilient 3000 power supplies enable a constant 3,000-W output power with an output voltage of 48 Volts, which offers plug-and-play connectivity and operating efficiencies of up 95%. The units are scalable and can be paralleled for load sharing, providing added flexibility for industrial customers looking for a solution to their unique power challenges.

Additional key features of the Resilient 3000 rectifiers include:

- Wide operating temperature range (-10 C to +70 C).
- Wide selectable output voltage range (48 to 58 volts DC).
- RS-485 communication.
- +5-volt auxiliary output.
- Compact size and light weight (approximately 7.5 pounds).
- High mean time between failures design.
- Simple connectivity—convenient two-piece connectors allow for rapid yet confident AC and DC connections and simple wire-and-go-connectivity assures rapid deployment and servicing.
- Over-voltage and high-temperature protection.
- Built-in surge protection.

For further information: www.ge.com

TI enables the widest bandwidth and lowest phase noise for next-generation high-speed systems

Texas Instruments (TI) has introduced an analog-to-digital converter (ADC) and phase-locked loop (PLL) with an integrated voltage-controlled oscillator (VCO) that deliver the widest bandwidth, lowest phase noise and highest dynamic range in the industry. The wideband ADC12DJ3200 is the fastest 12-bit ADC, delivering speeds up to 6.4 GSPS. The LMX2594 is the industry's first wideband PLL solution to generate frequencies of up to 15 GHz without using an internal frequency doubler.

High-density phased-array radar systems, 5G systems and satellite communications demand increased data throughput, higher bandwidth and lower power, all in smaller a footprint. A multi-node synchronisation reference design demonstrates how the ADC12DJ3200 and LMX2594 provide accurate, time-stable synchronisation for multi-node sampling systems including large-scale phased-array radars, digital storage oscilloscopes (DSOs) and 5G wireless testers. The reference design showcases the LMX2594's SYSREF forwarding feature and the ADC12DJ3200's aperture delay adjust, time stamp and calibration features to improve accuracy and ease system design.

For further information: www.ti.com

SolarEdge unveils the fastest AC EV charging rates by supplementing grid power with PV power

SolarEdge Technologies, a well known leader in PV inverters, power optimisers, and module-level monitoring services, has revealed the world's first inverter-integrated electric vehicle (EV) charger. By supplementing grid power with PV power, SolarEdge's Level 2 EV charger offers charging up to six times faster than a standard Level 1 charger with its innovative solar boost mode.

SolarEdge's HD-Wave inverter, once integrated with an EV charger, will not only provide the existing management and monitoring of solar production, but will also enable EV charging from a single inverter and dashboard. The combined solution will offer considerable cost savings on both hardware and labour by eliminating the need for an additional conduit, wiring, and breaker installation. The solution will also eliminate the need for an additional dedicated circuit breaker, which saves space and a potential main distribution panel upgrade.

Based on patent-pending technology, the EV charger is embedded into SolarEdge's HD-Wave inverter and leverages its solar boost mode. This mode utilizes both grid and PV to charge at 9.6kW (40 Amp) Level 2 charging, which is up to six times faster than standard Level 1 charging. If PV is not available, the inverter-integrated EV charger will use grid power to charge at 7.6kW (32 Amp) Level 2 charging, which is up to five times faster than standard Level 1 charging.

With a 12-year warranty, the inverter-integrated EV charger offers potential future operating modes, such as demand-response and charging at off-peak hours to optimise Time-of-Use (TOU) rates. The inverter-integrated EV charger is expected to be available in the last quarter of 2017.

For further information: www.solaredge.com

Smart power transformer maintenance

OMICRON's Primary Test Manager (PTM) software was optimised for initial screening, diagnostic testing and condition assessment of power transformers with the release of software version 4.00. All common chemical, electrical and dielectric tests on power transformers are now supported by one software.

Smart testing

With proper testing and maintenance, the lifetime of a power transformer can be extended by identifying and fixing defects before they can cause severe failures. A smart combination of an initial screening, e.g. by performing dissolved gas analysis (DGA) and power/dissipation factor tests, and focused diagnostic testing is often utilised to keep the lifecycle management process more cost efficient.

A variety of other electrical test methods, such as transformer turns ratio, DC winding resistance, short-circuit impedance as well as advanced methods such as dielectric response analysis or sweep frequency response analysis (SFRA), can be used to diagnose different problems within the power transformer.

Condition diagnosis in the past and nowadays

In the past all test data had to be transferred manually from the individual test devices to one common file. Comparisons and reports also had to be prepared manually. Since the software release 4.00, PTM supports all common diagnostic tests performed with various OMICRON test systems as well as the corresponding condition assessment, such as the assessment of DGA test data.

Thus, all data can be collected in one database, resulting in advantages such as overall assessment, easy data management, data comparison, trending, one comprehensive report and less training effort for employees. Combined with the time-saving advantages of new OMICRON test systems such as the TESTRANO 600 three-phase power transformer test system and the DIRANA for dielectric frequency response analysis, power transformer testing can be done in a fraction of the time needed in the past.

Ideal software for medium- and high-voltage asset testing

In addition to diagnostic testing and condition assessment of power transformers and associated equipment such as bushings and on-load tap changers (OLTC), PTM can also be used for circuit breakers, current and voltage transformers, and rotating machines.

For further information: www.omicronenergy.com

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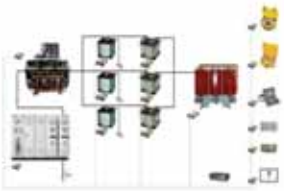

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Toshiba Launches New Series of Next Generation 15,000 RPM Enterprise Performance 2.5-inch HDD

Toshiba Corporation's Storage & Electronic Devices Solutions Company revealed the launch of AL14SX Series. It is a new addition to its line-up of enterprise performance hard disk drives (HDD) for mission critical server and storage applications.

The AL14SX Series of 15,000RPM 2.5-inch drives features a 12Gbit/s SAS interface. Available models are 4K native (4Kn) model and 512 emulation (512e) model that feature Advanced Format Sector Technologies, and 512 native (512n) model optimised for legacy applications and hypervisor environments. The AL14SX Series delivers a suitable choice for customers' diverse applications.

The AL14SX Series is available in 300GB, 600GB and 900GB capacities. The 900GB model offers a 50% increase in maximum capacity from the 600GB of the predecessor AL13SX Series. The 4Kn and 512e models also delivers an approximately 19% increase in sustained data rate, pushing it to 290MiB/s, and an approximately 28.7% improvement in power efficiency (W/GB). These improvements in capacity, speed and power-saving contribute to a lower total cost of ownership (TCO) for the server and system.

Customers also can select models supporting Sanitize Instant Erase (SIE), which realises fast invalidation of data recorded on the disks, allowing for efficient disposal and reuse.

For further information: https://toshiba.semicon-storage.com

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