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# Publisher's Letter



Mahadevan Iyer

“  
**An effective Energy Management System (EMS) needs to include all aspects of energy inputs and outputs...**  
”

Anywhere in the world, people are attracted towards well-lit retail stores. However, lighting involves use of energy, which is a scarce resource in most of the countries. Also, there are other energy consuming systems that are essential to run a retail store appropriately, for example: HVAC systems, Security systems etc. So, today not only maintaining the right retail store environment is a big challenge for the store owners, but also reducing the energy consumption to the minimum possible level adds to their headache.

With advent of intelligent process components, many companies have come forward to address the issue with their software solutions. So, the market is full with solutions. But the decision makers are often confused to pick the right one owing to their individual bias on certain things. And this leads to landing up into buying a solution that is often non-comprehensive.

An effective Energy Management System (EMS) needs to include all aspects of energy inputs and outputs. More clearly, that should reflect an integrated approach like covering HVAC&R (heating, ventilation, air conditioning and refrigeration) units, indoor lighting, store signage, indoor and outdoor temperature sensors, communication devices, weighing scales and security devices. Also, a good EMS keeps track of energy output and performance of on-site solar panels, which is gradually becoming a commonplace in retail stores worldwide.

Contextually, another important aspect is power back-up and parallel control circuitry. The decision makers should ensure that even, because of any reason, if the normal circuit channel stops functioning, the second one should take over immediately. It is always better to have a provision for the third channel too.

Do send in your comments at [miyer@charypublications.in](mailto:miyer@charypublications.in)

*Mahadevan*

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**Imteyaz Siddiqui,**  
ISA Advanced Instruments  
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## Feature



**Nuclear Plant  
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P K Chatterjee (PK)

“  
*Several Indian and international researchers are actively working to further develop the off-Grid technology to make it cheaper and more efficient...*  
”

## We Need Off-Grid Energy

In a sub-continent like India, it is not an easy task to bring all the remote places under the country-wide grid connection in no time. There are many challenges like inaccessibility, lack of transportability, cost of long length transmission lines, possibility of huge transmission loss and so on. In fact, as on date more than 300 million people in India have no access to grid electricity, and obviously the problem is especially acute in rural communities. Under such circumstances, we have no alternative but to use off-Grid technologies too, and this is globally a common practice today. In sub-Saharan Africa, Philips, in PPP model with the Dutch Government, has developed a new generation of sustainable, LED-based, solar-powered lighting infrastructure. The project is targeted to help 10 million people in 14 countries in sub-Saharan Africa. There are many other such examples.

After COP 21, most of the nations are trying to reduce their carbon footprint, where off-Grid technology can play a big role too. In small isolated rural areas, solar panels are much beneficial. In breezy villages, small wind turbines can create magic. They will not add much to the carbon weightage of the country – so the technologies deployed at small scale have multiple benefits. In addition to being flexible in size, microgrids can run on whatever power sources are available, including wind, hydropower and the source accessible at all sites, i.e., solar power.

Several Indian and international researchers are actively working to further develop the off-Grid technology to make it cheaper and more efficient. For example, At MIT's Tata Center for Technology and Design, researchers are exploring ways to extend electricity access to such communities using microgrids – independent electricity generation and distribution systems that service one village or even just a few houses. Robert Stoner, Deputy Director for Science & Technology at the MIT Energy Initiative (MITEI) and Director of the Tata Center says, "The statistics say that 1.5 billion people worldwide lack access to electricity, but many more don't have reliable access. We're looking for ways to make electricity available to everyone without necessarily having to go through the costly and time-consuming process of extending the national electric grid."

Please e-mail me your views at [pkchatterjee@charypublications.in](mailto:pkchatterjee@charypublications.in)

*P. K. Chatterjee*





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## Kakrapar Atomic Power Station is shut down after a leak

Kakrapar Atomic Power Station Unit-1 (KAPS 1-220 MWe) was shut down on March 11, 2016 after a leak in its Primary Heat Transport (PHT) system.

Various safety systems came into play and the core cooling systems got activated as per design. Reactor cooling was continuously maintained thereafter by systems provided in the design.

Environmental matrices in and around the plant were monitored for radioactivity by the Bhabha Atomic Research Centre (BARC) Environmental Survey Laboratory. No radioactivity or radiation was observed in plant premises or in public domain after the incident occurred.

The reactor building was accessed and the source of the leak was identified to be



from a coolant channel. The 220 MWe Pressurised Heavy Water Reactor (PHWR) core comprises of 306 coolant channels made of Zirconium-Niobium alloy, each of which houses 2 fuel bundles.

The coolant flows through these channels, transferring the heat from the fuel to the steam generator to produce steam for the turbine to produce electricity.

Fuel bundles from the identified channel have since been removed (the channel defueled) using sophisticated remotely handled tools.

Bundles were inspected and found to be intact without any damage. The affected channel has since been isolated and the leak arrested.

No workers involved in the operation were exposed to any undue radiation. Radiological conditions were normal – and cooling was maintained in all the remaining channels. All systems are operating normally, and the unit is in a safe shutdown state. Investigation will now be carried out to find the cause of the failure. The unit will be restarted after that inspection of relevant components and equipment, besides corrective actions. **ET**

## Sunil Khanna becomes Chairman of CII's Maharashtra council

Emerson Network Power (India) President and MD Sunil Khanna, has been elected as Chairman of the Confederation of Indian Industry's (CII) Maharashtra State Council. With his election, the CII State Council has also unveiled its theme for 2016-17, 'Building Maharashtra: Innovation, Integration and Investments for the State'.



"Manufacturing in Maharashtra is getting a greater focus than ever before, thanks to Prime Minister Modi's 'Make in India' initiative and the Chief Minister's announced goals this year to enhance ease of doing business in the state," said Khanna.

"As CII Chairman, I will work to transform Maharashtra into a global manufacturing hub with a special

thrust on ease of doing business, innovation, integration and investments," he added.

Previously, he served as VICE Chairman of CII Maharashtra's State Council, and was a member of the CII National Executive between 2008 and 2009.

Khanna has led Emerson Network Power India since September 2012. **ET**

## GE to evaluate renewable integration and energy storage possibilities in India

General Electric (GE) has announced that its Energy Consulting business has been chosen by IL&FS Energy Development Company Limited (IL&FS Energy) to examine the feasibility of integrated wind, solar and energy storage projects at its sites in Ramagiri in Andhra Pradesh and Nana Layja in Gujarat.

The move is in keeping with the momentum after the United States Trade and Development Agency (USTDA) and President Obama outlined numerous trade and investment initiatives with India last year at the US-India Business Council Summit, which included an initiative to invest nearly US\$ 2 billion for priority renewable energy projects in India.

"Energy storage technologies are essential for renewables. They help address the variability of wind and solar photovoltaic power generation and make renewable energy more acceptable to the grid," IL&FS Energy Managing Director Sunil Wadhwa said.

"For commercial deployment of these technologies, a robust regulatory framework needs to be in place. The flexibility and cost reductions that energy storage technologies provide to grid infrastructure would allow India to achieve an efficient, low-carbon intensity trajectory. The current challenge, however, is to address the initial high cost through a regulatory framework," he added.

IL&FS Energy, a subsidiary of Infrastructure Leasing & Financial Services Limited (IL&FS) – one of the largest wind independent power producers in India, is at the forefront of the country's renewable integration initiative.

"Energy storage can be particularly helpful for integrating variable renewable generation in India. As costs start coming down, energy storage will become an integral part of India's grid," GE's Energy Consulting Business Technical Director Sundar Venkataraman said. As per investment bank Lazard, energy storage costs are expected to come down significantly over the next five years. **ET**



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## PM Modi, Bangladesh PM dedicate second cross border power transmission system

Indian Prime Minister Narendra Modi and Bangladesh Prime Minister Sheikh Hasina have jointly dedicated the second cross border electricity transmission interconnection system between India and Bangladesh, through a video-conferencing link recently. The newly built link has connected Surjyamaninagar in Tripura to South Comilla in Bangladesh.

The two leaders also dedicated the transmission of 10 GBPS Internet connectivity between Cox Bazaar in Bangladesh, and Agartala in India. "We have already incorporated excess capacity on the electric



lines so that in the coming days, we may use it as quickly as needed," said Prime Minister Modi, as he welcomed the many avenues of co-operation that have opened up between the two countries in recent times.

On the occasion, Modi expressed that he had attached tremendous importance to the opening up of the new Internet gateway in the eastern part of India. E1

## India unlikely to achieve target of 40 GW rooftop solar power, says report

India is unlikely to achieve its ambitious target of 40 GW of installed solar rooftop power generation capacity by 2022, if it continues with its current government policies, according to a report released recently.

'Scaling Up Private Investment in Rooftop Solar' is a report authored by the Solar Rooftop Policy Coalition -- a consortium of the UK Department for International Development, the Climate Group, the Shakti Sustainable Energy Foundation, besides the Nand and Jeet Khemka Foundation.

The report has mentioned that India is planning to have 100 GW of solar power generation capacity by 2022, out of which 40 GW would be on rooftops, while the rest would



be ground-based projects.

However, the report has forecast that the present government policies would at best raise India's solar power generation capacity to 13.5 GW by 2022.

"The 40 GW target requires 86% growth each year, which is faster than the growth in mobile phone connections in the 2000s," the

report has noted and also outlined more than 50 recommendations in terms of policy to drive the Indian rooftop solar power generation market.

The report has pointed out that financial incentives have their limitations. "Capital subsidies have supported the market but their impact has been reduced because of limitations in the availability of funds," it said.

The work has also added that accelerated depreciation, whereby developers are allowed to value depreciation at 80% in the first year of deployment itself (while computing taxes to be paid) has played a role in incentivising the sector, but also deterred important capital resources from entering it. E1

## Indians to get 24x7 affordable and sustainable power by 2019, says Piyush Goyal

Union Minister of State (Independent Charge) for Coal, Power and New and Renewable Energy Piyush Goyal said that Indians would get 24x7 affordable and sustainable energy by 2019, since Prime Minister Narendra Modi is committed to ensure a better quality of life for every citizen of the country.

"I think this challenge of being able to provide power to every citizen is an opportunity. I am getting fantastic ideas and support from all stakeholders from this sector. Without a challenge people would see affordable, sustainable energy 24x7 by 2019," Goyal said at the India Smart Grid Week 2016 (ISGW) at Manekshaw Centre.

"India is the world's largest market,

considering that we are a billion people looking for a better quality of life. Prime Minister Modi is committed to ensure a better quality of life to every citizen. The poorest of the poor in India should benefit from the technological revolution which the world benefits from," the minister said.

He also said that affordable energy access to every individual in this country is a primary goal which could be achieved with the support of all stakeholders.



Comparing the technological revolution in Sweden with relevance to India, he said that India has the potential to do the same 100 times over.

"With a population of nine million, Sweden is able to do wonders and with a population of 1,200 million which India has, we will do wonders 100 times over," he added.

India Smart Grid Week (ISGW) 2016 was the second edition of the conference cum exhibition on smart grids and smart cities organised by the India Smart Grid Forum from March 15 to 19. The conference brought together experts in the field of electricity, infotech, communications and smart cities, to discuss challenges as well as opportunities to set up smart grids in India. E1



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THE FUTURE OF BRIGHT

## Clarke Energy bags 1<sup>st</sup> GE Jenbacher's order in Cameroon



Clarke Energy, the authorised distributor and service provider for GE's Jenbacher gas engines in 17 countries, is well known in the engineering design, installation and long-term maintenance of gas engine-based power plants.

U.K.-based Clarke Energy, is supplying a 1.4 MW J420 Jenbacher gas engine to Flour Mill SCTB s.a. (Societe Camerounaise de Transformation du Blé S.A.) to provide more reliable, cost-effective, on-site power for the


company's mills in the city of Douala. The project marks the first Jenbacher gas engine order in Cameroon for Clarke Energy.

The Jenbacher unit will permanently replace existing rented gas generators at the site, giving SCTB a more cost-effective, permanent, on-site power solution that will enable the company to save more than \$200,000 annually in fuel costs. The system is scheduled to enter commercial service in the second quarter of 2016.

"Changing from a rental power plant to a permanent installation provided by Clarke Energy and using GE's Jenbacher gas engine technology will enable us to save in excess of \$200,000 per year in fuel costs. Installing a permanent on-site power solution also will help us improve our mill's availability so we

can meet our production targets," said Fofou Gregoire, Project Manager of SCTB.

Clarke Energy worked with SCTB to develop a technical solution to deliver a permanent supply of reliable electricity from pipeline-sourced natural gas. The projected savings in fuel costs was a significant driver for the gas engine's installation. The project marks the first Jenbacher engine that Clarke Energy has supplied to SCTB.

"GE's gas engine technology has been proven to be an attractive technical and commercial solution for Cameroon. This installation will be our first in Cameroon and will immediately start to deliver cost savings and reliable energy to our customer SCTB," said Ali Hjaiej, Business Development Director—Africa, Clarke Energy. 


## Tata Power conferred with Sustainable Plus Platinum status by CII

Tata Power has been recognized as one of India's most sustainable companies with the Sustainable Plus Platinum Label for FY2015. The company has received a high Sustainability rating 'A' for its Sustainability performance according to a new assessment done by Confederation of Indian Industry (CII).

The company's Sustainability Policy integrates economic progress, social

responsibility and environmental concerns with the objective of improving quality of life. It continues to undertake efficient and sustainable business strategies for the holistic growth and development of its business and its communities. Tata Power has also adopted the guidelines laid down by the Global Reporting Initiative (GRI) for its Sustainability Reporting, which encompasses the 'Triple Bottom Line' (TBL)

approach, i.e., focus on financial, social and environmental performance.

SustainablePlus undertakes a comprehensive Environment, Social and Governance (ESG) analysis, of top 100 companies across 20 sectors, which contributes to ~95% of India's GDP. The assessment helps companies measure their performance, improve market opportunities as well as identify the challenges. 

## Suzlon wins 81.90 MW turnkey orders


As per a recent communiqué from the Suzlon Group, it has won an order for a combined capacity of 81.90MW. The orders have been received from an assortment of customers representing SMEs across diverse industry segments including food and agro, textiles, chemical, real estate and engineering. It also includes a consecutive repeat order from the country's first municipal corporation to invest in wind energy. Suzlon will install its robust multi-megawatt S111 90m, S97 120m, S97 90m and the S95 90m turbines with rated capacity of 2.1MW each.

The company will provide a comprehensive range of services to build and maintain the wind projects, which include

design, supply, installation, commissioning and dedicated life cycle asset management services. The projects are spread across the key wind states of Tamil Nadu, Gujarat, Andhra Pradesh and Madhya Pradesh, and are scheduled to be completed by FY17.

Ishwar Mangal, Chief Sales Officer, Suzlon Group said, "The order wins from our new and existing customers affirms our role as the preferred partner for end-to-end renewable energy solutions across industry sectors and across the country. Our technological expertise and continuously upgraded product portfolio have allowed us to offer customised solutions that are suitable to varying wind regimes. We will continue to

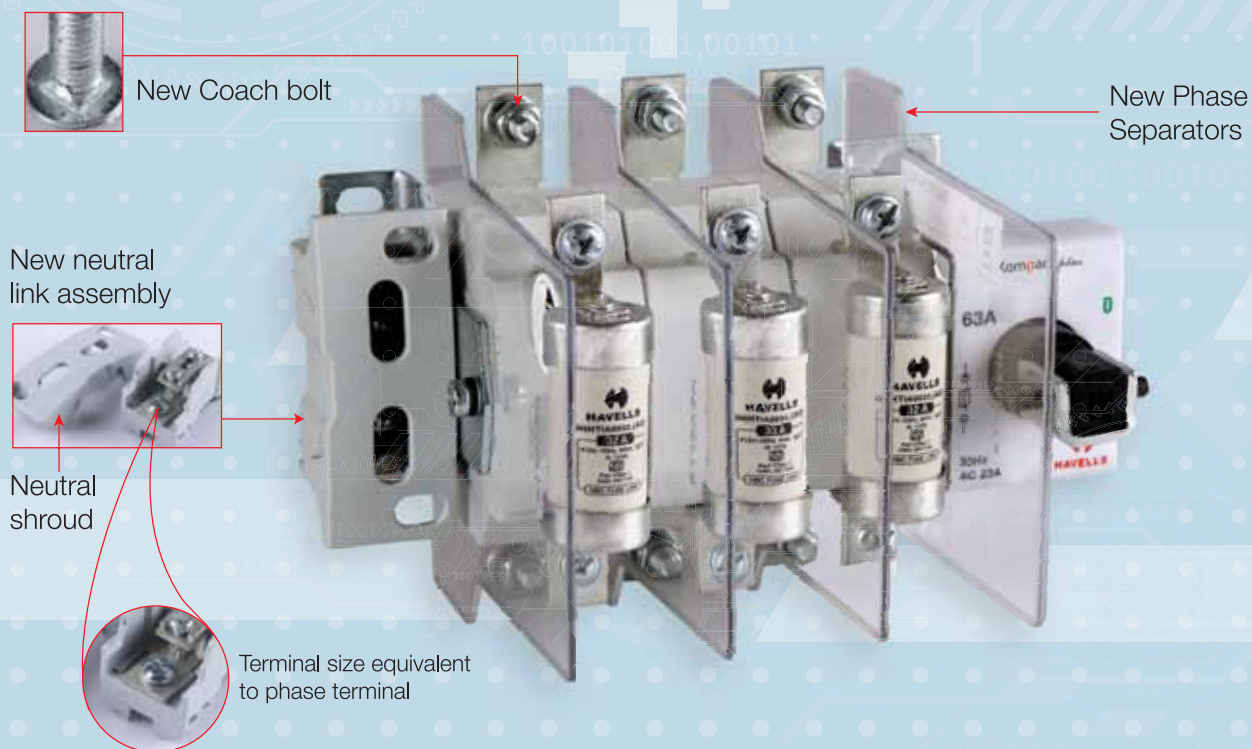
develop high yield products that effectively bring down the cost of energy. Suzlon is also committed to achieve the government target of 175GW by 2022. With over 18 years of market leadership, over 9GW installations, pan-India presence and best-in-class service, we are well positioned to capture the opportunities in the domestic market."

The S9X series portfolio is designed to optimally harness the available wind resources, and deliver higher energy and RoI to customers. The S97 2.1MW Wind Turbine Generator (WTG) features the time tested Doubly Fed Induction Generator (DFIG) technology, which is designed to maximise generation and unlock low wind sites. 

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## Yokogawa releases Plant Resource Manager version R3.30

Yokogawa Electric Corporation has released version R3.30 of its Plant Resource Manager (PRM) software tool for the centralised management of large amounts of data from plant monitoring and control devices and manufacturing equipment. PRM R3.30 is an upgrade to R3.20 and includes an improved management function for HART and enhancements to the navigation function. With this new PRM



A screenshot of the Plant Resource Manager (PRM) software tool...

version, Yokogawa aims to capture a larger share of the plant maintenance market.

Manufacturers are constantly looking for ways to improve maintenance efficiency by using software tools like PRM that can centrally manage large amounts of maintenance and other types of data from plant monitoring and control devices and manufacturing equipment. Maintenance personnel use such data to reduce plant downtime and enhance safety. 

## CG to supply transformers to PT PLN (Persero) of Indonesia


CG has won a significant order of USD 35 million (INR 236 crore approx.) from PT PLN (Persero), the state-owned electricity company of Indonesia, to manufacture and install 28 power transformers ranging from 83.3 MVA to 167 MVA and rated voltage 500 kV/150 kV. These power transformers will be installed across PT PLN's transmission network, spread over multiple substations and power plants in the Java, Sumatra and Kalimantan provinces of Indonesia. The delivery period is scheduled between May 2016 and March 2017.

The order falls under a project funded by PT PLN to enhance the performance of the Indonesian transmission grid. Power

transformers are critically important for PT PLN considering the present power situation in Indonesia. Through the deployment of CG's power transformers, PT PLN will be able to lessen its dependence on the import of heavy equipment, while simultaneously executing a timely implementation of its transmission network strengthening programme.

Bidding for the contract took the form of a competitive and transparent open book process introduced by PT PLN in 2012. All manufacturers taking part therefore had to pass stringent quality checks, particularly with regard to low losses and a higher degree of polymerization. The power transformers will

be manufactured in CG's world-class manufacturing facility in Indonesia.

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

## Wärtsilä to deliver Nordic countries' largest biogas plant

Wärtsilä has been awarded the order to supply a biogas liquefaction plant that will produce fuel for public transport vehicles, mainly in Norway.

The Wärtsilä plant will be installed at the paper mill in Skogn, Norway and will convert the cleaned biogas from fishery waste and residual paper mill slurry into liquid fuel. The liquid will be cooled to minus 160°C and stored in insulated tanks. The system has been specially designed to liquefy small methane-based gas streams. This novel technology is based on readily available, well proven components but features a highly advanced process design and control system. The environmental benefits of delivering renewable liquid biogas fuel are enhanced by the fact that sulphur oxide (SOx) and particle emissions are




Plan of the Wärtsilä plant that will be installed at the paper mill in Skogn, Norway positioning and glue pasting for power supply boards and produce around 24.8 million pieces per year...

virtually eliminated, while any released CO<sub>2</sub> has zero environmental impact since it is part of the existing circulatory CO<sub>2</sub>.

"Wärtsilä is very pleased at being contracted to deliver a compact solution

featuring proven technology that has been adapted to the needs of the customer. The system offers low operating costs and is energy efficient. Furthermore, the environmental footprint will be minimal. By enabling profitable projects for smaller gas streams, we are aiding the EU's target of having ten percent renewable fuel by the year 2020," says Timo Koponen, Vice President, Wärtsilä Marine Solutions.

"We expect strong demand in a fast growing market for liquefied biogas fuel. Wärtsilä's biogas liquefaction solution represents an important step forward in realising this potential. The fuel can now be produced economically and sustainably, which were key factors in the award of this contract," says Håvard Wollan, Chief Executive Officer of Biokraft A/S. 



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## SolarReserve finds a way to store electricity in salt

SolarReserve, a solar power company based in Santa Monica (USA), has announced a solution to store electricity using salt. Called Crescent Dunes, the SolarReserve power plant is a 110-megawatt (MW) facility with 10 hours of energy storage. That translates into 1,100 MW hours of storage, which is enough to power 75,000 homes. In other words, the facility can run for an additional 10 hours at full 110 megawatt output, merely from stored energy, that is, with zero sunshine.

Crescent Dunes claims to have managed this by using rings of billboard-size mirrors to reflect the sun onto a tower filled with salt.

The molten salt boils the water, producing steam, which powers turbines electricity-generating turbines.

"So far, in the industry that's state of the art, molten salt storage," said Yogi Goswami, a professor at the University of South Florida, who is also an expert on solar power. Goswami, who experimented with salt storage at Tampa University, said SolarReserve has demonstrated the commercial potential of the technology.

However, he also said that such energy storage has drawbacks, including the corrosive nature of salt, besides the high cost, adding that SolarReserve got around the corrosion



problem by encapsulating the salt in ceramic balls. Its molten salt technology includes the molten salt receiver, the heliostat collector field controls and tracking system, as well as the molten salt energy storage system. **EI**

## Private SA firm developing high temperature small modular reactor

South African private sector company Steenkampskraal Thorium Limited (STL) is developing a design for a small modular reactor, which it calls the High Temperature Modular Reactor (HTMR).

This is being done using expertise developed in South Africa by the now effectively abandoned Pebble Bed Modular Reactor (PBMR) project. Like the PBMR, the smaller HTMR will use small spherical fuel elements, or 'pebbles'.

STL, which also owns the Steenkampskraal thorium and rare earths mine in the Western Cape, is developing a 100 MWt HTMR-100,

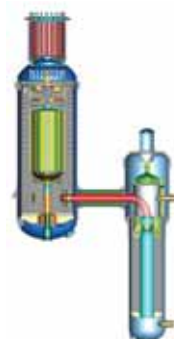
which would be able to produce up to 35 MWe," explained STL chairperson Trevor Blench at the Nuclear Africa 2016 conference, in Centurion, west of Pretoria.

"Almost every country in Africa needs power, water and food, but most cannot afford large-scale nuclear power plants. A small reactor like ours could cost about \$300 million. That's affordable for many African countries," he said.

The HTMR shares the inherent safety of other PBMR designs, demonstrated in practice in both the German original and the Chinese HTR-10 small experimental reactor.

The HTMR has been designed to be able to use uranium fuel, thorium-uranium fuel or thorium-plutonium fuel (an option for countries which possess plutonium; this option would not be relevant to Africa).

Like other designs, the HTMR could be manufactured in a factory and the reactor vessel could be transported to the site by road. **EI**



## UK-based Tokamak Energy aims to build small nuclear fusion reactors

United Kingdom-based nuclear power firm Tokamak Energy is in a race to mass produce small fusion reactors, with rivals including USA-based Lockheed Martin's famous Skunk Works team, who said in 2014 that they would produce a truck-sized nuclear fusion plant in a decade, but attracted criticism for providing few details.

Tokamak Energy's third fusion reactor prototype, which is currently under construction, aims to reach 15mC in the next 12 months and 100mC by the end of 2017, its Chief Executive David Kingham announced, adding that it has a target to produce electricity by 2025 and feeding it into the grid by 2030.

"If we progress quickly with relatively modest funding then we will get to a Wright brothers' moment in nuclear fusion and suddenly people will realise it is going to be possible," said Kingham, whose company is a spin off from the UK's National Fusion lab at Culham, near Oxford.

"That will unlock lots of investment around the world to solve some of the big challenges," he opined.

The company is also up against North America-based companies backed by Amazon's Jeff Bezos and Paul Allen,



Microsoft's co-founder, in the race to make a breakthrough. Tokamak Energy is aiming to accelerate the development of fusion energy.

Tri Alpha Energy, which harnesses particle accelerator technology is backed by Allen, while General Fusion, is backed by Bezos, besides Helion Energy, First Light Fusion and the University of Washington's Dynomak. **EI**



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## Siemens ready to buy Areva wind energy venture in Gamesa deal

Siemens is planning to buy Spanish-French wind power joint venture Adwen as part of a planned merger of its wind assets with those of Spain's Gamesa.

Siemens and Gamesa are planning to combine their wind assets to form the world's biggest wind turbine maker with about 10 billion euros (US \$11 billion) in sales, overtaking current market leader Vestas. However, the deal has stumbled over how to deal with Adwen, Gamesa's 50:50 joint

venture with French state-owned nuclear group Areva.

Siemens has been unwilling to fulfil certain parts of Adwen's contracts, including an obligation to develop and build a jumbo offshore turbine in France.

"What's at stake for France is simple: the creation of a complete and competitive industry with a strong industrial presence in



France," comments a French government official on the issue.

French Economy Minister Emmanuel Macron said that a solution would have to come from the companies involved.

"I want those factories to be built because we need this capacity. Since it looks probable that it will not be Adwen, they will be built by the partner that makes the best offer in terms of industry and employment," he added. **EI**

## World's largest floating solar farm built on UK reservoir with 23,000 panels

The world's biggest floating solar farm has been built on the Queen Elizabeth II reservoir in Walton-on-Thames, with 23,046 solar panels and measures up to 57,500 square metres (618,925 square feet) in size.

The reservoir is run by Thames Water and the solar farm is being funded and operated by solar energy company Lightsource. At a cost of £6 million, the solar farm, which has taken three months to build, generates enough electricity to power 1,800 homes – a peak power output of 6.3 megawatts.

The panels cover around 10% of the Queen Elizabeth II reservoir – and are not considered

to have any major adverse environmental impact, as the reservoir is primarily aimed at supplying drinking water.

The power will be used by Thames Water to power its water treatment plants.

A similar floating farm is to be built on a reservoir by United Utilities in Manchester.

However, the Japanese are building a



floating reservoir in Japan that will be twice the size of the QEII array when completed in two years, i.e., in 2018. **EI**

## Bureau Veritas gives seal of approval to KRISO's ocean thermal energy convertor

The global classification society Bureau Veritas has issued its first 'Approval-in-Principle' for an Ocean Thermal Energy Converter (OTEC).

The approval applies to a 1MW plant developed by the Korea Research Institute of Ships and Ocean Engineering (KRISO), which will be built for installation off the coast of South Tarawa, Republic of Kiribati, in the South Pacific Ocean.

OTEC is a sustainable way to produce electricity from the difference of temperature between deep cold and warm surface seawater. A working fluid is successively vapourised and condensed in a thermodynamic cycle, with the gas phase driving a turbo-alternator, which generates electricity.

KRISO's 1MW OTEC plant is the first practical level of plant on a pathway to building a 100MW commercial system. It consists of an octagonal 6,700-tonne, four-deck floating platform 35-metre (115 feet) across moored six kilometres (3.7 miles) offshore in a water depth of 1,300-metre (4,200 feet). A 1,000-metre (3,280-foot) pipe 1.2-metre (3.9-foot) in diameter will be used to pump cool water up from ocean depths, to be fed to a process plant on the platform.

Bureau Veritas' engineers verified a metocean/hydrodynamics analysis, mooring analysis, stability analysis, and examination of the riser design and system design concept.

Matthieu de Tugny, Senior Vice-President and Head of Offshore, Bureau Veritas, said,



"OTEC technology offers potential for round-the-clock clean renewable energy. We are excited to deploy our expertise in offshore energy, met-ocean studies and structures to help bring this project which will deliver clean electricity to remote areas to fruition."

Bureau Veritas said KRISO's 1MW OTEC plant is the first practical level of its kind on a pathway to build a 100 MW commercial system. **EI**



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## K N Vyas becomes the Director of the Bhabha Atomic Research Centre



**K N Vyas**

*He has a vast experience in design and analysis of nuclear reactor fuels...*

**K**N Vyas, a distinguished scientist and Associate Director, Reactor Projects Group of the Bhabha Atomic Research Centre (BARC) has taken over as Director, BARC, from Dr. Sekhar Basu, Chairman, Atomic Energy Commission and Secretary to the Government of India, Department of Atomic Energy. BARC is a premier multi-disciplinary Nuclear Research Centre of India having excellent infrastructure for advanced R&D with expertise covering the entire spectrum of Nuclear Science & Engineering and related areas.

Vyas graduated from the 22<sup>nd</sup> batch of the BARC Training School and joined Fuel Design & Development Section of Reactor Engineering Division of the BARC.

During the past 36 years, he has gained a vast experience in design and analysis of nuclear reactor fuels. Later, as Head, Reactor Projects Division, he has also worked for design and analysis of reactor systems. He has worked extensively in thermal hydraulics and stress analysis of critical reactor core components. Vyas has also participated in design & analysis of the Test Blanket Module planned to be installed in ITER, France.

Vyas has been conferred several awards, which include Indian Nuclear Society Outstanding Service Award 2011, Homi Bhabha Science and Technology Award 2006, DAE Awards in the years 2007, 2008, 2012 and 2013. He is also a Fellow of the Indian National Academy of Engineers.

## K Saini takes over as the Chairman of the Delhi Electricity Regulatory Commission



**Krishna Saini**

*He has 35 years of experience of working at various senior level positions in the Govt...*

**K**rishna Saini has assumed the office of Chairman of Delhi Electricity Regulatory Commission (DERC). He has been appointed as new Chairman of DERC on the recommendation of the Selection Committee constituted under Section 85 of the Electricity Act, 2003. The appointment follows permission granted by the Hon'ble High Court of Delhi in its order dated 24.02.2016. It would be subject to the result of the Writ Petition (C) No. 11605/2015 titled as Raman Suri Vs. Union of India & Others pending before Hon'ble High Court.

Saini, an officer of the Indian Revenue Service of 1981 batch, has 35 years of experience of working at various senior level positions in the Government of India.

He has worked in the areas of finance, commerce, economics, accounts, law, legislation, adjudication, auditing of financial statements and detection of irregularities. Saini has recently retired as Chief Commissioner of Income Tax. He has done MBA from La Trobe University, Melbourne, Australia and M.Sc. (Fiscal Studies) from University of Bath, U.K.

## California Energy Efficiency Industry Council elects C Henrikson to its Board



**Carmen Henrikson**

*She will serve on the Board's 2016 Executive Committee as Treasurer...*

**A**ccording to a communiqué from the TRC Companies, Inc., Carmen Henrikson its Associate Vice President of Energy Services in Oakland, California, has been elected to the Board of Directors of the California Energy Efficiency Industry Council. Henrikson will serve on the Board's 2016 Executive Committee as Treasurer.

Formed in 2009, the California Energy Efficiency Industry Council (Efficiency Council) is a 501 (c) (6) trade association representing non-utility businesses that provide energy efficiency and demand response services and products in California. The Efficiency Council is California's

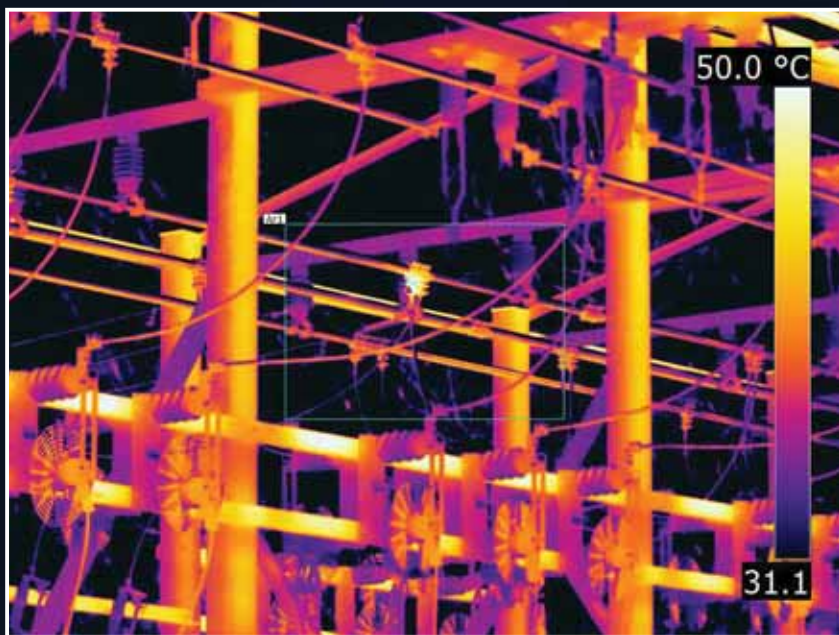
primary business voice for the energy efficiency and demand response industries. It represents member companies through support for efficiency policies, programs and technologies that foster sustainable jobs, long-term economic vitality, stable and reasonably priced energy systems and environmental improvement for all Californians.

"As a long-standing member and supporter of the Efficiency Council, TRC can attest to the extraordinary value and strong voice this organization provides its members. I am honoured to join the board and work with our energy allies to advance the Council's inspiring vision over the next several years," said Henrikson.

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## Focus on Energy recognises efforts in energy efficiency

**F**ocus on Energy is Wisconsin utilities' statewide energy efficiency and renewable resource program funded by the state's investor-owned energy utilities and participating municipal and electric cooperative utilities.

It is honouring 14 Wisconsin companies with a 2016 Excellence in Energy Efficiency Award. In coordination with local utility partners and Focus on Energy staff, these winners have displayed outstanding commitment to energy efficiency practice.

2016 Excellence in Energy Efficiency Award honorees include: Allcast Inc. - Allenton, WI; B & B Electric - Eau Claire, WI; Heartland Farms - Hancock, WI; Kohler Co. - Kohler, WI; Didion Milling - Johnson Creek, WI; Edgewood College - Madison, WI; Milwaukee County - Milwaukee, WI; Chippewa Valley Technical College - Energy Education Center - Eau Claire, WI; Fox Brothers Piggly Wiggly - Hubertus, WI; Expera Specialty Solutions - Kaukauna, WI; Oshkosh Defense, LLC - Oshkosh, WI; Kinnard Farms - Casco, WI; C & M Properties - Eau



Claire, WI; and Kettle Moraine Heating and Air Conditioning - North Prairie, WI.

Benefits of the energy efficiency projects implemented by these organizations are much greater than reduced energy consumption and cost savings. They support technology innovation, job creation, lowered environmental impacts, increased competitiveness and reduced dependence on non-renewable resources.

"Focus on Energy is thrilled to congratulate each of these winners. These recognized organisations are making smart energy decisions, lowering operating costs, and making Wisconsin business more competitive," said Chad Bulman, Director of Energy Programs for Focus on Energy.

On-site award presentations are being coordinated with all winning organizations, many in coordination with Earth Day and other sustainability events currently scheduled. **ET**

## Sepura's CEO wins the 'Business Person of the Year Award'

**T**he Sepura Group is a global leader in the design, manufacture and supply of digital radio products, systems and applications developed specifically for business and mission critical communications. Sepura's CEO, Gordon Watling, has been awarded Business Person of the Year at the Cambridge News Business Excellence Awards, held at King's College and hosted by Jonathan Dimbleby.

"We've had a very successful year. We have significantly strengthened our business through acquisition and innovative new product launches. Our recent move to new premises on the Cambridge Research Park reaffirms our long-term commitment to this area, which is why winning the Business of the Year Award has special significance for us," said Gordon Watling.

"The Award is recognition of our high levels of innovation, efficiency and customer service which, together with strong leadership from the

senior management team, has allowed us to consistently deliver double-digit growth over the last four years. To have that recognised - particularly within the community in which we operate, is extremely rewarding," he added.

"It's a great personal compliment to receive the Business Person of the Year Award, but once again the true merit goes to our employees, whose dedication, energy and enthusiasm have made Sepura the company it is today and created a platform for further successes in the future. These are exciting times for us; these awards serve as confirmation of our positive trajectory and, I hope, an indication of the many good things still to come," he concluded. **ET**



## PowerStream receives EDA Innovation Excellence Award

**P**owerStream Canada was acknowledged for its innovative achievement at the Electricity Distributors Association's (EDA) Annual Awards Gala held recently at Toronto in Canada, as it received the EDA Innovation Excellence Award in recognition of the company's successful Advantage Power Pricing (APP) pilot programme.

In partnership with Energate Inc. and funding from the Ministry of Energy, PowerStream's Advantage Power Pricing (APP) pilot was launched in May 2015 as a six-month, risk-free, technology-enabled dynamic pricing programme designed to provide residential customers with significant savings.

APP offered customers an ultimate low price of 4.9 cents/kWh of electricity for off-peak periods and a variable price during the on-peak period (weekdays, 3 p.m. - 9 p.m.), while equipping them with tools required to better manage their energy use. The programme gave participants the opportunity to save up to \$300 a year by paying a very low price for electricity during 82% of the week.

PowerStream introduced a second phase of the pilot on November 1, 2015 and will launch the third phase on May 1, 2016 with the hope of eventually offering the pricing plan to all of its customers. Each of these phases received funding from the Independent Electricity System Operator.

The EDA's Innovation Excellence Award recognised PowerStream's APP as a unique business model that not only empowers customers to better manage their utility bills, but one that also adds new value to multiple areas of the industry, including customer satisfaction and engagement, conservation and demand management, energy storage, and energy grid efficiency. **ET**





# Landscape Solutions



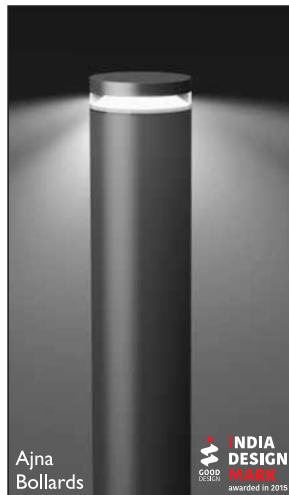
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# Control Of Compensated Self-Excited Induction Generator



Image Courtesy: [www.tecogen.com](http://www.tecogen.com)

In this article, GAA model is proposed to control the load voltage and frequency of an SEIG (Self-Excited Induction Generator). Simulated results are compared with experimental results on two test machines. A close comparison proves the validity of proposed modeling...





Where,

$$R_L = \frac{RX_{C\alpha}^2}{\left(a^2 R^2 + (a^2 X - X_{C\alpha})^2\right)}$$

and

$$X_L = \frac{R^2 X_{C\alpha} + X X_C (a^2 X - X_{C\alpha})}{a^2 R^2 + (a^2 X - X_{C\alpha})^2}$$

GA based approach i.e., GAA may be used to control the generated voltage and frequency of SEIG for any variation in its operating condition. In order to obtain the desired voltage and frequency 'GAA' is applied with following objective function;

$$OF = Y_T + k_1 V_{err} + k_2 V_{Lerr} + k_3 f_{err} \quad (6)$$

$$\text{Where, } V_{err} = \left(\frac{V_{ref} - V}{V_{ref}}\right)^2, V_{Lerr} = \left(\frac{V_{Lref} - V_L}{V_{Lref}}\right)^2 \text{ and } f_{err} = \left(\frac{a_{ref} - a}{a_{ref}}\right)^2$$

Table 1: Different cases for controlled operation of SEIG.

Sr. No.	Case Description	Weights		
		$k_1$	$k_2$	$k_3$
1	Stator Voltage, $V$ and Generated Frequency Control, $a$	1	0	1
2	Load Voltage, $V_L$ and Generated Frequency Control, $a$	0	1	1

Here  $V$ ,  $V_L$  and  $a$  are the values of generated stator voltage, load voltage and per unit frequency while  $V_{ref}$ ,  $V_{Lref}$  and  $a_{ref}$  are the desired values of generated stator voltage, load voltage and per unit frequency of SEIG.  $k_1$ ,  $k_2$  and  $k_3$  are weights. Table 1 gives the values of  $k_1$ ,  $k_2$  and  $k_3$  for the controlled operation of SEIG. Application of GAA model with specific value of weights i.e.,  $k_1$ ,  $k_2$  and  $k_3$  i.e., for a particular control results in to the appropriate selection of  $\alpha$  and  $C_{se}$ .

Objective function as given by (6) is minimised using GAA to maintain the power quality. Bounds on firing angle, ' $\alpha$ ' is 0 to 90 degrees. This approach results into a new and unique methodology to compute the values of  $\alpha$ , series capacitance and prime mover speed simultaneously for successful controlled operation of SEIG.

Fig. 3 shows the proposed scheme to control the voltage and generated frequency of SEIG and Fig. 4 shows the flow chart for the

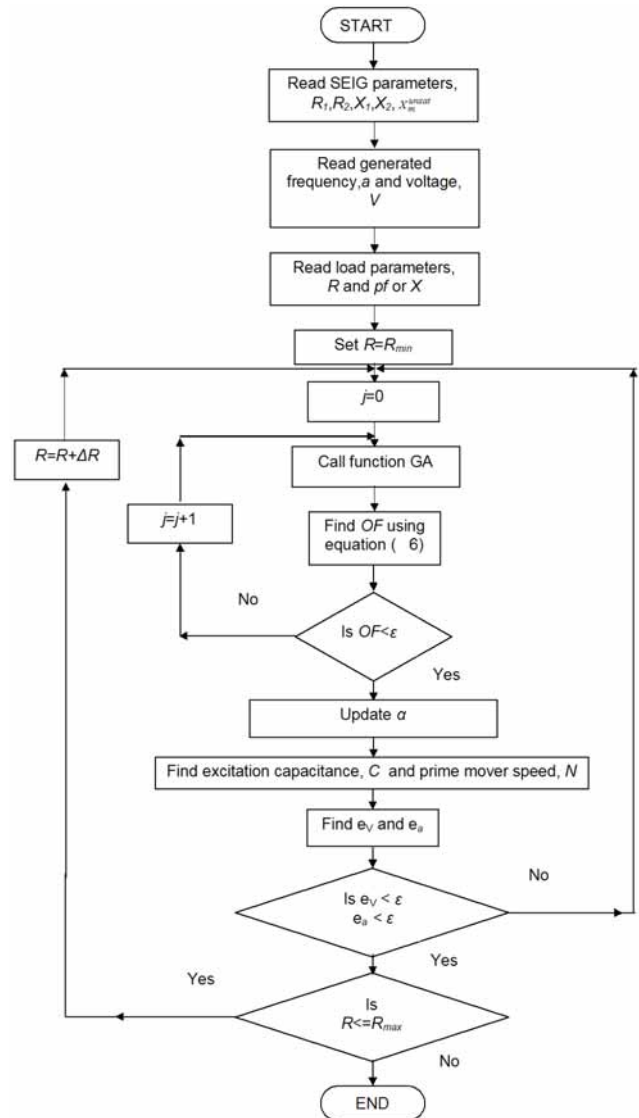


Figure 4: Flowchart of GAA using static exciter and series compensation for voltage and frequency control of SEIG... complete control of SEIG using GAA model.

## Results And Discussions

Table 2 and Table 3 shows the comparison between simulated results using GAA model with experimental results on SEIG-I and SEIG-II (Appendix-I).

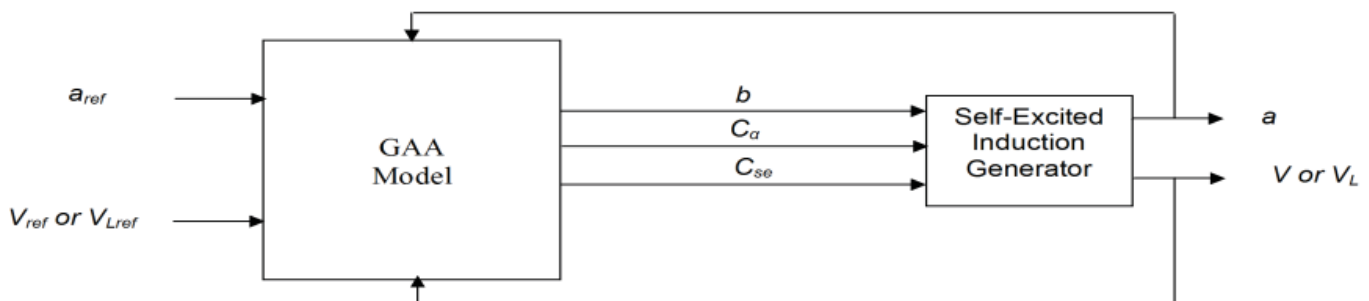


Figure 3: Voltage and generated frequency control of SEIG...

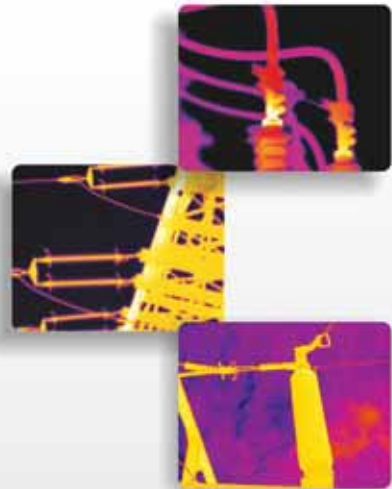
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Sr. No.	Load Current (A)	Generated Frequency (Hz)	Stator Voltage (Volt)	Simulated Results		Experimental Results	
				Excitation Capacitance ( $\mu\text{F}$ )	Prime Mover Speed (rpm)	Excitation Capacitance ( $\mu\text{F}$ )	Prime Mover Speed (rpm)
1	0.78	48.28	171.00	35.06	1462.80	36.00	1467
2	0.85	49.24	188.00	35.22	1492.65	36.00	1496
3	1.02	51.13	224.00	35.86	1550.70	36.00	1563
4	1.18	49.92	189.00	34.78	1517.85	36.00	1516
5	1.27	50.74	203.00	34.87	1543.05	36.00	1543

Table 2: Experimental verification of results for SEIG-I ( $X_{se} = 0$ , Load power factor = 1.0)...

Sr. No.	Load Current (A)	Generated Frequency (Hz)	Stator Voltage (Volt)	Simulated Results		Experimental Results	
				Excitation Capacitance ( $\mu\text{F}$ )	Prime Mover Speed (rpm)	Excitation Capacitance ( $\mu\text{F}$ )	Prime Mover Speed (rpm)
1	0.29	49.92	242.47	22.99	1512.90	23.30	1520
2	0.31	49.84	241.33	23.06	1511.55	23.30	1520
3	0.34	49.80	239.59	23.05	1511.85	23.30	1520
4	0.45	49.61	232.07	23.02	1512.75	23.30	1520
5	0.55	49.46	222.26	22.79	1514.25	23.30	1520

Table 3: Experimental verification of results for SEIG-II ( $X_{se} = 0$ , Load power factor = 1.0)...

Sr. No.	Load Current (A)	Generated Frequency (Hz)	Stator Voltage (Volt)	Simulated Results			Experimental Results		
				Excitation Capacitance due to static Exciter ( $\mu\text{F}$ )	Excitation Capacitance due to series capacitor ( $\mu\text{F}$ )	Prime Mover Speed (rpm)	Excitation Capacitance due to shunt capacitor ( $\mu\text{F}$ )	Excitation Capacitance due to series capacitor ( $\mu\text{F}$ )	Prime Mover Speed (rpm)
1	0.44	51.27	219.65	19.92	15.81	1547.88	19.70	15.60	1548
2	0.49	51.32	219.18	19.32	16.60	1561.01	19.70	15.60	1560
3	0.55	51.36	219.82	19.92	20.65	1541.60	19.70	18.86	1542
4	0.63	51.30	219.47	18.82	18.56	1573.86	19.70	19.70	1575

Table 4: Experimental verification of results for series compensated SEIG-II (Load power factor = 1.0)...

A close comparison as shown in above tables indicates the effectiveness of proposed GAA model.

### Load Voltage And Frequency Control

From the consumer point of view, load voltage and generated frequency are to be maintained irrespective of operating condition of the generators. Fig. 5 to Fig. 10 shows the simulated results on SEIG-I using GAA model. After considering the proper value of  $k_1$ ,  $k_2$  and  $k_3$  (Table 1) in the OF as described by equation (6), load voltage and frequency are tried to maintain as rated values of machine. Unity power factor load is considered here for simulation purpose.

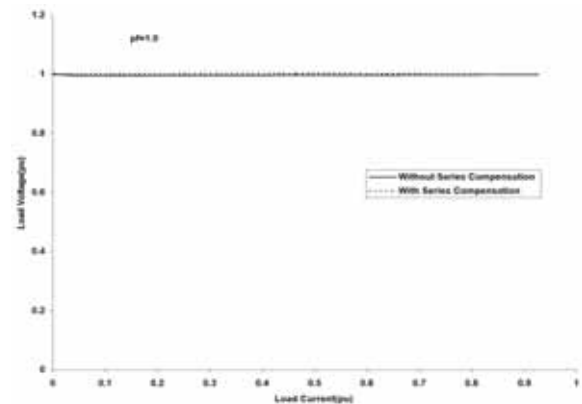


Figure 5: Variation of load voltage for 'load voltage and generated frequency control' of SEIG-I at unity power factor load...




## Recognition of ERDA (West) - Rabale Laboratory by BIS for Evaluation of Distribution Transformers as per IS: 1180

**ERDA (West) Laboratory was established in 2012 at Rabale** to cater to customer base in the Maharashtra Region. ERDA has set up a new state-of-the-art test facility at its Rabale Laboratory for testing of Distribution Transformers up to 200 kVA, 11/22/33 kV. Test facilities have been accredited by NABL, Govt. of India vide certificate No.T-2844 & T-0071.

**We are pleased to inform you that, we have received Grant of Recognition from BIS, under Laboratory Recognition Scheme - 2013 (Ref: WROL/LRS/OSL-7132925 dated 31.12.2015) for evaluation of distribution transformers as per IS: 1180.**

The Laboratory is equipped to evaluate Distribution Transformers for the following tests as per IS: 1180. You have to submit the sample at single point - **ERDA (West), Rabale**.

### Tests for BIS Sample :

At ERDA, Rabale	At ERDA, Vadodara
Measurement of winding resistance	Oil leak test
Measurement of voltage ratio and check of phase displacement	Short circuit withstand tests
Measurement of short circuit impedance and load loss at 50% and 100% load	Determination of sound level
Measurement of no-load loss and current	Paint adhesion test
Measurement of insulation resistances	BDV and moisture content of oil in the Transformer
Induced overvoltage withstand test	
Separate source voltage withstand test	
Pressure test as per Cl.21.2(h) & 21.3(d)	
Lightning Impulse test	
Temperature rise test	
No load current at 112.5% voltage	

Contact us:

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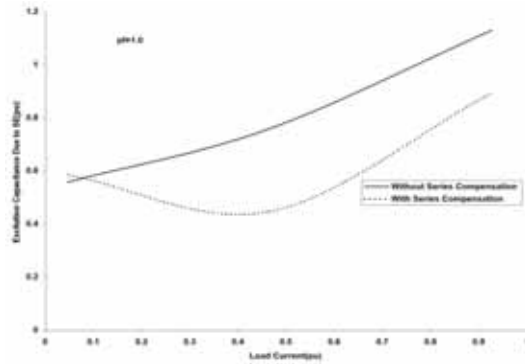


Figure 6: Variation of excitation capacitance due to SE for 'load voltage and generated frequency control' of SEIG-I at lagging power factor load...

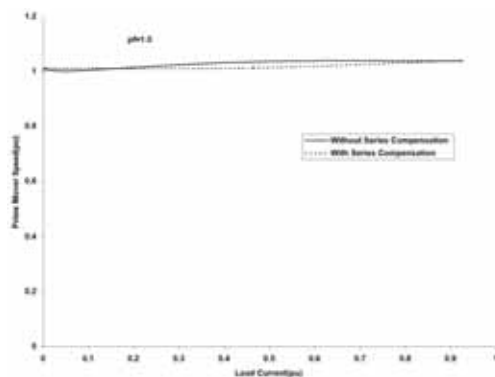


Figure 7: Variation of prime mover speed for 'load voltage and generated frequency control' of SEIG-I at unity power factor load...

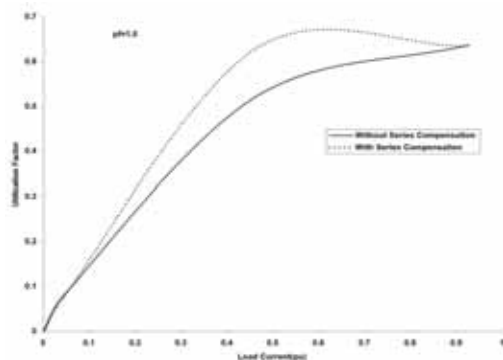


Figure 8: Variation of utilization factor for 'load voltage and generated frequency control' of SEIG-I at unity power factor load...

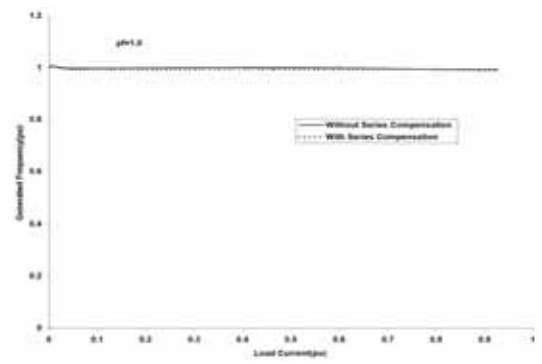


Figure 9: Variation of generated frequency for 'load voltage and generated frequency control' of SEIG-I at unity power factor load...

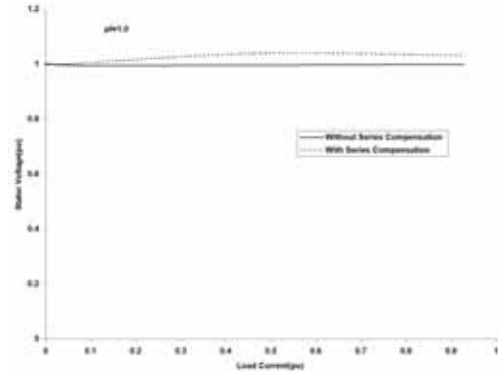


Figure 10: Variation of stator voltage for 'load voltage and generated frequency control' of SEIG-II at unity power factor load...

## Conclusions

In this article a new model based upon genetic algorithm is proposed to control the terminal voltage and frequency of a self-excited induction generator.

Simulated results as obtained using proposed model GAA are compared with the experimental results on two test machines.

Close agreement between the simulated results and experimental values confirms the validity of proposed modeling.

As evident from simulation results, proposed modeling is effective to control the generated voltage and frequency of the machine.

As observed from Fig. 5 and Fig. 9, a complete control is possible using GAA model. Stator voltage and generated frequency remains constant irrespective of load on the generator.

For this control, the excitation and operating speed should vary with load and this variation is shown in Fig. 6 & Fig. 7. However stator voltage will change and it has been shown in Fig. 10. Series compensation using series capacitor is found to be effective to reduce the burden in SE and for improvement in utilization of machine as shown in Fig. 8.



**Dheeraj Joshi**

Associate Professor

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# Linking Danish and German Power Grids



The HVDC Light valve hall...

The Offshore windfarm...

50Hertz and Energinet.dk will establish a 400 MW offshore interconnection using offshore wind-park connections. ABB will provide the complete HVDC station for the interconnection...

By providing the HVDC (High Voltage Direct Current) system, ABB will be a key technology contributor to the 'Kriegers Flak combined grid solution' project, establishing the world's first offshore interconnection using national grid connections to the future Danish Kriegers Flak and operating German Baltic 1 and 2 offshore wind farms.

Energinet.dk owns the Danish electricity and gas transmission system. Their main task is to maintain overall short-term and long-term security of electricity and gas supply. They have also developed the main Danish electricity and gas transmission infrastructure. 50Hertz is responsible for the operation, maintenance, planning and expansion of the 380/220 kilovolt transmission grid throughout northern and eastern Germany. One of their core tasks is to keep the relationship between frequency and voltage stable within permissible limits.

Recently, ABB has received an order worth around \$140 million from transmission system operators Energinet.dk (in Denmark) and 50Hertz Transmission (in Germany) to design, supply and install an HVDC converter station in Bentwisch, Northern Germany. The HVDC Light 'back-to-back' converter station, the first of its kind in Europe, will allow the connection of asynchronous AC power grids of Eastern Denmark and Germany. ABB was also previously awarded a \$100 million AC subsea cable system order for connecting the Danish Kriegers Flak wind farm in 2015.

The interconnector will have a capacity of 400 megawatts (MW), equivalent to the energy requirement of more than 400,000 households. In addition to allowing integration of more renewable energy into the grid, the interconnector project will provide enhanced power security and offer additional opportunities for energy trading.

The integration of renewable energy and development of interconnections are key elements of ABB's Next Level Strategy, addressing the growing need for electricity with minimum environmental impact," said Claudio Facchin, President of ABB's Power Grids Division.

ABB will provide the complete HVDC station including transformers, converter valves, cooling systems, control and protection and other related equipment at the converter station. HVDC Light provides sophisticated features to the network such as the 'black-start' power restoration capability and exceptional power control, to regulate the system with changes in the wind speed.

Interestingly, ABB has been awarded over 110 HVDC projects since it pioneered the technology more than 60 years ago, representing a total installed capacity of more than 120,000 megawatts and accounting for about half the global installed base. It developed HVDC in the 1990s and leads the way in this technology as well, having delivered 18 out of 24 VSC HVDC projects commissioned in the world.

The 'Kriegers Flak – Combined Grid Solution' (CGS) will connect the Danish region of Sjaelland and German Mecklenburg-Western Pomerania. It should have a capacity of 400 megawatts (MW). The project partners expect construction to begin in late 2016 or early 2017. Operation is planned to start by the end of 2018.

ET

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- > TRANSFORMER TEST SETS
- > CIRCUIT BREAKER ANALYZERS
- > PRIMARY AND SECONDARY INJECTION TEST SETS
- > BATTERY TEST SETS
- > ON LINE MONITORING SYSTEMS

## TDX 5000

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- > Output voltage up to 12 kV
- > Tan Delta, capacitance, dissipation factor measurements and exciting current test
- > PADS - Power Apparatus Diagnostic Software for automatic testing, assessment and report
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Patented technology for capacitance and Tan Delta measurement
- > Light and compact



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# Interview

**“Our customer base is now spread all across the country...”**



ISA Advanced Test And Diagnostic Systems is a global manufacturer of high-end Test and Measurement (T&M) systems for the power industry. In an exclusive interview with Electrical India, Imteyaz Siddiqui, Regional Area Manager – South Asia & GCC, ISA Advanced Instruments India Pvt. Ltd., is focusing on various aspects of his company's business in India to P K Chatterjee. Excerpts...

## **What's your observation on the standards of the test & monitoring solutions being used in India?**

From my experience, which spans more than a decade, in test and measurement industry, I have observed a sea change over the years. The customers or users have become more quality conscious, and hence, do not want the equipment to fail. They categorically ask to perform Factory Acceptance Tests (FATs) of all the products they are purchasing before taking the delivery at their site. Utilities in their tenders are asking for longer warranty periods, eventually forcing manufacturers and suppliers to realize the importance of the quality of their products. Hence, the quality of test equipment has become very important.

Users are ready to invest more money in better and more reliable testing equipment than buying the cheapest one available in the market. They have also realized that the cheapest equipment may not be the cheapest solution in the longer run. Some customers are now calculating the total cost of acquisition over a period of 3–5 years, and they have realized that a good-quality test kit that may be costly at the time of purchase – turns down to be cost effective in 3 to 5 years compared with the cheapest kit.

Monitoring of electrical assets, especially the high-cost items like HV and EHV equipment, is becoming increasingly important. Continuous monitoring provides data in real time, and we can make a decision to repair or replace the unit in time and avoid any catastrophe based on the trending of certain parameters.



## How is ISA Advance Instruments India Private Limited's business shaping up in this country?

Although we started our operation a bit late, thanks to the great support from our esteemed customers, we are growing our business at a good pace. Since September 2012, when we started our Indian operation, we have not looked back. We are earnestly overwhelmed with the support of our customers. Our customer base is growing continuously, with the word-of-mouth publicity from the happy customers being the main reason behind this continuous growth.

## What is your role in introducing new Test & Monitoring (T&M) solutions in India?

Our company is one of the important contributors to the newest development in test and monitoring solutions.

We regularly take the feedback from our customers and pass it on to our management team in Italy. Based on the customer's suggestions & requirements, our team of R&D and design engineers keep innovating the new products and/or solutions.

## What are your new products lining up to be introduced in 2016?

We have introduced quite a few products in 2016. The first product launched in 2016 is TDX 5000, which is a compact solution for Capacitance and Tan Delta Measurement. On the basis of the concept of variable frequency measurement, this unit is fairly light and extremely convenient in terms of portability.

Another product hitting the market in 2016 is eKAM. eKAM is a new, fully automatic electronic primary injection test equipment. The eKAM test system includes two portable units: one is the control unit with a large graphical display that adjusts the output, and the other is the current unit (up to 2000/3000/5000A). It can also perform Step and Touch tests with the optional modules STLG-STSG and ground grid accessory kit.

We have also launched CBA 3000, which is the most advanced and compact solution for Circuit Breaker Testing. The ultimate all-in-one circuit breaker analyzer is safer, faster, and more accurate for any timing test; motion and speed analysis; multiple contemporary static and dynamic contact resistance measurements; Both Sides Grounded (BSG) test, under-voltage condition test; and so on. All these functions are integrated in a single lightweight test case without the need of additional external modules to connect.

## Who are your major clients at present and which new segments are you targeting at?

We are extremely happy that in a short span of our presence in the Indian market, we have been able to develop a strong base of customer all around the country. On the one hand, we are associated with utilities like GETCO, MSETCL, NTPC, NPCIL, TANTRANSO, KPCL, KSEB, and BSPTCL as our major customers, and on the other hand, we have acquired businesses from major manufacturers like BHEL, ALSTOM, ABB, GE and C&S. We also have a strong presence among third-party service provider companies and EPC contractors.

Geographically speaking, our customer base is now spread all across the country, right from Kashmir to Kerala and from Maharashtra to North East.

## How do you train the buyers on the new technologies?

Our major focus is to spread technical awareness in the industry. We have been organizing regular workshops in partnership with M/s Knowledge Kluster Pvt. Ltd., in which industry experts from all across the globe are invited to share their experience.

We also provide on-site training to all our customers to use the kits effectively and efficiently. Our engineers stay in constant touch with the users and guide them thoroughly until they are well versed with the instruments and start using these optimally.

## What kinds of after sales support do you provide?

I always believe that in test and measurement industry, like all technical industries, good after-sales-support is the key to success. This is the reason, I always encourage my team members to go the extra mile to support all our customers. We have experienced that timely support provided to customers keeps aside major problems that may arise due to late response of a service provider.

We have a very strong team of qualified engineers – who are always ready to proactively support all our customers. Their dedication and hunger to delight a customer with timely support by providing time-bound solutions have helped us grow exponentially. The fact that most of our orders are either repeat or referral orders makes us happy. What I like about my team members is their

eagerness and effort in continuously raising the bar of excellence in after-sales-support.

## What kind of R&D do you conduct in ISA, and roughly what is the percentage of annual turnover spent for the same?

Our R&D team is based in our headquarters in Taino, Italy, where we have a mixed team of experienced and innovative young engineers – who are continuously working on improving the quality of the existing products and developing new projects simultaneously.

## Do you also develop software for the instruments that you supply?

Yes, we have a team of software engineers who are developing software and firmware for all our products. Not only this, they are taking feedback from the market, and working to improve already developed software to meet the need of the customers. We are also intending to address customisation based on the requirement.

## What would you like to communicate to your potential customers?

Through your esteemed magazine, I would like to request all those customers, who sometimes under the awe of established brand name, are a bit reluctant to try new entrants like us that 'give us an opportunity to serve you and feel the difference!'

---

*I believe that in T&M industry, like all technical industries, good after-sales-support is the key to success. This is the reason I always encourage my team members to go the extra mile to support all our customers...*

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# Exergy Analysis Of Cogeneration Power Plants



Image Courtesy: Clarke Energy

About the exemplary picture above: During the 2011 Queensland floods, some areas of the Oxley Creek STP in Rocklea were flooded, causing significant damage to the existing Jenbacher cogeneration engine and related plant that had been operating for over a decade. Queensland Urban Utilities (QUU) opted to replace this equipment, and at the same time sought to replace the aging engines at the Luggage Point STP in Pinkenba. Two of GE's Jenbacher J416 containerised generator modules were selected. This power plant can generate up to 2.2 MW of electrical output and a further 2.2 MW of thermal energy in the form of hot water used to warm the digesters...

**C**ombined Heat and Power system (CHP system) or a cogeneration system is the simultaneous generation of multiple forms of useful energy through sequential operation in a single, integrated system. Such a system consists of a number of individual components like prime-mover, generator, heat recovery and electrical interconnection all configured into a whole integrated system.

The prime mover drives the overall system – and typically a cogeneration system derives its identification by its type. Prime movers for cogeneration (or CHP) systems include reciprocating engines, gas turbines and steam turbines. These prime movers use fuels such as coal, oil, natural gas or alternative fuels and produce shaft power. The produced shaft power (or mechanical energy) is generally used to drive a generator (to produce electricity) – or sometimes used to drive compressors, pumps and fans. Heat energy from the systems can be used in direct process applications, or indirectly used to produce steam, hot water, hot air etc for the process.

## What are the benefits?

- i) In sugar industries, the bagasse, which often poses disposal problem, is used as fuel for cogeneration scheme. This increases cost effectiveness. This is true for many other cases like rice husk of rice mills, saw dust of saw mills, refinery gases of refineries etc.



- ii) Lower emissions to the environment and neutral in carbon, sequestration.
- iii) They offer large cost savings and make for additional competitiveness for industrial and commercial users.
- iv) Cogeneration provides one of the most important vehicles for promoting liberalization in energy markets.
- v) Cogeneration provides an opportunity to have more decentralised forms of electricity generation – in such cases the plants are designed to consume locally available waste material (Biomass or Refinery gases) as fuel, and generate electricity for the local needs avoiding transmission losses. Flexibility in the system use is increased – especially if natural gas is the energy carrier.

### Types of cogeneration systems

#### a. Steam turbine cogeneration system:

The two types of steam turbines widely used are the back pressure (Fig.1) and the extraction condensing steam turbine (Fig.2) types. The choice mainly depends on the quantities of power and heat, quality of heat and economic factors. The thermodynamic cycle is the Rankine cycle.

#### b. Gas turbine cogeneration system:

Gas turbine systems operate on the thermodynamic cycle known as Brayton cycle. There are two types of systems namely open cycle gas turbine cogeneration system (Fig.3), and closed cycle gas turbine cogeneration system (Fig.4).

#### c. Reciprocating engine cogeneration system:

Reciprocating engines have the advantage of starting quickly,

respond to the load well and have good part-load efficiencies. Hence, these find applications in the distributed generation of industrial, commercial and institutional facilities.

### Exergetic evaluation of cogeneration plants

Cogeneration of heat and power means production of two different forms of energies. To determine the efficiency of any cogeneration plants or to evaluate its performance, a common platform needs to be defined because the forms of energies differ in their 'grade.' The first law of thermodynamics deals with only 'quantitative' aspect of energy. This can give thermal efficiencies of plants – sometimes an energy utilisation factor (EUF) is used for the evaluation of performance.

$$EUF = \frac{W_{eg} + Q_{eg}}{F_{eg}}, \text{ Where}$$

$W_{eg}$  : Net electrical energy generated

$Q_{eg}$  : Process heat obtained

$F_{eg}$  : Fuel consumed

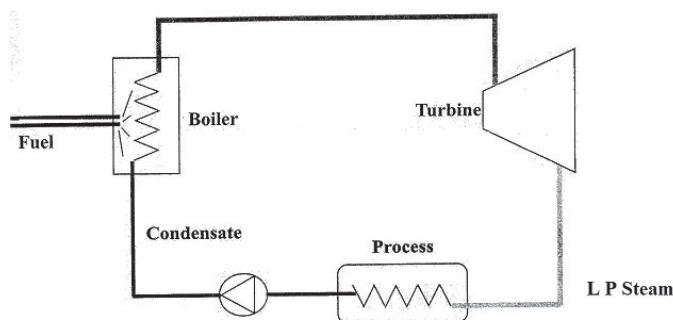


Fig. 1: Back Pressure Steam Turbine...

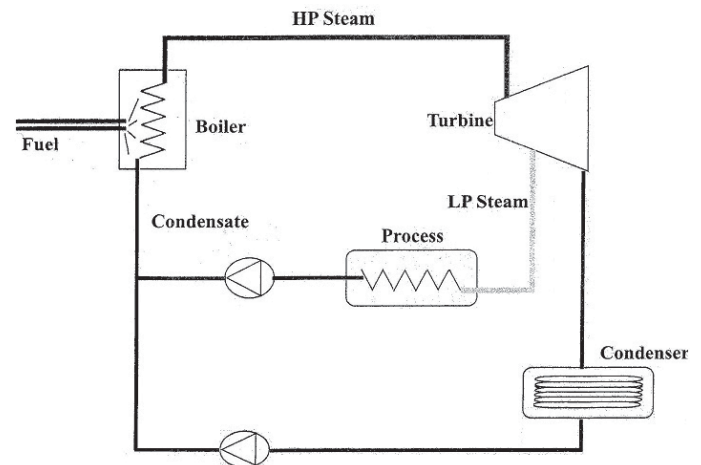


Fig. 2: Extraction Condensing Steam Turbine...

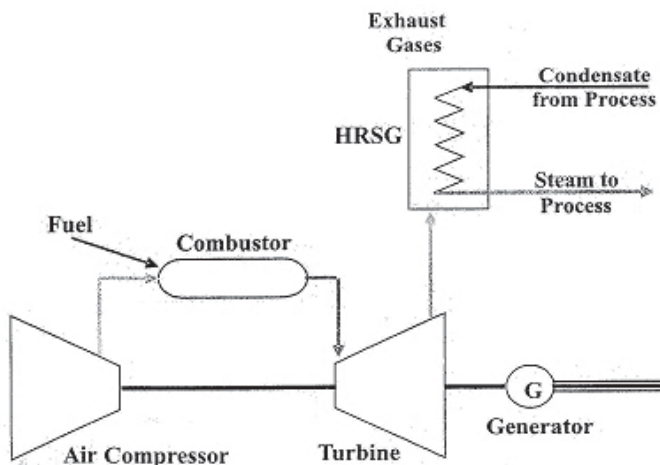


Fig.3: Open Cycle Gas Turbine Cogeneration System...

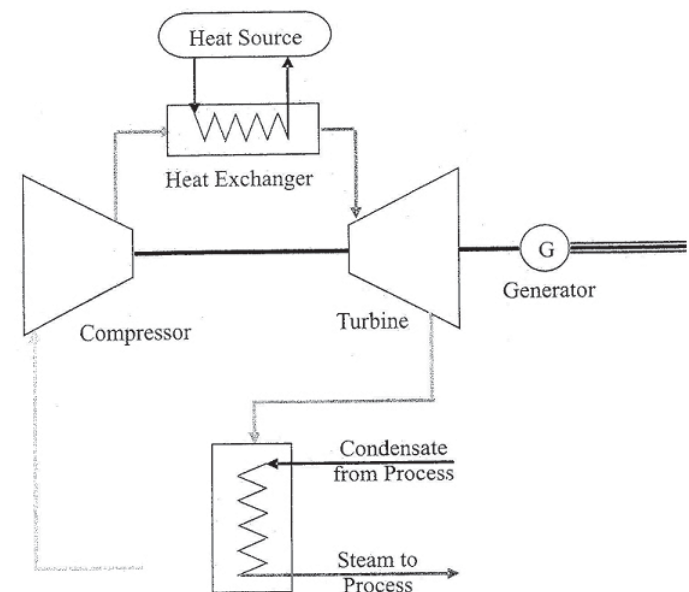


Fig.4: Closed Cycle Gas Turbine Cogeneration System...




**Table1: Typical cogeneration performance parameters...** (adapted from: California Energy Commission, 1982)

Prime mover in cogeneration package	Nominal range (Electrical)	Electrical generation / heat rate (kcal/kWh)	Efficiencies		
			Electrical Conversion	Thermal Recovery	Overall Cogeneration
Smaller Reciprocating Engine	10 – 500 kW	2650 – 6300	20 – 32	50	74 – 82
Larger Reciprocating Engines	500 – 3000 kW	2400 – 3275	26 – 36	50	76 – 86
Diesel Engines	10 – 3000 kW	2770 – 3775	23 – 38	50	73 – 88
Smaller Gas Turbines	800 – 10000 kW	2770 – 3525	24 – 31	50	74 – 81
Larger Gas Turbines	10 – 20 MW	2770 – 3275	26 – 31	50	78 – 81
Steam Turbines	10 – 100 MW	2520 – 5040	17 – 34	--	--

But, qualitatively,  $W_{cg}$  is high grade energy while  $Q_{cg}$  is low grade energy. Therefore, energy efficiency cannot be the entirely satisfactory criterion of performance of the plant – as it gives equal and same weightage to both heat and electricity. Hence, a thermodynamically more accurate method of evaluation can be based on 'exergetic efficiency'. Exergy is the measure of energy 'quality' and the exergetic efficiency is a measure of perfectness of a thermal system. Thermodynamics suggests the use of exergetic factor, which exactly indicates the quality of heat in terms of its work potential. An even more correct performance value is obtained if the exergy content of the fuel is also taken in to account.

Through a study conducted by the present authors, it has been shown that there can be a remarkable difference between energy and exergy efficiency of the same system. This study was conducted on a heat matched, bagasse based cogeneration plant of a typical 2500 tcd sugar factory using back pressure and extracting condensing steam turbine. It has been shown that the boiler is the major component contributing most to the plant's total inefficiency.

Even a modern boiler with current technology utilises only 37% of chemical exergy of the fuel in steam generation and 63% is lost in combustion irreversibilities associated with the boiler. This suggests that there is enough scope for improving exergetic efficiency of boiler. Back pressure steam turbine cogeneration plant is the most efficient configuration from the point of integrating process steam demand and incidental power generation. Extraction condensing steam turbine cogeneration plant is the highly efficient steam power cycle from the surplus power generation point of view. In general, bagasse based cogeneration plants in the Indian sugar industries are considered environmentally and economically attractive. 



**Dr S C Kamate**  
Principal  
Shaikh Engineering College  
Belgaum



## Smartphone based electricity app launched

**P**iyush Goyal, Minister of State for Power, Coal and New & Renewable Energy launched a mobile application which provides highlights of power availability in the country on a real-time basis.


The application provides a wealth of information pertaining to the current demand met, shortages if any, surplus power available and the prices on the Power Exchange. Real time data and comparison with previous day's or year's data is also available. Data from multiple sources, including the states and Power Exchanges, has been made available through a single portal for convenience of all.

A user friendly interface, based on the geographical map of India, facilitates all the consumers or stakeholders in visualising power availability and prices at the overall country level as well as at the state level. The information disseminated through the application will empower consumers, thereby leading all stakeholders to be more responsive and efficient, bringing more economy to the country.

He said that the app will empower common people to demand 24X7 power, adding that the application will take transparency to the

next level and make state governments more accountable. He said that this app would work as manifestation of the Prime Minister's vision of good governance by inculcating transparency in the system and will put pressure on power producers across the country.

The application can be accessed through [vidyutpravah.in](http://vidyutpravah.in). The mobile version will be freely available for download from the playstore for both Android and iPhones, he said.

The Vidyut PRAVAH mobile application will provide market price of power from the power exchange, shortage data including peak hour and total energy shortage. 



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# Nuclear Plant Simulator In Action



The full-scope simulator for the HTR-PM...

WSC licensed CNPSC and INET (Tsinghua University's Institute of Nuclear and New Energy Technology) to develop the simulator...

WSC is a privately held, technology driven company with engineering simulation as its core competence. Its vision is to provide the Power Industry with innovative, state-of-the-art, simulation technology products and services, that will add value in the design, commissioning and safe and reliable operation of their power generating or process plant assets.

WSC's joint venture China Guangdong Nuclear Simulation Technology subsidiary has completed the on-site installation and commissioning of the Pebble Bed Modular High Temperature Reactor simulator. A site acceptance certificate has been signed, marking the official start of use of the simulator system.

WSC licensed CNPSC and INET (Tsinghua University's Institute of Nuclear and New Energy Technology) to develop the simulator. Within 3KM, WSC modified Flowbase to include Helium (He) as the heat transfer medium as well as developing the heat structure in Flowbase. WSC was responsible for supporting integration of the reactor model in 3KM that was developed by INET. CNPSC were responsible for developing for the balance of plant models, integration, hardware, installation, and virtual DCS.

According to World Nuclear News, "Work began on two demonstration HTR-PM units at China Huaneng Group's Shidaowan site in December 2012. China Huaneng is the lead organisation in the consortium to build the demonstration units together with China Nuclear Engineering Corporation (CNEC) and Tsinghua University's Institute of Nuclear and New Energy Technology (INET), which is the research and development leader. Chinergy, a joint venture of Tsinghua and CNEC, is the main contractor for the nuclear island. The simulator will be used for the training and licensing of nuclear power plant operators, as well as for supporting emergency exercises, and plant design and operation verification. The Shidaowan simulator features a complete replica of an HTR plant's control room, including the instrumentation and control system. The demonstration plant's twin HTR-PM units will drive a single 210 MWe turbine. It is expected to start commercial operation in late 2017. Eighteen further units are proposed for the Shidaowan site, near Rongcheng in Weihai city."

ET

(Courtesy: <http://www.world-nuclear-news.org/>)



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# AT&C Loss Reduction

A T & C loss is nothing but the sum total of technical and commercial losses and shortage due to non-realisation of billed amount...







**P**ower generation, transmission and distribution are the three activities in power industry. Energy is consumed and loss is incurred in every step of the above activities. Among the three activities, losses in power distribution is the maximum as it has grown up in an unplanned manner. It is around 35% in India. The figure varies widely in every state (varies from 9.13% in Pondicherry to 85.49% in Manipur: AT&C Loss, PFC Report 2012-13). Power utility company suffers for high loss. And some steps have been taken in some states to reduce losses. Further initiative and activities are required to improve in this area. Innovative idea and its implementation, R&D in this field are the prime requirements for reduction of loss. In this article, different losses and remedial activities thereupon have been stated. Some innovative ideas have been described as well.

Distribution loss consists of two parts: a. Technical loss and b. Commercial loss. It is also called AT&C loss.

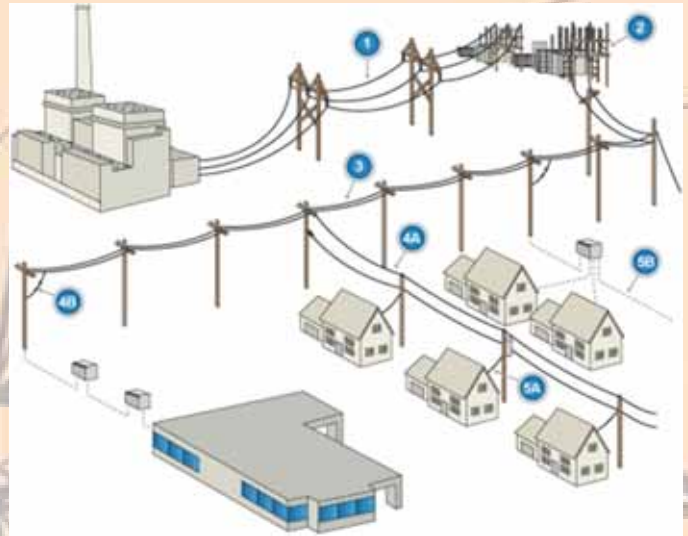
AT&C loss is nothing but the sum total of technical and commercial losses and shortage due to non-realization of billed amount.

AT&C Loss =  $(\text{Energy input} - \text{Energy billed}) \times 100 / \text{Energy input}$ .



Technical loss depends upon losses incurred from machinery (Transformers), lines and improper maintenance of plant and machinery etc. By taking care of these areas, we can reduce these technical losses. To reduce technical losses the following action can be taken:

1. Network reconfiguration: It gives an option to handle the increased demand – and increases system reliability. Construction of more numbers of high voltage distribution lines as and where they are techno-commercially feasible.
2. Reduction of LT lines – so that current in the line reduces and hence copper loss of the line. Introduction of HT distribution system, where it is possible.
3. Power factor improvement, close to 1, by automatic power factor controller, using at different places.
4. Regulating voltage in distribution circuit by automatic voltage booster.
5. Balancing load in three phase distribution, thus reducing losses and neutral current. Better management of distribution transformer, SCADA (Supervisory Control And Data Acquisition System) is an effective tool for load management.
6. Improvement in transformer design to reduce iron loss and copper loss as well. Amorphous core transformer may be used for reduction of iron losses.



Power Generation / Transmission / Distribution...

7. Periodic audit may be introduced to know the scope of loss reduction.
8. Load research is needed.
9. Coating is necessary on bare conductor to reduce copper loss.
10. Periodic maintenance of distribution system is needed for loss reduction.

**Long time loss reduction: strengthening, upgrading and improvement of sub-transmission and distribution system:**

#### Commercial loss reduction

Commercial loss in developed countries is negligible but the situation is opposite in many developing countries.

Theft is the one of the main causes of the high losses. Theft occurs in several ways, viz: by tapping power lines and tempering / by passing meter etc. The following points are important for reduction of these losses.

1. Replacement of defective meters by electronic meters / smart meters.
2. Development of process and ways for theft detection and suitable correction of the same.
3. Introduction of remote disconnection / reconnection and meter reading arrangement so that appropriate action may be taken as and when required.
4. Law enforcing and stringent action to the theft of power.
5. Introduction of several communication systems for load side management.
6. Substation automation and distribution automation for loss detection and corrective action.
7. Process reengineering for improvement of existing customer complaint, improvement in all sorts of delay in billing, arrangement for spot billing etc. Improved process with IT application may reduce this loss.
8. Customer oriented management approach, like implementation of call centre for 24 hours, improving customer care, implementation of MIS. Some projects like integrated volt / VAR control (IVCC) involves near real time control of distribution and minimises losses by about 2% and Capacitor control algorithm for distribution capacitor Automation project to optimise regulation of voltage.

Delayed distribution series reactors enable 2.5 to 5% change in impedance – ensures the flow on the line within allowable limit.





Meter bypassed...

## Best practices of AT&C loss reduction

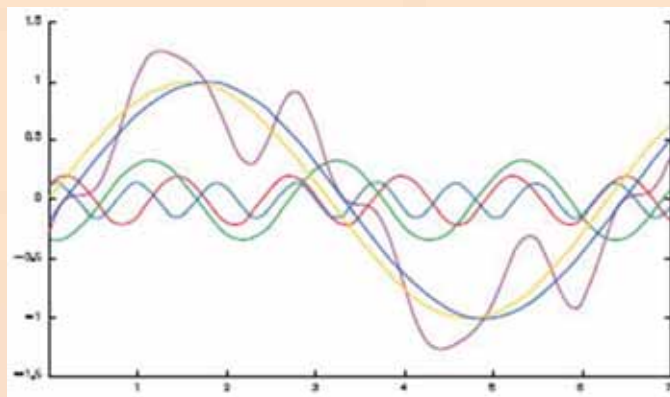
- HVDS: Introduction of high voltage distribution system.
- AB Cable. : Replacement of bare conductor by AB Cable for shielding of possibilities of power theft.
- Metering: AMC / Smart metering to the consumer for reduction of commercial losses and billing and collection ease.  
Smart meter has the following capabilities:
  - It can register real time or near real time consumption of electricity or export both.
  - Read the meter both locally or remotely
  - Remote connection or disconnection of electricity
  - Remote communication facilities through Power Line Carrier (PLC) / wireless modem (like GSM ) etc.

Smart meter is also referred to as Automatic Meter Reading (AMR) or Advanced Metering Infrastructure (AMI).



From various reports it has been found that the theft of electricity in many developing countries ranges from 20 to 35 % in distribution network. Different ways and means are proposed by different authors for reduction of losses.

Some ways to avoid these are: Automatic meter reading system incorporated with communication system (GSM), Artificial intelligence system based on energy consumption pattern, Power line impedance technique, and Injection of unwanted harmonics to illegal consumers.



Electrical waveform with harmonic distortion...

Application of intelligent control in electric system can improve power quality – and at the same time it can prevent illegal activities. To get these benefits, the intelligent control system should be customised as per the specific situation to get better results.

The emerging new technologies and planning have direct impact on power industry and its loss reduction. Quality of power may also be improved by these combined applications.

- IT – development of communication technology and its application,
- Power Electronics – development of remote control arrangement,
- Artificial intelligence,
- Satellites,
- Distribution system planning – like custom power devices: power quality analysis, filter design, harmonic analysis etc.

For AT&C loss reduction, the Government of India has taken some flagship schemes, like R-APDRP (Re-structured Accelerated Power Development and Reform Programme ).This scheme is a revised version of APDRP, which was started in 2002-03.

Two more schemes are also coming, namely:

- Deen Dayal Upadhyay Gram Jyoti Yojana (DDUGJY) for strengthening and augmentation of sub- transmission and distribution infrastructure for rural area. This will lead to reliable and quality power and loss reduction as well.
- Integrated Power Development Scheme (IPDS), for urban area, where loss reduction is one of the main targets.

Loss reduction in distribution sector can be ensured by application of different technological approaches, different govt schemes – and application of strict law and order. Penalty for theft of electricity may be stringent and action to be taken immediately by disconnecting the supply and restricting of reconnection for a period of few years. Application of intelligent control in electrical system can improve power quality to great extent, and it can prevent illegal activities. Besides availability of funds in different schemes, strong will force with ownership of the distribution system and active participation in the process can lead India to theft free distribution sector and can save around 35% losses annually (equivalent to Rs. 40,000 crore ) approx.



**Robbin Pramanick**  
Chief Project Officer  
WESCO Limited

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# DEIF Offers Critical Power Solutions for Data Centres



Data centres depend on availability of reliable 24x7 power, since power outages can result in lost revenue and poor customer satisfaction. Emergency standby and backup power solutions are thus vital requirements which are unavoidable while running data centres. However, there are products which can ensure that power outages are simply not allowed to happen.

Here are some reliable power solutions which help data centres run uninterrupted.

## What the industry needs

Modern organisations depend on reliable access to data. Meeting their needs has led to a tremendous growth of data centres.

Managing a data centre can be a significant challenge, as it needs to have high availability, extremely secure, scalable, and connected to great communications infrastructure. Infrastructure which can support future expansion for at least over a decade without major modifications is preferred. Availability of reliable power is the biggest challenge for data centre growth.

Demand for continuous power supply and energy efficient products to manage the operating costs is high. Power outages force data centres to look for alternate power sources, where diesel genset are the most favoured option for in house power generation. On the other hand, downtime results in lost revenue and poor customer satisfaction. Hence a data centre with higher availability is always a favoured destination for clients to have their servers.

## DEIF understand your requirements

DEIF specialises in developing emergency, standby and backup power solutions for both, captive and colocation data centres. DEIF has a strong track record in developing emergency, standby and backup power solutions for mission-critical facilities such as data centres.





DEIF's Automatic Genset Controller, AGC-4 features proven technology for a wide range of generation systems in critical power applications.

Deploying DEIF's solution for your mission critical facilities will give you the crucial business edge over your competitors and benefit you in numerous ways to elevate your data centre to Tier-4 level by reducing your maximum annual downtime.

### Increased reliability and flexibility

Normally N+1 systems are used in data centres to have reserve genset. We further add to the reliability of system by providing a redundant controller so that your backup genset power has no single point of failure. In DEIF's redundant control system, two controllers operate in Hot Standby mode, with one as active controller while the other acts as a standby controller. The standby controller is connected to the active controller through CAN bus and remains updated with the latest events and information. In case of any unexpected fault in the active controller, the standby controller assumes control without any load or speed jumps during transition, thus ensuring continuous flow of power.

### Fast energy backup

AGC-4 controllers are capable of synchronous starting of multiple genset using Close Before Excitation and deliver record start-up in less than ten seconds for multiple genset in parallel, redundant control

systems, or even an entire redundant power plant. Switching over the load of whole data centre quickly to a backup genset is made efficient using digital voltage control. Communication between DEIF's Digital AVR and genset controllers facilitates enhanced performance. The Digital AVR also delivers superior step load performance leading to lesser requirement of reserve power and hence less number of online gensets for a given load.

### Fuel optimisation

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

### Remote monitoring

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




### Scalability

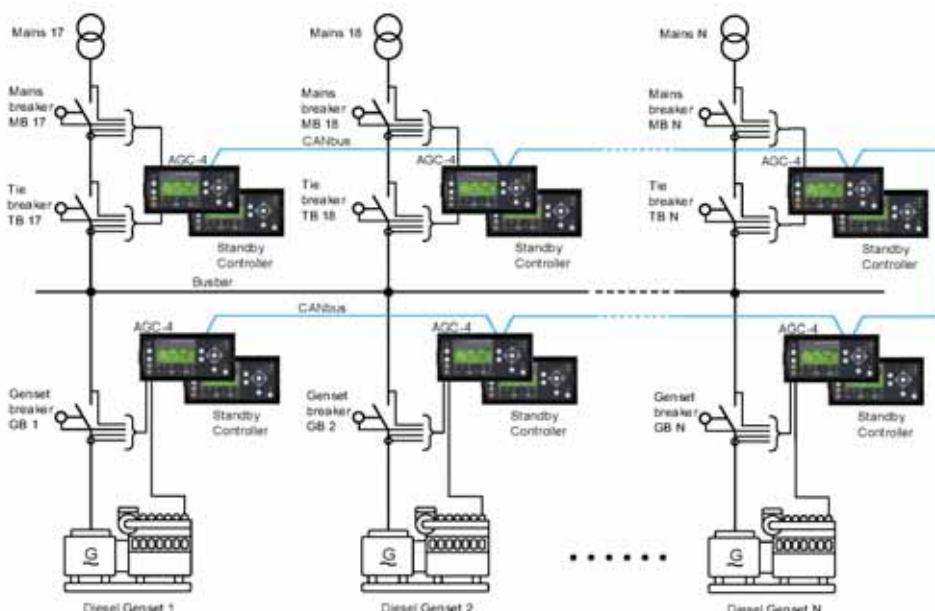
Aiding your future growth and expansion plans, DEIF's controllers system is fully scalable multi-master system of up to 256 genset with plant management option in one application without making major modifications in the existing project.

### Quick Service

DEIF has a classic team that has strong technical know-how in the areas we operate and a support system at your service 24 by 7 which is nearer to you to solve the toughest challenges that you may face. DEIF India has offices in Mumbai, Delhi, Bangalore, Ahmedabad, Chennai and a repair centre for fault identification & rectification in Mumbai. Choosing DEIF means reliable and fast on-site service & support.

DEIF not only meets data centre requirements, but also exceed the expectations of our customers. 

If you wish to be the preferred destination of your probable clients to have their servers and be distinguished from the rest, please get in touch with us at [india@deif.com](mailto:india@deif.com) or call 022-4245 2000. We will be happy to help you.





# Cable reel for energy chains proves its worth on the stage

## The igus e-spool achieves success in noise emission tests

The e-spool from igus, a cable reel for energy chains, passed all noise tests at the igus test laboratory with flying colours. This means it has distinguished itself as an ideal solution for applications in noise-sensitive areas such as in stage engineering. With the space-saving e-spool, energy, media or fibre optic data cables can be run together in a single system, as it requires no slip ring.



The Cologne-based motion plastics specialist igus operates the largest testing laboratory in the industry with a floor area of 2,750 square metres, where all products have to pass various tests. There, more than 3,000 basic and user-specific tests are performed annually for energy chain systems alone in 180 test facilities under real conditions. These include tests at various temperatures and pressures, or even in contact with chemical substances. For example, tests are also conducted in the special noise chamber. It was here that the e-spool from igus was subjected to an intensive test for its noise emissions during operation. e-spool is an alternative to conventional cable reels for very tight radii and installation spaces. In the tests, the cable-friendly energy, data and media supply system of the latest generation has been proved extremely quiet. In particular the absence of slip rings minimises the noise development significantly in this special reel. An e-spool equipped with 'anti-vibration matting' was able to reach levels below 46dB (A) in these tests.

The tests at igus test lab also proved the performance of the e-spool with respect to its service life. In addition to the noise emissions, this special insulated option was tested for compliance with the service life expectancy for a customer. This result was amazing -- at full extension to twelve metres, the integrated return spring held the required tension of the pull-out e-chain at all times, and a maximum rotational movement of the used igus twisterband, the e-spool surpassed the required 24,000 double strokes by far, completely trouble-free. The twisterband worked as the rotating link through which cables are routed smoothly for the chain and which allowed the rotation of the reel. igus offers e-spools with one or two twisterbands, depending on the number of cables to be routed. The achievable life is dependent on the application and execution of up to about one million movements. For the model with spring reel, the spring must be replaced after 75,000 double strokes. In the e-spool power with motor drive, that is not necessary.

### Suitable for noise-sensitive applications


The latest test results prove that the e-spool is ideal for use in noise-sensitive applications such as stage installations. Finally, moving stage elements must be moved as smoothly and quietly as possible. At the same time, the energy supply system needs to be as compact as possible in order to manage with limited space. Similarly, factories or logistics centres, where noise emission limits are



(Source: igus GmbH)

Tests conducted in the 2,750 square metre test lab demonstrated the low noise emissions of the e-spool. Thus, the cable reel without slip ring qualified for low operation noise in the stage sector.

increasingly becoming a norm, are suitable areas of its application. But there are even more features such as the strain relief of the cables, the variable guiding in all directions, as well as halogen-free components support the use of an e-spool. The latter is particularly important in order to achieve the required fire safety standards. For this purpose, igus offers the appropriate chainflex cables with TPE outer jacket for moving applications.

The e-spool energy supply system is available in standard catalogue sizes of four to 14 metres. For special projects which are either particularly compact or for very long extension lengths up to 50 metres, igus also offers customised special solutions. All components together according to customer requirements with completely pre-assembled cables and optional installation. 

For more information, write us at - [Harish@igus.in](mailto:Harish@igus.in) or visit is at [www.igus.in](http://www.igus.in)



# Aging Assessment Of Power Transformer Insulating Oil



The most expensive and important equipment in electric power system, power transformer plays a vital role in maintaining reliable and efficient electricity supply. The condition evaluation of insulating oil of power transformer is performed by oil contamination test and the Dissolved Gas Analysis (DGA) method...





The power transformer is the pivotal device of the power system. Insulation is the major component, which plays an important role in the life expectancy of the transformer. DGA of insulating oil is universally used and considered as an important indicator of a transformer's overall condition all over the world. Power transformer windings are most commonly insulated with multiple layers of insulating cellulosic paper and immersed in mineral insulating oil. Transformer life known to us is based on the designed parameter with respect to normal operation and climate conditions. To determine the performance and aging of the asset, insulation behaviour is a main indicator. Transformer failure may be avoided by monitoring the condition of the oil in an operational unit and, based on the results, corrective action may be taken. Transformer oil contains about 70% of diagnostic information. The variations in different oil characteristics may therefore be used to identify/detect the type of incipient failure in the transformer. Several methods are available for the interpretation of laboratory results, such as those recommended in IEC Standard 60599 and IEEE Standard C57.104-1991. Currently, there are several methods developed to do the interpretation of the fault type from the dissolved gases data. In this article, the five methods and their advantages and disadvantages of interpretation of the fault gases are studied.

### Transformer Oil

Oil used for insulation in transformers is mineral oil and it is obtained by refining crude petroleum. Animal oils and vegetable oils are not used for this purpose as these form fatty acids on heating, which are corrosive for the cellulosic paper used in insulation. Mineral oils were in use as liquid dielectrics in electrical equipment for over hundred years now. Despite the availability of a variety of synthetic oils, with far more superior properties, mineral oils held its way, due to their abundant availability and economy.

Three properties that are fundamental to use of mineral oil as dielectric are:

- High insulating property,
- Good oxidative and ageing stability and good heat transferability.

### Insulating Oil Quality

The condition of the oil greatly affects the performance and the service life of transformers. A combination of electrical, physical and chemical tests is performed to measure the change in the electrical properties, extent of contamination, and the degree of deterioration in the insulating oil. The results are used to establish preventive maintenance procedures, to avoid costly shutdowns and premature equipment failure, and extend the service life of the equipment. There is a multitude of tests available for insulating oil. Threshold levels for these tests are specified in ASTM D3487 for new oils and IEEE Guide 637-1985 for service oils.

### Dissolved Gas Analysis (DGA)

DGA has become a very popular technique for monitoring the overall health of a transformer. By analyzing oil sample for dissolved gas content

it is possible to assess the condition of the equipment and detecting faults at an early stage. Dissolved gas analysis, like a blood test or a scanner examination of the human body, can warn about an impending problem, gives an early diagnosis, and increases the chances of finding the appropriate cure. So, this technique is a very efficient fault diagnostic technique for transformer – and lots of approaches have emerged to analyse the results. The increasing dissolved gases in DGA not only indicates the fault inside the transformer, but also points to insufficient cooling system. The gases in oil tests commonly evaluate the concentration of hydrogen ( $H_2$ ), methane ( $CH_4$ ), acetylene ( $C_2H_4$ ), ethylene ( $C_2H_2$ ), ethane ( $C_2H_6$ ), carbon monoxide (CO), carbon dioxide ( $CO_2$ ), nitrogen ( $N_2$ ), and oxygen ( $O_2$ ).

Information from the analysis of gasses dissolved in insulating oil is one of the most valuable tools in evaluating the health of a transformer – and has become an integral part of preventive maintenance programs. Data from DGA can provide:

- warning in advance of developing faults
- monitoring of the rate of fault development
- confirmation on the presence of faults
- checks on new and repaired units
- assistance to the convenient scheduling of repairs
- allowance to the monitoring of units under temporary overload.

### Operating Procedure for Dissolved Gas Analysis (DGA)

Following major steps are followed to provide the analysis using DGA:

**Detection:** The generation of any gas above the normal level is detected first, and then appropriate guidelines are utilized so that possible abnormality can be recognized at the earliest so that damage to the transformer could be minimized.

**Evaluation:** The impact of the abnormality or fault on the serviceability is evaluated by using a specified set of guidelines and recommendation.


**Action:** Lastly the action is recommendation, which begins with increased surveillance and confirming or supplementary analysis – and leads to either a determination of load sensitivity, reducing the loads on the transformer, or actually removing the unit from service.

The earliest possible detection of gases is required for the fault gas analysis technique to be successful. The following methods are used for detecting fault gases:

- Direct measurement of the amount of combustible gas in the gas space or relay (Total Combustible Gas (TCG)).
- Direct measurement of the amount of combustible gas dissolved in the oil (gas-in-oil monitors).
- Chromatographic separation and analysis for the individual components in a gas mixture extracted from a sample of the transformer oil or a sample of the transformer gas space.


Table 1: generations of gases in oil by some typical fault in transformer active part modes...

Types of fault	Decomposable gases in transformer oil
1.Arcing in oil	$CH_4$ , $C_2H_4$ , $H_2$
2.Overheating of solid insulating materials	CO, $CO_2$
3.Overheating of oil and paper combination	$CH_4$ , $C_2H_4$ , CO, $CO_2$ , $H_2$
4.Arcing of oil and paper combination	$H_2$ , $C_2H_4$ , CO, $CO_2$



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Table 2: Permissible concentrations (ppm) of dissolved gases in the oil of a healthy transformer...

Sr. No.	Gases Concentration (ppm)	Less than four years in service	4-10 years 5n service	More than 10 years in service
1	Hydrogen	100-150	200-300	200-300
2	Methane	50-70	100-150	200-300
3	Acetylene	20-30	30-50	100-150
4	Ethylene	100-150	150-200	200-400
5	Ethane	30-50	100-150	8500-10000
6	Carbon-monoxide	200-300	400-500	600-700
7	Carbon- dioxide	3000-3500	4000-5000	9000- 2000

### Incipient Faults And Faults Gases

The operating principle of transformers is based on the slight albeit harmless deterioration of the insulation that accompanies incipient faults, in the form of arcs or peaks resulting from dielectric breakdown of weak or overstressed parts of the insulation, or hot spots due to abnormally high current densities in conductors. Whatever the cause, these stresses will result in the chemical breakdown of some of the oil or cellulose molecules constituting the dielectric insulation.

Gases that are produced in transformer oil can be divided into three groups as follows:

#### A. Hydrocarbon and hydrogen

- Methane (CH<sub>4</sub>)
- Ethane (C<sub>2</sub>H<sub>6</sub>)
- Ethylene (C<sub>2</sub>H<sub>4</sub>)
- Acetylene (C<sub>2</sub>H<sub>2</sub>)
- Hydrogen (H<sub>2</sub>)

#### B. Carbon oxides

- Carbon monoxide (CO)
- Carbon dioxide (CO<sub>2</sub>)

#### C. Non fault gases

- Nitrogen (N<sub>2</sub>)
- Oxygen (O<sub>2</sub>)

Gases, which are produced by the degradation of oil as a result of elevated temperatures, may be caused by several factors as Severe overloading, Lighting, Switching transients, Mechanical flaws, Chemical decomposition of oil or insulation, Overheated areas of the windings and Bad connections which have a high contact resistance.

### Conditioning Monitoring Utilizing Total Dissolved Combustible Gas (Tdcg) In Oil

The previous dissolved gas analysis record is very important for determining whether the transformer is behaving normally or not. A four-level criterion has been developed to classify risks to transformers, when there is no previous dissolved gas history, for continued operation at various combustible gas levels. The criterion uses both concentration gases as shown in table 3. This table is used to make the original assessment of a gassing condition on a new or recently repaired

Table 3: Dissolved gas concentration...

Dissolved Key Gas Concentration Limits (ppm)								
Status	H <sub>2</sub>	CH <sub>4</sub>	C <sub>2</sub> H <sub>2</sub>	C <sub>2</sub> H <sub>4</sub>	C <sub>2</sub> H <sub>6</sub>	CO	CO <sub>2</sub>	TDCG
Condition-1	100	120	35	50	65	350	2500	720
Condition-2	100-700	121-400	36-50	51-100	66-100	351-570	2500-4000	721-1920
Condition-3	701-1800	401-1000	51-80	101-200	101-150	571-1400	4001-10000	1921-4630
Condition-4	>1800	>1000	>80	>200	>150	>1400	>10000	>4630

transformer or is used if there are no previous tests on the transformer for dissolved gases or if there is no recent history.

Table.3 lists the dissolved gas concentrations for the individual gases and TDCG for conditions 1 through 4. The four conditions are described below:

**Condition 1:** TDCG below this level indicates the transformer is operating satisfactorily. Any individual combustible gas exceeding specified levels should prompt additional investigation.

**Condition 2:** TDCG within this range indicates greater than normal combustible gas level. Any individual combustible gas exceeding specified levels should prompt additional investigation. Action should be taken to establish a trend. Fault(s) may be present.

**Condition 3:** TDCG within this range indicates a high level of decomposition. Any individual combustible gas exceeding specified levels should prompt additional investigation. Immediate action should be taken to establish a trend. Fault(s) are probably present.

**Condition 4:** TDCG within this range indicates excessive decomposition. Continued operation could result in failure of the transformer. Proceed immediately and with caution. Table 3 is only suitable if no previous tests on the transformer for dissolved gas analysis have been made or that no recent history exists. If previous history of the transformer is there, then this table only determines the situation which is stable or unstable. For such type of conditions we will consider the TCG and gassing rates for providing the necessary analysis.

### Methods Of Fault Gas Detection

Insulating oils under abnormal electrical or thermal stress breakdown to liberate small quantities of gases. The composition of these gases is dependent upon type of fault. By means of DGA, it is possible to distinguish fault such as partial discharge (corona), overheating, and arcing in a great variety of oil filled equipment. DGA can give early diagnosis and increase the chances of finding the appropriate cure. There are many methods in DGA. In this article, six of the more commonly used methods were studied:

#### Roger ratio method

The Roger's method utilizes four gas ratios: CH<sub>4</sub>/H<sub>2</sub>, C<sub>2</sub>H<sub>6</sub>/CH<sub>4</sub>, C<sub>2</sub>H<sub>4</sub>/C<sub>2</sub>H<sub>6</sub> and C<sub>2</sub>H<sub>2</sub>/C<sub>2</sub>H<sub>4</sub>. Diagnosis of faults is accomplished via a





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simple coding scheme based on ranges of the ratios as shown in tables 4(a) and 4(b) below.

Table 4 (a): GAS RATIO CODES...

Gas ratio	Ratio code
$\text{CH}_4/\text{H}_2$	R1
$\text{C}_2\text{H}_6/\text{CH}_4$	R2
$\text{C}_2\text{H}_4/\text{C}_2\text{H}_6$	R3
$\text{C}_2\text{H}_2/\text{C}_2\text{H}_4$	R4

Table 4 (b): ROGER'S RATIO CODES...

Gas Ratios code	Range	Code
R1	$\leq 0.1$	5
	$\geq 0.1, < 1.0$	0
	$\geq 1.0, < 3.0$	1
	$\geq 3.0$	2
R2	$< 1.0$	0
	$\geq 1.0$	1
R3	$< 1.0$	0
	$\geq 1.0, < 3.0$	1
	$\geq 3.0$	2
R4	$< 0.5$	0
	$\geq 0.5, < 3.0$	1
	$\geq 3.0$	2

The combination of the coding gives 12 different types of transformer faults. The type of faults based on the code is shown in table 5 below.

Table 5: Classification based on Roger's ratio codes...

R1	R2	R3	R4	Diagnosis
0	0	0	0	Normal Discharge
5	0	0	0	Partial Discharge
1-2	0	0	0	Slight Overheating $< 150^\circ\text{C}$
1-2	1	0	0	Overheating $150^\circ\text{C}$ - $200^\circ\text{C}$
0	1	0	0	Overheating $200^\circ\text{C}$ - $300^\circ\text{C}$
0	0	1	0	General Conductor Overheating
1	0	1	0	Winding Circulating Currents
1	0	2	0	Core & Tank circulating currents, overheated joints
0	0	0	1	Flashing without power follow through
0	0	1-2	1-2	Arc with power follow through
0	0	2	2	Continuous sparking to floating potential
5	0	0	1-2	Partial discharge with tracking (note CO)

### IEC ratio method

This method originated from the Roger's Ratio method, except that the ratio  $\text{C}_2\text{H}_4/\text{CH}_4$  was dropped since it only indicated a limited temperature range of decomposition. Although IEC three-ratio method is widely used in transformer fault diagnosis, but because the number of code combination is larger than fault type number, no matching often

occurs in the diagnosis. Here, the remaining three gas ratios have different ranges of code as compared to the Roger's ratio method and they are shown in table 4(b). The faults are divided into nine different types as listed in table 6.

Table 6: IEC Ratio Codes...

Gas Ratios code	Range	Code
R4	$< 0.1$	1
	$0.1$ - $1.0$	0
	$1.0$ - $3.0$	2
	$> 3.0$	2
R1	$< 0.1$	0
	$0.1$ - $1.0$	1
	$1.0$ - $3.0$	1
	$> 3.0$	2
R3	$< 0.1$	0
	$0.1$ - $1.0$	0
	$1.0$ - $3.0$	1
	$> 3.0$	2

Table 7: Classification based on IEC Ratio Codes...

R4	R1	R3	Diagnosis
0	0	0	Normal ageing
1	0	0	Partial discharge of low energy density
1	1	0	Partial discharge of high energy density
0	1-2	1-2	Discharge of low energy (Continuous sparking)
0	1	2	Discharge of high energy (Arc with power flow through)
0	0	1	Thermal fault $< 150^\circ\text{C}$
2	0	0	Thermal fault $150^\circ\text{C}$ - $300^\circ\text{C}$
2	0	1	Thermal fault $300^\circ\text{C}$ - $700^\circ\text{C}$
2	0	2	Thermal fault $> 700^\circ\text{C}$

### Duval Triangle Method

The Duval Triangle diagnostic method for oil-insulated transformers was first developed in 1974 by Michel Duval of Hydro Quebec's Institute of Research (IREQ). This method has been proved to be accurate and dependable over many years and is now becoming popular for the fault diagnosis.

In this method uses three hydrocarbon gases only ( $\text{C}_2\text{H}_2$ ,  $\text{C}_2\text{H}_4$  and  $\text{CH}_4$ ). These three gases correspond to the increasing levels of energy necessary to generate gases in transformers in service. The Triangle method is indicated in Figure 1.

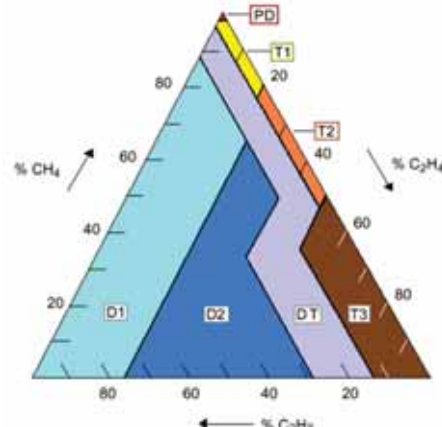


Fig. 1: Duval Triangle...

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Table 8: classifications of faults detectable by Duval Triangle...

Symbol	Fault	Example
PD	Partial Discharge	Discharge of the cold plasma (corona) type in gas bubbles or voids, with the possible formation of X-wax in paper.
D1	Discharges of low energy	Partial discharges of the sparking type, including pinholes, carbonized punctures in paper. Low energy arcing including carbonized perforation or surface tracking of paper, or the formation of carbon particles in oil.
D2	Discharges of high energy	Discharge in paper or oil, with power follow, resulting in extensive damage to paper or large formation of carbon particles in oil, metal fusion, tripping of the equipment and gas alarm.
T1	Thermal fault < 300°C	Evidenced by paper turning brownish (> 200°C)
T2	Thermal fault 300°C-700°C	Carbonization of paper, formation of carbon particles in oil.
T3	Thermal fault > 300°C	Extensive formation of carbon particles in oil, metal coloration (800°C) or metal fusion (> 1000°C)
DT	Mix of Thermal & Electrical fault	

### Triangle Coordinates

$$\% C_2H_2 = \frac{100x}{x+y+z}; \% C_2H_4 = \frac{100y}{x+y+z}; \% CH_4 = \frac{100z}{x+y+z}$$

With  $x = [C_2H_2]$ ;  $y = [C_2H_4]$ ;  $z = [CH_4]$  in ppm

In addition to the 6 zones of individual faults mentioned in Table 8 (PD, D1, D2, T1, T2 or T3), an intermediate zone DT has been attributed to mixtures of electrical and thermal faults in the transformer.

### Key gas method

This is one of the most frequently used diagnostic tools and, unfortunately, one of the weakest in our arsenal. The combination of frequent use and poor diagnostic capability unite with the result being the source of a significant number of misdiagnoses in the field. The dependence on temperature of the types of oil and cellulose decomposition gases provides the basis for the qualitative determination of fault types from the gases that are typical, or predominant, at various temperatures. These significant gases and proportions are called key gases.

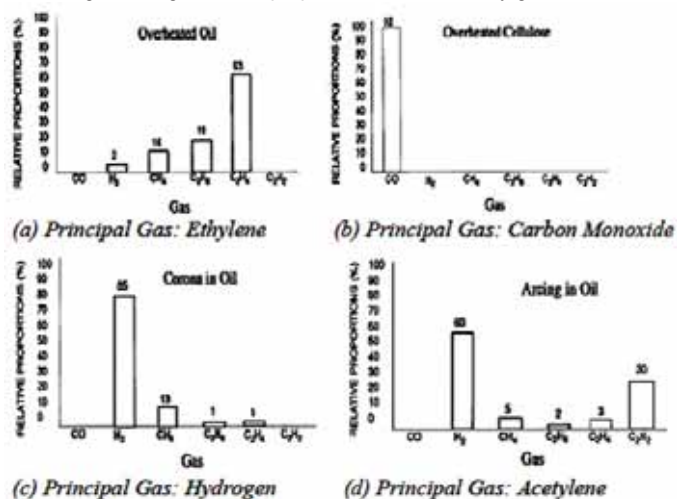


Fig. 2: Key Gases Diagnosis...

The IEEE guide Key Gas Method offers diagnosis through calculating the relative proportions (in percent) of these key gases to the rest of the gases in the transformer. The proportions indicate the general fault type – and these fault types with their relative proportions of gases (in percent) are followed in figure 2.

### Conclusion

As the population of transformers in service increases and their operating time extends, much attention has been focused on their availability and reliability. Most of the decay products that progressively damage the properties of oil-paper insulation in power transformers result from secondary chemical reactions between decomposed molecule under the impact of electrical, chemical and thermal stresses. In this article, a brief analysis has been made about commonly used five types of DGA methods that find use in the DGA for power transformers.

It was found that the Duval-Triangle method is the best, because, it always provides a diagnosis, with a low percentage of wrong diagnoses as compared to all methods, then Ratio methods and the Key-Gas method, because, it often provides wrong diagnoses. Those methods using specific codes in their interpretation are more accurate if they make a prediction. Further application of these techniques as a monitor during the factory proving tests of power transformers, is being developed employing very much greater detection sensitivities than used in the field.



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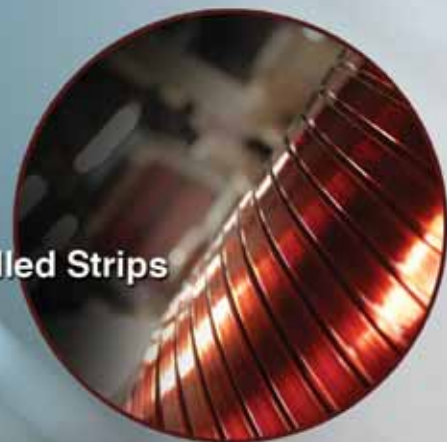
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# Solar Power In Education Sector

We all witness the rapid rise in the number of schools in India, so there is a huge energy demand which is inevitable in these places...







**E**nergy is one of the most fundamental needs of our universe. Energy has come to be known as a 'strategic commodity' and any uncertainty about its supply can threaten the functioning of the economy, particularly in developing countries. Solar energy is the core source of all energies on earth. It is the most readily, freely available, non-polluting and the most abundant renewable energy source.

The earth is approximately spherical in shape, about  $1.27 \times 10^4$  km in diameter. The radiant energy from the sun covers the entire electromagnetic spectrum.

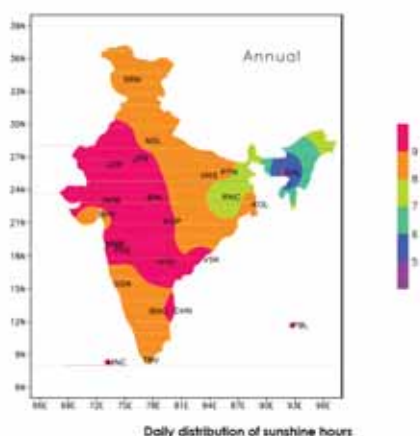
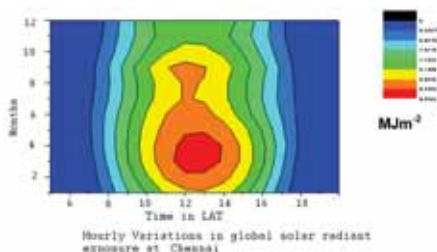
The atmospheric interference restricts this spectrum to 290 to 3000nm – which is called 'solar radiation.' The energy flux received from the sun outside the earth's atmosphere is of nearly constant value – and is termed as the Solar Constant ( $I_{sc}$ ), its value is accepted as  $1367 \text{ W/m}^2$ .

Approximately 162,000 Tera ( $10^{12}$ ) watt of solar energy reaches earth's surface. The solar energy received by the earth is more than 15,000 times the world's commercial energy consumption and over 100 times the world's known coal, gas and lignite.

#### **Meteorological Data (Analysis of radiation data)**

India has an area of 35million Sq.Km, and its strategic geographical location enables it to have a long and sunny days (275 to 330 days) for most part of our country. Indian Meteorological Department (I.M.D.) is maintaining a network of radiation measuring stations in India. The hourly variation data for solar radiation shows the maximum insolation falls between 12 noon to 2PM (Red patches). The annual meteorological data shows that except north east part of India, all other regions receive more solar radiation annually.





## Solar Photovoltaic (PV)

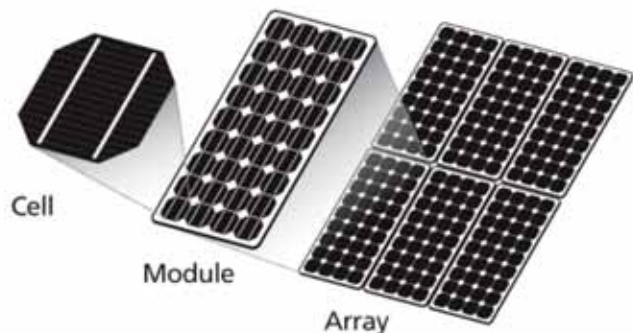
Photovoltaics (PV) is the direct method of converting sunlight (photons) into electricity through a device known as the 'Solar Cell'. Many different solar cell technologies – such as mono-crystalline and poly-crystalline silicon, thin films such as amorphous silicon, cadmium telluride, copper indium gallium selenide and concentrator-based high-efficiency III-V, etc. are available in the market today.

The basic PV or solar cell typically produces only a small amount of power. To produce more power, solar cells (about 40) can be interconnected to form panels or modules. PV panel output range is from 3 to 330 Watts and efficiency of 11 to 15% at commercial level. If more power is needed, several panels can be installed on a building or at ground-level in a rack to form a PV array.

For large electric utility or industrial applications, hundreds of solar arrays are interconnected to form a large utility-scale PV system.

## Rooftop Installation Requirements

The shadow-free area required for installation of a rooftop solar PV system is about 12 Sq. Mtrs per kW (kilowatt). This number includes



provision for clearances between solar PV array rows. The solar panels may be installed on the roof of the building with a south facing, tilt angle that varies in Tamil Nadu from 11 to 13 degrees depending on the latitude of the location. Sufficient area shall be available for servicing the system. The minimum clearance required for cleaning and servicing of the panels is 0.6m from the parapet wall and in between rows of panels. In between the rows of solar panels sufficient gap needs to be provided to avoid the shading of a row by an adjacent row. The solar grid inverter shall be placed indoor in a safe and easily accessible place.

**For 1MW of power 14,000Sq Mtrs (Rooftop) space area is required.**

## Capital Subsidy

Capital Subsidy by the Ministry of New and Renewable Energy (MNRE): The Ministry of New and Renewable Energy of the Government of India provides capital subsidies for solar PV systems subject to certain conditions. As of March 2014, the capital subsidy for rooftop solar PV systems was 30% of the benchmark cost or 30% of the actual cost, whichever is less. The up-to-date benchmark cost and capital subsidy terms and conditions may be checked on the website of MNRE (see: [www.mnre.gov.in](http://www.mnre.gov.in)).

## Solar PV Plant in Educational institution:

### Statistics of School Education:-

We all witness the rapid rise in the number of schools in India, so there is a huge energy demand which is inevitable in these places. All schools depend upon conventional energy sources for electricity. The table below shows total number of schools in our country.

Type of schools	Total count
Primary	790640
Upper Primary	401079
Secondary	131287
Senior Secondary	102558
Total	14,25,564

## Energy Consumption in Schools

For example, the energy consumption in a school that comprises 20 class rooms +5 office rooms +5 rest rooms. The data shown above are just to depict the energy consumption in schools. Only the major loads are shown there.

## Cost of Solar Project to Meet the above Energy Requirement

From the above table, it is roughly estimated that, the energy consumed per day is 91.5 units and the money spent annually towards electricity bill is 2.05 lakhs.

If we install solar PV to meet 91.5 units of energy a day, we need to spend approximately 12 lakhs INR (excluding subsidy). The payback period is roughly estimated as 5.7 years.

## Need of the Hour - Switch to Solar Energy

The above data shows that schools spend more money towards energy than what they actually spend for books and class room aids.





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Type of Loads	Total Quantity	Power consumed (Approx.) (W)	Energy consumed/day (7 hours) (in units)	Energy consumed /Month of 30 days (in units)	Energy Consumed annually (10 months) (in units)	Rupees spend annually towards energy consumption @750 paise/unit
Lighting load	150	40	42	1260	12600	94500
Fan Load	90	75	47.25	1417.5	14170.5	106278
Well pump/Motor loads	2-3Hp	746	2.238	67.14	670.14	5025
Total energy requirement/day			91.5 units			
Total amount (approx.) spend by a school towards energy consumption/annum						2,05,803 rupees
For 14,25,564 Schools, the approx. money spend towards energy consumption/annum						293 billion rupees

Energy/day	Total sun hours	Kwp required (Consider an overall system efficiency of 85%)	Cost/watt for on grid set up in (INR)	Project cost (INR)	Subsidy @30% (INR)	Total amount to pay (INR)	Money Spend for electricity bill(INR) (from above table)	Pay back after
91.5 units	5	21.52Kwp	75	16.15 lakhs	4.85 lakhs	11.4 lakhs	2.05 lakhs	5.7 years

Unfortunately most of the existing educational infrastructure of India is solely dependent on conventional energy.

But these days, we can see a tremendous decline in fossil fuel content, and in fact they are expensive and irregular. Using DG (during power outages) set and maintaining them are really expensive and can cause health hazard too.

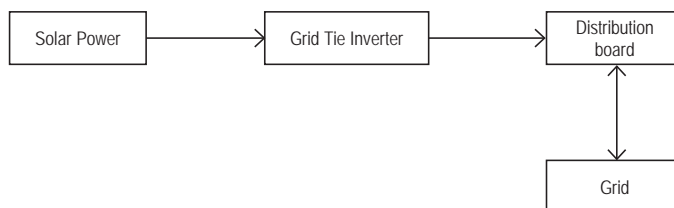
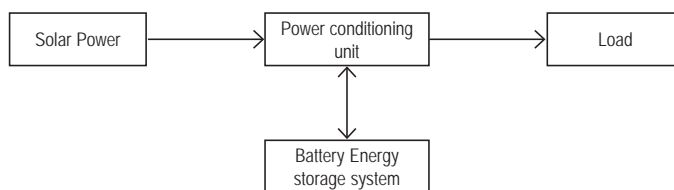
### Benefits of Institution by Installing Solar Plant in Their Premises:

- Most of the schools have spacious premises including terrace, which is ideal for rooftop solar installation (no need to spend money to buy extra spaces).
- Educational institutes and offices are operated in morning hours only, i.e, during sun shine hours
- Government subsidy of 30% towards solar plant installation
- Can reduce electricity bills
- Can generate revenue if they can add extra power to the grid as well
- Payback period in 5-6 years
- Long lasting – 20 to 25 years
- Can contribute a pollution free and healthy environment
- Demonstration and awareness creation to students

### Types of Solar Plant

- Solar off Grid connection

Distributed/decentralised renewable power projects using solar energy are utilised directly and stored in BES (Battery energy storage) system



### Solar Grid Tie (on grid)

In grid-connected Solar Photo-Voltaic (PV) systems, solar energy is fed into the building loads that are connected to the grid through a service connection with surplus energy being fed into the grid and shortfall being drawn from the grid. Production of surplus energy may happen when solar energy produced exceeds the energy consumption of the building. This surplus is fed into the grid.



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S. No.	Accessories	Specification	Compliance with standards and codes
1	PV Panel	Crystalline silicon (efficiency >13%), fill factor >70%	IEC 61215 / IS 14286 IEC 61730 Part 1 and 2
2	PV Panel mounting structure	Hot dip galvanised steel with a minimum galvanisation thickness of 120 microns or aluminium alloy.	
3	Solar Grid tied Inverter	Operating frequency=47.5 to 52.5Hz, Power factor >0.98, THD <3%, efficiency >95%	Anti-islanding protection as per VDE 0126-1-1, IEC 60255.5/ IEC 60255.27, Safety compliance IEC 62109-1, IEC 62109-2, Environmental Testing IEC 60068-2 (1,2,14,30)
4	DC Combiner Box	Should be combined with DC fuse protection for the outgoing DC cable(s) to the DC Distribution Box	
5	DC Distribution Box	Thermo-plastic IP65 DIN-rail mounting type DC surge protection device (SPD)	Class 2 IEC 60364-5-53
6	AC Distribution Box	The AC distribution box shall be of the thermo plastic IP65 DIN rail mounting type	
7	Cables	All cables shall be supplied conforming to Voltage rating: 1,100V AC, 1,500V DC as required. For the DC cabling, XLPE or XLPO insulated and sheathed, UV stabilised single core flexible copper cables shall be used. Multi-core cables shall not be used For the AC cabling, PVC or XLPE insulated and PVC sheathed single or multi-core flexible copper cables shall be used. Outdoor AC cables shall have a UV-stabilised outer sheath	IEC 60227/ IS 694 & IEC 60502/ IS 1554
8	Earthing	Earthing shall be done in accordance with the standards, provided that earthing conductors shall have a minimum size of 6.0 mm <sup>2</sup> copper, 10 mm <sup>2</sup> aluminium or 70 mm <sup>2</sup> hot dip galvanised steel. Unprotected aluminium or copper-clad aluminium conductors shall not be used for final underground connections to earth electrodes	IS 3043-1986
9	Lightning and Over Voltage Protection	Lightening arrestors is to be made of 1 ¼" and 12 feet long GI spike on the basis.	
10	Surge Protection Devices (SPD)	Surge protection shall be provided on the DC side and the AC side of the solar system	The SPDs shall be of type 2 as per IEC 60364-5-53
11	Junction Boxes	Junction boxes and solar panel terminal boxes shall be of the thermo plastic type with IP 65 protection for outdoor use and IP 54 protection for indoor use	
12	Caution sign	In addition to the standard caution and danger boards or labels as per Indian Electricity Rules, the AC distribution box near the solar grid inverter, the building distribution board to which the AC output of the solar PV system is connected and the Solar Generation Meter shall be provided with a non-corrosive caution label.	
13	Metering	An energy meter shall be installed in between the solar grid inverter and the building distribution board to measure gross solar AC energy production (the "Solar Generation Meter"). The Solar Generation Meter shall be of the same accuracy class as the service connection meter or as specified by state electricity regulatory commission.	





During the night, or when during the day energy demand in the building exceeds solar energy generation, energy is drawn from the grid. Grid-connected solar PV systems have no battery storage and will not work during grid outage.

For buildings with grid-connected solar PV systems, the service connection meter needs to be of the bidirectional type, whereby import kWh and export kWh are separately recorded.

### Advantage of Grid Connected Solar Systems in School Premises

- The maximum power consumption of an educational institute take place during the daytime. So, Grid tie solar system which eliminates the use of batteries completely is the best option for such institutions
- Once net metering system is adopted, with the feed in tariff policy, user can earn money by selling the electricity generated by the plant.
- The cost of batteries can be avoided.

### Limitation with Grid Tied Solar System

- The only drawback in adopting grid tied system is, if the grid goes off (for any reason), we cannot inject the generated power from the solar plant to the grid.

### Anti-islanding

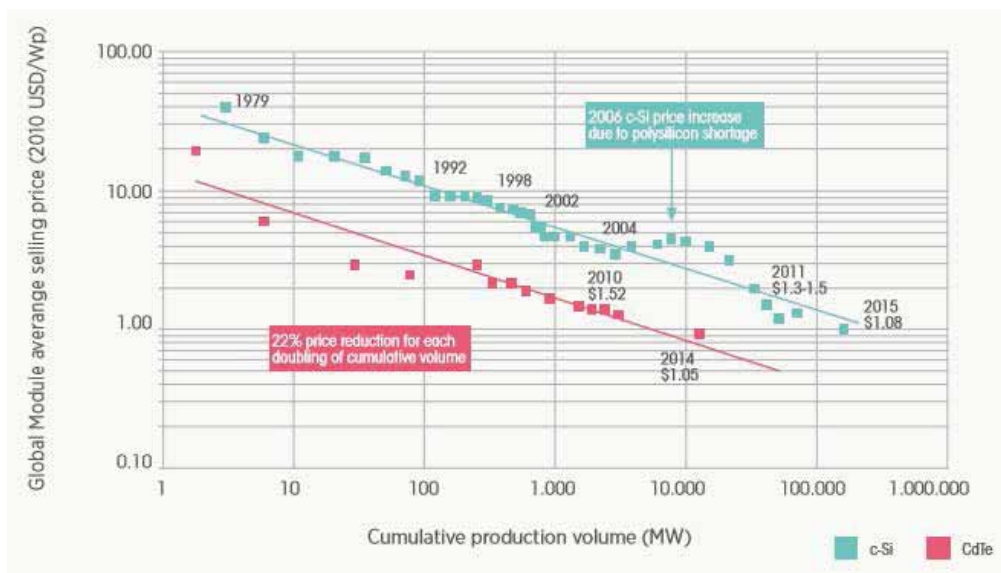
Anti-islanding protection is a way for the inverter to sense when there is a problem with the power grid, such as a power outage, and shut itself off to stop feeding power back to the grid.

This is because when problems arise with the power grid, it is assumed that workers will be dispatched to deal with the issue, and they want the power lines to be completely safe, and not have electricity flowing from all the nearby PV grid-tie systems.

### Conclusion

Utilizing solar energy is definitely free, clean, safe, abundant, renewable, but the high initial investment, higher cost per unit of electricity, long-term payback and poor conversion efficiency are some major drawbacks that have held back this ideal energy source.

Two reasons contribute to this high cost, the need to use large amounts of expensive semiconductor material, and the low conversion efficiency. Scenarios show that solar energy will be, in the long term, the most important energy source, provided that the cost of photovoltaic modules is substantially decreased. The challenge is to reduce the total costs of a photovoltaic system.



But when we analyse solar PV cost for the past 5 years in the global market, there is a significant fall in the price. As per NREL data, in 2011, the median reported installed price of residential and commercial PV systems was \$6.13/W for systems of 10 kW or smaller, \$5.62/W for systems of 10–100 kW, and \$4.87/W for systems larger than 100 kW. The capacity-weighted average reported installed price of utility scale PV systems (ground-mounted systems at least 2 MW in size) declined from \$6.21/W during 2004–2008 to \$3.42/W in 2011.

The drop in installed system prices has resulted from module and non-module cost reductions, but module costs have declined more quickly, thus heightening the PV industry's recent emphasis on reducing non-module costs. It is reported that there is a fall of 6 to 7% in PV price every year. The above graph shows the decline of PV cost for a large scale PV installation in the global market.

As new technology emerges, there can be new way to reduce the cost of PV. The instability and health hazard issues of conventional energy sources in the power market led to the emergence of renewable energy sources. Solar energy generation will be the strong pillar, which can provide sustainable energy production, clean and healthy environment. <sup>⑤</sup>



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# Future Of TRANSMISSION LINE



There is a need for information on the attempts of EHV transmission and experiences during installation. Sharing new design concepts, tower construction ideas, operation and maintenance aspects of these EHV lines will help in avoiding duplication of efforts...



Power is the basic key for growth of any country's economy. The increased demand of electricity, need to optimise the utilisation of power generation capacity and increase in the interconnections are the major issues with which power sector is dealing with. Energy consumption per person is also rising tremendously in developing countries. However, installing a new power plant cannot be a solution every time. Dense population, availability of land, initial and installation cost can be the major issues in this case. Huge transfer of power from generating plants to load centre at long distance with bulky transmission lines is causing to upgrade voltage class to Extra High Voltage (EHV) from High Voltage (HV).

There are indications that EHV network will grow at a very fast rate worldwide as compared to previous few decades. Increase in transmission distance with maximum possible reduction in power loss with saving in the economic costs of transmission lines is the major boost worldwide for moving from HV to EHV. Efforts regarding this already initiated worldwide.

There is a need for information on the attempts of EHV transmission and experiences during installation. Sharing new design concepts, tower construction ideas, operation and maintenance aspects of these EHV lines will help in avoiding duplication of efforts. Therefore, this article is an attempt to provide a summary of the relevant efforts in terms of all these issues going on in different countries throughout the world.

### Why EHV

The world will need greatly increased energy supply in the next 20 years. The demand of electricity is increasing twice as fast as overall energy use and is likely to rise by more than two-thirds till 2035. In 2012, 42% of primary energy used was converted into electricity. With the United Nations predicting world population growth from 6.7 billion in 2011 to 8.7 billion by 2035, demand for energy must increase substantially over that period. Both population growth and increasing standards of living for many people in developing countries will cause strong growth in energy demand, as outlined above. Over 70% of the increased energy demand is from developing countries, led by China and India – China overtook the USA as top CO<sub>2</sub> emitter in 2007. Growth of

***With the United Nations predicting world population growth from 6.7 billion in 2011 to 8.7 billion by 2035, demand for energy must increase substantially over that period...***

Power Sector infrastructure in India since its Independence has been noteworthy making India the third largest producer of electricity in Asia. Generating capacity has grown manifold.

The distance between generating stations and load centers is increasing day by day. The amount of power to be handled is increased from 11kV to 765 kV in India. This need is the basic cause behind emergence of EHV. EHV transmission has emerged from various advantages like reduction in line drop and increase in transmission efficiency.

For HV transmission volume of conductor material is given by the formula:

$$\text{Volume of conductor} = \frac{3P^2 \rho l^2}{WV^2 \cos^2 \phi}$$

P	= power transmitted in watts for 3-phase
V	= line voltage in volts
cos $\phi$	= power factor of the load
l	= length of the line in meters
R	= resistance per conductor in ohms
$\rho$	= resistivity of conductor material
a	= area of X-section of conductor

So, the volume of conductor material is inversely proportional to the square of transmission voltage and power factor. So, EHV transmission reduces the volume of conductor material.

Transmission efficiency is given by formula,

$$\text{Transmission efficiency} = \left[ 1 - \frac{\sqrt{3} J \rho l}{V \cos \phi} \right] \text{ approx.}$$

Transmission efficiency is directly proportional to their line voltage where  $j$ ,  $\rho$  and  $l$  is constant.

$$\% \text{ line drop} = \frac{J \rho l}{V} \times 100$$

The above equation shows that the percentage line drop decreases when the transmission voltage increases. In addition, very high voltages (345 kV and above) are subject to corona losses. These losses are a result of ionization of the atmosphere, and can amount to several megawatts of wasted

power. Power losses due to corona is given by formula

$$P = 242.2 \left( \frac{f + 25}{\delta} \right) \sqrt{\frac{r}{d}} (V - V_c)^2 \times 10^{-5} \text{ kW/km/phase}$$

Where,

$f$  = frequency

$V$  = phase natural voltage

$V_c$  = disruptive voltage per phase

Reduction in conductor size leads to losses. Mitigating the losses during EHV transmission is the major challenge to be faced along with other structural and geographic challenges.

### Challenges

Transmission lines travels hundreds of miles in difficult terrain, under varying and extreme environmental conditions – using variety of construction equipment. The engineering challenges become much more difficult with higher voltages as structures become very tall and heavy.

### Construction of tower depends on

**Type of geometry:** such as Peak of the transmission tower, Cross arm of the transmission tower, Boom of transmission tower, Cage of transmission tower, Leg of transmission tower.

**Weight of tower:** The weight of the tower varies substantially with height, duty (straight run or corner, river crossing etc.), material, number of circuits and geometry. The average weight of 670 towers for 500-kV lines included in the EPRI survey (EPRI 1982) is 28,000 lb (Pounds = kg \* 2.2046). The range of reported tower weights is 8,500 to 235,000 lb.

**Circuit configuration:** Due to unavailability of the shortest distance, straight corridor transmission line has to deviate from its straight way when obstruction comes. In total length of a long transmission line, there may be several deviation points.

According to the angle of deviation there are four types of transmission tower-

- A - type tower – angle of deviation 0° to 2°.
- B - type tower – angle of deviation 2° to 15°.
- C - type tower – angle of deviation 15° to 30°.
- D - type tower – angle of deviation 30° to 60°.

Every country has individual challenges,





which are unique to that country or region.

The problems posed in using such high voltages are different from those encountered at lower voltages. Major problems are:

- Increased current density because of increase in line loading by using series capacitors
- Use of bundled conductors
- High surface voltage gradient on conductors
- Corona problems: audible noise, radio interference, corona energy loss, carrier interference, and TV interference
- High electrostatic field under the line
- Switching surge over voltages, which cause more havoc to air-gap insulation than lightning or power frequency voltages
- Increased short-circuit currents and possibility of ferro resonance conditions
- Use of gapless metal-oxide arresters replacing the conventional gap-type Silicon Carbide Arresters, for both lightning and switching-surge duty

Carrier Communication and Signaling in the frequency range 30 to 500 kHz. Extra high voltage carrying lines cause corona losses, and to reduce these losses can be reduced by use of bundle conductors. These consist of two or more conductors in bundle. Each conductor carries equally distributed among these conductors in bundle, so reduces the corona losses.

The electrostatic effects are caused by the extremely high voltage, while electromagnetic effects are due to line loading current and short circuit currents. Electrostatic field causes damage to human life, plants, animals, metallic objects – such as fences and buried pipelines.

Although, it is not a biological effect, electromagnetic interference of power frequency as low as  $2 \text{ kV/m}^2$  with certain cardiac pacemakers could have medical significance. In short, corona effects, electrostatic fields in the line, losses, audible noise, carrier interference and radio interference became recognised as steady

partial discharges. Corona loss occurs if the line to line voltage exceeds the corona threshold, and it can be overcome by the use of bundle conductors.

Increased short-circuit currents and possibility of ferro resonance conditions leads to the phenomenon appears after transient disturbances (transient overvoltage, lightning overvoltage or temporary fault) or switching operations (transformer energising or fault clearing). Its effects are characterised by high sustained over voltages and over currents with maintained levels of current and voltage waveform distortion, producing extremely dangerous consequences. The solution adopted is the use of switched damping resistors. Cross-tripping parallel energised circuits also can be used occasionally. Transient oscillations may stress transformer insulation or cause circuit break.

The overall aim of insulation coordination is to reduce to an economically and operationally acceptable level of the cost – and disturbance caused by insulation failure. In insulation coordination method, the insulation of the various parts of the system must be so graded that flash over, if occurs, it must be at intended points. In order to protect electric power system equipment from lightning and switching over voltages, surge arresters are used within the system as a tool for insulation co-ordination. The purpose of using a surge arrester is to always limiting the voltage across the terminals of the equipment to be protected below its insulation withstanding voltage.

When a single phase-to-ground fault occurs on an energised transmission line the faulted phase is tripped, and automatically reclosed after a suitable dead time. Auto reclosing reduces operating cost and improves the reliability of service of the network, but further causing problems with arcing. Mitigating with above limitations to boost the performance of EHV system can be the major area of research in coming days.

## World scenario

American Electric Power started transmitting power at a nominal voltage of 765kV and a maximum voltage of 800kV in 1969. Since then, 765kV transmission lines

***When corona is present on the conductors, EHV lines generate audible noise, which is especially high during foul weather. The noise is broadband...***

- Shunt reactor compensation and use of series capacitors, resulting in possible sub synchronous resonance conditions and high short circuit currents
- Insulation coordination based upon switching impulse levels
- Single-pole reclosing to improve stability, but causing problems with arcing.

## Efforts to mitigate the problems

The basic proof justifying the Corona Problems, Audible Noise, Radio Interference, Corona Energy Loss, Carrier Interference, and TV Interference in power transmission is explained in “Corona Effects on EHV AC Transmission lines” by Snigdha Sharma et.al. When corona is present on the conductors, EHV lines generate audible noise, which is especially high during foul weather. The noise is broadband that extends from very low frequency to about 20 kHz, Pulse type of corona gives interference to radio broadcast in the range of 0.5 MHz to 1.6 MHz, Corona on conductors also causes interference to

state problems, which govern the line conductor design, line height, and phase-spacing used to keep the interfering fields within prescribed limits. Use of synchronous condensers due to high line charging currents at load end only became impractical to control voltages at the sending-end and receiving-end buses. Use of Shunt compensating reactors for voltage control at no load and switched capacitors at load conditions became necessary. All these are still categorised as steady-state problems. However, the single major problem considered with EHV.

Voltage levels is the over voltages during switching operations, which is commonly known as switching-surge over voltages. Effect of high surface voltage gradient on conductors is when in an insulation system, the voltage gradient (voltage stress) exceeds a critical voltage, the air molecules surrounding the high voltage transmission line conductors become ionized resulting in



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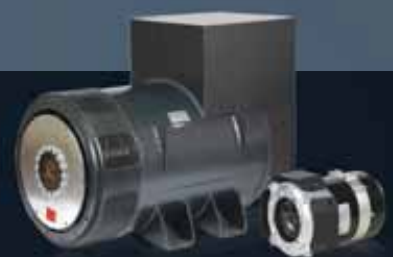
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Country	Enhanced Voltage (kV)	Year	Transmission Distance (km)
USA	345-765	1969	300
Russia	750-1150	1985	2000
Japan	500-1000	2000	250
Canada	315-735	1965	900
India	400-765	2000	440
South Africa	400-765	1988	440
Poland	400-765	1986	114
China	500-750-1000	2009	640

of nominal voltage have been introduced in other areas such as New York (by NYPA), Brazil, Venezuela, and South Africa. In Eastern Europe, Poland and Hungary started to operate of 750kV transmission lines of nominal voltage in the 1970s in order to receive power from the former Union. Recently, China and India also developed 765 kV and 1,000 kV transmission lines.

#### Indian scenario


India is presently placed at a junction of the globalised and liberalised economy,

which provides a great opportunity to exploit its potential, and lead to sustained economy growth and welfare of its populace. Present transmission network in India is 765kV lines existing 8,056 ckms, 400kV lines existing 1,25,039 ckms and 220kV lines existing 144,966 ckms. The major goal for India towards self reliance is UHVAC transmission

systems. Having introduced 765kV as the highest transmission voltage, the country is aspiring to shift to 1200 kV (voltage) transmission networks during the XIIth plan period. A large network comprising 1200 kV transmission superhighways is being planned as part of the National Transmission Network.

#### Conclusions

This article reviewed the efforts going on worldwide to meet the heavy electric power

demands with minimal losses. Need, advantages and technical problems in implementing EHV technology, efforts to overcome that problem are mentioned and studied. Comparative study on EHV transmission lines used in different countries and a comparison between them and the low voltage levels have been performed. Accordingly, the advantages of EHV transmission lines are summarized. Finally, different research areas are identified. 



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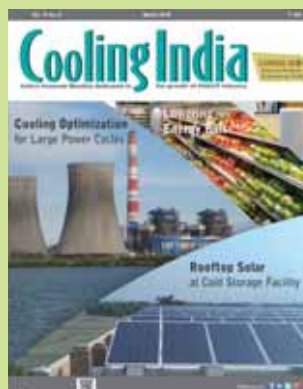
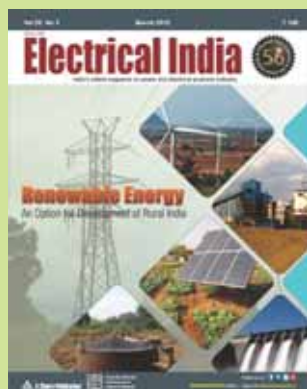


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## Sterlite Grid becomes India's 1st to deploy Aircrane for power transmission project; partners US' Erickson for aerial expertise

**S**terlite Power Grid Ventures Limited (Sterlite Grid) has become India's first private power transmission developer to deploy Aircrane for setting up of a power transmission line in the extremely challenging terrain of Jammu & Kashmir. Sterlite Grid has partnered with US-based Erickson Inc. to install nearly 160 transmission towers in the rough terrain of Pir Panjal ranges, using Erickson's S64 Aircrane, a heavy lift helicopter.

With the NRSS 29 Project set to commence in mid-2016, Sterlite Grid expects to commission the transmission network between Punjab and Jammu & Kashmir nearly 10 months ahead of schedule.

Erickson will help Sterlite Grid erect towers for the NRSS 29 power line in the remote Himalayan region at altitudes of 9,000-12,500 feet. Erickson will fly materials and steel to build the towers utilising. The S64 Aircrane is capable of high-precision aerial lift work. Erickson has 40 years of experience building transmission towers utilising the Aircrane in similarly remote and austere environments.

With J&K's power demand at about 3,000 MW, the Project will enable the state to draw double the power from the national grid. Today, the state is dependent on local hydro power projects and a single transmission line passes through avalanche/landslide prone areas connecting J&K with the national grid. The NRSS 29 project will strengthen the existing power transfer capability by 70%, provide an alternate route for power transfer and increase reliability of the grid. It will enable exchange of more than 1,000 MW of power between J&K & Northern Grid and create provision for future expansion. The NRSS-29 is the largest private sector transmission project awarded in India till date.

"We, at Sterlite Grid, are committed to the nation's vision to electrify every home. We strongly believe innovation and cutting-edge technologies will be the key drivers to achieve faster growth. We are glad to introduce a global leader like Erickson to the potential of India's infrastructure sector and look forward to working with them on future projects," said Pratik Agarwal, Vice Chairman, Sterlite Grid.



"Erickson is excited to have been awarded this strategic contract in India by Sterlite Grid. India is a large market for Erickson and we believe we can offer a competitive advantage in the construction of infrastructure projects in the country. As a business, we are pivoting towards long-term, infrastructure projects in the emerging and developing markets. We are looking forward to building a long-term relationship with Sterlite Grid and India,"

said Jeff Roberts, President and CEO, Erickson.

Sterlite Grid, India's largest private developer of independent power transmission systems, is building ~450 Circuit Kilometre of transmission lines and 400/220-kilovolt (kV) gas insulated substation

(GIS) in Amargarh, J&K (Northern Region Strengthening Scheme -29Project). To complete this line, nearly 1,150 towers will be erected in the most challenging terrains of PirPanjalrange which lies in the inner Himalayan region.

Sterlite Grid is known for introducing robust technologies in power infrastructure development. It is the first Indian company to use LiDAR based surveys to optimise transmission lines and heli-stringing for least disturbance to neighbours and early commissioning. Recently Sterlite Grid joined hands with Sharper Shape, Finland's leading drone solutions provider, to deliver cutting-edge drone-technologies for the power transmission industry.







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## ElMeasure's Intelligent ACCL



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iACCL allows supply from mains as long as the load current is below the programmed current. When the mains supply fails and the stand by generator supply is on, it connects the DG power to each consumer in sequence and starts monitoring its load. Whenever the load current exceeds the allotment, power is automatically switched off for 10 seconds, and automatically restored. This cycle repeats five times. Each time it repeats with double the time (20, 40, 80 & 160) and then enters lockout mode until it is 'Reset' manually. This helps protect against over voltage from DG side. Its current limiting capabilities are ideally suited to efficient utilisation of standby generators. 

For further information: [www.elmeasure.com](http://www.elmeasure.com)

## Measure temperatures safely with FLIR's new TG54 and TG56 spot IR thermometers

FLIR launched the new TG54 and TG56 Spot IR Thermometers, which allow professionals to quickly and easily take measurements in places that are out of reach for most IR thermometers. These thermometers let users take non-contact temperature measurements with a distance-to-spot ratio of 24:1 (TG54) and 30:1 (TG56). That means that with a TG56, they can measure a one-inch sized target from up to 30 feet away! A built-in laser and powerful LED help pinpoint the problem area, even in poor lighting conditions.

Both thermometers have a large, color display and a graphical menu structure so the high and low alarms are easy to set and can't be missed. Every temperature setting is simple to find and select, including emissivity, which has pre-determined levels and can be custom adjusted.

The TG54 and TG56 allow users to view their current temperature readings along with their last two readings together on one screen. This makes comparing temperature differences convenient without having to memorise or write them down.

The main differentiating feature between the two products is that the TG56 includes a thermocouple Type K input for added flexibility while taking measurements. 




For further information: [www.flir.in/TG54-56](http://www.flir.in/TG54-56)

## SCOPE wins Best Product Award in Overall Category at ELECRAMA 2016



SCOPE T&M Pvt Ltd has proudly launched its indigenously developed Wireless Surge Arrester Leakage Current Analyzer – model SA 30i+ which received the Best Product Award as Best Overall Product developed by an Indian or an overseas exhibitor, at at ELECRAMA 2016.

SA 30i+ is a state-of-the-art, online test system for Residual Life Assessment of Metal Oxide Surge Arresters. The instrument measures and directly displays values of Total Leakage Current and Third Harmonic Resistive Leakage Current. It provides system harmonic compensation as per IEC 60099-5-B2. It also provides Corrected Resistive Leakage Current after applying correction factors for change in system voltage and temperature. The SA 30i+ can be pre-loaded with LA identity details (LA Identification, Type, Serial Number, Location, Rated Voltage etc). Tests conducted on the same ID of arresters are saved under the same folder. Trend analysis software, SAData picks up this data and stores them in a similar fashion on a personal computer. This analysis software enables the user to take a decision to repair or replace arresters considering safety limits. 

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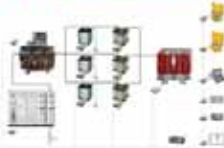
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## Architectural Lighting Solutions

**K**-LITE INDUSTRIES an ISO company, has launched a new series of LED based Architectural Lighting Solutions.

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80 testing requirements and internationally reputed makers such as Nichia / CREE, besides also being RoHS, LM 79 and CE certification compliant. The luminaire efficacy (lumens per watt) is much above 100 for all luminaires. Varied optical options for lighting distribution and co-related colour temperature (CCT) for cool white, neutral white or warm white are available to suit specific requirements.

Its Sleek Polar Lighting Solutions is a contemporary design, while Polar Lighting is in perfect continuity with geometric lines of square columns.



**For further information:** [www.klite.in](http://www.klite.in)

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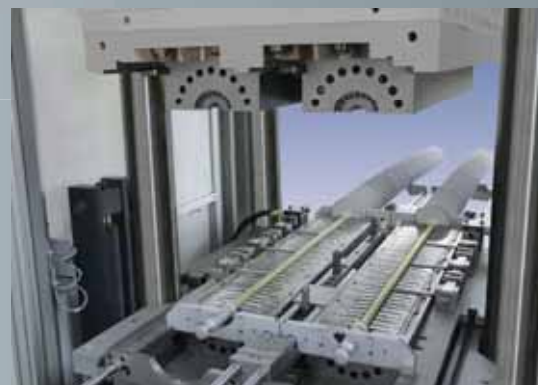
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