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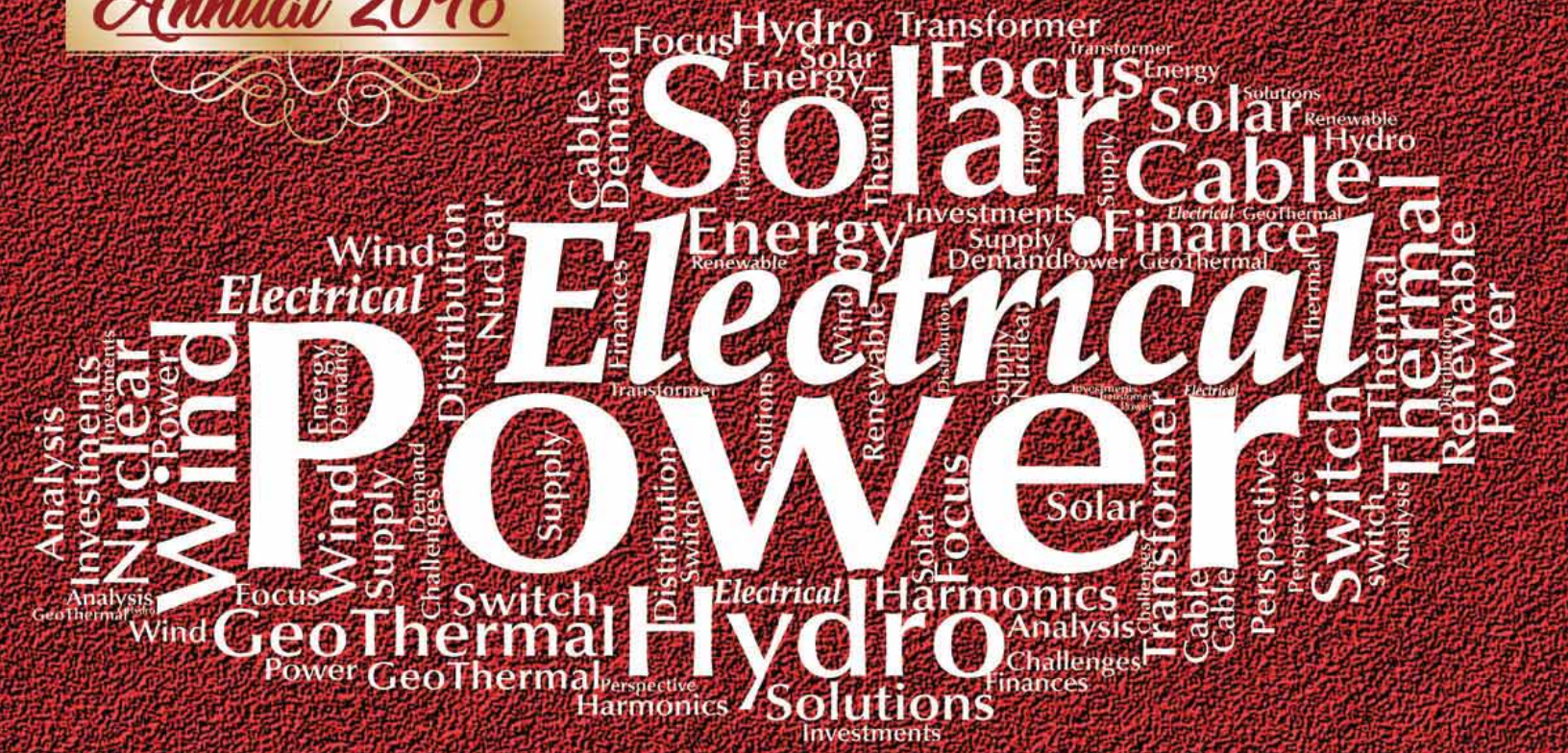

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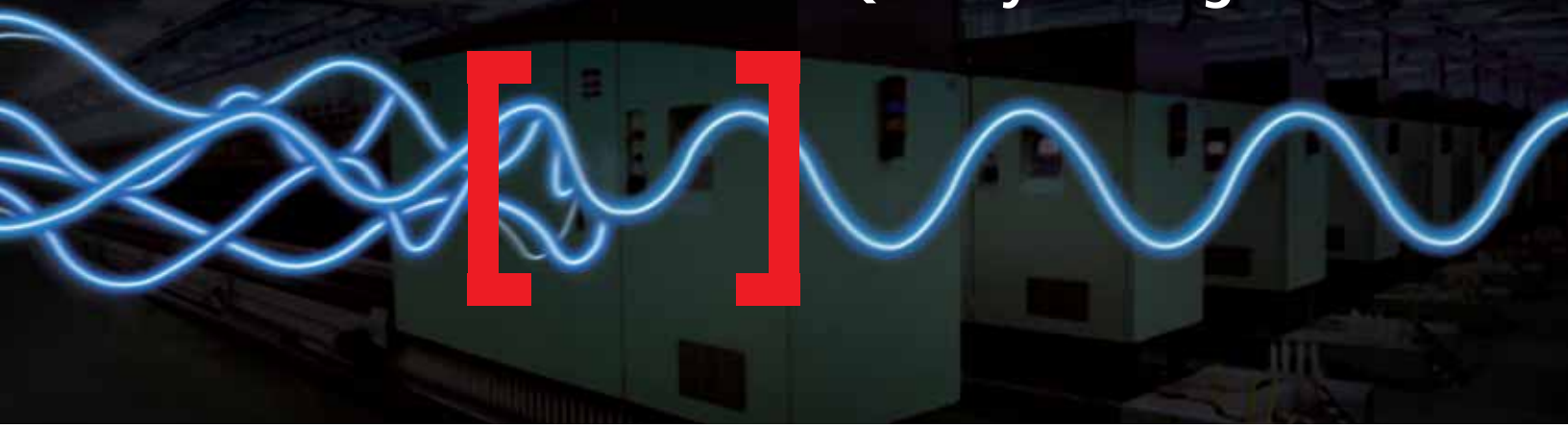

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Publisher's Letter

Present Power Scenario In India

> "All countries are now amassing their 'power from renewables' agenda. India too is not an exception..."

While delivering this Annual Issue 2016, on behalf of Electrical India team, I convey my sincere gratitude to all our readers, writers, advertisers and patrons. 'Hope your continued support will help us grow further in the coming days too...

India has enough electricity generation capacity (~307.3 GW) today, so that just through the thermal power plants, the country is positioned to address the peak load demand (~159 GW). However, we are yet to achieve cent per cent electrification of the country, and that poses a big challenge for the people living in the remote or difficult-to-reach places.

During 2016-17 (till now) 16,398 Circuit Kilometers (CKM) of transmission lines have been commissioned, and the overall increase in the transformation capacity has been 39,060 MVA in the same period. Looking at the gross picture, we see that as on October 31, 2016, the total transmission capacity of 220 kV and above voltage levels was 357,949 CKM, and the transformation capacity of substations was 698,009 MVA.

As on 31st October' 2016, the total transmission capacity of the inter-regional links is 62,650 MW, which is expected to be increased to 68,050 MW by the end of 12th plan i.e., 31st March, 2017. However, in a large country like India, mere growth of transmission lines will not serve the purpose of reaching electricity to all. We have to build up decentralized power generation capacity for many places where grid connection is not feasible.

Decentralized Power Generation or harnessing Distributed Energy Resources (DER) has now been a growing global trend. Navigant Research has recently reported that installed DER capacity, including Distributed Generation (DG), energy storage, microgrids, EVs, and Demand Response (DR), will triple between 2016 and 2025, growing from 124 GW to 373 GW worldwide.

Considering the great challenge posed by 'climate change,' all countries are now amassing their 'power from renewables' agenda. India too is not an exception; rather the country's ambitious target for developing 175 GW of renewable power capacity by 2022 is of huge significance. In fact, it is the largest target so far set by any developing nation.

Coming back to the context of decentralized power generation. Recently, our Power Minister, Piyush Goyal has said, "Apart from shifting to renewable energy, we are focusing upon distributed energy production, where consumers themselves can start generating power. In fact, the rooftop solar power programme will be expanded from 300 MW today to the 40,000 MW in the next six years. It will not only provide energy security but will also give support to the thousands of people living in areas inaccessible to grid based power supply."

According to me, this is the best solution to reach power to all houses by 2022.

Do send in your comments at miyer@charypublications.in

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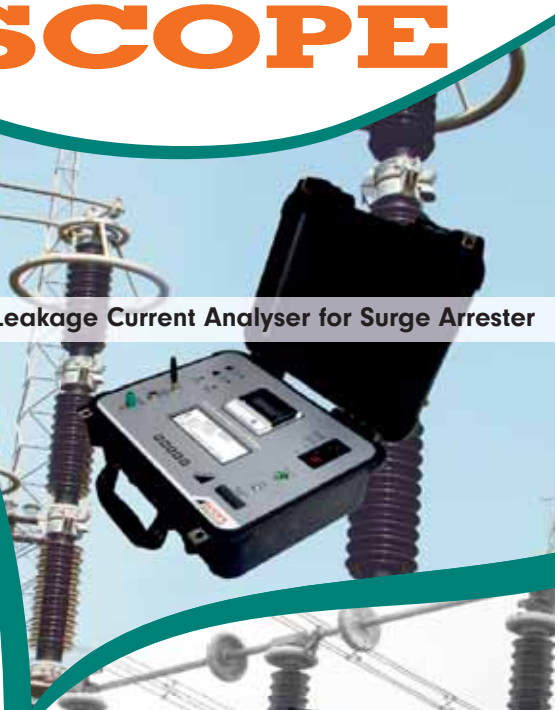

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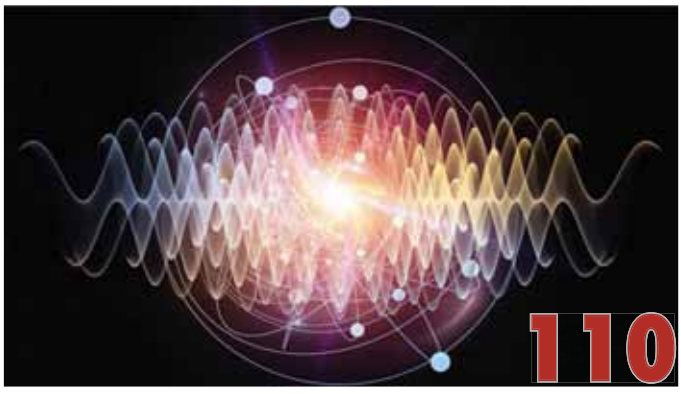

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Editorial

Evolving Technologies Are Making Things Simpler

P K Chatterjee (PK)

> New technologies originating from innovative ideas are setting a new trend of re-looking at and easing the traditional methods...

Electricity is an ever-expanding field. Whether it is at high or micro volt level, as challenges are increasing, never-seen-before kind of innovative (technical) ideas or concepts are also emerging to mitigate them. This continuous race of innovation is creating many new devices or components, which are much simpler, safer and easier to handle & install within a never-thought-of kind of less time.

For example, recently, Leoni, the wellknown European provider of cables and cable systems to the automotive sector and other industries, is working on a concept to develop cooled charging cables for electric and hybrid vehicles. One of the major challenges that the electric or hybrid vehicle drivers face today is – long charging time. As per the existing scenario, a car like the Tesla Model S with an 85-kilowatt battery and a range of about 400 km needs to be charged in a charging station within 15 minutes.

Leoni's current concept is targeting to bring down the charging time to three to five minutes for a range of 100 kilometres. Obviously, it will require flowing current at a much higher rate from the charging point to the car's battery. It may even go to the tune of 400 amperes. Conventional charging systems, which are designed for lower currents, will overheat and give way in such a case. Leoni is proposing use of a cooled charging cable. It will withstand such high strain. Also, the major advantage will be the cable's cross section – that will significantly reduce, which in turn will keep the charging cable flexible and easy to handle.

Contextually, let me cite another example from Siemens. The company has recently delivered three of its new mobile resilience transformers to Westar Energy, a well known energy company in Kansas. The innovative technology, specifically designed for quick response, will allow Westar to replace a large power transformer within days instead of months. The new transformers, highly optimised for weight and dimension through advanced voltage and power rating, will allow Westar to keep power up and running for its 690,000 customers across the eastern part of the state.

Westar engineers and maintenance personnel developed the concept. Then personnel from Siemens and Westar worked together to walk the concept to practical design. In addition to its easy mobility feature, the transformer design includes modular pre-installed cooling systems and operation on multiple voltage levels. The cable termination for 138kV and 115kV grid connections allows for maximum flexibility in the substation and the ability to use the units in several different locations.

Thus, obviously new technologies originating from innovative ideas are setting a new trend of re-looking at and easing the traditional methods of doing things.

P. K. Chatterjee

{ The future of Publishing is about having connections to readers and the knowledge of what those readers want.

- Seth Godin }

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Regulation

MNRE issues bidding guidelines for wind power projects

Ministry of New and Renewable Energy (MNRE) has issued guidelines for transparent bidding process for implementation of scheme for setting up of 1000 MW Wind Power Project connected to Inter-State Transmission System (ISTS).

As per guidelines, the Wind Power Projects will be selected through open and transparent competitive bidding followed by e-reverse auction and the capacity may go higher than 1000 MW, if there is demand from buying entities. The implementing agency SECI has already floated RfS document for selection of bidders under the scheme.

A view of a wind park from India...

Discoms of non-windy state and UTs and also the bulk consumers of any state/UT who intend to buy 10 MW or more can buy wind power under the scheme.

PTC India Ltd, trading company selected by SECI under the scheme, will sign Power Purchase Agreement (PPA) with wind projects at bidded tariff and back-to-back Power Sale Agreement (PSA) with Buying Entities at a pooled price of the total bids selected. The term of PPA and PSA will be 25 years.

Bidder can bid for a minimum capacity of 50 MW and maximum up to 250 MW. The selected bidder is required to inject wind power at ISTS interconnection point. Bidder is allowed to install 5% of additional rated capacity that will compensate auxiliary consumption and system losses up to interconnection point.

Provision relating to pass through of GST impact, part commissioning, efficiency in generation, performance monitoring have also been stipulated in the guidelines. BI

Transformer

ABB to supply traction transformers for Indian Railways

ABB has won an order from Alstom to supply 1600 traction transformers for 800 new electric freight locomotives in India. The new locomotives will expand Indian Railways' capacity, easing congestion on busy routes for both freight and passenger services.

Traction transformer for Indian locomotive...

Traction transformers feed power at safe voltages to essential train functions like traction, brakes, lighting, heating and ventilation, as well as passenger information, signaling and communication.

Used by rail operators around the globe, ABB traction transformers are manufactured at its plants in Switzerland, India and China, and provide the highest levels of availability and reliability for uninterrupted train service.

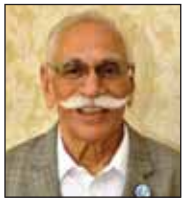
The transformers will be manufactured locally in ABB's Vadodara facility in Gujarat, supporting the government's 'Make in India' initiative to encourage manufacturing in the country. ABB will supply 25 kilovolt (kV)/50 hertz (Hz) underframe traction transformers for the 800 locomotives (2 units per locomotive). The compact transformers are designed for the most demanding conditions, including extreme temperatures and voltage fluctuations. They will support heavy freight loads over long distance haulage under rigorous conditions, including steep inclines.

Sanjeev Sharma, CEO and Managing Director, ABB India, said, "The scale of this order is a recognition of our ability to deliver technologically-advanced reliable products, locally and to cater to evolving customer needs." BI

On-shore WPP

IWTMA welcomes MNRE's on-shore guidelines

The Indian Wind Turbine Manufacturers' Association (IWTMA), an apex body for wind sector has welcome the move to make available financial assistance from the centre – through National Institute of Wind Energy (NIWE) – for analysing the wind power potential and the time series data from all the wind masts installed by the NIWE without charging any cost.



D. V. Giri

This move forms part of the new set of guidelines issued by the Union Ministry of New and Renewable Energy (MNRE) for development of On-shore Wind Power Projects (WPPs) and for facilitating the academia and research institution for the wind industry.

As regards to the type certification and quality assurance, the new guideline states that the type certificate of the wind turbine model should mandatorily include the Hub and the Nacelle assembly/manufacturing facility in India.

The MNRE guideline further states that "no wind turbine model shall be allowed for installation in the country until it has obtained type and quality certification. To facilitate State Nodal Agencies, investors, lenders and developers, the MNRE will bring out the list of type and quality certified wind turbine models eligible for installation in the country. The list will be regularly updated by the MNRE through an on-line automated tracking and approval process." An on-line registry of wind turbines installed in the country will be created by the NIWE and the wind project developer shall upload monthly performance report of the wind turbine on the web-portal created by NIWE.

DV Giri, Secretary General, IWTMA, said, "We at IWTMA strongly take exception to the new move by the MNRE to create an on-line registry and mandating the wind project developers to upload monthly performance report of the wind turbines would certainly reduce the importance of the NIWE." BI

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Finance

Azure Power reveals tie-up of US$ 470 million financing

Azure Power, a well known independent power producer in the solar power sector in India, has tied-up approximately US$ 470 million financing for its projects to be commissioned in 2017. This is one of the largest financing done till date in the Indian solar sector. With this tie-up Azure Power's cumulative financial commitment to the solar sector in India has crossed over US$ 1 billion.


Inderpreet Wadhwa

The company tied-up approximately US$ 161 million as part of its pre-IPO, initial public offering and concurrent private placement recently. Further, the company tied-up approximately US$ 309 million for the project finance of its 450+ MW large-scale utility as well as commercial & industrial solar power projects in the states of Karnataka, Punjab, Andhra Pradesh, Uttar Pradesh and Delhi.

Inderpreet Wadhwa, Founder and Chief Executive Officer, Azure Power, said, "The tie-up of one of the largest financing for pure play solar PV projects is a testament to our track record of strong project development, engineering and execution capabilities. We intend to use the proceeds to grow organically and to continue development of solar power plants in India. We are also delighted to make this contribution towards realisation of our Hon'ble Prime Minister's commitment towards clean and green energy, through solar power generation."

Contextually, the company developed India's first utility scale solar power project in 2009. Since then, they have lowered levelized cost of energy through value engineering, operational research and efficient financial strategy to deliver cost-efficient energy for their customers.

Solar PV Project

Rays Power Infra commissions solar PV project in Telangana

Rays Power Infra, one of India's well known Solar Energy companies, has revealed the commissioning of its latest Solar PV project in the state of Telangana. The 5.75 MW project was undertaken for the company's most prestigious client – Earth Solar.

Execution of the project commenced within seven months of its inception. It was executed by Rays Power Infra on turnkey basis, right from land acquisition till commissioning. Additionally, the extensive project was completed at a remote location with very tough site conditions.


The project is spread across 27 acres of land...

The 5.75 MW project is spread across 27 acres of land in the Medak District of Telangana. It has been commissioned under Government of Telangana's competitive bidding – 2012 process and open offer route 2013.

With this project, the total portfolio of commissioned projects under Rays Power Infra goes up to 320 MW in India, and 76 MW in the state of Telangana. Power generated by the solar plant is utilised to electrify nearby villages by routing it to GSS.

Sanjay Garudapally, Director – Business Development, Rays Power Infra, said, "This project is very special for us as it was the first secondary acquisition for our group. I want to congratulate my highly skilled team of professionals, who played a vital role at every stage of this project's execution and commissioning within the set timeline."

RPIPL is a known solar EPC company in the country. It provides Consulting-Engineering-Contracting-Commissioning services with extensive experience and expertise dedicated only to the development of solar power plants.

Milestone

BHEL forays into two new countries - Togo and Benin

Bharat Heavy Electricals Limited (BHEL) has achieved yet another milestone in expanding and consolidating its footprint in the international market by securing export orders for supply of industrial motors to Togo and Benin.

Scancem International DA, Norway (Heidelberg Cement group) has placed the order for the motors for their cement plants, Ciments Du Togo S.A. & Cimbenin S.A, Benin. The motors will be manufactured and supplied by BHEL's Bhopal unit.

BHEL has been present in the African continent almost since beginning of its export journey that commenced about 45 years back and has references today in almost half of the African continent.

The company has recently built 500 MW Kosti Thermal Power Plant - the largest thermal power plant of Sudan. This plant was inaugurated by His Excellency Omer Hassan Ahmed El-Basheer, President of Sudan in the presence of Atul Sobti, CMD, BHEL and senior officials of the Govt. of Sudan. The project came close on the heels of the successful commissioning of BHEL's 28 MW Nyaborango Hydro project in Rwanda, 2x20 MW Steam Turbine and Generators for cogeneration application at Tendaho Sugar Factory in Ethiopia.

BHEL now has footprints in 80 countries across all the six inhabited continents.

As an integrated power plant equipment manufacturer with over 50 years of experience and having installed over 170 GW globally, BHEL is currently engaged in the execution of all types/range of power equipment; Thermal, Gas, Nuclear, Hydro and Solar, in addition to supplying products and systems to other major infrastructure sectors of the economy like Transmission, Transportation, Oil & Gas, Defence & Aerospace and Water.

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Business

NTPC signs MoU with the administration of Andaman & Nicobar

National Thermal Power Corporation (NTPC) has decided to set up Solar Power projects of 50 MW capacity with Battery Energy Storage System at different locations in Port Blair, Andaman & Nicobar (A&N) Islands – as part of its Green Commitment to Government of India. In this regard, a Memorandum of Understanding (MoU) has already been signed between NTPC, A&N Administration and MNRE in New Delhi.

The MoU was signed by Subhash Muley, ED (Nuclear and RE), NTPC; Sanjeev Khirwar, IAS, Commissioner cum Secretary (Power), A&N; and V.K. Jain, Adviser MNRE in the presence of Upendra Tripathy, IAS, Secretary, MNRE; Gurdeep Singh, CMD NTPC; A.K.Jha, Director(Technical) and senior officials from MNRE and NTPC.

Officials standing after signing the MoU...

The power generated from these solar plants shall contribute towards increased Renewable Energy Deployment and Greening of A&N islands.

The Andaman & Nicobar Islands, located in the east of the Indian mainland geographically, float in splendid isolation in the Bay of Bengal. Once a hill range extending from Myanmar to Indonesia, these picturesque undulating islands, islets numbering around 572, are covered with dense rain-fed, damp and evergreen forests and endless varieties of exotic flora and fauna. Most of these islands (about 550) are in the Andaman Group, 28 of which are inhabited. The smaller Nicobars, comprise some 22 main islands (10 inhabited). The Andaman and Nicobars are separated by the Ten Degree Channel which is 150 Kms. wide. EI

Membership

CERN Council accepts India as an Associate Member

India and European Organization for Nuclear Research (CERN) have signed an agreement, on November 21, 2016, making Indian an Associate Member State of CERN. This follows CERN Council's adaptation of the resolution to this effect on September 15, 2016. The agreement was signed by Dr. Sekhar Basu, Chairman, Atomic Energy Commission and Secretary, Department of Atomic Energy and CERN Director General, Dr. Fabiola Gianotti at its DAE office in Mumbai.

CERN is the world's largest nuclear and particle physics laboratory, where scientists and engineers are probing the fundamental structure of the Universe by using the most sophisticated scientific instruments and advanced computing systems. CERN is based in Geneva on the French-Swiss border. Presently CERN has 22 member states, four associate member states, and the observer status is given to four states and three International Organizations.

Participation in CERN programs is a success story of scientific collaborations and cooperation where researchers from large number of national Institutes and Universities from India work together in forming active collaborations in the pursuit of fundamental knowledge, achieving scientific and engineering breakthrough as well as training the next generation of scientists. In fact, the participation of Indian scientists dates back to early 1960s, which has become much stronger and closer for the last quarter of a century with the support of Department of Atomic Energy (DAE) and Department of Science and Technology (DST). In 1991, DAE had signed a formal agreement with CERN, which continues till today. In recognition of most significant contributions, in 2003, India was awarded the Observer status of CERN, and subsequently invited to join CERN as an Associate Member. Last year, the Indian Cabinet gave its approval following which the CERN Council has accepted India as an Associate member. EI

Finance

World Bank approves additional grant to support GRPV in India

The World Bank Board recently approved an additional grant of $22.93 million to further enhance the installed capacity of Grid-connected Rooftop Solar Photovoltaic (GRPV) Program in India and strengthen the capacity of relevant institutions for widespread installation of GRPV.

The additional Global Environment Facility (GEF) grant will support the overall US$625 million GRPV program approved by the World Bank Board earlier this year, and a total program investment of US$915 million in solar rooftop developments.

It will provide incentives to the State Bank of India (SBI) to lend to riskier categories of GRPV customers such as the Non-Banking Financial Institutions (NBFCs) and Small and Medium Enterprises (SMEs) to finance and install GRPV. It will also strengthen the investment climate for GRPV by building capacity of the main stakeholders involved in the expansion of GRPV.

Under the ongoing program, SBI is on-lending funds to solar PV developers and end-users, who wish to invest in mainly commercial and industrial rooftop PV systems.

Junaid Ahmad, World Bank Country Director in India, said, "The Grid-connected Rooftop Solar program is critical to harnessing India's solar potential. This additional financing will strengthen the capacity of key institutions and help in bringing international best practices to support the program fulfill its aim of developing at least 400 MW of GRPV across India."

The GEF grant includes knowledge support to the Electricity Distribution Companies (Discoms), training for State Nodal Agencies (SNAs), learning and knowledge sharing programs for policy makers and regulators to develop regulatory frameworks, technical training for investment bankers and technical and knowledge capacity building programs for project developers and SMEs – all of which will be guided by the MNRE alongside the World Bank. EI

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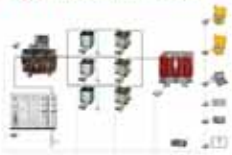

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Penetration

Gamesa to supply 304 MW at five wind farms in India

Gamesa continues to make further inroads into the Indian market, where the company is the number-one OEM, having commanded the leadership spot for three years in a row. Specifically, Gamesa has secured five new orders for the supply of a total of 304 MW to several customers.

The company will supply, install and commission the turbines, as well as handling the operations and maintenance services at all of the facilities. Moreover, at four of the complexes, the company will take charge of construction.

Gamesa's wind farm in India...

In all, Gamesa will supply 80 of its G114-2.0 class S turbines (160 MW) and 72 of its G97-2.0 MW class S (144 MW) turbines, both of which were specifically configured for the Indian market with the aim of maximising turbine performance at low wind speed sites. These projects are slated for commissioning during the first quarter of 2017.

Gamesa has been present in India, where it has installed over 3,000 MW, since 2009. According to MAKE Consultancy, the company is the leading OEM in India, with a market share of 34% in 2015 (up from 25% in 2014), having dominated this market for three years in a row.

With more than 35,800 MW installed, Gamesa has a footprint in 55 countries. Its comprehensive response includes also the wind turbine's operation and maintenance services, that manages for more than 22 GW. The company has production centres in the main wind markets: Spain and China, as the global production and supply hubs, while maintaining its local production capacity in India and Brazil.

Thermal Power

India Power Corporation takes control of 1,000 MW Meenakshi plant

India Power Corporation Limited (India Power), a publicly listed Kanoria Foundation entity, has taken over the control of 1,000 MW thermal power plant of Meenakshi Energy Private Limited (Meenakshi). The Meenakshi plant will enable India Power to add capacity of thermal power generation to its portfolio.

Of the 1,000 MW, 300 MW is already operational and 700 MW is under advance stage of implementation, which will be commissioned by the third quarter of next year.

(L2R): H. Kanoria and R. R. Kanoria

India Power is also setting up a 450 MW (150 MW x 3) power plant in Haldia, West Bengal. The first unit of the Haldia plant will be commissioned by end of December 2016, the second unit by March 2017, and the final unit by next year. The investment is about Rs 3,500 crore, one of the largest in the state in recent years.

Hemant Kanoria, Chairman, India Power, said, "India Power has been able to grow its businesses profitably despite the downward growth trajectory in the energy space over the last few years. With low level of debt and large enterprise value, the company has been able to create value for its shareholders in spite of the adverse power sector environment."

India Power Corporation Ltd. was incorporated in 1919. The company has actively forayed into a diversified portfolio, with renewable and conventional modes of power generation, transmission, distribution & power trading. It currently operates 95.2 MW of wind assets in Rajasthan, Gujarat and Karnataka, and has also developed a 2 MW grid connected solar power plant along with West Bengal Green Energy Development Corporation Ltd. Asansol.

Enrichment

Schneider Electric India boosts its automation business

Schneider Electric, the global automation specialist and a well known company for energy efficiency, is all set to increase its industrial automation footprint in India. Catering to increased demand across various sectors, the company expects to launch as many as 365 products and solutions this year.

The company emerged as a major player in the global process automation market in 2014 following its acquisition of Invensys Plc. It is now eyeing an even bigger market presence in India. Increasing its portfolio of products, solutions and services here, it will further enable itself to address growing regional and country-wide demand in four key sectors – Power, Oil and Gas, Water and Waste Water (WWW) and Mining, Metals and Minerals (MMM).

The company expects to grow its position in the Indian Automation market in the wake of strong demand due to various government initiatives such as 'Make in India' and Smart City Mission that have Automation at their very core. Also, the company feels that Automation would be the key for India to become a global manufacturing hub – as it would need innovation as well as consistency in quality and efficiency while keeping price competitive to compete globally.

Rajat Kishore, MD and VP, Process Automation, Schneider Electric Systems India says, "Automation will be a high growth area in India. Despite the fact that Manufacturing contributes about 17% to India's GDP, there is still significant untapped potential when compared to global benchmarks. The manufacturing industry is undergoing tremendous change due to Urbanization, Industrialization and Digitization megatrends. To add to this, even as energy demands are set to double in the next 40 years, CO_2 emissions will have to be reduced by half to avoid irreversible damage to our planet. So we have to become three times more efficient. Automation will drive this efficiency improvement".

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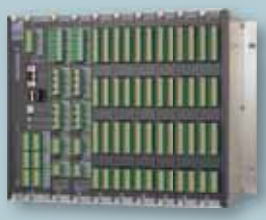

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Storage

Sungrow installs PV & Energy Storage Microgrid plant

Sungrow, a well known PV inverter manufacturer, has proclaimed that the world's largest PV & energy storage microgrid power plant with 13 MW of PV inverters and 7 MW of energy storage inverters, has been successfully installed in Shuanghu, China, the highest region in the world located in China's Tibet province.

The 20 MW microgrid power plant aims to provide electricity to over 14,000 people living in the vicinity, with average elevations reaching heights of over 5,000 metres. With temperatures often dipping below -5^{0}C and the lowest temperatures recorded at -40^{0}C, Shuanghu County's extreme climate has frequently posed challenges to inverters and other solar components, operating in the region's frigid conditions.


World's largest Microgrid...

Sungrow's solar and energy storage inverters, together with its batteries systems, are employed in this project. The company's inverters are designed with standardised container specifications, drastically shortening the time required for installation and commissioning, which in turn reduces overall installed costs. In difficult geographic locations, where labour and other installation-related costs are proportionately higher, these types of cost reductions are even more accentuated. Backed by solar inverter hardware, the company's massive microgrid power plant is also intelligently designed for remote monitoring and makes unattended operation a reality. "We are always dedicated to bringing green and effective energy to markets in need, especially for those who reside in areas with limited access to electricity," said Renxian Cao, President of Sungrow.

IT Partner

MHPS chooses TCS for development of an ICT Platform

Tata Consultancy Services (TCS); a well known IT services, consulting and business solutions organisation; has been chosen by Mitsubishi Hitachi Power Systems (MHPS), a renowned company in the field of thermal power systems, as a collaborating company for the development of an ICT platform for thermal power plants.

MHPS has revealed the establishment of a Global Service Centre (GSC) in the Philippines, designed to cater to thermal power plant operators, primarily in the Southeast Asia region. The GSC will support efforts to optimise plant Operation and Maintenance (O&M), leveraging the latest ICT for services including remote monitoring. Through improvements in plant utilisation and efficiency, MHPS seeks to promote the enhancement of client asset value.

TCS will provide analytics driven by cutting-edge digital technologies including AI, whilst also bringing its global best practices in using Internet of Things (IoT) technologies to the table. Through this, TCS looks to support the development of MHPS' ICT platform, and hopes to contribute to the creation of future business value for MHPS.

Contextually, TCS offers a consulting-led, integrated portfolio of IT, BPS, infrastructure, engineering and assurance services. This is delivered through its Global Network Delivery Model. A part of the Tata group, India's largest industrial conglomerate, TCS has over 371,000 of the world's best-trained consultants in 45 countries. The company generated consolidated revenues of US $16.5 billion for year ended March 31, 2016 and is listed on the BSE Limited and National Stock Exchange of India Limited. The company offers a global engagement model that allows a customer to choose the sourcing strategy best suited to his/her business needs.

Project

OPIC signs a commitment with ReNew Power for solar farm in India

The Overseas Private Investment Corporation (OPIC), the U.S. Government's development finance institution, has signed a commitment with ReNew of approximately $74 million for a 100 MW solar project in the Indian state of Telangana. This project will diversify the country's power generation mix with a clean source of renewable power and help the country reduce GHG emissions.


Elizabeth L. Littlefield

The Telangana solar project is the first project approved under the ReNew Master Financing Facility, a $250 million facility between OPIC and ReNew to be used for the development, construction, and operation of solar energy projects awarded under the Government of India's Jawaharlal Nehru National Solar Mission. Under the ReNew Master Financing Facility, up to 400 MW of new solar renewable power generation will be constructed in India across multiple projects.

Generating electricity from renewable energy can reduce a country's dependence on fossil fuels and offers significant health benefits, in addition to being a sustainable source of energy. As the fourth largest energy consumer in the world, India must overcome a number of challenges to meet its rising energy demand and sustain economic growth. Currently, solar energy accounts for approximately one percent of total energy capacity in India, or 7.5 gigawatts. This project will support the Government of India's goal to have 170 GW of installed renewable capacity by 2022, of which 100 GW are to be solar.

OPIC President and CEO Elizabeth L. Littlefield, said, "In India, outdoor air pollution is an ever growing public health concern. OPIC's partnership with Renew Power Ventures will have a transformative impact by helping India both reduce its emissions and increase energy capacity in the country through a diversified power generation mix."

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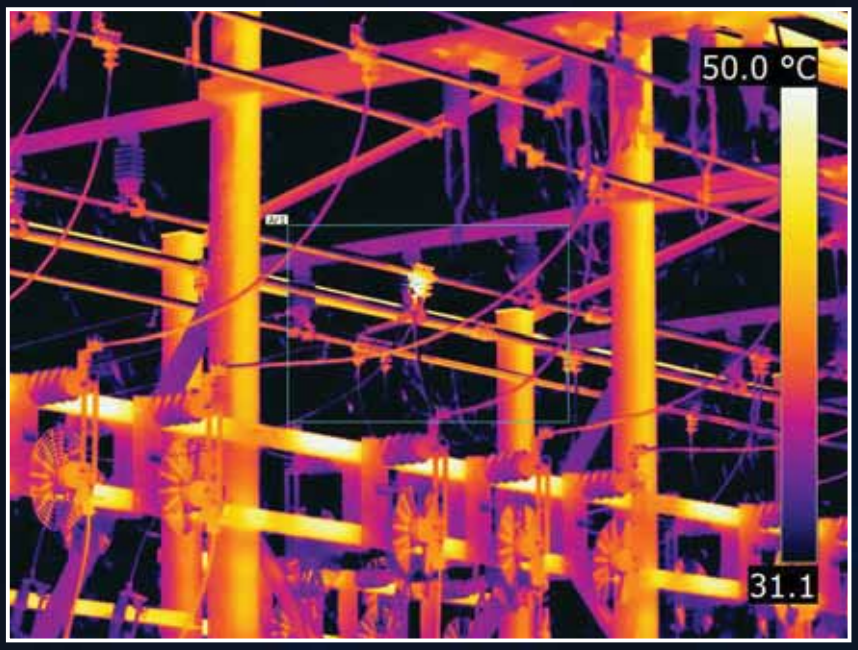

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Nuclear Safety

France's EDF improves operational safety

An International Atomic Energy Agency (IAEA) team of experts has said that France's Électricité de France S.A. (EDF) has improved operational safety by addressing all suggestions made in a 2014 IAEA review – but noted that some further work is needed. The Corporate Operational Safety Review Team (OSART) has concluded a four-day follow-up mission to assess work that EDF has conducted in response to the mission two years ago.

Nuclear safety is of topmost priority...

Corporate OSART missions review a utility's central functions that affect operational safety on all its nuclear power plant sites. This is done by objectively assessing safety performance using the IAEA's Safety Standards and proposing recommendations and suggestions for improvement where appropriate.

Follow-up missions are standard components of the OSART programme and are typically conducted within two years of the initial mission. EDF operates 58 nuclear reactors across France. The four-member team comprised experts from the Czech Republic, Slovakia and the IAEA.

"EDF has undertaken significant work to address the issues identified by the OSART mission in 2014, and we saw good progress to maintain high levels of operational safety at its nuclear fleet," said Team Leader Peter Tarren, Head of the IAEA's Operational Safety Section.

"Though all suggestions we made in 2014 have been addressed, we also noted that more time and work is needed for some suggestions to be fully implemented. We encourage EDF to continue its work to ensure sustainable improvement," he added.

Geothermal Energy

World Bank supports expansion of geothermal energy generation

The World Bank's Board of Directors have approved an IBRD loan of US$250 million and a Clean Technology Fund Grant of US$39.8 million for a Geothermal Development Project in Turkey, which will help create renewable energy by tapping heat sources deep in the ground..

The Geothermal Development Project aims to encourage private sector investment in geothermal energy development in Turkey by reducing risks for investors through a Risk Sharing Mechanism (RSM) and by providing access to long term financing.

Turkish citizens, will benefit from new economic and employment opportunities created by increased geothermal development. The global community will also benefit from the lessons learned through use of the risk sharing facility in designing similar mechanisms to stimulate geothermal exploration in other markets.

Johannes Zutt, World Bank Country Director for Turkey, said that the World Bank was pleased to help the Government of Turkey to expand geothermal capacity in the country.

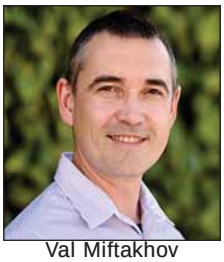
In his words, "Increasing renewable energy generation capacity is critical to achieving energy security and climate change mitigation in Turkey. The renewable energy sector has been growing rapidly in Turkey over the past decades, and geothermal power plants, which use subterranean heat to drive electricity-generating turbines, can provide low-carbon baseload power to drive economic growth and boost prosperity."

The project includes: Establishment of a Risk Sharing Mechanism for Resource Validation, to support the exploration and test drilling stages; and Setting up of a Loan Facility for Resource Development that will support the power plant development phase.

Charging

SCP partners eMotorWerks for its power customers

Recognising the need to support rapidly growing electrical demand for Electric Vehicles (EV), Sonoma Clean Power (SCP) has partnered with award-winning eMotorWerks to provide up to 1,000 free smart charging units to SCP customers while program funds last. eMotorWerks is well known for cloud-connected, EV charging solutions that provide intelligent control that allows customers to automatically take advantage of lower energy pricing.


Val Miftakhov

For utilities, the eMotorWerks technology assists in managing EV demand and integrating more renewable energy into the electrical mix, all while maintaining grid stability. SCP customers may choose free of charge, between eMotorWerks' best-selling JuiceBox Pro charger or a JuicePlug EVSE adapter that converts existing, basic residential charging stations, into smart charging units. Also, participants can receive $250 for joining SCP's smart-grid charging rewards program.

The eMotorWerks technology is focused on internet-enabled Electric Vehicle Supply Equipment (EVSE) products that are remotely connected to JuiceNet, a patented, cloud-based communication, control, and intelligence platform that dynamically matches users' historical charging patterns, real-time input, and signals from grid operators and utilities to increase grid flexibility to meet EV charging demand, as well as maximise the use of renewable power.

Val Miftakhov, Founder & CEO of eMotorWerks, said, "Our leading smart charging technology is the perfect solution for Sonoma Clean Power's needs. By taking into account EV owners' historical charging patterns and charging configurations, that take advantage of lower-cost, off-peak electricity pricing, SCP can meet growing consumer demand for EV charging, while at the same time maintain a reliable and stable grid experience for everyone."

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Research Funding

US DOE to invest $30 million for R&D on Fuel Cell technologies

The Energy Department (DOE) of the United States of America will make approximately $30 million funding, subject to appropriations, for research and development of low-cost hydrogen production, onboard hydrogen storage, and proton exchange membrane fuel cells to advance the widespread commercialisation of fuel cell electric vehicles.

Selected projects will leverage national lab consortia launched under DOE's Energy Materials Network (EMN) this past year, in support of DOE's materials research and advanced manufacturing priorities.

The fuel cells market is growing rapidly, and has seen an annual growth rate of 30% every year since 2010 as well as $2 billion annual revenue in 2014. Light duty vehicles are an emerging application for fuel cells that already enable 95% lower petroleum consumption per mile than conventional internal combustion engine vehicles.

Applicants to this Funding Opportunity Announcement (FOA) will collaborate with national lab consortia launched within the EMN. The EMN consortia have been established to make unique, world-class capabilities at the national laboratories more accessible to industry, facilitating collaborations that will expedite the development and manufacturing of advanced materials for commercial markets.

The FOA topics include: PGM-free Catalyst and Electrode R&D; Advanced Water Splitting Materials; Hydrogen Storage Materials Discovery and Precursor Development for Low-Cost, High-Strength Carbon Fiber for Use in Composite Overwrapped Pressure Vessel Applications. Concept papers are due December 20, 2016 and full applications will be due February 21, 2017. The Department's Office of Energy Efficiency and Renewable Energy accelerates development and deployment for energy efficiency and renewable energy technologies and market-based solutions. EI

Power Plant

Wärtsilä supplies a 57 MW power plant to Sierra Leone

Wärtsilä has been appointed the Engineering, Procurement and Construction (EPC) contractor for a 57 MW Smart Power Generation plant to be supplied to CECA SL Generation Ltd., a Sierra Leone company co-owned by CEC Africa Investments and TCQ Power. The turn-key order includes six Wärtsilä 32 engines running on heavy fuel oil. The plant is expected to be operational within 18 months from the ground-breaking.


Wärtsilä Power Plant in Freetown...

The project will have a significant impact on the development of Sierra Leone's energy infrastructure. Upon completion of this project, the availability of energy in Sierra Leone will increase by 40%. Wärtsilä's scope of supply includes the EPC of the power plant, plus 1.3 km of fuel pipeline from a jetty to the site, and 8 km of overhead power lines.

Electricity access in Sierra Leone is amongst the lowest in the world with less than 15% of the population having access to the grid. The existing installed system capacity serving the capital Freetown totals about 84 MW, predominantly from hydro sources.

During the dry season, when the available hydropower drops to extremely low levels, the reduced availability and subsequently high cost of electricity impose lost economic opportunities for the local population and businesses. The new 57 MW power plant is responding to a critical need for baseload generation capacity.

According to Karim Nasser, CEO at TCQ Power, the new power station will provide reliable and efficient 24hr electricity to the locals, which eventually will facilitate the country's economic growth. EI

Solar Energy

Lightsource to initiate investment in solar energy in India

Lightsource Renewable Energy, a well known solar energy company in the UK and Europe, is spearheading a £2billion investment in solar energy in India. The firm has revealed its plans to design install and manage more than three Gigawatts (GW) of solar photovoltaic (PV) infrastructure in partnership with a number of reputable Indian companies over the next five years.


Nick Boyle

In addition to creating over 300 solar jobs in India, this investment will also create over 300 UK jobs. Many more jobs will also be created in related industries, such as construction and steel fabrication to facilitate the installation of the new sites.

The first partner revealed is SREI Infrastructure Finance Limited, which is renowned for infrastructure financing entity in India specialising in financing, development and advisory functions.

Lightsource's CEO, Nick Boyle, said, "We are delighted to be announcing our investment plans for the solar PV market in India. The Indian Government has ambitious plans for renewable energy and we're very pleased that Lightsource will be contributing significantly to that goal.

"India will be a key market for Lightsource in the future. We are excited to be working with SREI, our first partner. Together we will be contributing towards the Indian Government's and our individual companies' ambitions," he further added.

Currently the leading solar PV energy generator in the UK and Europe, and one of the top ten largest solar PV energy generators globally, Lightsource has deployed more than £1.7 billion of solar assets – and manages an operational portfolio of more than 1GW – enough to power more than 330,000 households each year. EI

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Substation

Sterling and Wilson bags multi-states substation project

Power Grid Corporation of India (PGCIL) has recently awarded Sterling and Wilson – India's well known Turnkey MEP and EPC player, with the project of extension of 400kV and 132kV substations; including transformers and reactors under the North Eastern Region (NER) of India's Strengthening Scheme-IV & VII spread over five states. This project comprises nine locations of North Eastern Region namely Imphal, Silchar, Balipara, Bongaigaon, Misa, Kopili, Nirjuli, Agartala, Mokokchung of five states namely Manipur, Assam, Arunachal Pradesh, Tripura and Nagaland. This scheme will strengthen the capacity of distribution network of North Eastern Region with more reliability.


A Sterling And Wilson's project...

Sterling and Wilson is to supply, install, test and commission the civil work for various 400kV and 132kV substations including transformers and reactors under the North Eastern Region IV and VII at Imphal, Silchar, Balipara, Bongaigaon, Misa and Agartala Sub-Stations. Powergrid also intends to Procure Spare Transformers at Nirjuli, Kopili and Silchar and Spare Reactors at Bongaigaon of North Eastern region. The Sub-stations involve Supply, Installation, Testing and Commissioning of a number of Transformers ranging from 50MVA to 500MVA and Reactors ranging from 31.5MVAR to 125MVAR. The project is valued at Rs. 250 Crore inclusive of all taxes and duties.

The project is expected to be commissioned in next 18 months from the date of award of the project. However, some of the priority sub-stations will be commissioned much ahead of the schedule.

Academic Partnership

ReNew Power partners with IIT Delhi

ReNew Power Ventures, India's well known renewable energy company exchanged a Memorandum of Understanding (MoU) with the Indian Institute of Technology, Delhi (IITD) to set up a research facility on renewable energy. This exchange took place in presence of the President of India at the Rashtrapati Bhavan between Sumant Sinha, Chairman & CEO, ReNew Power and Dr. Bodh Raj Mehta, Director, IIT Delhi (L2R in the Picture). The MoU is aimed at encouraging and nurturing talent in the field of renewable energy at the IIT Delhi campus – thereby encouraging opportunities for academic research to advance India's fast growing renewable energy sector.


Photo taken during MoU exchange...

Under the Memorandum of Understanding, ReNew Power and IITD will establish a Chair in the area of Renewable Energy and Storage with representatives from both the entities. The collaboration will jointly propose research and training programmes for representatives of both ReNew and IIT Delhi to lead or participate in.

Several activities around research and policy advocacy are planned under the initiative wherein the centre will be providing advice papers and status reports for the Government of India and multilateral organisations on renewable energy policy matters as a part of its objective.

Courses for undergraduate, graduate and PHD students from a leading institute such as IITD through ReNew's research centre will not only provide numerous opportunities for prospective renewable energy scholars but also develop a thought process around India's postion as a rising renewable energy nation worldwide.

Project Order

APR Energy bags 50MW power generation project in Benin

APR Energy, a well known fast-track power solutions company, has signed a contract for a 12-month project by the Ministry of Energy, Water and Mines in Benin to provide 50MW of power generation using its fuel-flexible aeroderivative turbines. The turbines will be fuelled by natural gas, with the ability to seamlessly switch to diesel based on cost and availability. The project is expected to come online in December.

John Campion, Chairman and Chief Executive Officer, APR Energy, said, "We are honoured to assist Benin in its effort to become self-reliant when it comes to power generation."


John Campion

"Benin currently imports a significant portion of its electricity from neighbouring Ghana, Ivory Coast and Nigeria, and this project will allow Benin to grow its economy using domestically produced power, Campion informed.

He further stressed on the point that another economic benefit will come from the fact that most of the employees; who will install, operate and maintain their power plant; will be hired and trained from the local workforce.

APR Energy has its name for large-scale, fast-track power solutions, providing customers with rapid access to reliable electricity when and where they need it. As per the company, they combine state-of-the-art, fuel-efficient technology with industry-leading expertise to provide turnkey power plants that are rapidly deployed, customisable and scalable. Serving both utility and industrial segments, APR Energy provides power generation solutions to customers and communities around the world, with an emphasis on Africa, the Americas, Asia-Pacific and the Middle East.

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Tata Power appoints three Independent Directors

Tata Power, the well known integrated power company of India, has recruited three Independent Directors. The appointment of Anjali Bansal, Vibha Padalkar and Sanjay Bhandarkar on the Board of the company shows its intention to attract high quality talent and expertise. The appointments of Independent Directors are in terms of Regulation 30 of the SEBI (Listing Obligations and Disclosure Requirements) Regulations, 2015.

Tata Power together with its subsidiaries and jointly controlled entities presently has an installed gross generation capacity of 9,432 MW and a presence in all the segments of the power sector.

Bansal is a Senior Advisor to TPG Capital (TPG), a leading global private equity fund, based in Mumbai. Vibha Padalkar is Executive Director and Chief Financial Officer at HDFC Standard Life Insurance Company Limited (HDFC Life). While, Sanjay Bhandarkar is the former Managing Director of Rothschild's Investment Banking operations in India.

The appointment of all three Independent Directors was passed at a Board meeting. The company has also declared that none of the above named Independent Directors are related to any of the other Directors of the company.

Central Power Research Institute appoints new Director General

V. S. Nandakumar

He has over 28 years of experience in short circuit testing of HV equipments…

V. S. Nandakumar has been appointed as the Director General of Central Power Research Institute (CPRI) on 23rd September, 2016. Prior to assuming this charge, he worked with Intertek-ASTA, since May 2014, as High Voltage Technical Expert, responsible for providing technical support in HV business across geographies. Prior to joining Intertek, he worked at CPRI as Joint Director of the 2500 MVA High Power laboratory of CPRI in Bangalore, India, till March 2014.

Nandakumar has over 28 years of experience in short circuit testing of HV equipments – such as Power Transformers, Circuit Breakers, GIS etc. While at CPRI, he was a part of the management consultant team of the institute offering consultancy service to the National High Power Test Laboratory, an Online Short Circuit test station being established in India. He is a Member of the BIS Sectional Committee ET-08 on High Voltage Switchgear and Controlgear.

As the representative of CPRI and Intertek, he is a member of the STL Technical Committee and Management Committee since 2006. Nandakumar has also been a representative of both CPRI and Intertek at the Short Circuit Testing Liaison (STL) – and participated in its Technical and Management Committee Meetings.

Gowtama has taken charge as the Chairman & MD of BEL

M. V. Gowtama

He joined BEL at Ghaziabad Unit in January 1983 as a Probationary Engineer...

M V Gowtama has taken charge as the Chairman & Managing Director (MD) of Bharat Electronics Limited (BEL). He joined BEL at Ghaziabad Unit in January 1983 as a Probationary Engineer. He was initially posted to the D&E-Radar Division, where he contributed to the development of Receiver sub-system of Cyclone Warning Radar. In about three-and-half years, his team was able to design, develop, manufacture, deliver and commission the first Cyclone Warning Radar at Paradip in Orissa.

Gowtama was transferred to Hyderabad Unit in May 1986. At Hyderabad Unit, he worked in the D&E, Testing, System Integration, Installation & Commissioning groups of Ajanta project till 1998. He completed MTech in Advanced Electronics from Jawaharlal Nehru Technological University, Hyderabad, even while in service.

From 1998 to 2006, he worked on the Sangraha programme of Indian Navy. With ToT from DLRL, his team developed different ESM systems for submarines, helicopters, medium and long-range aircraft. However, a new D&E division was established in 2006 to address future businesses in line with the new defence procurement policy and Gowtama had the opportunity to lead this D&E group as AGM.

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SIFL appoints Sameer Sawhney as CEO

Sameer Sawhney

He is a veteran in the banking industry with over two decades of experience...

Srei Infrastructure Finance Limited (SIFL), a Kanoria Foundation entity, has appointed Sameer Sawhney as Chief Executive Officer (CEO). Sameer is a veteran in the banking industry with over two decades of experience and expertise in building businesses.

He has held senior leadership roles in global banks across Corporate and Investment Banking, Transaction Banking, Global Markets and Private Banking businesses. Having worked in several countries across Asia, Australia, Middle East, Europe and America, Sameer has a deep understanding of both emerging and developed markets. Prior to this appointment, he was the Regional CEO, Managing Director – South East Asia and India, ANZ Bank driving the business, customer and country strategy across the bank's key markets.

Hemant Kanoria, CMD, SIFL, said, "We have reinvigorated our businesses, strengthening our team, and growing profitably despite adverse market conditions. Sameer's appointment as CEO adds to our strength and will bring dynamism in our business. He has a proven track record and experience in managing a wide variety of roles. His knowledge of lending products, capital markets and risk management will help us capitalise on new opportunities."

ABB names Timo Ihamuotila as new CFO

Timo Ihamuotila

He brings with him 26 years of experience in the communications and banking...

According to ABB sources, Timo Ihamuotila has been named Chief Financial Officer (CFO) and Member of the Executive Committee, which will be effective from April 1, 2017. He succeeds current CFO Eric Elzvik in an orderly transition process.

He is joining ABB from Nokia, where he has held the position of CFO since 2009. In this role, he was key in helping in turning around and reposition Nokia as a "global leader in the technologies that connect people and things" through business model changes, active portfolio management and operational improvement.

Ihamuotila brings with him 26 years of experience in the communications and banking sector – and has deep experience in areas as finance, controlling, mergers and acquisitions, commercial and general management.

Prior to taking his current role, he held positions at the Finnish communications technology firm that included Executive Vice President of sales, General Manager of a business unit and Group treasurer. Earlier in his career, he held positions at Citibank and Kansallis Bank. He earned a Master of Science degree in economics and a post graduate degree in finance from the Helsinki School of Economics.

Terrence Curtin succeeds Tom Lynchas of TE Connectivity

Terrence Curtin

He was appointed President of TE Connectivity in March 2015 later elected to the B of D ...

TE Connectivity (TE) has appointed Terrence Curtin to succeed Tom Lynchas as the company's Chief Executive Officer (CEO), effective from March 9, 2017. Curtin was previously elected to TE's Board of Directors at the company's annual general meeting held on March 2, 2016 –and is currently TE's President.

He was appointed President of TE Connectivity in March 2015 and elected to the Board of Directors in March 2016. In his role as President, he has responsibility for all of the company's connectivity and sensor businesses, as well as M&A activities. Prior to his current role, he served as President of TE's Industrial Solutions segment. Before that, from 2006 to 2012, he served as Executive Vice President and Chief Financial Officer of TE – and led the financial aspects of the company's separation from Tyco International.

Prior to TE, Curtin was the Vice President and Controller of the Electronics segment of Tyco International from 2001 to 2006. He holds a Bachelor's of Science degree in Accounting from Albright College and is a member of its Board of Trustees.

Lynch will serve as the company's CEO until the transition to Curtin on March 9, 2017. Upon transition, he will continue as Executive Chairman of the Board.

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Wolfspeed Wins 2016 R&D 100 Award

Wolfspeed, a Cree company and a well known supplier of Silicon Carbide (SiC) power products – including best-in-class SiC MOSFETs, Schottky diodes, and modules – has won a 2016 R&D 100 Award for its high temperature, Wide Bandgap (WBG) underhood inverter for electric vehicles.

The company's high-temperature, WBG underhood inverter was developed in response to the need for smaller, lighter, and more efficient systems with higher power density in the electric vehicle market.

L2R: Ty McNutt and Kraig Olejniczak of Wolfspeed, Sreekant Narumanchi and Kevin Bennion of NREL and Eric Dede of Toyota

The core of Wolfspeed's WBG underhood inverter consists of three commercial Wolfspeed CAS325M12HM2SiC half-bridge power modules, which are rated for 1200V and 325A of continuous RMS current at high temperatures.

Presented by the R&D 100 Awards Committee and R&D Magazine, the 54th annual R&D 100 Awards honoured the 100 most innovative technologies and services of the past year. Selected by an independent panel of more than 50 judges, the award winners were recognised for their contributions to advancing science and technology across five primary categories: analytical/test, IT/electrical, mechanical devices/materials, processes/prototyping, and software/services, and four special recognition categories: market disrupter services, market disruptor products, corporate social responsibility, and green technology.

Dr. Jef Beerten Bags The First ABB Research Award

Dr. Jef Beerten of the University of Leuven (KU Leuven) and EnergyVille, postdoctoral fellow of Research Foundation – Flanders (FWO), Belgium, has been the first recipient of the ABB Research Award in Honour of Hubertus von Gruenberg. He has been recognised for his doctoral thesis, "Modeling and Control of DC Grids." Dedicated in honour of former ABB Chairman Dr. Hubertus von Gruenberg, the award recognises outstanding academic work in energy and automation and is accompanied by one of the highest research grants of its kind. It will be given every three years.

A view of the award ceremony...

Jef Beerten's dissertation offers new insights into phenomena governing the stability of High-Voltage Direct Current (HVDC) grids interacting with existing HVAC grids. Point-to-point HVDC connections are already employed and offer a more efficient and cost-effective method for bulk long-distance power transmission. Meshed HVDC grids interacting with existing AC infrastructure offer a solution of efficiently and cost-effectively routing renewable energy to where it will be ultimately consumed. Current tools for studying large-scale power systems are however typically designed for understanding the behaviour specific to AC grids. He has devised new tools, models, and methods for designing and controlling meshed HVDC grids, which use fast-switching power electronic converters for AC-DC conversion in order to improve the understanding of how today's HVAC grids will interact with future HVDC grids.

Su-Kam Power Systems Bags Two Awards

Su-Kam Power Systems, a well known player in the power back-up industry in India, showcased a wide portfolio of solar products suitable for the residential home systems, architects, interior designers, town planners, engineers, builders, contractors etc. at the 25th edition of 'Intersolar Expo' 2016, India's Largest Exhibition and Conference for the Solar Industry, organised by MMI India Pvt. Ltd, one of the leading organisers of trade fairs in India.

L2R: Pawan Agrahari, Regional Manager, Maharashtra and R Sivarajan, CTO of Su-Kam Power systems with others...

The company also bagged two prestigious awards in Roof Top Solar-EPC category and Best Innovation Brand in the Renewable Energy Sector, presented by Solar Today magazine – one of the media partners of Intersolar Expo. Su-Kam has received the coveted awards for the company's continuous quest to offer hi-tech innovative solar power back-up solutions to individuals and organisations across the globe.

A knowledge-driven company, Su-Kam has presence in more than 70 countries worldwide covering the major expanse of Africa, Middle East Regions, South East Asia, Latin America etc.

With innovation at heart, Su-Kam develops intelligent power back-up solutions, engineered to be energy efficient, and thus reduce the users' carbon footprint. The company has a number of patents in its credit.

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NTPC Wins At Dun & Bradstreet Infra Awards 2016

India's largest energy conglomerate, NTPC planted its roots way back in 1975 to accelerate power development in the country. Since then it has established itself as the dominant power major with presence in the entire value chain of the power generation business.

It became a Maharatna company in May 2010, one of the only four companies to be awarded this status. It was ranked 400th in the '2016, Forbes Global 2000' ranking of the World's biggest companies.

NTPC is receiving award...

Recently, NTPC has been awarded as Leading Infra Company in the Power Sector at Dun & Bradstreet Infra Awards 2016 for Excellent Financial & Operational Performance in Power Generation Category.

The award was presented by Mansukh L Mandaviya, Minister of State for Road Transport & Highways, Shipping and Chemicals & Fertilizers, Government of India (GoI). The award was received by K. Biswal, Director (Finance) and A. K. Rastogi, Company Secretary on behalf of NTPC.

As India's largest power utility, NTPC has an installed capacity of 47,228 MW, and it holds plans to become a 128,000 MW company by 2032. It is committed to generate and provide reliable power at competitive prices in a sustainable manner by optimising the use of multiple energy resource with innovative eco-friendly technologies – thereby contributing to the economic development of the nation, social upliftment of the society and promoting a healthy environment.

IREDA Earns Recognition For Its Corporate Governance

Indian Renewable Energy Development Agency Limited (IREDA), a Miniratna PSU, under the Ministry of New and Renewable Energy (MNRE) was awarded "Golden Peacock Award" for "Excellence in Corporate Governance" for the year 2016 by the awards Jury under the Chairmanship of Justice M.N. Venkatachaliah, former Chief Justice of Supreme Court of India.

The award was presented by Baroness Sandip Verma, Global Chairperson, Advisory Council, Institute Of Directors, India and Chairperson, European External Affairs Committee to P. Sreenivasan, General Manager (HR) IREDA at a glittering function in London. In the award function, Vijay Karia, Chairman & Managing Director, Ravin Group of Companies, India; Stephen Haddrill, Chief Executive, Financial Reporting Council, UK; and Lt. Gen. J. S. Ahluwalia, PVSM (Retd.) were also present.

A view of the award ceremony...

The award function was felicitating the organisation, which has undertaken significant initiatives to improve its governance and sustainability practices and created new benchmarks. Further, the organisation that has gone beyond the statuary, ethical and sustainable compliance requirements and achieved high standards of corporate excellence. IREDA is a Public Limited Government Company established as a Non-Banking Financial Institution in 1987.

BHEL Adds More Feathers To Its Cap

Bharat Heavy Electricals Limited (BHEL), an integrated power plant equipment manufacturer and one of the largest engineering and manufacturing company of its kind in India, is engaged in the design, engineering, manufacture, construction, testing, commissioning and servicing of a wide range of products and services for core sectors of the economy. Its growth has been synchronous with achieving self-sufficiency in the indigenous manufacturing of heavy electrical equipment.

Atul Sobti is receiving the award...

It has won five 'National Safety Awards' for outstanding achievements in terms of the longest accident free period and lowest accident frequency rate at their works.

The awards were received by Atul Sobti, CMD, BHEL from Bandaru Dattatreya, Minister of State (Independent Charge) for Labour & Employment.

The greatest strength of the company has always been its highly skilled and committed workforce that has always ensured success. Consequently, 36 employees of BHEL bagged eight 'Vishwakarma Rashtriya Puraskars' for the year 2014, among a host of public and private sector companies in the country.

Significantly, BHEL and its employees have been winning both these prestigious national awards, instituted by the Government of India, Ministry of Labour, consistently, since their inception.

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How & Where Are We Going?

P K Chatterjee
Editor

Our government has formulated an Integrated Energy Policy (IEP) document that gives a roadmap to develop energy supply options and increased exploitation of renewable energy sources. This article tries to explore how far our power industry is aligned to the global trend…

Although a few decades back depletion of the fossil fuels was the prime issue drawing the topmost attention of the global science and technology community, and there were isolated efforts to search and/or develop alternative energy sources for generation of electricity, practically since December 1997, i.e., after the Kyoto Protocol, the paradigm started leaning in favour of Renewable Energy (RE). Today, all the nations in the world are targeting to exponentially enrich their RE-based power production capacity. However, we are still decades away to witness a completely RE-dominated energy-world. The recent report titled, "World Energy Outlook 2016 (WEO 2016)," by the International Energy Agency (IEA) echoes the same status quo.

The transformation

The flagship publication of IEA states, "As a result of major transformations in the global energy system that take place over the next decades, renewables and natural gas are the big winners in the race to meet energy demand growth until 2040."

Dr Fatih Birol

A detailed analysis of the pledges made for the Paris Agreement on climate change shows that the era of fossil fuels appears far from over and underscores the challenge of reaching more ambitious climate goals. Still, government policies, as well as cost reductions across the energy sector, enable a doubling of both renewables – and of improvements in energy efficiency over the next 25 years. Natural gas

continues to expand its role while the shares of coal and oil fall back.

"We see clear winners for the next 25 years – natural gas but especially wind and solar – replacing the champion of the previous 25 years, coal. But there is no single story about the future of global energy: in practice, government policies will determine where we go from here," says Dr Fatih Birol, the IEA's Executive Director.

Thus, from Dr Birol's comment, three trends are prominent: first of all to curb global carbon footprint, coal will be replaced by natural gas as far as and as soon as possible. Secondly, wind and solar technologies will witness further boost. And thirdly or most importantly, although the direction of the journey is fixed towards RE-based society, the pace of the journey will be determined by the policies set by respective government of each country.

Indian initiative to boost the O&G sector

Throwing more light on TRANSFORMATION, a communiqué from IEA states that this transformation of the global energy mix described in WEO-2016 means that risks to energy security also evolve. Traditional concerns related to Oil and Gas (O&G) supply remain – and are reinforced by record falls in investment levels. The report shows that another year of lower upstream oil investment in 2017 would create a significant risk of a shortfall in new conventional supply within a few years.

Under such circumstances, when the investment in the O&G sector is inadequate, and emerging compliance rules are imposing several restrictions on use of coal, any wise nation will try to be more reliant on RE-sources, especially, when it is abound in any of the RE resources. That way India has a great potential for harnessing solar energy and wind energy (including off-shore wind energy). And, our government's pre-conceived target of 175 GW of renewable energy capacity by 2022 is a very timely and practical one.

Also, our government is trying to attract investment in the O&G sector. The recent call of our Minister of State (I/C) for Petroleum & Natural Gas Dharmendra Pradhan inviting the foreign investors to participate in the Discovered Small Fields Bidding Round – 2016 indicates our effort to enrich the sector.

Dharmendra Pradhan

According to Pradhan, "The government is following principles of Enhancing production; Attracting investment and technology; Generating employment; Transparency; and Minimising administrative discretion. Oil and gas sector has also been identified as the major national initiative under 'Make in India' policy reform. Hydrocarbon Exploration and Licensing Policy has been launched to make future exploration bidding rounds more attractive for investors."

Indian emphasis on harnessing RE resources

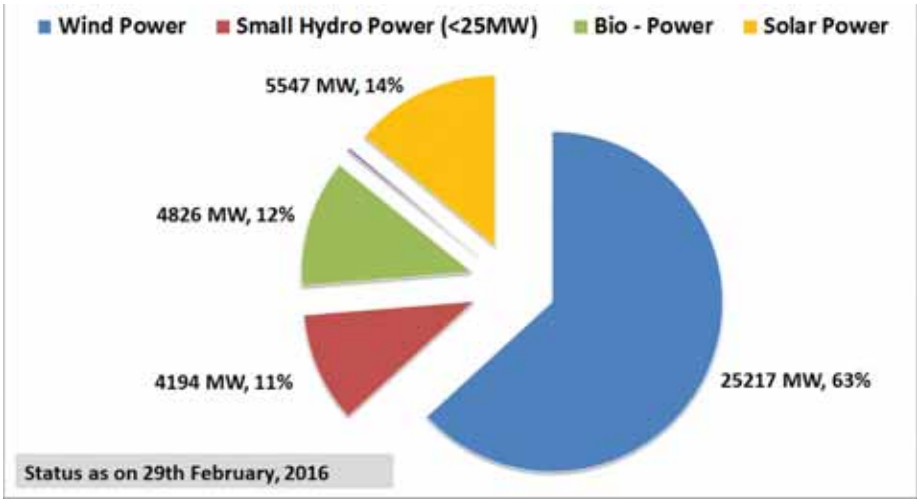
According to Piyush Goyal, Minister of State (IC) for Power, Coal, New & Renewable Energy and Mines, "Three Phases of auction of e-bid Re-gasified Liquefied Natural Gas (RLNG) have been completed so far and 4th Phase is presently under operation from 1st October, 2016 to 31st March, 2017. Under the 4th Phase, Power System Development Fund (PSDF) support ranging from Rs 0.21 per unit to Rs 0.22 per unit has been secured by the successful bidders in the reverse auction."

WEO 2016 states, "In the longer-term, investment in oil and gas remain essential to meet demand and replace declining production, but the growth in renewables and energy efficiency lessens the call on oil and gas imports in many countries. Increased LNG shipments also change how gas security is perceived. At the same time, the variable nature of renewables in power generation, especially wind and solar, entails a new focus on electricity security."

As per Goyal, our government has formulated an Integrated Energy Policy (IEP) document that gives a roadmap to develop energy supply options and increased exploitation of renewable energy sources. In addition, for promotion of Renewable Energy (RE), government has amended the National Tariff Policy for electricity in January 2016. By this amendment several provisions for promotion of RE have been made.

While explaining the plan to achieve 100 GW of solar energy by 2022 through installation of projects, Goyal has detailed the schemes that

Breakup of All India Renewable Energy Installed Capacity

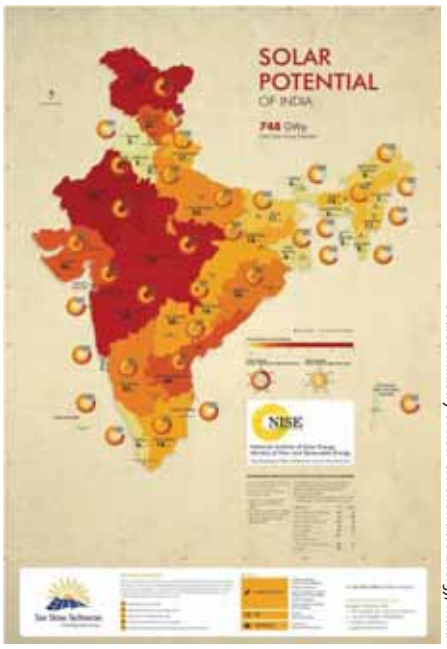


Source: Ministry of Power, Govt. of India

have been launched by the Ministry of New and Renewable Energy (MNRE).

They include: Scheme for Development of Solar Parks and Ultra Mega Solar Power Projects; Scheme for Development of Solar PV Power Plants on Canal Banks/ Canal Tops; Scheme for setting up of 300 MW of Grid connected Solar PV Power Projects by Defence Establishments under Ministry of Defence and Para Military forces with Viability Gap Funding (VGF) under Batch-IV of Phase-II/III of National Solar Mission; Implementation of scheme for setting up of 1,000 MW of Grid- Connected Solar PV Power Projects by CPSUs with VGF under Batch-V of Phase-II of JNNSM; Implementation of Scheme for Setting up of 15000 MW of Grid connected Solar PV Power Projects under Batch II of Phase II of National Solar Mission (by NTPC/NVVN); Setting up of 2000 MW Grid connected solar power with VGF through Solar Energy Corporation of India (SECI); Development of Solar Cities Programme and Scheme for Development of Solar Zones in the country.

Wind and Solar Energy Potential in India (Source: MNRE)



Source: Ministry of New & Renewable Energy, India

It is not only the solar projects, MNRE has also made an ambitious plan for wind power generation. The ministry had sanctioned a scheme for setting up of 1,000 MW Inter State Transmission System (ISTS) connected Wind Power Projects on 14th June 2016. The scheme provided for formulation of Guidelines by MNRE for implementation of the scheme. Accordingly, MNRE has issued the required Guidelines on 22nd October 2016.

As per the guidelines that will be implemented by Solar Energy Corporation of India (SECI): Wind projects will be selected through open and transparent competitive bidding process followed by e-reverse auction; Eligible project capacity will be minimum 50 MW and maximum 250 MW per bidder; Trading Company, selected by SECI, will sign Power Purchase Agreement (PPA) with selected bidder and back-to-back Power Sale Agreement (PSA) with buying entities at a pooled price of the total bids selected.

The duration of PPA and PSA will be 25 years from commencement of the commercial operation date of the project. The transmission of power up

Piyush Goyal

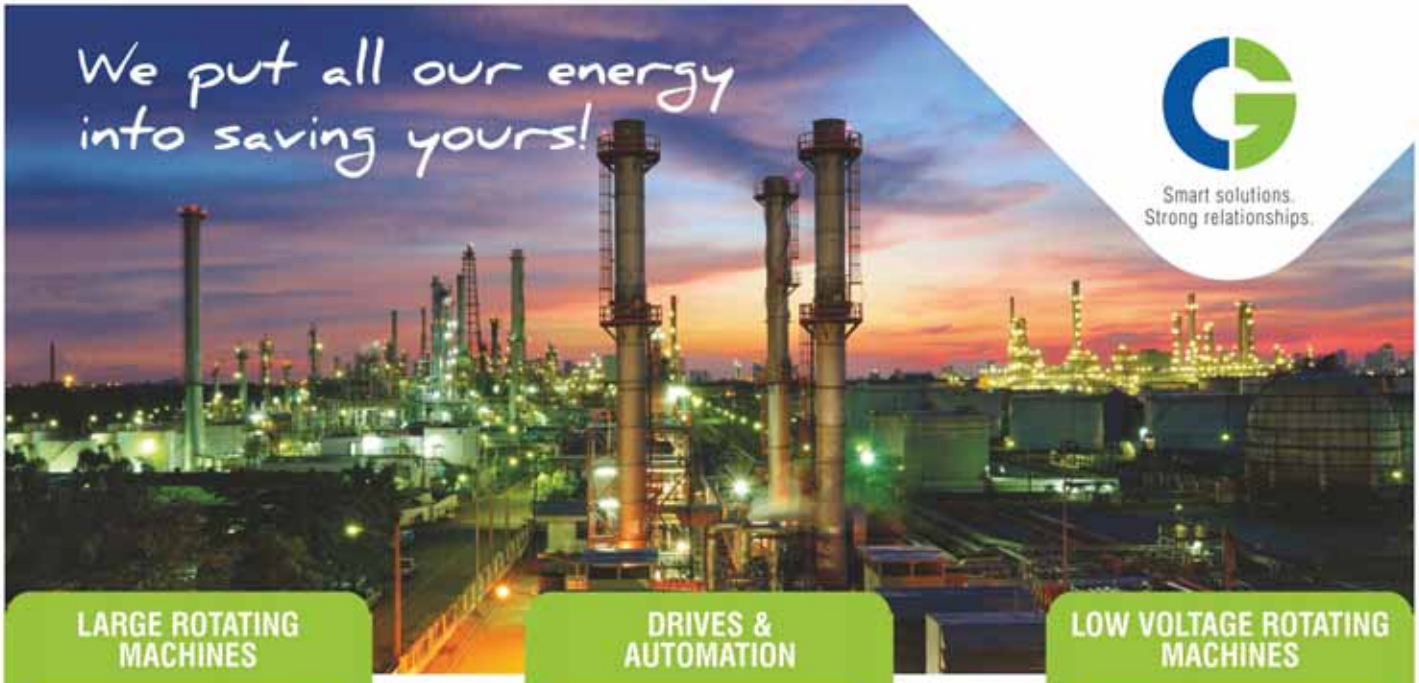
to the point of interconnection where the metering is done for energy accounting shall be the responsibility of the bidder. Use of state transmission system to bring wind power at ISTS point is also allowed; Part commissioning allowed subject to commissioning of at least 50 MW or 50% of the allocated Project Capacity, whichever is higher; Project to be completed within 18 months from issue of Letter of Award. Maximum period of 27 months allowed for completion of project with penalties; Minimum declared Capacity Utilisation Factor to be 20%. Provision of compensation in case of shortfall in minimum generation; and wind projects will have to submit monthly performance data through online.

Achievement in the recent past

So far we have seen the potentials, trends and future plans, let us now have a look at the achievements in the last two and a half years – in other words during the regime of the BJP government. Recently to answer questions in Rajya Sabha, our Power Minister Goyal has given the following details, which have been accepted undisputedly.

He has stated, "A capacity addition of 14.30 GW of renewable energy has been reported during the last two and a half years under Grid Connected Renewable Power, which include 5.8 GW from Solar Power, 7.04 GW from Wind Power, 0.53 from Small Hydro Power and 0.93 from Bio-power."

NITI Aayog (NITI: National Institution for Transforming India) has presented the achievement of the various infrastructure ministries including MNRE before the Prime Minister on 22nd August 2016. The progress and



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As on 30.09.2016

(All figures in circuit kms.)

Programme / Achievement		HVDC						765 kV				400 kV						220 kV						Total Central, State & JV/ Private Sector					
		± 800 kV			± 500 kV							Central Sector			State/ Private Sector			Central Sector			State/ Private Sector			Central Sector			State/ Private Sector		
		Central Sector	State Sector	Total	Central Sector	JV/Private Sector	Total	Central Sector	State Sector	JV/Private Sector	Total	PGCIL	DVC	Total CS	State Sector	JV/Private Sector	Total	PGCIL	DVC	Total CS	State Sector	JV/Private Sector	Total	PGCIL	DVC	Total CS	State Sector	JV/Private Sector	Grand Total
Programme 2016-17		2597	0	2597	0	0	0	3123	750	1313	5186	3642	311	3953	5799	762	10514	78	0	78	5009	0	5087	9440	311	9751	11558	2075	23384
Sept, 2016	Programme	24	0	24	0	0	0	0	0	0	0	13	0	13	114	576	703	0	0	0	587	0	587	37	0	37	701	576	1314
	Achievement	2574	0	2574	0	0	0	945	337	758	2040	581	0	581	457	0	1038	0	0	0	248	0	248	4100	0	4100	1042	758	5900
Upto Sept, 2016	Programme	2597	0	2597	0	0	0	3123	750	1133	5006	1993	0	1993	3090	942	6025	0	0	0	2597	0	2597	7713	0	7713	6437	2075	16225
	Achievement	2574	0	2574	0	0	0	2336	337	950	3623	2262	0	2262	1754	1362	5378	28	0	28	3538	0	3566	7200	0	7200	5629	2312	15141

Source: Central Electrical Authority, India

Target Set for Next 3 Years for Various Sources of REs

Source	2016-17	2017-18	2018-19
Solar Power	12,000	15,000	16,000
Wind	4000	4600	5200
Biomass	500	750	850
SHP	225	100	100
Grand Total	16725	20450	22150

Source: Press Information Bureau, India

overall achievement made under Wind Power, Solar Power, Solar Roof Top, Solar power capacity tendered, state policies etc., were satisfactory.

Conclusion

According to Bloomberg New Energy Finance's annual long-term view [New Energy Outlook (NEO)], "Cheaper coal and cheaper gas will not derail the transformation and decarbonisation of the world's power systems. By 2040, zero-emission energy sources will make up 60% of installed capacity. Wind and solar will account for 64% of the 8.6TW of new power generating capacity added worldwide over the next 25 years, and for almost 60% of the $11.4 trillion invested."

Today, India's 307.28 GW of installed electricity generating capacity is significantly higher than around 160 GW of peak load demand. In fact, India's coal generation capacity alone is higher than its peak demand. However, there are some challenges, like coal supply shortages, high level of Transmission and Distribution (T&D) losses, delayed evacuation due to lack of T&D infrastructure, challenges arising out of RE integration, and poor financial health of utilities, that are still keeping parts of the sub-continent dark (under load shedding).

An alternative to load shedding is on-site generation of electricity to supplement the power grid. Our government has approved stepping up of India's solar power capacity target under the Jawaharlal Nehru National Solar Mission (JNNSM) by five times, reaching 100,000 MW by 2022.

It is commercial losses that play a major role in the sector – and need to be eliminated. Government is working on that through encouraging decentralised power generation, wherever necessary and feasible.

The present BJP government has taken up several measures to reduce energy consumption in the country. One of the widespread and effective steps is distribution of LED lamps at reasonable price under different schemes through DISCOMs.

The state-owned Energy Efficiency Services Ltd (EESL) that distributed around 6 lakh LED bulbs a year is today giving close to 8 lakh bulbs a day. 'Affordable LEDs for All' programme, being led by EESL, involves replacement of incandescent lamps/CFL bulbs with LED bulbs to save energy and reduce the bills of customers.

Lots of reformative steps are being taken in the Indian power sector, it's not possible to include everything within the small span of this article.

However, I hope, from the information presented so far, it is evident that our present Indian government too is driving the power reform's vehicle in the direction of the latest, best global practices, maintaining a good balance between renewables and fossil fuel developments, which is unavoidable in the near future.

Also, our government is focused on reducing the total energy consumption in the country.

The Indian government is committed to provide affordable, 24x7 powers to all households by 2019. Its effort has convinced around 293 global and domestic companies to invest to 266 GW of solar, wind, mini-hydel and biomass-based power projects in the country.

We may see about US$ 310 to 350 billion worth investment in the RE sector of India in the next 5 to 10 years.

However, as government is nothing but a group of selected people (representatives) – of the people, for the people and by the people; the citizens of India have a major role to play to translate its (government's) goal (or target) into reality.

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ISA s.r.l. is a reputed manufacturer of high quality electrical test and measurement equipment since 1938. With a state-of-the-art manufacturing facility at Taino, Italy; the company's operations are spread over more than 100 countries, either through resource centers or through fully trained sales representatives. Innovative products with rugged hardware and user-friendly software are the hallmark of brand ISA. Every product at ISA is developed, designed and manufactured in compliance with international standards and is tested thoroughly to be used in severe working environments like HV / EHV substations and heavy industrial plants.

ISA's customer base includes:

- **Power utilities**
- **Equipment manufacturers**
- **Oil & Gas sector**
- **EPC contractors and electrical consultants**
- **Testing service companies**
- **Renewable energy producers**

Our Product Portfolio

- **Multi-functional Test Kit for Power Transformer, Instrument Transformer etc. (STS Family)**
- **Automatic Three Phase Relay Test Kit (DRTS Family)**
- **Single Phase Secondary Injection Kit (T 1000 Plus / TD 1000 Plus)**
- **Circuit Breaker Analyzer (CBA 1000 / CBA 2000 / CBA 3000)**
- **Primary Current Injection Kit (T 2000 / T 3000 / eKAM / KAM)**
- **Automatic Tan Delta Test Kit (TDX 5000 / STS 3000 + TD 5000)**
- **Metal Oxide Surge Arrestor Test Kit (SCAR 10)**
- **Battery Test Set (BTS 200 MKII/ELU 200 MKII)**
- **Online Diagnostics & Measurement System**

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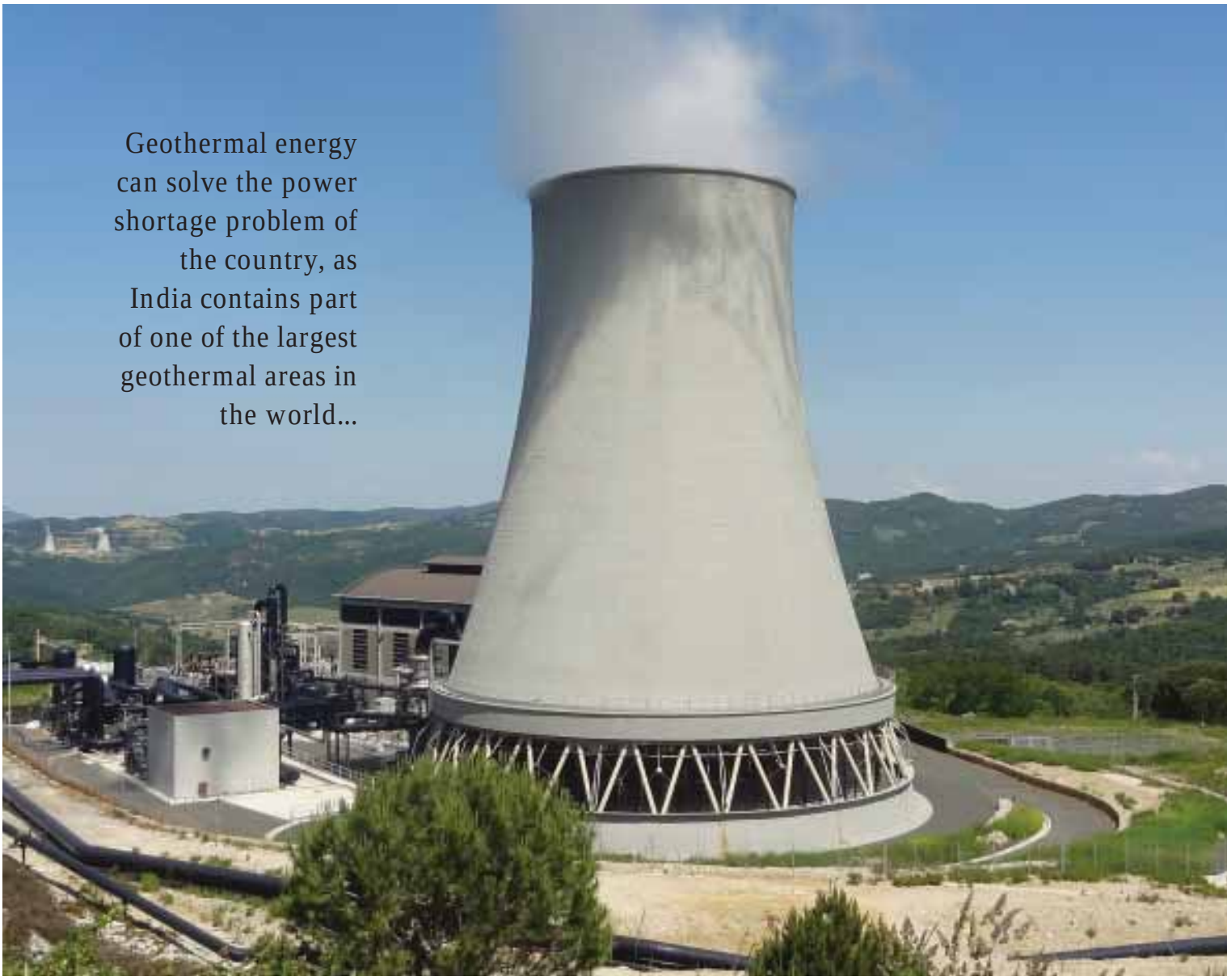
Power Generation

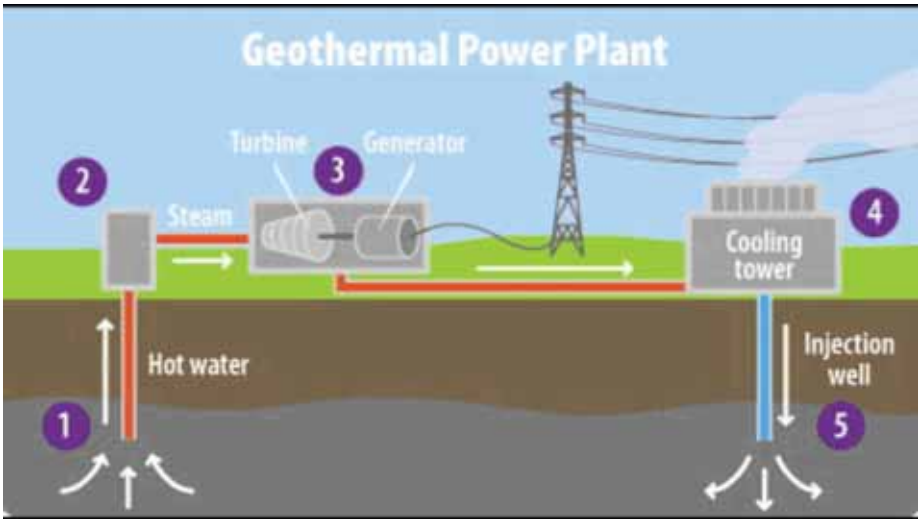
Basant Kumar
DGM (Electrical)
Oil & Natural Gas Corporation Ltd, Mumbai

About 71% of the total installed capacity of the country is based on thermal power generation by burning fossil fuels-coal, oil & natural gas. However, these fossil fuels have got limited stock and are going to last up to a certain time. Moreover, these are not environmental friendly and dependence on them specially oil makes country economy susceptible to foreign countries polices and pressure.

The source of geothermal energy is very vast and almost infinite as the heat stored below the surface of the earth. A geothermal source may

Geothermal energy can solve the power shortage problem of the country, as India contains part of one of the largest geothermal areas in the world...





contain steam, water, a steam/water mixture or just hot dry rock.

The economic viability of hydrothermal (hot water or steam) system for electrical power generation is guided by temperature of the reservoir. When hot water resources are used through a 'binary' process to generate electric power, the heat from hot water is allowed to vaporize a heating fluid. This heat transfer fluid in a closed system is used to turn a turbine which runs a generator.

Geothermal energy can solve the power shortage problem of the country as India contains part of one of the largest geothermal areas in the world.

Power Scenario Of India

The latest power generation scenario of the country is :

Thermal	1,70,137.88 MW	60.69 %
Hydel	42,473 MW	15.15%
Nuclear	5780 MW	2.06%
Gas	24,473 MW	8.73%
Diesel	993.53 MW	0.35%
RES (Renewable Energy Source)	36,470.64 MW	13.00%
Total installed capacity	280,328.5 MW	

As per Central Electricity Authority (CEA), the peak demand estimated for the September 2015 was 3.20 % less to generation. This indicates the acute power generation scenario of the country.

Different Source Of Power Generation

As seen from above, burning fossil fuels-coal, oil & natural gas generates 60.69% of electrical power. Coal, oil & natural gas have got their limited stock and are going to last up to a certain period. To enhance their known reserves and to increase exploitation more complicated technology is needed to be applied. The import of fossil fuel, mainly oil & coal, makes India more prone to outside pressure and our economy becomes dependent on other countries policies. Moreover, these fossil fuels are not

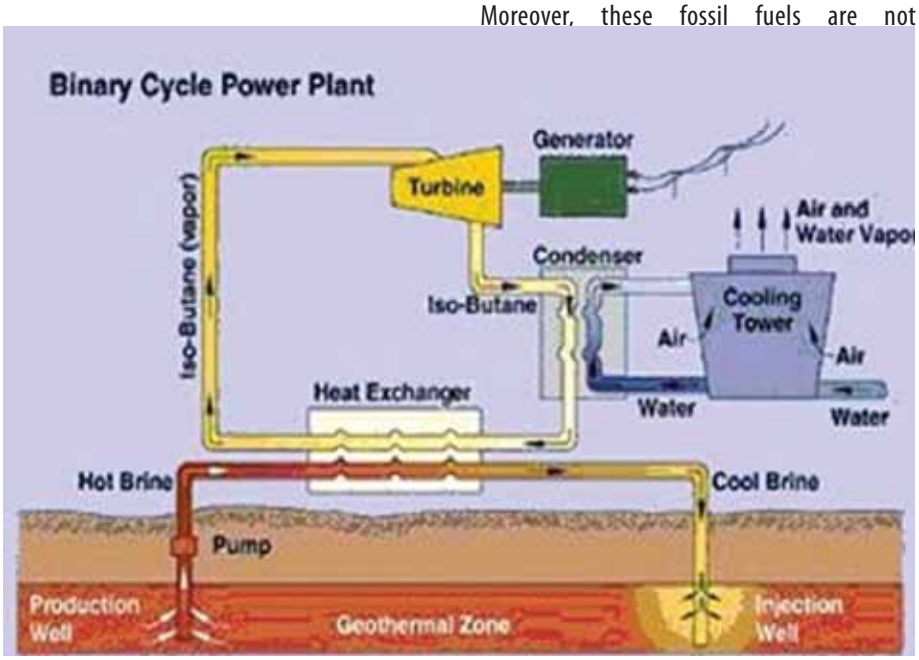


Figure 1: Binary cycle geothermal power plant...

Figure 2: Showing approximate location of geothermal springs...

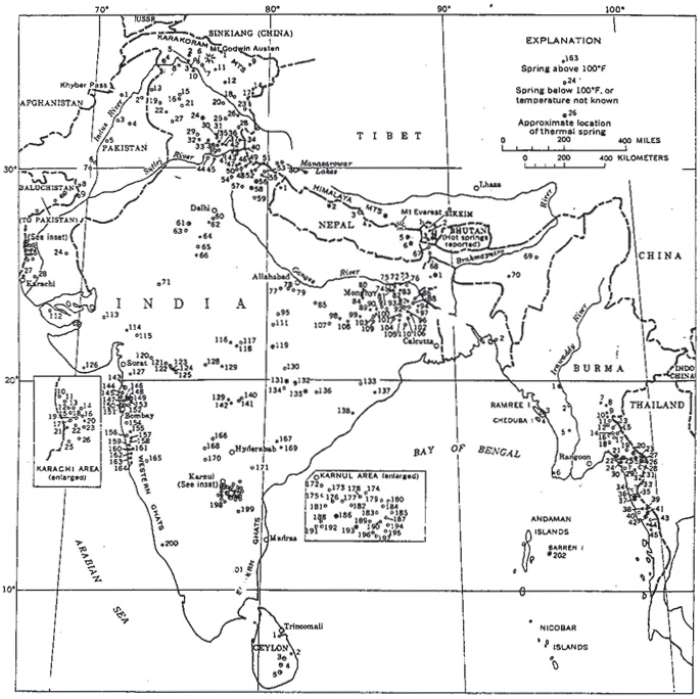


Figure 3: Temperature range of geothermal springs in India...

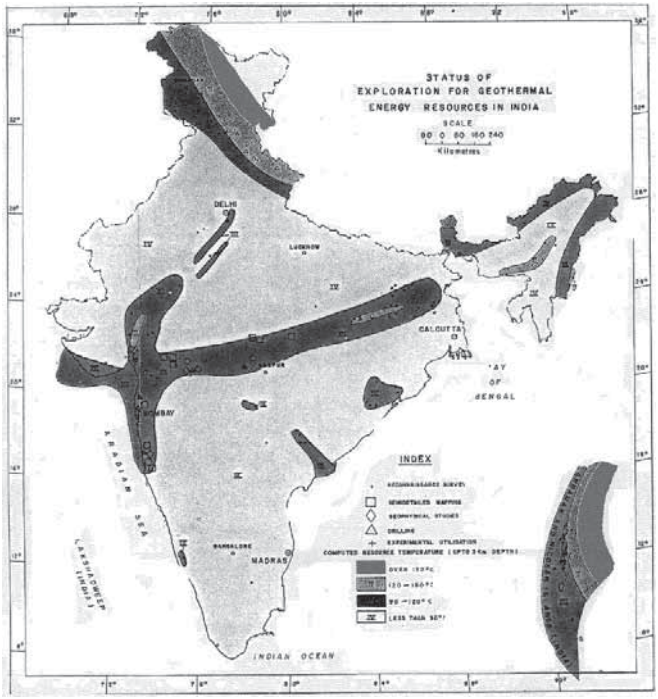


Table 1: Well Productivity - Binary Cycle (Flow Rate - 125,000 Lb/Hr)

Temperature	Hot Water Required (lb/kWh)	MW/Well	Wells/25 MW
250° F / 120° C	400	1.375	18.7
300° F / 148° C	210	2.62	9.5
350° F / 176° C	110	5.0	5.0
400° F / 210° C	80	6.875	3.6
450° F / 231° C	75	7.333	3.4
500° F / 259° C	60	9.166	2.8

environmentally friendly, and their increasing use is concern for environmental pollution. Nowadays, stress is shifting on using renewable and relatively non-polluting energy resources such as solar, wind, tidal, geothermal for electrical power generation. Geothermal energy is a renewable form of energy and is most widely utilized non-conventional alternative to fossil fuels today. Today, USA generates about 3,386 MW through geothermal power plants. The total worldwide generation of electricity from geothermal energy is about 12,800 MW.

Advantages Of Geothermal Energy

Geothermal energy has the following advantages:

i. It is one of the cheapest methods to generate electrical power.
ii. It is environment friendly and there is no danger of any type to life.
iii. Area required to set up a power plant is less than that for a similar capacity of other power plant.
iv. It is not dependent upon weather and most of the market variables and policies as the source of energy is free from such constraints.
v. Besides power generation, additional minerals can be obtained from the produced hot water depending upon the reservoir source.
vi. There is no waste by product, which is very big problem for coal based and nuclear power plants.

Geothermal Process

The source of geothermal energy is very vast and almost infinite as the heat stored below the surface of the earth. The heat from the earth's core continuously flows outward. Sometimes the hot magma (molten rocks and minerals) rises all the way to the surface. Most often, however, it remains just below the earth's crust, heating nearby rock and water(rain water that has seeped into the earth) – sometimes to temperature exceeding 700°F. Some of the water travels back up through faults and cracks and reach the surface as hot springs but most stays below as a geothermal reservoir. The earth's natural heat is cleaner and has less detrimental environmental impact than conventional source of energy. If only 1% of this energy were harnessed, this would amount to more than 500 times the known oil & gas resources in the world. With time and technology improvements more of this enormous reservoir of energy will be utilized.

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- Phase Separator

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Table 3: Selected five geothermal sites in India...

Name / Location	Latitude / Longitude	Temp. Surface ° C	Temp. Average Sub-Surface ° C	Reference Number on Figure 2
1. Tattapani, Sarguja	23° 41 08″; 83° 38′	88	160	98
2. Surajkund	24° 09″ ; 85° 30′	87	165	90
3. Puga Valley	33° 13′; 78° 19′15″	84	225	26
4. Cambay-Kathan	22° 14′; 72° 41′ (Cambay Well)	-	251	-
5. Bugga-Manuguru	17° 56′; 80° 45′	55-58	173-215	169

Table 2: Number of thermal springs recorded in individual states...

Area	Total Number Of Reported Thermal Springs
NORTHERN REGION	
J & K	37
H. P	34
U. P.	37
Haryana	3
TOTAL	111
NORTHEAST REGION	
Assam	4
Meghalaya	1
Arunachal	11
TOTAL	16
WESTERN REGION	
Rajasthan	8
Gujarat	13
TOTAL	21

Area	Total Number Of Reported Thermal Springs
EASTERN REGION	
Sikkim	7
Bihar	60
West Bengal	6
Orissa	11
Andaman-Nicobar	1
TOTAL	85
CENTRAL REGION	
Maharastra	40
M. P.	13
TOTAL	53
SOUTHERN REGION	
A. P.	43
Karnataka	6
Tamil Nadu	2
Kerala	3
TOTAL	54
GRAND TOTAL	340

Geothermal Technology For Power Generation:

A geothermal source may contain steam, water, a steam/ water mixture or just hot dry rock. In order for the geothermal resources to be of commercial value, it must contain water or steam.

Power generation from geothermal energy can be divided into three phases:

i. Project planning, drilling and testing to establish production capacity of geothermal wells and proper management of the geothermal reservoir.

ii. Construction of the insulated pipeline to transport geothermal fluid to the power plant from the wells and transport back the spent water, after the heat is extracted to injection wells located on the periphery of the reservoir.

iii. Erection and management of the power plant and supplying the power to the grid.

The economical viability of hydrothermal (hot water or steam) system for electrical power generation is guided by temperature of the reservoir. When hot water resources are used through a 'binary' process to generate electric power, the heat from the hot water is allowed to vapourize a heating fluid (Freon, Isobutene, Isopentane etc.). This heat transfer fluid in a closed system is used to turn a turbine, which runs a generator as shown in the figure I.

After exploration is completed and the geological condition of a tract arc right, a number of wells are drilled into the production zones. The process of drilling, completion and stimulation of a geothermal well is basically similar to those of oil & natural gas wells by utilizing techniques such as hydraulic fracturing used in oil and gas industry and combining this with technological advances specific to geothermal energy, the production rates from geothermal wells could be increased far beyond their natural capacity.

In addition, a bi-phase turbine (currently in use) are capable of producing power from both the steam and brine flow, thereby potentially increasing power generation.

Temperature within the reservoir will have direct bearing on the viability of the power generation project. If the temperatures within the reservoir are high, the pressure within the reservoir will be greater – and the number of wells needed to sustain the power plant can be reduced. The high pressure will also allow for use of a less expensive high-pressure turbine for the plant.

Electricity from geothermal energy will be economical where the temperature gradient is greater than 5°F per 100 ft. The electrical power generated from a geothermal reservoir is directly proportional to the rate of fluid production. After the heat is extracted from the produced geothermal fluid (hot water or steam) the spent hot water and condensed steam is injected back into the periphery of the reservoir to keep it in recharged condition throughout the life of the period. Well productivity is indicated in table-1.

> The earth's natural heat is cleaner and has less detrimental environmental impact than conventional source of energy...

Geothermal Sites In India

India contains parts of one of the largest geothermal areas in the world, namely the Himalayan geothermal belt. It is 150 km wide and 3000 km in length covering parts of India, Nepal, Tibet, China, Myanmar and Thailand.

There are over 340-recorded geothermal sites in India. Table 2 shows the number of hot springs in India. The highest numbers of geothermal springs (60) are recorded in Bihar.

Table 3 indicates most five suitable geothermal sources in India. Fig 2 depicts the approximate location of geothermal springs in India. Fig 3 depicts the temperature range of geothermal regions.

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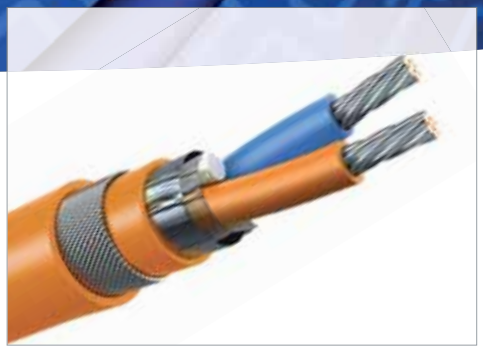

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"CPRI offers discount to MSME manufacturers..."

Central Power Research Institute (CPRI) is the power house of the Indian electrical industry. Set up in 1960 by the Government of India, it functions as a centre for applied research in electrical power engineering – assisting the electrical industry in product development and quality assurance. In an exclusive e-interview with Electrical India, V S Nandakumar, Director General, CPRI, is fielding questions from P K Chatterjee. Excerpts...

What are the priority research areas for CPRI at present?

CPRI carries out R&D in four different conventional sectors viz. Thermal Generation, Hydro Generation, Transmission and Distribution.

Advanced Non-Destructive Evaluation (NDE) based Condition Assessment (CA) and Remaining Life Assessment (RLA) of plant components, Ultra Super Critical (USC) and Adv - USC Plants, IGCC technology and Waste Heat Recovery Systems are some of the thrust areas under Thermal Engg. Vortex rope mitigation, Renovation, Modernization and up-gradation (RMU), Silt erosion, Transient operation are some of the thrust areas under Hydro Generation. Design and development of equipment for 1200kV UHV AC System, Development of controllers for FACTS devices, data analytics in Energy Domain, Smart Grid, Novel Forecasting Techniques for renewable energy, Innovative solutions to demands of real time security analysis of transmission grids, cyber security, Transmission Towers with reduced Right of Way, Composite insulators are some of the areas that

are being investigated/ planned to be investigated under transmission research. Distribution Automation, measures to reduce energy losses, Advanced Metering, micro grids and suitable control mechanism, Energy storage: electrical and thermal storage with enhanced charge-discharge efficiencies and new technology routes, Integration of renewable energy being some of the thrust areas under the Distribution Research.

Recently, CPRI has forayed into R&D in efficient lighting with its LED research scheme, which is a joint initiative of CPRI and BEE.

What kind of certificates do you offer to the Indian companies?

CPRI has built up expertise to cater to the entire gamut of services required by the Power Sector covering Generation, Transmission and Distribution under one roof. CPRI houses unique facilities for High Power Short Circuit Testing of power equipment, evaluation of EHV/ UHV equipment upto 1200kV rating, Power Cables and Accessories, HV & LV Power Capacitors, Power Systems Studies with Real Time Digital Simulator (RTDS) Facility, Transmission Line Tower & Accessories Testing, Conductor Vibration Studies, Seismic Qualification, Transformer Oil Testing, Materials Characterization, Insulation Properties, Communication Protocol Testing for Power System Automation, Energy Meter evaluation, Testing of Refrigerators, Air Conditioners and domestic electrical appliances Including LED and SPV Lighting Systems.

We carryout testing of all kinds of electrical power equipment as per various national and international standards for ensuring reliability & stability of power system and issue test certificates / reports to Electrical Manufacturers and Utilities across the country...

We carryout testing of all kinds of electrical power equipment as per various national and international standards for ensuring reliability & stability of power system and issue test certificates/ reports to Electrical Manufacturers and Utilities across the country.

Are the CPRI certificates valid internationally?

Yes. Many overseas manufacturers across the world test their products in CPRI and get the test certificates. CPRI Certificates are widely accepted in many countries. The main reasons for such wide acceptance apart from good testing infrastructure and expertise are national/international accreditations like:

- ISO/IEC 17025
- Intertek ASTA - UK
- MEMBER STL
- ISO 9001:2008 for R&D and Consultancy projects
- INMETRO Brazil
- Kingdom of Bahrain
- Corporate Member in
  a) DLMS UA (Device Language Message Specification User Association)
  b) UCA IUG (Utility Communication Architecture International User Group)

What are the latest additions to CPRI's testing capacity?

CPRI has been upgrading, augmenting its test facilities and additional test facilities being created based on the growing needs of Indian Power Sector. To name a few:

- Centre of excellence for simulation of Power System & Failure analysis
- Centre of excellence for Dielectric Studies
- Centre for Advanced Research in the area of Energy Efficiency & Energy Audit
- Centre for excellence of Life Cycle Management & Condition Assessment of HV substation & power plant electrical Equipment
- Test facilities for Pre-qualification test on 400kV XLPE Cable
- Modernisation of Short Circuit Test Facilities and Augmentation of Power Transformer Test Facilities
- 1200kV AC & DC Test facility at Ultra High Voltage Research Laboratory (UHVRL), CPRI Hyderabad.
- Solar PV Panel, Solar light, Solar pumping and LED light test facility at Bangalore.
- Test facilities for testing of CRGO and CRNGO electrical steels for transformer applications.
- Battery testing facilities
- APFC Panels testing facilities
- Smart meter testing facilities

CPRI is also adding new test facilities under XII Plan Capital project scheme. To name a few:

- Augmentation of High power short circuit test facilities by adding two additional 2500 MVA Generators at Bangalore Unit.
- 350 MVA online Short circuit test station at Hyderabad Unit.
- Setting up of new regional testing laboratory at Nashik.
- Smart grid research laboratory at Bangalore Unit.

- Test facility for solar based Grid tied Inverter systems (up to 50kVA) and solar PV modules (up to 500 Wp)

What are the emerging areas where CPRI have started offering consultation these days?

- Development of 1200kV system in India,
- Establishment of NHPTL at Bina (Mgmt. consultant)
- Pollution mapping studies
- Smart Grid - SCADA/EMS/DMS consultancy
- Power System Design and Operational Studies
- Loss minimization in power distribution networks of utilities and Industries
- Energy Efficiency Labelling, Energy Audits for utilities
- Remaining Life Assessment (RLA) of Thermal & Hydro power
- Diagnostic testing of generators and substation equipment
- Coal & Ash analysis
- Conductor vibration studies and Seismic qualification studies
- Tower testing
- Transformer oil reclamation

Recent initiatives

- Development of STATCOM for Bhilai Steel plant
- High Temperature Superconducting (HTS) fault current limiter
- Innovative biomass gasification boiler

Do you have any plans to promote MSME segments?

CPRI offers discount to MSME manufacturers on the testing charges to encourage them to carry out more tests in CPRI.

What are CPRI's action plans to make our prime minister's vision 'Make in India' materialise?

As part of the R&D carried out under the National Perspective Plan, the motto has always been product/process developments with indigenous technologies. To this end, CPRI has collaborated with various industries of repute like BHEL, CDAC Trivandrum, NML etc. in the past through various R&D projects. Indigenous prototypes had been developed as part of those earlier associations. At present, CPRI is in collaboration with CSIR-Central Institute of Mining & Fuel Research, Dhanbad and ISM, Dhanbad for a project with the aim to develop Selection Methodology for Road Header and Tunnel Boring Machine in Different Geological Conditions for Rapid Tunneling. This is a first of its kind project that will be carried out in India and will help the Indian industry at large. CPRI has also collaborated with IISc and CDAC for a project with the aim to develop power conversion and control technologies for renewables and hybrid microgrids. CPRI has collaborated with Raychem RPG Pvt. Ltd. for development of Low Cost Silicon Rubber Insulator for 11 kV applications. The resulting product can also find huge demand in International Market. CPRI has collaborated with IIT Madras to develop Polymer Nano-composite Materials to be used for EHV DC transmission line insulators and diagnostics adopting Laser Induced Breakdown Spectroscopy (LIBS).

What are your contributions towards reduction of carbon footprint in Indian power industry?

In the light of the requirement to cut-down on carbon foot-prints, CPRI has taken up R&D on renewable energy, waste to energy etc. in a big way. CPRI has several on-going projects on renewable energy. Apart from this, one of the In-House R&D Project aims to develop a lab scale microwave based plasma gasification reactor technology suitable for Multi-Fuel Gasification in the Indian Context. The developed reactor will convert organic waste into combustible syngas for electric power and thermal energy. As part of another project undertaken under the National Perspective Plan, an innovative biomass gasification boiler has been designed. The project aims to grow enhanced biomass using sewage water and convert the same into electrical power through biomass gasification boiler. Apart from this various R&D Projects on renewable energy forecasting and development of inverters/converters for solar/wind integration to the Grid, are under execution.

In the light of the requirement to cut-down on carbon foot-prints, CPRI has taken up R&D on renewable energy, waste to energy etc., in a big way. CPRI has several on-going projects on renewable energy...

What is your message to the Indian Power Community?

With the planned reforms in the distribution sector and renewed target for integrating 175 GW of renewable energy to the Grid coupled with increasing thrust on energy savings by way of replacing all incandescent/CFL/Tube lights with LED bulbs, India's power sector is on the cusp of a new age expected to be marked by meaningful innovation and improved efficiency. The adoption and absorption of newer technologies suited to the Indian condition will have a major role to play in achieving improved efficiency. The future calls for greater cooperation and synergy among all the stake holders of the Indian Power Sector. Together, we definitely can achieve the dream of 'Make in India' and ensure 24/7 power for all.

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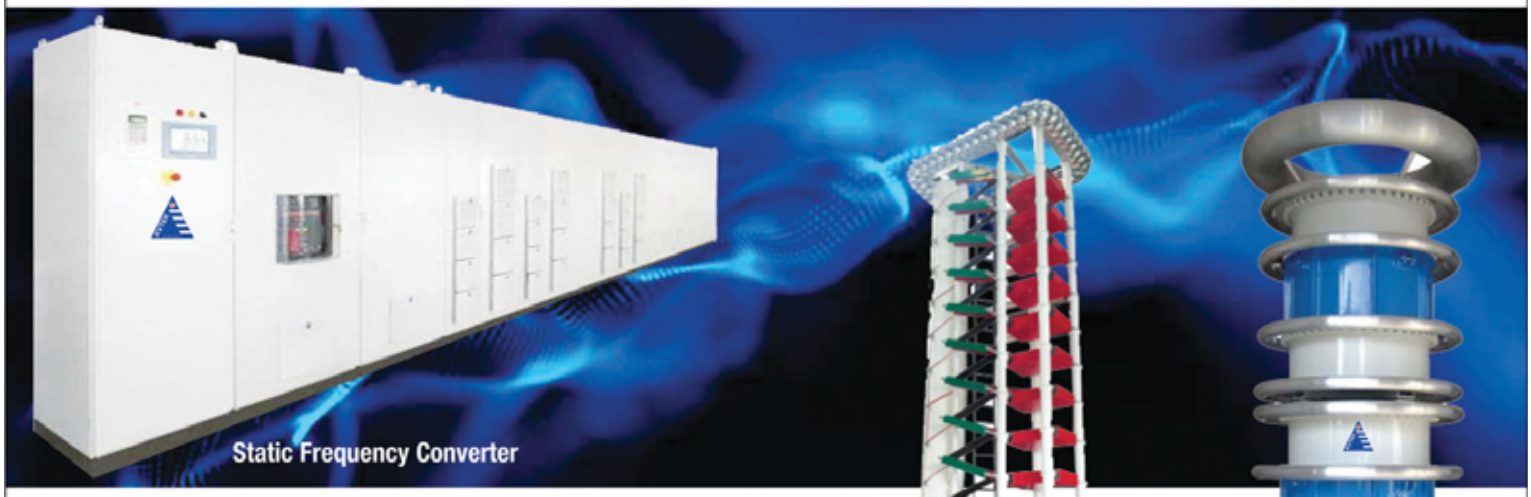

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- HV AC Series Resonant Test System
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- Static Frequency Converter
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- HV AC Dielectric Test Set
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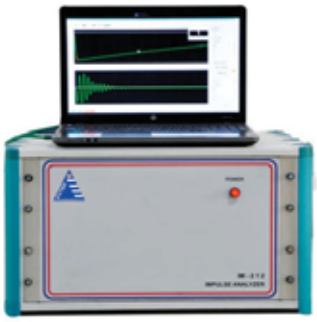
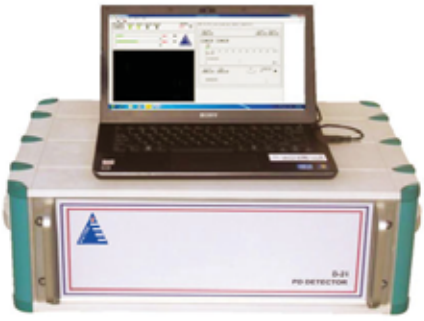
- Transformer Loss Measuring System
- AC/ DC Kilo Voltmeter
- CT/ PT/ CVT Test Set
- Bushing Monitor

Impulse Voltage Test System

HV AC Series Resonant Test System



Impulse Analyzer



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Addressing Energy Needs & Environmental Challenges

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Shri Dharmasthala Manjunatheshwara College of Engineering and Technology
Dharwad

Nuclear energy can make a valuable contribution to worldwide socio-economic development. In this article, the need of nuclear energy to meet the growing energy needs, the present scenario in India and in the world, the advantages and disadvantages of nuclear energy for environmental safety and the international measures taken for nuclear safety are discussed. If the growing world economy continues to rely on traditional thermal energy sources, carbon emissions would significantly rise and environmental consequences like greenhouse effect, global warming, and climate change would progressively become a serious cause for concern...

Nuclear science and technology is one of the greatest scientific and technological achievements of humankind. Nuclear science and technology is widely applied in various sectors, with over 50 years of development, such as energy, industry, agriculture, health and environmental protection, and is playing an important role in the prospering economy, and in improving peoples' livelihoods and promoting sustainable development. With global economic development and rising energy consumption, supply of traditional energy sources is becoming more stretched, and climate change is becoming an increasingly severe challenge. Given its advantage as a clean, safe energy source that could be applied at a large scale, more and more countries are placing importance on nuclear energy. Accelerating the peaceful use of nuclear energy is the common wish and inevitable choice of many countries.

The attraction of nuclear energy is supported by the improved performance of the nuclear energy industry since the 1980s. Improvements in safety have been matched by improvements in efficiency. Nuclear plants are more economical to run, availability and productivity have increased, and there is less downtime for maintenance. The long term stability of the cost of electricity generated by nuclear power is also an important attraction.

Addressing Energy Needs

Nuclear power today accounts for 15 per cent of global electricity generation and the world now has more than half a century's experience in handling this technology, which is equivalent to over 14,000 reactor years; expertise and confidence in the area have steadily grown. Furthermore, rising oil prices and growing environmental concerns over the last decade have led to a reconsideration of sustainable energy fuels. In this context, nuclear power has resurfaced as a keen contender for large-scale energy generation.

Sustainable growth cannot be fully restored without secure access to energy and electricity. Our obligation to future generations is to address these challenges of energy security and sustainability today. Cleaner, carbon free sources will also help to respond to growing energy demand. Projections suggest that by 2030 energy demand in the world will increase by 45 per cent and electricity consumption by 75 per cent. Nuclear energy has the potential to meet a significant part of future demand, while reducing tensions on hydrocarbon markets and alleviating the risk of global climate change.

Although nuclear power is not a panacea for all the world's energy problems, it will continue to play an important role in the global energy mix. Growing global demand for energy throughout the 21st century will reflect continued population growth, the drive by developing countries to connect the 1.6 billion people who have no access to electricity and the 2.4 billion who have no access to modern energy systems. We have to understand that there is no development without energy, and if we need to improve the lives of one third of humanity who live on less than $2 per day, we need to increase our supply of energy and electricity. In this context, there are a number of key drivers that are fuelling increased interest in nuclear energy, in particular, energy security and the environmental benefits.

In most countries relying on the nuclear option, the costs of generating nuclear electricity, which internalise safety, radiation protection and waste management and disposal, are competitive with alternatives. According to the study published in 2005 by the Organisation for Economic Co-operation and Development (OECD), based on data provided by 21 countries on 130 power plants, the average lifetime costs of generating electricity, levelised at 10% discount rate, range between 30 and 50 US $/MWh for nuclear, 35 and 60 for coal and 40 and 63 for gas.

Besides its contribution to electricity supply, which could be increased significantly in many countries, nuclear energy has the potential to broaden its market to non-electricity applications. Nuclear reactors produce heat, which can be used directly for process or district heating, to desalinate water or to produce hydrogen by different means. It offers opportunities for the nuclear power to play major role in policies to address security to supply and global climate change issues.

Indian Scenario

India has an installed electricity generation capacity of 274 GW. Whereas, it presently requires 1,100 billion kWh of electricity, which is stated to go up to 1,524 billion kWh by 2016-17, 2,118 billion kWh by 2021-22 and 3,880 billion kWh by 2031-32 considering an average GDP growth rate of 8%. As a measure to bridge this gaping hole, India has been investing heavily to augment its nuclear power generation capacity. It has already installed a few nuclear reactors and is in the process of setting up a few more. India initially plans to increase its nuclear electricity generation form present 5,780 MW to 63 GW by 2032, but the target was revised in 2011 to a more realistic 27.5 GW. The Atomic Energy Commission envisages a target of 500 GW of nuclear energy generation by 2060.

With experience of over half a decade in the field of nuclear technology, India, in the words of Dr Chidambaram, former Chairman, AEC, is 'the only developing country that has demonstrated its capability to design, build, operate and maintain nuclear power plants, manufacture all associated equipment and components, and produce the required nuclear fuel and special materials'. Indeed, India can claim to have experience in construction, operation, and maintenance of a varied range of nuclear power plants. India has accumulated vast experience in operating Pressurised Heavy Water Reactors (PHWR). India's first prototype Fast Breeder Reactor (PFBR) is going to be ready for synchronisation in near future. Water (coolant) Water (moderator) Energy Reactor (WER) is of Russian design which uses horizontal orientation of the steam generator module. As far as future plans are concerned,

Table 1

Power station	State	Type	Units (MW)	Capacity (MW)
Kaiga	Karnataka	PHWR	220*4	880
Kakrapar	Gujarat	PHWR	220*2	440
Narora	UP	PHWR	220*2	440
Madras	Tamilnadu	PHWR	220*2	440
Rajasthan (Kota)	Rajasthan	PHWR	100*1	1180
			200*1	
			220*4	
Tarapur	Maharastra	BWR	160*2	1440
		PHWR	540*2	
Kundankulam	Tamilnadu	WER	1000*1	1000
			Total	5820

Government of India has agreed on principle for the plants mentioned in Table 1.

The objective of Indian Government is to double the present installed capacity of 5820 MW by 2018 and more than eleven times to 63,000 MW by 2031-32.

Several analysts have argued that given India's limited and low-grade uranium reserves, the development of the nuclear programme beyond 10,000 MWe would imply increasing dependence on uranium imports. However, this viewpoint tends to overlook the logic of India's three stage nuclear power programme that envisages large-scale utilization of India's significant thorium reserves. It is in order to tide over the transition from fast breeder reactors to the thorium cycle that India needs uranium. Therefore, unlike the case of coal or oil or gas, where imports appear to be a permanent reality, uranium dependency would be for a limited period of time till India graduates to the thorium cycle. As far as India's three stage nuclear power generation is concerned, we are just at the beginning of the second stage. India is among the very few countries pursuing this technology. Even the World Nuclear Association, which is dedicated to the promotion of nuclear technology, sees little scope of development of this technology as long as abundant uranium is available. However, given the peculiarities of the Indian resource base, Dr Homi Bhabha had prescribed a three-stage programme for the country that would culminate with the exploitation of India's large thorium reserves.

Environmental Challenges

During the second half of the 20th century, it was becoming clear to the scientific community that the average environmental temperature of the earth's surface is increasing due to human activities, which emit certain gases like carbon-dioxide, nitrous oxide, methane etc called the Greenhouse Gases (GHGs).

The Kyoto Protocol is an international treaty, which extends the 1992 UN Framework Convention on Climate Change (UNFCCC). The protocol binds its parties by setting internationally binding emission targets. The first commitment period was from 2008 to 2013 and the collective emission reduction target was 5.2% over 1990 levels. The second period is from 2014 to 2020, an extension targeting 18 % GHG emission cuts over 1990 levels.

As it is turning out, focusing only on renewable energy may not yield the desired results. Renewables like wind and solar and biomass will certainly play roles in a future energy economy, but those energy sources cannot scale up fast enough to deliver cheap and reliable power at the scale the global economy requires. While it may be theoretically possible to stabilize the climate without nuclear power, in the real world there is no credible path to climate stabilization that does not include a substantial role for nuclear power. It is essential for at least bigger developing countries to go for atomic energy option.

But the mad race for setting up nuclear power plants, owing to their chequered past, has raised a red flag over the issue. Although the world has ambitious plans regarding nuclear energy, people residing near uranium mines and nuclear reactors are paying the price for that ambition. Usually, those working directly or indirectly in the mines and those living in the surrounding areas of mines and nuclear reactors bear the brunt of harmful radiations. Poverty and illiteracy further compounds the problems, as these people usually are not aware of the harmful effects of nuclear radiation and only take notice when these effects reach alarming levels.

Leakage from nuclear power poses another threat to the ambient life and property. The most prominent example has been the Chernobyl disaster. Incidents of thyroid cancer have increased among the young people exposed to the radiation. Apart from this, there has been an increase in the frequencies of Down's syndrome, congenital abnormalities, miscarriages and pre-natal mortalities among the people exposed.

The management of radioactive waste is an important concern for governments and society at large. The volume of waste is small but its radio toxicity is high. Progress towards the construction, commissioning and operation of repositories for all types of radioactive waste should fully address this concern, and in a manner that enhances public confidence.

Also, since nuclear power plants are fundamentally heat engines, waste heat disposal becomes an issue at high ambient temperature. Droughts and extended periods of high temperature can cripple nuclear power generation, and it is often during these times when electricity demand is highest because of air-conditioning and refrigeration loads and diminished hydroelectric capacity. In such very hot weather a power reactor may have to operate at a reduced power level or even shut down.

An additional concern with nuclear power plants is that if the by-products of

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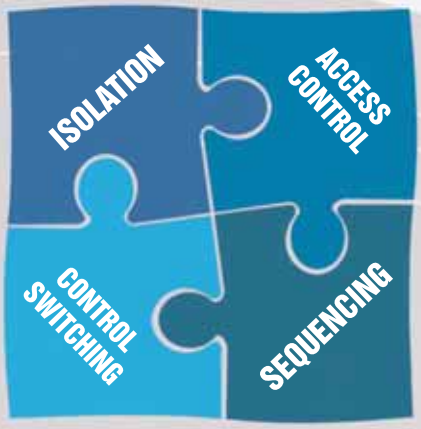

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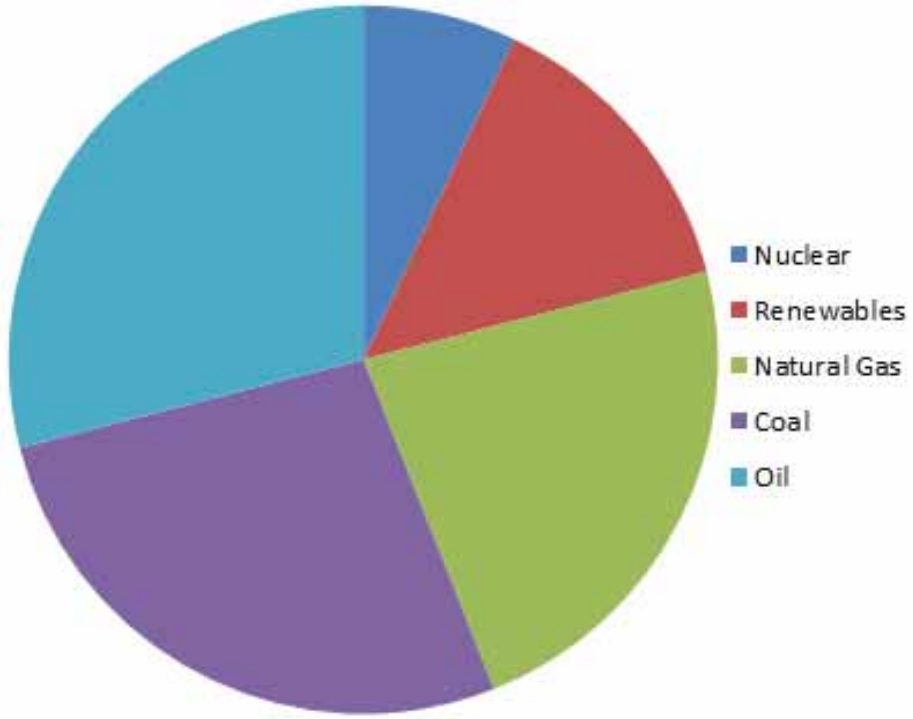
Projected World Energy Mix - 2035



nuclear fission (the nuclear waste generated by the plant) were to be left unprotected it could be stolen and used as a radiological weapon, colloquially known as a 'dirty bomb.'

Environmental Safety Measures

a) International non-proliferation efforts should be strengthened, and States must comply with their respective non-proliferation obligations.

b) The operating nuclear power plants in the world have maintained an excellent safety record. The continuing safe operation of the current fleet of nuclear power reactors is essential for continued confidence in the use of nuclear technology. All States having or developing a nuclear power programme should give high priority to ensuring safety. In addition, States should develop and maintain appropriate effective physical protection measures.

c) Consideration should be given to measures that will help to ensure reliable access to nuclear fuel supply, while maintaining the normal operation of the international nuclear fuel market.

d) The safe management of spent fuel, which for some countries includes reprocessing and recycling, as well as the disposal of radioactive waste are of great importance for the sustainable development of nuclear power. Each State remains responsible for the management of its spent fuel and radioactive waste. The participants encourage international cooperation in these fields. Each State should take appropriate steps to ensure that adequate financial resources are available to support the safety of nuclear installations throughout their life, including during the decommissioning phase, and the safety of the management of spent fuel and radioactive waste.

e) Countries developing nuclear power programmes are responsible for the development of the necessary infrastructure. Some countries, including developing countries, may seek assistance and support from countries with existing infrastructures and capability.

f) International cooperation should be continually strengthened to carry forward research and development of advanced nuclear technologies.

Conclusion

So, far we saw both the positive side and negative side of the nuclear energy. Nuclear power contributes to global energy security while addressing climate change and avoiding air pollution. Nuclear power is a base load source of electricity that can make a major contribution to meeting energy needs in a sustainable manner in the 21st century.

Today the advancement of nuclear power in the world is crippled by governmental policy, regulation, and misconceptions.

In the long term, it is reasonable to expect that the energy needs of the world will be met from a number of different sources, only one of which will be nuclear fission.

However, to ensure the energy security of the Nation in the medium term and to allow time for the development of new energy technologies which can drastically reduce greenhouse gas emissions, the world needs to initiate immediately a program to implement nuclear fission reactors on a large scale.

Greater public awareness on the merits of nuclear energy in world energy mix must be generated. While none can deny the risks involved in nuclear fission, the investments made in the safety processes and regulatory procedures to minimize these must be adequately brought out. The government must also encourage transparency in calculating the costs of nuclear electricity generation, which ample studies have proven is cost competitive in many scenarios.

The overall safety is much better than it was 10 years ago, but we still have vulnerabilities in safety, as well as in security. In the nuclear domain, the role of governments goes beyond setting national energy goals. Nuclear energy, if produced safely, offers promise. The requirement hence is to fast-track civilian nuclear expansion while maintaining the highest standards of nuclear safety and security. Today's world has to carefully make the right choices to assure the future generations of a brighter and secure tomorrow.

Governments should work together with private stakeholders to enhance the effectiveness of regulatory regimes and to ensure that the nuclear industry keeps safety and environmental protection as its highest priority – because we should not protect the environment, we should create a world where the environment doesn't need protection.

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- Data centers, Hotels, Hospitals, Shopping malls and Office buildings
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"We are ready to execute power projects within the challenging timelines..."

Toshiba JSW Power Systems Pvt. Ltd. (TJPS) is a **Joint Venture** between **Toshiba Corporation, Japan** and **JSW Group, India**. It was initially incorporated to manufacture and market **Super-critical Steam Turbines** and **Generators** for Thermal Power Plants in India. It has been merged with **Toshiba Thermal & Hydro Power Systems Company**, a division of **Toshiba India Private Limited**, to broaden the gamut from **Manufacturing to One-stop Solution for Engineering, Manufacturing, Procurement, Construction and Services (EMPCS)** of **Thermal Power Plant**. In an exclusive e-interview with **Electrical India**, **Managing Director** of the company **Yoshiaki Inayama** is briefing on their operations to **PK Chatterjee**. Excerpts...

How is Toshiba JSW Power Systems' business growing in India?

India currently has an installed capacity of 306 GW as of September 2016, and as per planned programme to attain energy security, the installed capacity relating to planned GDP growth, the estimated demand of electricity by 2031-2032 would be in the range of 2,632 Billion units as against the current estimate of 1,227 Billion units. This demand would entail development and application of new and efficient technologies.

Toshiba with its developed and continued efforts on enhancing efficiency would play an important role in application of its state-of-the-art equipment including Ultra Super critical and Advance Ultra super critical technologies. In addition to that, it is very important to improve existing plant efficiency by applying proper maintenance and/or replacing old units with Ultra Super critical plant.

With our manufacturing facility in Chennai having an installed capacity of 3000MW, Toshiba JSW is geared to contribute to the government's goal to provide 24x7 electricity for Domestic , Industrial, Commercial and Agriculture sector. We are actively participating – and are in the process of positioning ourselves as a significant player in the Thermal Power Sector as a Turnkey EPC contractor and Number 1 EMPCS company in India. We are also ready to execute power projects within the challenging timelines demanded by the IPPs. We can also contribute to improve executing plant efficiency utilising our facility and Toshiba's technology and experience.

Could you please tell me about your company's contribution in erecting the Kudgi Super-critical Thermal Power Station in Karnataka?

In February 2012, Toshiba Group won the order for three 800MW steam turbine and generator island packages (STG) for the Kudgi Super-critical Thermal Power Station from NTPC.

In our continuing effort to contribute towards growth of power sector in India, upon delivering the first Generator of the Contract awarded by Toshiba, the Indian unit of Toshiba M/s TJPS shipped its first 'Made-in-India' Generator for Kudgi Unit 2, marking a significant milestone in its endeavour to offer customers state-of-the-art power generations solutions manufactured in India.

The 800-megawatt Generator for Unit 2 of the Kudgi Super-critical Thermal Power Station in Karnataka state was Toshiba's first large-scale generation system to be manufactured and assembled with locally procured parts and systems, and tested in India. With this shipment TJPS embarked on its local manufacturing – from procurement to testing and shipping, for customers in India and the neighbouring countries.

The major supplies have been made and delivered at Kudgi site and installation work is proceeding at fast pace. Toshiba is proceeding the works at site in line with targeted schedule of the Customer.

> TJPS' Chennai Factory has state-of-the-art manufacturing facilities – such as high performance and productivity large machine tools, CMM for turbine blades, robotic welding system for turbine components, highly automated Generator components manufacturing facilities and world's largest High Speed Balancing Machine...

We are committed to deliver state-of-the-art and the highest quality products and support the Indian Government's 'Make-in-India' campaign. With the manufacturing and supply of Turbines and Generators, we will continue to develop and contribute to the growth of Power sector for benefit to end users FOR THE NEXT INDIA.

What are your other continuing projects?

In the last FY, TJPS was awarded a full EPC Contract by Uttar Pradesh Rajya Vidyut Utpadan Nigam Ltd. (UPRVUNL), valued at Rs. 3436 crore for 660 MW Harduaganj Ultra-supercritical Thermal Power Project. It is the first turnkey EPC contract for TJPS in India. Apart from this, TJPS is currently executing orders of NTPC Darlipali that involves supply of 2x800 MW steam turbine generator island.

What are the fundamental differences in components' construction between an ordinary and a super-critical power plant?

It is evident that with application of higher steam parameters, the improvement of efficiency in performance is achieved that brings several benefits to the user and ultimate consumer. This is achieved with improvement in design of components, construction and operational flexibility with reduced maintenance schedules.

The main area where variation in components in manufacture and construction of Super Critical Steam Turbines over Sub Critical Steam Turbine are as follows;

a. Materials for Rotors, Blades Nozzles and Casings which consist steam passage are heat resist, high strength materials.
b. Design for high-efficient cooling is applied. In addition to that high efficient blade design and sealing design are allied for better efficiency.
c. Special welding and machining technologies are applied for high strength materials.

How are you addressing the 'Make in India' drive?

Toshiba JSW Power Systems Pvt Ltd (TJPS) has already established itself as a dominant player in the Supercritical Steam Turbines And Generators (STG) in the 660 – 800 MW category in India, having won orders for eight units of Steam Turbine Generator sets as of now.

Today, TJPS is a leading manufacturer for thermal power generation equipment in India, established with an aim to offer one-stop solution for Engineering, Manufacturing, Procurement, Construction and Services (EMPCS) of thermal power plants in India – and our aim is to become World's No. 1 EMPCS company.

On August 19, 2016, TJPS marked a significant milestone in its endeavour to offer customers state-of-the-art power generations solutions with shipment of its first 'Made-in-India' steam turbine generator. The 800-megawatt steam turbine generator (STG) for Unit 2 of the Kudgi Super-critical Thermal Power Station in Karnataka state was Toshiba's first large-scale generation system to be manufactured and assembled with locally procured parts and systems, and tested in India.

With this shipment we embarked on our local manufacturing – from procurement to testing and shipping, for customers in India and the neighbouring countries. We are determined to continue to deliver excellent products under our commitment to the Indian Government's 'Make-in-India' campaign. With the manufacturing and supply of turbines and generators, we will continue to contribute to the growth of industries FOR THE NEXT INDIA.

What is exactly meant by EMPCS, and what's its significance?

EMPCS refers to Engineering, Manufacturing, Procurement, Construction and Services.

Toshiba with its extensive experience and global exposure in Power Equipment covering Thermal, Hydro, Geothermal, Nuclear, renewable energy besides control systems have been providing services that cover Engineering, Manufacturing, Procurement, Construction and after sales Services for ensuring that products supplied continue to fulfil the purpose for which these products are provided.

With its global reach and availability of feedback for efficient use and continued performance, Toshiba provides single point solution for providing state-of-the-art products covering most optimised design, manufacturing processes using raw materials and components that comply with desired quality, sequential construction for meeting scheduled targets and ensuring continued after sales services for efficient operation of products. This signifies that the product is effectively and efficiently in use for its designed life.

What are the most innovative aspects of your turbine or generator manufacturing technology?

TJPS Chennai Factory has state-of-the-art manufacturing facilities, such as high performance and productivity large machine tools, CMM for turbine blades, robotic welding system for turbine components, highly automated Generator components manufacturing facilities and world's largest High Speed Balancing Machine.

We also have engineers and supervisors who are trained for Industrial Engineering and Six-Sigma, and they have been improving our manufacturing processes.

In addition to those, in order to manufacture quality products in time, TJPS has many high-skilled operators – and they have been improving their skills continuously.

What is your comment on the cost-competitiveness of the Toshiba JSW products?

Toshiba while designing and manufacturing the products for power sector and especially Steam Turbine Generator sets consider the operational costs for its useful life as prime so that the owner continues to reap commercial advantage over the useful life of Power plant.

Toshiba also ensures that initial product cost is competitive and meets the market benchmarks. As Toshiba takes pride in its products and their performance, the Owner's concern for initial costs and operating cost for its useful life provides reliable and competitive cost of power generation to have reasonable return on investment.

In 1994, two units of 500 MW each were made commercially operational in Uttar Pradesh for UPRUVNL on turnkey basis. The STG sets designed, supplied and commissioned by Toshiba are performing extremely well. The plant load factor achieved by these two units for last 22 years have been in excess of 80%, and especially from 2001 to 2016 the Plant Laod Factor (PLF) has been above 83% – and in the year 2015-2016 the PLF touched 90%. From the factual data, it is seen that even after 22 years the units are performing excellently.

In addition, the performance level of Steam Turbine Generator units supplied for Mundra UMPP owned by M/s Coastal Gujarat Power Limited (A Tata Power company), the units have been performing extremely well since 2012.

We at TJPS strive to achieve best results for our customers in providing products and services that make owners to have uninterrupted and reliable output from our products.

How do you go about servicing or maintenance of the generators and turbines?

We continue to provide timely advice and services to projects commissioned by Toshiba in India. For doing so, our engineers positioned at tjps chennai, tjps gurgaon support our customers effectively, and additionally we also support our customers with our globally certified and experienced technically qualified engineers from Japan, Australia and USA for ensuring applicability of new methodologies for providing services for efficient operation of units.

We, besides utilising global technical knowledge developed by Toshiba group, have developed sufficient service facility at our Chennai works – and also our Technical Advisors at TJPS Chennai and Gurgaon for existing Steam Turbine Generator units in India including control systems.

For the equipment which are outsourced by us, which is an auxiliary or an ancillary component, we tie up with manufacturers of these components and provide services to our customers under single point responsibility.

What would you like to communicate to the decision makers who are planning to construct new power plants?

While we appreciate and respect the decision of each decision maker's planning to construct new plants, we believe that main aspects should be focused on quality, ease and flexibility of operation and availability of services – besides cost competitiveness covering initial investment as well operational costs for the entire useful life of the equipment.

We would like to stress emphatically on the following:

a) Technology with efficiency

b) Reliable product performance

c)The overall costs covering initial costs for setting up the plant and operational costs for its useful life for ensuring targeted return on investment for providing affordable and reliable power from the generating plant. EI

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Keeping in view the falling tariff in Solar PV, there has been talk of having competitive bidding in wind power also, however it would be a challenge to opt for competitive bidding in case of wind as the wind power is very site specific – even in locations which are high wind zone as compared to solar which is more widespread phenomenon...

The present scenario in the renewable power viz. solar PV, is reminiscent of frenzy seen in the years ~ 2005/2006 to 2009/2010 for coal based power projects, when every businessman worth its salt wanted to put a super critical thermal power plant housed as Independent Power Project (IPP) – 2 x 660 MW being a standard configuration. Some were more aggressive having planned for phase II also i.e., another of 2 x 660 MW plant to be implemented after the commissioning of phase I. And why not ? The Electricity Act 2003 had brought clarity for the private investment in the power sector – generation was delicensed, power trading was made a distinct activity paving the way for setting up of power exchanges, DISCOMs were to purchase power – only after competitive bidding with case 1/case 2 bidding options thus curtailing the monopolist role of NTPC/state GENCOs, regulation related to SERC & CERC were fine tuned, provision of APTEL for resolving up of dispute etc. etc.

Central govt. had kick-started the mad race with successful auction of Ultra Mega Power Projects (UMPP) under Case 2 bidding through Power Finance Corporation (PFC), wherein, large capacity coal based power project sites were offered alongwith captive coal blocks with enough coal reserves to run the plants for 30 to 35 years and assured off-take from participating DISCOMs. States followed suites with their own Case 2 bidding. Parallely, govt also allocated long term coal linkages and coal blocks with tapering linkages till the blocks get fully operationa. Attracted with the fuel security in form of captive coal block/long term coal linkages and assured of power off-take by DISCOMs through Case 1 bidding, business houses successful in other businesses jumped into the power sector. Power sector became the new Eldorado. Private Equity (PE) players soon followed suit and invested large amount of funds in such power plants – some took call on promoters with successful track record by taking minority stake with assured buy back plans or exit through IPO, some were more adventurous and went with majority stake. Most of these PE players were attracted by huge power demand deficit projected and sky high merchant power rates prevailing at that point of time.

Fast forward to 2017

Many of these thermal IPPs are yet to be commissioned, delayed on account of Indian ground realities of red tapeism, delays in getting approvals & clearances, environmental & forest

issues etc. Those which have been commissioned are staring at bleak scenario, what with long term PPA with DISCOMs not in place/not being honoured in right spirit, cover of fuel security blown away and merchant power rate plunging to a level barely enough to cover the variable cost, what to talk of capacity charges. The PLF of the recently commissioned thermal projects is barely touching 60% though their viability during appraisal was assessed at base case PLF of 80 to 85%.

The situation has become so grim that the IPPs are not in a position to lift coal even at their lowest permissible threshold stipulated in their Fuel Supply Agreement (FSA) with Coal India, which may trigger payment of penalty by the IPPs to Coal India. The scenario had started changing from 2011-12 when allegation of favouritism in coal block allocation started and finally led to cancellation of coal blocks by Hon'ble Supreme Court in 2014. To make it worse Coal India Ltd (CIL) restricted coal quantity under long term linkage to IPPs for the quantum of power to be supplied to DISCOMs under long term PPA awarded through competitive bidding. However, as only few DISCOMs came out with competitive bids for long term PPA, most of the IPPs which got commissioned had to rely on costlier e-auction/imported coal (recently the coal scenario has changed) to run their plants and sell the power at Power Exchange at a low rate barely covering their variable cost. Worst were the IPPs where PE players had invested as they turned off the tap for further investment towards cost over-run and let the project suffer. This also brought out the short comings of PE investment. Typically PE horizon for investment spans 5 to 7 years, post which they look for exit with returns. In coal project their logic was similar – they were looking for 4 to 5 years of construction and 2 to 3 years for exit. The script went haywire once the projects got delayed and the few ones which got commissioned didn't generate enough cashflow to entice new investors to give exit to the existing PE players.

Desperation of private sector promoters of coal based power plants

Promoters of some coal based power plants are so desperate that they are even willing to forgo their equity investment for a token amount in favour of new investors as they would like to get the co-llaterls - corporate guarantee of their holding/flagship companies and in some cases even their personal guarantee given to the lenders of the power project to secure the loan, released. This is due to the assessment that as the projects are stuck up and the loan has become sub-standard, the lenders would exercise their rights and may invoke the corporate guarantee/ personal guarantee to realize their dues. By this action they would be able to atleast insulate their existing business or their personal assets from the lenders of the power project. Further, as most of these projects have also run into huge cost over-runs requiring infusion of additional equity, by surrendering the project they would also not be required to bring their part of equity. However, despite the offer of promoters' stake at token or at near nil valuation and the lenders willing to take a hit on substantial part of their debt, there has not been much success in inviting new investors to the beleaguered power projects. There appears to be no appetite left in the investors to invest in thermal power projects.

Implementation risk weighs high on hydro power projects

The story is similar in case of hydro power projects. Being site specific the implementation risk is highest in case of hydro projects on account of geo-technical surprises despite of detailed surveys. Delay in getting timely clearance for forest & environment, coupled with time taken in 'Rehabilitation & Resettlement' (R&R) plan are other major factors contributing in delay. Many hydro projects got stalled/delayed midway on account of geological surprises leading to considerable delay, as first - understanding the nuisance of the surprise and then tackling it by alternative ways of construction took lot of time, besides increasing the project cost. Once a project start drawing debt it is suicidal for it to get stranded for any reason whatsoever, as interest to the lenders i.e. 'Interest during construction' (IDC) is still payable, besides the inflationary pressure on the construction materials. Many of the hydro projects in the Himalayan region from Himachal Pradesh to Arunachal Pradesh are stuck up on various grounds. The project completion cost have increased and in some cases nearly doubled raising doubts on their financial viability. In the meantime, the investors have been trapped with no exit option. Even if these projects are completed it would be a long haul before they start generating surplus for the investors. In one such hydro project the state govt. had to intervene and takeover the project to complete it as the investors refused to infuse additional funds on account of delays and increase in cost.

Fate of natural gas based power plants

Prior to fiasco in coal based thermal IPPs, power projects based on natural gas had also faced similar scenario, wherein enticed by availability of cheap domestic gas to run the power plants on account of bountiful (so called) gas recovery by Reliance in the KG basin, a number of gas based power projects were put up in 2004 to 2008. The gas from KG basin did flow and touched 60 mmscmd by 2010 and was soon to touch its peak outflow capacity of 80 mmscmd, then suddenly the flow of gas from the basin started petering out and became a trickle of around 10 – 12 mmscmd, which was not even sufficient for priority sector like fertiliser.

It is reported that RIL has cut the gas reserve estimate of KG6 basin from 14 trillion cubic feet (tcf) to 2.9 tcf. In the mean time the price of crude and therefore natural gas escalated to a level where it was not viable to run the gas power plants on imported gas i.e. on LNG (lately the scenario has changed), the fact that as most of the gas based power plants were in the eastern coast near KG basin and the LNG terminals were in the western coast, also did't helped. The gas based power plants were trapped without any gas and to top it the DISCOMs refused to pay for the capacity charges on one or other pretext – court case followed, which is yet to be concluded till date. As these gas based power plants were shut down due to no fault of theirs, Lenders declared their loan facilities as NPA. Majority of these gas power plants are just sitting idle or running at 1/3rd capacity, though the crude and gas prices have fallen globally, on account of logistic involved in transporting the gas from west coast (where the LNG terminal are located) to east coast (where majority of these gas power plants are located).

Mess created in liquid-based power plants

Not to recall the mess in the mid to late 1990s which was created in liquid based power projects viz. Dabhol, wherein the costly imported fuel (naptha) soon made the cost of generation unviable. Though in this case the mess was also outcome of internal issues in the promoter company i.e., Enron.

Not so success story of biomass power plants

The story of Biomass power plants is no different, which is one of the few renewable source of power capable of feeding firm power to the grid. Planned to run on crop residue, rice husk, bagasse etc., these plants got caught between the vicious circle of tariff hike and increase in the cost of biomass. Among the biomass – rice husk and bagasse are most sought after biomass fuel, wherever they are available. However, rice husk is also a preferred fuel for many small scale local industries like brick klins, foundries etc and majority of bagasse is utilised internally by the sugar factories for co-generation, therefore, running power plant on these two is not financially viable as both are costlier and lead to higher variable cost. That leaves the option of running the power plant on mix of crop residue, which brings its own set of complexities. In the pre-feasibility stage it is assumed that as the crop residue needed to be removed from the fields for planting of next crop and at times they are burned in the field itself, it would be available to the developers at a nominal cost. No sooner the plants are commissioned the felony of such logic became apparent. With a biomass power plant in vicinity, the rate of biomass followed the classical theory of demand supply. Collecting biomass residue from far off locations from the power plant increases the transportation cost. Further, as the crop residue are available only within a short window of time – just after harvesting and before planting of next crop - that too once or twice in a year in most states, collecting and storing to run the power plant throughout the year also became a big challenge. Storage for biomass for long term use required land, was susceptible to fire hazards and also led to deterioration in calorific value. To top it all, many a times the travelling grate boiler which is best suited for biomass crop residue required modification to run on a particular biomass residue, which required shut down of the plant for a considerable time. At present, majority of the biomass plants are shut down and the loans given to them are sub-standard.

Burning of crop residue in the fields by the farmers mostly in Punjab and Haryana have been blamed for pollution & smog in Delhi and even the prodding from High Court to the state govts of Punjab and Haryana to ensure that the farmers do not burn the crop residue in the fields have not resulted in stoppage of such practice. To be fair, both the state govts came up with policy for biomass power projects in order to ensure that the menace of burning of biomass residue in the fields is tackled. The policy ensured yearly preferential tariff, exclusive command area for collection of biomass for a biomass project so that there is no competition for biomass among the power projects etc. Many developers lured by the incentives being offerd came up in both the state to put up the biomass based power project. However, as elaborated above on account of various issues, only few are running and most of them are shutdown causing heavy losses to the investors and creating sub-standard assets in the books of lenders. Few of them which are operating are those which are attached to rice mills or sugar mills with AFBC or CFBC boilers and using their internally generated rice husk or bagasse.

> Gujarat was among the first states to offer lucrative tariffs for solar power projects. Soon other states followed suit. The initial initiative by the state govt to develop solar power was based on MoU route wherein the tariff was known upfront and also the deadlines to commission the solar projects for which the tariffs were applicable...

Failure of 'Renewable Energy Certificate' (REC)

To give boost to renewable power the central govt imposed 'Renewable Power Obligation' (RPO) on the DISCOMs. Further, as the renewable power is not spread evenly in the country, the concept of 'Renewable Energy Certificate' (REC) were introduced. The renewable generator were given the option either to sell their power to DISCOMs at preferential tariff or to sell the energy and environment attributes associated with the RE generation, separately. In the second option the environment attributes can be exchanged by the generator in the form of REC. The obligator of RPO can purchase the REC from the renewable generator to fulfil its RPO. An elaborate mechanism of issuance and trading of RECs through power exchange was worked out. However, due to absence of strict penalty on non-compliance of RPO resulted in most of the obligators shunning from buying the REC. presently, not more than 5 to 6% of the REC put up for sale are cleared at the exchange.

Focus on renewable sector – Solar PV to the fore

When all was looking gloomy in the power sector, renewable power projects emerged as a silver lining. Taking into view the inherent advantages offered by the renewables viz. wind & solar, central & state govt gave all support by having conducive policies for renewables, mainly to harness solar power. 'Ministry Of New & Renewable Energy' (MNRE), GoI came out with preferential tariff. Gujarat was among the first states to offer lucrative tariffs for solar power projects. Soon other states followed suit. The initial initiative by the state govt to develop solar power were based on MoU route wherein the tariff was known upfront and also the deadlines to commission the solar projects for which the tariffs were applicable. As the prices of modules plunged worldwide with each passing days, the developers took advantage of the crashing prices of modules and implemented the projects at the fag end of the deadline to take advantage of lower module prices. Lucrative tariffs and lower than estimated capital cost of solar modules boosted the returns to the developers and soon the solar power became the new Eldorado. The slide in tariff of energy from solar plants started once 'NVVN' the trading arm of Central CPSU – NTPC, invited bids for around 1000 MW of solar through a process of tariff based reverse bidding. The reverse

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bidding process ushered in a transparent and competitive system which led to developers quoting lower prices taking advantage of drop in the module prices. The state power utilities also followed suit and the rest is history. With reverse auction bidding the prices quoted by the developers fell to a level in certain cases that the lenders started raising doubts on their financial viability. In many such cases of aggressive bidding the lenders stipulated higher contribution from the promoters in form of decrease in debt:equity ratio.

As the solar PV become flavour of the season, what with conducive govt policies, concern over pollution from fossil fuel based power plants and falling module prices, the plant size at single location increased from kW size to MW size and plus. The early MW size of 1 to 5 MW in single location in no time became 5 to 10 MW and at present plant size of 25 to 50 MW are common. So far so good ! However, to have 'Economy of Scale' (EoS) the Developers have now started eyeing plant capacity of 100 MW plus at single location, some are planning of 300 to 500 MW and there are talks of even putting up ultra mega solar projects with capacity of 1000 MW plus at single location in line with UMPP for coal based power projects. However, large capacity installation of solar PV in the range of 500 MW plus at a single location are fraught with danger of destabilising the grid which emerges from the infirm (i.e., unpredictable) nature of the electricity from solar PV. The power from solar PV power plants are solely dependent upon the vagaries of nature and dependent upon the presence of sun light. Apart from the infirm nature, the electricity from solar PV is also prone to variability which means the electricity from solar PV is non-controllable i.e., the power output would be a non-steady output. In solar PV, the energy output is directly related to the intensity of sun light termed as insolation – higher the insolation, higher is the output. The electricity in Solar PV starts flowing to the grid after some time past sunrise and ebbs out before sunset- typical time of electricity generation would be from 7-8 am in the morning to around 4-6 pm in the evening, with some variations in summers and winters. Further, the electricity from solar PV typically follows a bell curve with peak levels reaching in the afternoon from 11-12 am to 1-2 pm. The output is also susceptible to any shade on the solar panels and therefore is negligible during rainy or foggy days. Similarly, the energy from wind mostly peaks during night and 80 to 90% generation is during the peak season spanning 5 to 6 months from March/April to Sep/Oct, generally coinciding with the monsoon months.

In my article 'Grid stability must before ramping up Solar PV' published in October 2015 edition of 'Electrical India', I had elaborated on the need for taking measures to stabilise the grid before ramping up the solar PV in line with govt's vision of adding 100 GW of solar power and another 60 GW of wind power to the grid by 2022. As of now the renewable portfolio of solar & wind account for ~10% of the total installed power capacity and contribute ~4 to 6% of electrical energy which is on account of their lower PLF. Even with 60 to 70% achievement of targeted solar & wind capacity by 2022, the renewable portfolio may account for ~25 to 30% of installed capacity, contributing ~12 to 15% of electrical energy. As Solar PV and Wind both would be generally generating during off peak hours, measures for sucking up the excess power during non-peak hours through mass storage devices to be used during peak time has to be in place in order not to de-stabilise the grid. In context of Solar PV it would mean storage device for 4 to 6 hours, to shift excess power generated during day off peak to evening peak hours. Mass storage devices for 4 to 6 hours would be costly and would add to the generation cost of electricity from the renewables. Therefore, there is reluctance from the DISCOMs to call bids with such large capacity storage.

Apart from the need to shift off peak surplus power from renewables to peak hours which would require storage of 4 to 6 hours in case of Solar PV, there is a greater need for having a back up storage for ½ hours to 1 hour in case of large capacity Solar PV projects, to take care of grid disturbance during sudden inclement weather like storms or cloud cover. As long as the plant capacity at a single location hovers around 50 to 100 MW, their impact on grid in case of disturbance would be manageable. The impact on grid would become pertinent once the focus shifts towards installation of capacities in the range of 500 MW plus in solar PV at a single location.

There are already news of Load Dispatch Centres (LDCs) of some states instructing solar projects to back down during their peak generation hours which may be on account of over supply to the grid, among other reasons. This is despite the fact that solar power projects have 'must run' status as there is no fuel involved in energy generation and therefore, normally, it should have been the other way round i.e. the thermal power should have been instructed to back down. However, for a cash starved DISCOMs it is beneficial to back down solar power as payment for energy from thermal power (under long term PPA) is paid through a 2 part tariff - fixed (capacity) charges to cover the plant's fixed expenses like lenders interest etc., and variable charges to cover fuel cost. In case the thermal plant is instructed to back down the fix or capacity charges are still payable. As solar plants are not paid through 2 part tariff and are only paid for the energy injected in the grid, in case of backing down they are not paid. The DISCOMs are yet to face grid disturbances on account of sudden power loss due to inclement weather from mega Solar PV installations (capacities exceeding 500 to 1000 MW plus at a single locations), as mega solar pv plants are still in planning or implementation stage. The moment the DISCOMs face one or two grid breakdown on account of inclement weather the reaction would be typical– lot of hue & cry, formation of a panel to fix accountability etc. etc.

Issues being faced by the wind power plants

Now let us see what is happening in the wind power, which is slated to add 60 GW by 2022, on top of the present ~ 27 GW. Wind power has been in India for the last 25 to 30 years and is already a matured sector. However, as against falling capital cost of Solar PV, the installation cost of wind power has been steadily inching upwards – from around Rs 50 million per MW in 2007-08 to Rs 70 to 85 million per MW currently – depending upon site and type of 'Wind Turbine Generator' (WTG). Sites having higher PLF command a premium. Similarly, WTGs having higher hub height alongwith longer blades and gauranting higher PLF increase the project capital cost. The reason for increase in the capital cost of wind power projects being that it is just like other E&M equipment consuming lot of steel and copper, not to talk of cement for a solid foundation. The cost of all these ingredients have

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been increasing in line with inflation – say for a blip here & there. In contrast major part of the cost of solar pv consists of solar panels where the cost have been continuously falling. No wonder the cost of solar pv which was around Rs 200 million per MW in 2010 has fallen to around Rs 50 miilion to 60 million per MW, depending upon location and features like trackers etc. The higher or lower cost of installation is also reflected in the sale rate of both the renewables – in case of wind the preferential tariff across the states has increased form around Rs 3 p.u. to around Rs 5 p.u. whereas in case of solar pv it has drastically fallen from around Rs 15 p.u. in 2010-11 to around Rs 5 p.u. Fall in tariff in case of solar pv has also been helped by the fact that as against preferential tariff route in wind, the tariff in solar are determined through bid process, which results in competitive environment.

Keeping in view the falling tariff in solar pv there has been talk of having competitive bidding in wind power also, however it would be a challenge to opt for competitive bidding in case of wind as the wind power is very site specific even in locations which are high wind zone as compared to solar which is more wide spread phenomenon. The wide variation in PLF in case of wind power is another factor as compared to Solar PV where the variation in PLF among different sites are of narrower range. Further, the identification of high wind locations is usually minimum of 2 to 3 years process as it involves putting wind mast for collection of wind data for at least one or two yearly cycle. Moreover, majority of better wind zone locations are already acquired or taken on lease by the WTG manufacturers and are subsequently put on sale by them. This model of pre-owning the wind power locations is one of the biggest stumbling block among other reasons, in opting for competitive bidding in wind power as it would lead to arm twisting by the WTG manufacturers of a developer who would be L1 in the competitive bidding and scouting for the winds sites.

Wind power developers are already facing challenges in state like Tamilnadu, Rajasthan and Maharashtra where they generate energy which is more than the RPO requirements of these states. In the state of Tamilnadu the wind IPPs have suffered in recent past – first due to delayed realisation of their dues by around 1year and subsequently due to congestion in evacuation corridor as well as shutting down of local sub-stations, due to which they were not able to pump in power, leading to loss in revenue. The situation continued even though some of the wind IPPs migrated from preferential tariff regime selling to state DISCOMs to private companies through group captive mode as they were still not able to evacuate power on account of continuing congestion in the evacuation corridors. This is on top of the cross subsidy charges levied by the state power utilities which can be as high as Rs 2 p.u. in some states. In states like Maharashtra the wind IPPs have not been paid for the last 8 to 10 months. The situation is also not good in MP where delay in payments to wind IPPs frequently reach 4 to 6 months.

> As of now the renewable portfolio of solar & wind account for ~10% of the total installed power capacity and contribute ~4 to 6% of electrical energy which is on account of their lower PLF. Even with 60 to 70% achievement of targeted solar & wind capacity by 2022, the renewable portfolio may account for ~25 to 30% of installed capacity, contributing ~12 to 15% of electrical energy...

Experience of Solar PV cos

As of now the Solar PV companies are able to get their dues nearly on time. First, as the installed capacity is less compared to wind and secondly, being the flavour of the time – what with central govt having full focus on it, no state wants to rock the boat. However, going forward this may not be the case as the proposed huge Solar PV addition to the grid without proper storage has the potential to destabilise the grid. Secondly, the sale rate of power from Solar PV are still higher then the 'Average Price of Pooled Power' (APPC) of most of the state or the prevailing rate for power (Day Ahead Market – DAM) at Energy Exchange. Thirdly, in case of surplus power in the grid, despite 'must flow' status of renewable power, it would make commercial sense to the DISCOMs to back down the power from solar PV, as backing thermal power being sourced through long term PPA would still entail payment of fixed charges, which would be a double whammy for cash starved DISCOMs (as currently being done by some states). Presently, the DISCOMs are not obligated to compensate for loss of revenue to the renewable power in case of back down. This is an irony as the renewable power has the status of 'must flow' and must not be backed down. The proliferation of roof top solar in the cities would further expedite it as it would directly replace the power being supplied by the DISCOMs to creditworthy city users, leading to loss of business to these DISCOMs.

With huge capacities planned in Solar PV, sooner or later many of these power plants would be facing delays in getting sales revenue or worse loss of revenue on account of refusal from DISCOMs to off-take the power on one pretext or other as being faced by other sub-sectors of power viz. coal/gas based, biomass power projects and presently being faced by the wind power projects. As most of these Solar PV plants are financed by lenders on non-recourse basis to the tune of around 60 to 80% of the completed cost, it would in turn erode the capability of the plants to pay their dues to the lenders on time and may become sub-standard. Even if a capacity of around 50 GW to 60 GW is commissioned as against the target of 100 GW, with a 70% debt it would amount approximate debt of Rs 1,900 billion to 2,300 billion (with a per MW cost of ~Rs 5.50 crs), which may stare at becoming stressed.

This would shake the confidence of the investors, which includes many marque names in the Private Equity field. After the sordid fate of investors in the thermal IPPs, a setback in renewable sector would shake the confidence of the investors in the entire Indian power sector for times to come.

Way forward

Power from renewables is inflation free, sustainable, available in abundance and above all carbon free. For a country like India which imports majority of fossil fuel, harnessing the renewables for power would lead to self reliance and saving on foreign exchange. Govt of India has

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rightly stepped up the target of adding power from renewable and due focus is being given in tweaking the policies from time to time to achieve the increased target. States have also realised the importance of renewable and are encouraging its development by facilitating land acquisition and expediting approvals.

Among the renewables, Solar PV is more widespread, modular, scalable with low gestation period and easy to maintain. The disadvantage is its largely infirm nature, which needs to be taken care as not to destabilize the grid and would therefore require storage mechanism. One, for short duration, say for ½ hour to 1 hour to take care of sudden inclement weather and second, for 4 to 6 hours to shift the energy from off peak hours (noon hours) to peak hours (evening and night). As the option currently for such storage is through batteries which would escalate the cost of power from renewables drastically, not much serious thought on this issue has been given by the DISCOMs. In any case most of the DISCOMs in the country are in financial mess and are being bailed out from bankruptcies by the govt from time to time. Though the issue is being discussed at various forums, no concrete plan has emerged till now. There is not much push from regulators or planners also on this account on the apprehension of increase in power tariffs. In some isolated grids like Andaman Island Solar PV is being planned with enough storage to take care of night load, as it would replace the DG power sets which are majorly powering the present power needs of the island. There are reports of 'Central Electricity Authority' (CEA) planning for Pump Storage hydro schemes, a viable option for long term sustainable mass storage for infirm renewable power, it would take anywhere from 5-6 years to 8-10 years before such pump storage hydro projects are commissioned.

As the pace of addition of Solar PV capacity to the grid gathers steam, without storage, the Indian power sector is definitely staring at a catastrophe in the times to come, which would inturn trap the investors as well as create stressed assets for the lenders. It is high time that the planners, policy makers and Regulators ensure that the DISCOMs or for that matter any institution which is inviting solar pv bids e.g. 'Solar Energy Corporation of India' (SECI), NVVN etc, reserve some part of the capacity under bidding with storage. Start with ½ - 1 hours storage and gradually increase it to 4 to 6 hours. Initially there would be a lot of reluctance as this would lead to spike in the bids but ultimately the advantage of grid management and stabilization would override it. With proliferation of storage devices (read batteries as of now) it's cost would come down as it has happened in the case of Solar PV projects. In the long run, hydro power projects – conventional storage or pumped storage including pure pump storage would be a viable and sustainable mass storage in the Indian context, till a new mass storage technology emerges which is both i.e. financially viable and environmentally friendly.

WiE Strides Forward

This year AMEU Women in Electricity (WiE) held its first conference under the theme 'Women Powering Smart Cities'...

The AMEU is an association of municipal electricity distributors as well as national, parastatal, commercial, academic and other organisations that have a direct interest in the electricity supply industry in Southern Africa. AMEU Women in Electricity (WiE) was established on 3rd August 2015. Its aim was to bring together women in the electricity industry to create awareness on the benefit of gender representation beyond transformation compliance, to share progress on WiE initiatives, provide a networking platform to build strong and united partnerships between delegates within the industry and to gather more insights into challenges and needs of women in the industry.

This year AMEU Women in Electricity (WiE) held its first conference under the theme 'Women Powering Smart Cities.' The Women in Electricity initiative was created with the purpose of empowering women in the male dominant electricity industry. Its main aim was to achieve meaningful transformation by identifying the right candidates with the right skills set to tackle current and future challenges in energy management. The conference was instrumental in ensuring that WiE continues to live up to this original aim.

The conference had an excellent attendance of 160 delegates from different areas in the electricity industry, who are all passionate about women issues ranging from competence to confidence. The programme was facilitated by Ms Lungi Mbewu of City Power.

The event was attended by the leadership of AMEU including Sicelo Xulu (Current AMEU President), Sandile Maphumulo (Past President), Ms Sy Gourrah (Past President), Moferefere Tshabalala (President Elect), Vally Padayachee (AMEU Strategic Advisor) and AMEU Exco members.

All in all the conference was graced by a variety of phenomenal speakers. The AMEU Vice President Elect and WiE Chairperson, Mrs Refilwe Mokgosi, welcomed the guests and briefly explained the programme goals. Her speech clearly captured the fact that she is very determinant and positive about the future success of WiE in South Africa as a whole.

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Carbon Credits For Financing Renewable Projects

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It is always useful to recycle the waste material. Recycling process consumes about half of the energy to produce same quantity of products, which would have been otherwise made from the virgin materials...

Carbon credit is the tradable commodity and is equivalent to one ton of carbon dioxide reduced or sink from the atmosphere. There are six greenhouse gases and any of these gases if reduced/avoided/sunk from the atmosphere, carbon credits can be earned. These gases are carbon dioxide, methane, nitrous oxide, per fluoro carbons, hydro fluoro carbon and sulphur hexafluoride. Firms in European Union and in other developed countries are buying the carbon credits – called CER (Carbon Emission Reductions) form the Indian firms.

Carbon Emission Reduction

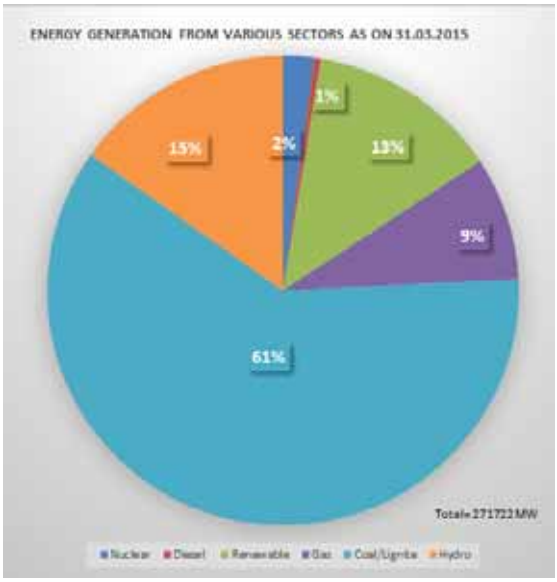
CERs are registered and issued by the Executive Board of Clean Development

Table 1: CDM projects approved in India

Sl. No.	Sector	No. of Projects	No. of CER (Annual)
1	Energy industries (Renewable/Non-renewable sources)	918	71,899,363
2	Manufacturing Industries	47	2,186,074
3	Energy Demand	77	2,729,642
4	Waste handling and disposal	23	2,110,094
5	Metal Production	3	877,754
6	Transport	4	964,777
7	Afforestation and Reforestation	15	1,072,157
8	Fugitive emissions from fuel(Solid, Oil and gas)	2	63,911
9	Chemical Industries	3	320,114
10	Energy Distribution	2	967,681
Total		1094	83,191,566

Reference: http://www.cdmindia.gov.in/

Chart 1



Reference:-http://www.indiaenvironmentportal.org.in/files/file/growth_2015.pdf

Mechanism (CDM) of United Nations Framework Convention on Climate Change (UNFCCC). The Clean Development Mechanism (CDM), defined in Article 12 of the Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO_2, which can be counted towards meeting Kyoto targets.

As of now 1094 CDM projects have been approved in India. Read Table 1 for details.

Ways To Get Carbon Credits

Carbon Credits Potentials Through Solid Waste Management.

Solid waste management practices release high quantities of greenhouse gases in the atmosphere. This sector therefore creates significant opportunities for carbon mitigation, which could eventually become tradable carbon credits. Following procedures can be used to reduce/avoid GHG emissions from the waste materials.

a. Avoidance And Utilization Of Methane From The Landfill Side

Methane (CH_4) constitutes approximately 50% of landfill gases, with the remaining 50% being CO_2 mixed with small quantities of other gases. If these gases are not collected, would escape to the atmosphere causing global warming. Mitigation/abatement option is available to capture and utilize the methane for energy generation.

b. Energy Generation Through The Process Of Pyrolysis Using Waste As A Raw Material

Pyrolysis is a thermo chemical decomposition of organic material at elevated temperatures in the absence of oxygen. It creates combustible gases for further use by using organic waste.

c. Energy Efficiency/ Saving Through Recycling Of The Waste Material

It is always useful to recycle the waste material. Recycling process consumes about half of the energy to produce same quantity of products which would have been otherwise made from the virgin material. As per the Energy Information Administration (EIA) website, a paper mill uses 40% less energy to make paper from recycled material than it does to make paper from fresh lumber.

Greenhouse Gas emissions reduction by recovering metals and materials through Electronic Waste collection and recycling process performed at Attero Recycling Pvt Ltd plant located in Roorkee, Uttarakhand, India. *ANNUAL CER: 4569*

Composting Project at Coimbatore in Tamil Nadu, India. The project activity is to treat 600 Tons Per Day (TPD) of Municipal Solid Waste (MSW) in the city of Coimbatore. *ANNUAL CER: 121376*.

Carbon Credits Potentials Of Solar Power And Wind Power Plant

From the pie chart 1, about 27% of the electricity is generated form thermal power plants and 13% is form renewable sources. Solar PV projects and Wind power plants are economic friendly and electricity is produced with less emission of Greenhouse gases. Solar or Wind power is used to inject power to the grid, this can replace the power generated from the conventional energy sources thereby reducing the carbon dioxide emissions. Such projects can earn carbon credits in the form of CDM projects.

24 MW Wind Energy based Power Generation in Theni, Tamil Nadu. *ANNUAL CER: 48089*.

Grid Connected Solar PV Project by M/s. D. J. Malpani in Rajasthan. *ANNUAL CER: 21209*.

Carbon Credit Potential From Other Sources

a. Uisng Biogas/Improved Cooking Stoves

Distribution of improved cooking stoves in the villages of Maharastra: The project activity plans to disseminate the improved cook stoves over a period of time amongst BPL and ST household in rural areas and includes 14250 numbers of cook stoves disseminated amongst the rural households who has signed tripartite agreement from 19 districts of Konkan, Nashik and Pune division in Maharashtra. *ANNUAL CER: 14234*

Mahasakthi Women Cooperative Federation is a Community Based Organisation (CBO) and is an apex federation of four Mutually Aided Thrift Cooperative Societies of women. The Federation is registered as Mahasakthi MAC Samakya Ltd. The purpose of the project activity is to set up 6,000 biogas plants (digesters) of 2 m^3 capacity each for single households having minimum of two cows and place to build biogas digester in 4 Mandals of Anantapur district where the CBOs is working, and in this way replace Non-Renewable Biomass with biogas for cooking and heating water. This will contribute strongly to sustainable development of the rural households involved in the project. A biogas plant of 2 m^3 capacity is sufficient to provide cooking fuel to a family of four to five. Each household will install a 2 m^3 biogas plant and feed cattle dung, into the anaerobic digester. The technology is tried and tested in India, and has been in use for many years. By utilizing cattle dung in a controlled anaerobic digestion and combustion system, biogas will be available for cooking energy and heat water for bath. Biogas will be used on a two-ring gas stove having 4" burner with a flame temperature of 870°C, supplied as part of the project activity. The biogas slurry will be used as bio-manure. Implementation of the project depends on the successful validation and registration of the project as a CDM project activity since the project will be financed completely from carbon revenues. After the project is registered as a CDM activity, carbon forward funding will enable the construction of domestic bio-digesters. An end user agreement

will be signed between the NGO SUCHI and the end user after construction, wherein the end user is aware of emission reductions from the use of biogas, and are willing to give up their rights and transfer the credit ownership to Mahasakthi Federation. *ANNUAL CER: 14570*

b. Using Zero Emission Water Purification/ Air Purification Method

Zero Energy Water Purifier CDM Project in India by Hindustan Unilever Limited: The project activity involves the sale of the zero energy water purifier, Pureit and its cleaning kits (Germ kill Processor) in India. The project activity results in the avoidance of the usage of conventional, energy intensive methods of water purification such as boiling or other thermal or electrical means for obtaining safe drinking water. Thus, the project activity contributes to the reduction in the GHG gas emissions due to conventional methods of water purification and also provides safe drinking water to the consumers of India at an affordable, subsidized price. *ANNUAL CER: 1294678.*

c. Using Waste Heat Recovery Mechanism

Waste heat recovery from Circular cooler of Sinter Machine-3 of Rashtriya Ispat Nigam Limited in Visakapatanam, Andhra Pradesh: The project involves utilization of waste heat energy of hot sinter cooler gases. The hot gases coming out of sinter circular cooler will be recovered partially for use as process heat directly into sinter machine extended hood. The hot gases at 275°C are sucked by hot air fan, will be deducted in one multi cyclones to dust content of 200 mg/cum and will be supplied to extended hood at the rate of 315000 cum/hr. Further, hot gases are also supplied to ignition furnace. By supplying hot gases at 275°C as direct heat to sintering. The solid fuel (coke) requirement at sinter machine will be reduced accordingly. *ANNUAL CER: 37047*.

d. From Agricultural Lands

Improvement in Energy Efficiency through Micro-Irrigation Systems (MIS) in cultivation of Banana Crop in Jalgaon, Dhule Nadurbar and Nashik districts, Maharastra State, India: The purpose of the project activity is reduction of carbon dioxide emissions associated with grid electricity consumption for pumping of water from bore wells/open wells for cultivation of banana crop. The proposed project will replace Flood Method of Irrigation (FMI) with Micro Irrigation Systems (MIS) that will reduce electricity consumption required for pumping of water. MIS comprises of Drip Method of Irrigation (DMI) that delivers water directly to the root zone of crops resulting in better water use efficiency. MIS reduces working hours in delivering water – and thus reduces the consumption of electricity. MIS also is stated to increase productivity and quality of agriculture product. The project offers a range of other environmental and social benefits. *ANNUAL CER: 20448*.

e. From Oil & Gas Industries

Gas Flaring Reduction Project at GGS, Chariali, Sibasagar, ONGC, Assam: Oil and Natural Gas Corporation Limited (ONGC) is one of the largest oil and gas producer of India, engaged mainly in exploration and production of crude oil, natural gas and other value added products. The proposed CDM Project activity includes the installation of 2 gas compressors that recovers the natural gas otherwise being flared during the production and processing at the onshore platform. The project activity involves recovery of the natural gas being hitherto flared through capture and compression and putting it back to the production downstream. The process will lead to the "avoidance of gas flaring" and thereby protecting the environment. The recovery of the gas by compressing it back into the system would be achieved by installation of reciprocating gas compressor installation of pipeline network for drawing flared gas from the flare header to the compressor and from the compressor to the trunk pipeline for further processing. The project activity will thus recover and utilise about 12,266 scmd of natural gas. *ANNUAL CER: 7511*.

> Solid waste management practices release high quantities of greenhouse gases in the atmosphere. This sector therefore creates significant opportunities for carbon mitigation, which could eventually become tradable carbon credits...

f. With Green Building

Green Building at Kolkata: ONGC Limited new office building at New town area of Rajarhat in Kolkata is built with a consideration towards sustainable development, and to minimize the environmental impact due to the building construction and operation activity, ONGC Limited has decided to follow the New Construction (NC) standards under Indian Green Building Council - Leadership in Energy and Environmental Design (IGBC- LEED) Green Building Rating System. The building is being constructed as per the of the Platinum Rating standards & this is in spite of the fact that following the design standards for platinum rating significantly increases the capital cost of the building when compared to the cost of the building which would have been constructed otherwise. The benefit of the savings due to the reduction in energy consumption does not often adequate return on the incremental capital cost of the buildings. Thus, ONGC has decided to implement the project as CDM project. The proposed CDM project activity will assist the sustainable growth of West Bengal state by reducing the dependence on fossil fuel intensive power from Northern, Eastern, Western and North Eastern (NEWNE) grid. *ANNUAL CER: 1756*.

g. Using Energy Efficient Lighting

Uttar Pradesh Lighting Energy Efficiency Project (ULEEP) in EDD I ALLAHABAD & EDD Kaushambhi & Fatehpur Divisions of Allahabad Zone, Uttar Pradesh, India: The purpose of this project is to distribute New self-ballasted Compact Florescent Lamps (CFLs), at a price comparable to that of Incandescent Lamp (ICL), to domestic consumers of EDD Allahabad and EDD Kaushambhi, Fatehpur divisions of Allahabad Zone of Purvanchal Vidyut Vitaran Nigam Limited (PUVVNL) in Allahabad District, Uttar Pradesh India. This project targets to discount & distribute approximately 255,791 New CFLs to the eligible consumers in the project area. The CFL would be distributed in exchange of a less energy efficient (i.e., higher wattage, equivalent luminosity) Incandescent Lamps (ICL). New CFLs will be distributed only to registered consumers of the PUVVNL who return operating ICLs in equal numbers. The ICLs will be collected and destroyed so as to ensure these less efficient ICLs are not used elsewhere. *ANNUAL CER: 50952*.

Reference for CDM projects: http://www.cdmindia.gov.in/

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"Sustainable energy is the bedrock of sustainable development..."

The **World institute of Sustainable Energy (WISE)** is a not-for-profit institute established in 2004 in Pune, India, committed to the cause of **promoting sustainable energy and sustainable development**, with specific emphasis on issues related to **renewable energy**, **energy security**, **energy efficiency**, and **climate change**. In an exclusive interview with **Electrical India**, **G. M. Pillai, I.A.S., Founder Director General, WISE (Pune)**, is detailing their activities to **PK Chatterjee**. Excerpts...

Do you think now India is harnessing Renewable Energy (RE) at right pace?

The present Central Government has announced a massive increase in RE targets – 175 GW by 2022 and 40% of electricity from RE by 2030. That is a great step in the right direction. Against this, our current achievement is 42 GW, as on 31st March 2016. In order to achieve the new targets, many actions e.g., payment security to generating companies, technology upgradation, establishing a robust solar manufacturing sector, low interest debt to RE projects, uniform and forward looking RE policies across states etc., need to be put in place. Most importantly, at the state level and among the public, there is still no realization that RE is the energy source of the future and it's phased development is critical to establish an alternative energy system, by the time fossil fuel extraction peaks, decline and eventually deplete completely. I am sure the central government is seized of these issues and will evolve positive solutions.

Which form of renewable energy (solar or wind) is most suitable for our country in general, and why?

In a post-fossil fuel world – expected to be a reality by mid-21st century – we would need to tap all forms of renewable energy including 'eco-scale' and 'human-scale' hydropower. So it is unfair to declare one form of renewable energy as most suited to our country. However, in terms of universal and ubiquitous availability, abundance of the resource and the potential for diversity of applications different forms of solar energy (PV and thermal) would be the single most important renewable energy source not just for India, but for the world. Solar energy can be deployed for wide-ranging electrical, thermal and energy substitution applications. It is suitable for industrial process heat, water desalination and numerous such other applications. Such a ubiquitous source of energy is certainly superior to other kinds of RE. Let us not forget, that the world runs on solar energy. You just need to look at the MNRE assessed potential for RE in India, to appreciate this. Wind energy potential in the country is a little above one lakh megawatts. Whereas, solar energy potential is over seven lakh megawatts. Wind can increase its potential through new technologies and by foraying into new areas like offshore wind for which considerable potential exists in India. WISE, as part of EU supported global consortium is involved in studying the offshore wind potential in India. Although offshore wind is currently expensive, its price has fallen by half in Europe during the past three years. We can expect offshore wind to be commercially viable by 2020 in India also.

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What is the latest cost comparison (per kW wise) between solar and wind projects?

The latest per kWh cost of solar energy discovered through competitive processes, is down to around Rs.4.63 and is now comparable to the cost of wind power. This has happened mainly because solar power has gone through a price discovery process through competitive bidding since 2012, in India. Another contributory factor has been China's entry into the sector in a big way, toppling the technology monopoly of some western manufacturers. Wind Power, historically has not been subjected to this competitive process in India and has enjoyed a sheltered existence under the Feed-in-Tariff regime established by regulators. However, even the regulators do not have clear data on cost of production of the wind turbine or its O&M. This cost discovery is essential to ensure transparency, for increasing profitability to investors and ensuring grid parity of wind, without subsidy props, in the future. The wind industry claims to have developed more efficient technology for low-wind regimes like those in India. However, the cost of turbines, on a per megawatt basis, has seen a historical increase. The gains from decline in commodity prices (like steel etc.,) in the global market should have been passed on to investors, since wind is a heavily material intensive technology. In fact, material intensity is the Achilles heel of wind power. An average turbine of 1 MW size needs about 130 tons of material. The decline in commodity prices is a temporary phenomenon linked to low crude oil prices. When oil prices go up in the not-too-distant future, material prices will also go up. So, I foresee the possibility of solar power overtaking wind in the future. However, it is a game of the market and hence is not exactly predictable.

Are we really focused on small scale multiple projects or still looking at a few big projects? What is the threshold in this field?

The architecture of the power sector and especially the grid, will undergo huge transformations in a R.E. dominated power sector of the future. Basically, an RE dominated power system is supposed to be distributed and decentralized. However, the geographic reality of India is such that a lot of grid-friendly solar power (both PV and thermal) for example, is sitting in our desert areas in Gujarat and Rajasthan. So, mega project development would become a geo-strategic necessity to feed the grid supplying power to our industrial and urban areas, where in-situ RE generation in large quantities will not be possible. For example, the roof area of a high-rise multistoreyed building will not be sufficient to produce enough solar power necessary for the entire building. However, mega project development can face constraints relating to logistics, environmental concerns and availability of resources like water for cleaning up solar panels in desert areas. In the case of wind power, since windy sites are in specified areas of concentrated resource zones, whether the investor invests in one turbine or hundred turbines is immaterial because all turbines would be bunched together in the wind resource zone. So, in practice, most wind power generating zones would be 'mega' zones only. However, in the interior and rural areas, it would make sense to go for a decentralized architecture of mini-micro or islanded local grids by hybridizing different RE technologies. But the right kind of configuration with base load power, electricity storage, demand management and dispatch management systems would become necessary to ensure 24/7 power. It is difficult to bet on any threshold in this regard. It will be a natural evolution resulting from technology development, the market and choices people make.

What is WISE's contribution in the country's targets for achieving 15% renewable energy by 2020?

WISE was the first institution to come out with a detailed analysis of what needs to be done to achieve the 15% target, in a study supported by Shakti Sustainable Energy Foundation. We had indicated technology-wise required installation capacities, based on analysis of capacity factors etc., and projected required annual growth rates. Other policy measures required to be put in place were also indicated. The report was presented in a seminar in Delhi attended by the then Member (Energy) of the former Planning Commission. The report was also widely circulated to all stake holders in the country. We have also contributed through skill upgradation programmes, knowledge outreach to the RE industry, consultancy support to government, regulators and the RE industry. Being a research, knowledge and outreach institution, this is our role and we will continue to support the efforts of RE development in the country.

What kind of momentum have you successfully generated at the state level (Maharashtra)?

WISE is not a state level institution, even though we are located in Pune. We are active in about 14 states in the country. However, through a project supported by Shakti Foundation, when the recent RE policy of Maharashtra came out, we mounted an analysis of the policy and held seminars to propagate the findings. We also submitted our findings to the Maharashtra government, who thereafter decided to review the policy. Besides, we prepared a DPR for a canal-top solar power pilot project in Maharashtra and completed a study pointing out the potential of repowering of old wind power projects in Maharashtra. All findings and DPRs etc., have been submitted to the Maharashtra Energy Development Agency.

What kind of training programmes does WISE conduct?

WISE has over the years, trained over 4100 personnel from the RE industry and government. Our training programmes cover all cutting edge areas in the RE sector including wind power, wind resource assessment, offshore wind, solar PV and thermal power, renewable policy/ regulation and climate change mitigation. Besides, we also undertake broad spectrum training in areas of sustainable development.

What is your contribution in developing national policies on sustainable power generation?

RE policy development has been our forte. We have helped many state governments and electricity regulators in framing RE policy and regulation. Some of the states where we have been particularly active are Kerala, Karnataka, Andhra, Tamil Nadu, Maharashtra, Gujarat, Orissa and Bihar. We also provide inputs to MNRE in national policy development. Earlier, we have critiqued the Integrated Energy Policy of the Planning Commission and provided inputs for its revision. Currently we are working in Orissa to support OERC in developing a mini-micro-grid policy for the state – again an initiative supported by Shakti Foundation. Besides, as the entire country knows, WISE pioneered the concept of an RE Law for India way back in 2005 by drafting a Model RE law and articulating its advocacy through seminars and directly approaching law makers in the country. We continue to contribute in this area. We were involved in the committee appointed recently by the MNRE to draft a RE Bill for India, as per decision of the current Central Government. We believe, an overarching national legal and policy framework like an RE law will go a long way in achieving our national goals in a time-bound manner.

Please tell me something about WISE's global activities

WISE's focus has always been to undertake RE development initiatives in India. However, at the global level, we have done work in Indonesia and Lao PDR to support their governments in RE policy development. We have also trained personnel from West Asia and Africa on aspects of RE development. Besides, we have been involved in DPR preparation for solar energy projects in the Arab Gulf region. Currently, we are also a partner in a global consortium undertaking preparatory studies for offshore wind power development in India – especially in the state of Gujarat – in a project titled FOWIND, supported by the European Union.

What is your message to the nation on sustainable development?

Sustainable development is our only hope to preserve civilization and modernity in a post-fossil fuel world. Sustainable energy is the bedrock of sustainable development. Being a country of continental size, we are fortunate to be blessed with large resources of sustainable energy. As is normal, our society is neck deep into discussing contemporary problems and in the process forget to develop a national discourse on the vital issues of the future. As a nation, we need to seriously debate our future and the ways and strategies to ensure sustainability of development in a post-fossil fuel era. We need to recognize that economy is a subsystem of the ecosphere. The current energy profligacy is a boon of millions of years of solar energy stored in fossil fuels – or 'a gift of ancient sunlight' as one author called it. Fossil fuels are finite and will be extinguished one day about which there is a scientific consensus – the dispute is only about the date of such 'peaking' and depletion. My learning tells me that we will have serious fossil fuel crisis by 2050. Hence, the importance of a planned transition in the next 30 years to an alternative energy system and a development model predicated on accepting the limits of nature and a finite planet. This transition needs to be very carefully and meticulously planned to avoid sudden disruptions, collapse or unrest. Then only we can ensure sustainability of development. It is in our national interest to articulate a serious discourse on this issue.

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Future Perspective For Renewable Energy In India

Jay B. Thakar
Entrepreneur
Solar Energy Sector & Electrical Contracting Business

Power is one of the most critical components of infrastructure crucial for the economic growth and welfare of nations. The existence and development of adequate infrastructure is essential for sustained growth of the Indian economy. Currently, the power sector is at a crucial juncture of its evolution, with many private producers and domestic manufacturers also playing a significant role in various capacities, and greater reliance on markets, subject to regulation. Developers of Power Plants have been facing numerous constraints like coal/gas allocation, environment clearance, land acquisition, financing and funds tie-ups, etc. for last about 4 years. This has resulted in only very few new projects coming up.

Present Electricity Scenario

India's generation capacity will have to increase up to seven times the present figure to meet our growth needs. The major part of our energy mix consists of fossil fuels. They are finite sources and have serious environmental consequences. In times of depleting resources and climate threats, the best way forward for India is to take the dual path of energy efficiency and renewable power generation like wind power generation and solar electricity generation. It is imperative to tap into these huge renewable power sources and judiciously utilize the non-renewable resources, keeping energy conservation in mind.

To achieve this, the renewable energy programme is investing in supporting mechanisms that strengthen the call for clean and renewable energy policies through advocacy and awareness building and creating a supportive renewable energy implementation environment. Its activities are also aimed at helping compliance with evolving renewable energy deployment targets; and building supportive policy evidence through research around grid as well as off-grid business models.

> The power generation shortfall in India is estimated at 11% of the total energy, and 15% of the peak capacity requirements and these figures are likely to increase. This is despite the fact that the country is already consuming more than 2 million barrels of imported oil a day – a figure that is growing by about 10 percent annually...

Power Sector At A Glance All India

Total Installed Capacity: (As on 30.09.2016)

Sector	MW	% of Total
State Sector	102,090	33.32%
Central Sector	76,312	24.91%
Private Sector	127,956	41.77%
Total	306,358	

Fuel		MW	% of Total
Total Thermal		213,229	69.60%
Total Thermal	Coal	187,253	61.12%
	Gas	25,057	8.18%
	Oil	919	0.30%
Hydro (Renewable)		43,112	14.1%
Nuclear		5,780	1.9%
RES** (MNRE)		44,237	14.5%
Total		306,358	100.00%

Environmental Effects Of Fossiel Fuel Based Power Plants

- **Varying Impacts**
  Power companies use a variety of processes to create electricity, and not all processes affect the environment in the same way. For example, coal is a much more environmentally problematic source of energy than solar power, which has minimal environmental effects. Other forms of electricity generation include natural gas, hydroelectric power plants, nuclear energy and oil.
- **Greenhouse Gases**
  Most mechanisms for generating electricity release carbon dioxide and other greenhouse gases – gases that absorb and emit radiation – into Earth's atmosphere. While small quantities of carbon dioxide exist naturally in the atmosphere, the generation of electricity has greatly increased the presence of greenhouse gases in the planet's atmosphere. The overwhelming majority of scientists believe that this contributes to an unnatural degree of global warming that has the potential to affect the global climate, destroy animal populations and change local ecosystems.
- **Pollution and Acid Rain**
  Almost all forms of electricity generate waste. For example, natural gas releases carbon dioxide and nitrogen oxide. Earth's atmosphere traps these gases, leading to air pollution and smog. Weather patterns and geological variations can affect the prevalence of smog in a particular area. For example, a valley trapped between hills with little wind might trap a pocket of smog. When smog containing sulfur dioxide and nitrogen oxide is released into the atmosphere, it can contaminate precipitation and rain back down as acid rain.
- **Waste Disposal Challenges**
  Almost all forms of electricity generation produce some waste, but energy sources such as nuclear energy produce dangerous solid wastes. Some sources of radioactive waste remain radioactive for thousands of years, which means the waste can cause cancer and genetic mutations in humans and animals. Radioactive waste may alter the soil's chemical composition, making it unsafe for local wildlife and potentially killing off plant species. Burning coal produces a type of solid waste called ash, which is frequently deposited in landfills, contributing to landfill overfill. The Environmental Protection Agency says it is possible to recycle this material into cement and other useful products, and some coal manufacturers recycle their waste.
- **Injuries to Wildlife**
  Both the generation and delivery of electricity can harm local wildlife. Birds may fly into power lines, resulting in electrocution. Wind farms endanger flying animals such as bats and birds. No power generation system can be perfect, and power plant accidents can also injure animals. For example, a 2009 study found that the Chernobyl nuclear disaster resulted in lower animal populations even 20 years after the disaster.

Renewable Energy In India

India was the first country in the world to set up a ministry of non-conventional energy resources, in early 1980s. Renewable energy in India comes under the purview of the Ministry of New and Renewable Energy (MNRE). Newer renewable electricity sources are targeted to grow massively by 2022, including a more than doubling of India's large wind power capacity and an almost 15 fold increase in solar power from April 2016 levels. Such ambitious targets would place India amongst the world leaders in renewable energy use and place India at the center of its International Solar Alliance project promoting the growth and development of solar power internationally to over 120 countries.

As of 30th April 2016 India's cumulative grid interactive or grid tied renewable energy capacity (excluding large hydro) reached about 42.85 GW, surpassing the installed capacity of large scale hydroelectric power in India for the first time in Indian history. 63% of the renewable power came from wind, while solar contributed nearly 16%. Large hydro installed capacity was 42.78 GW as of 30 April 2016 and is administered separately by the Ministry of Power and not included in MNRE targets.

From 2015 onwards, the MNRE began laying down actionable plans for the renewable energy sector under its ambit to make a quantum jump, building on strong foundations already established in the country. MNRE renewable electrictricity targets have been upscaled to grow from just under 43 GW in April 2016 to 175 GW by the year 2022, including 100 GW from solar power, 60 GW from wind power, 10 GW from bio power and 5 GW from small hydro power. The ambitious targets would see India quickly

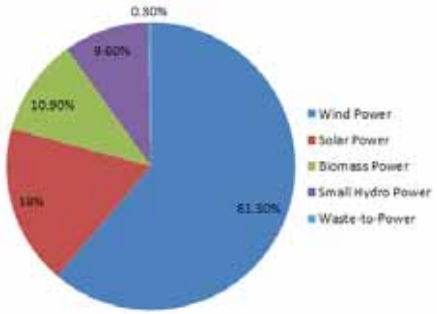
Table 1: Installed Grid Interactive Renewable Power Capacity in India as of July 31, 2016 (RES MNRE)

Source	Total Installed Capacity (MW)	2022 target (MW)
Wind Power	27,441.15	60,000.00
Solar Power	8,062.00	100,000.00
Biomass Power (Biomass & Gasification and Bagasse Cogeneration)	4,860.83	*10,000.00
Waste-to-Power	115.08	
Small Hydro Power	4,304.27	5,000.00
Total	44,783.33	175,000.00

becoming one of the leading green energy producers in the world and surpassing numerous developed countries. The government intends to achieve 40% cumulative electric power capacity from non-fossil fuel sources by 2030.

Renewable Energy Overview And Targets

Installed Grid Interactive Renewable Power Capacity in India as of July 31, 2016 (RES MNRE)



- Wind Power: 27,441.15 MW (61.3%)
- Solar Power: 8,062 MW (18.0%)
- Biomass Power: 4,860.83 MW (10.9%)
- Small Hydro Power: 4,304.27 MW (9.6%)
- Waste-to-Power: 115.08 MW (0.3%)

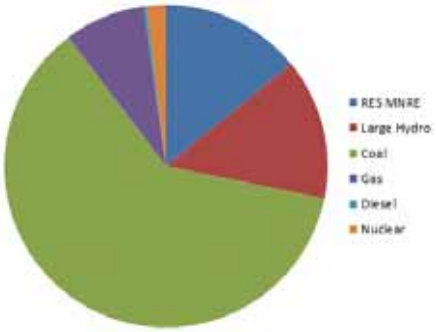
Grid Connected Renewable Electricity

The table 1 refers to newer and fast developing renewable energy sources, and are managed by the Ministry for New and Renewable Energy (MNRE). In addition, as of April 30th 2016, India had 42,783 MW of installed large hydro capacity, which comes under the ambit of Ministry of Power.

In terms of renewable energy sources under the responsibility of the Ministry of New and Renewable Energy by April 2016, wind power was the leading source of renewable power with 26.9 GW installed capacity, almost two thirds of the total renewable power installed capacity. Next came solar power with 6.8 GW installed capacity and biomass power with 4.8 GW accounting for 15.8% and 11.3% of the total renewable power installed capacity. Small hydro power accounted for 4.3 GW and waste-to-power accounted for just over 0.1 GW installed capacity. Total installed renewable power capacity in this category was just under 43 GW by April 2016.

In terms of meeting its ambitious 2022 targets, as of April 30, 2016, wind power was almost half way towards its goal, whilst solar power was below 7% of its highly ambitious target, although expansion is expected to be dramatic in the near future. Bio energy was also at just under half way towards its target whilst small hydro.

Installed Grid Power Capacity All Source In India As Of April 30, 2016



- RES MNRE: 42,849.38 MW (14.1%)
- Large Hydro: 42,783.42 MW (14.1%)
- Coal: 185,992.88 MW (61.4%)
- Gas: 24,508.63 MW (8.1%)
- Diesel: 918.89 MW (0.3%)
- Nuclear: 5,780 MW (1.9%)

Power was already 85% of the way to meeting its target. Overall India was 24.5% towards meeting its final 2022 renewable power installed power capacity of 175 GW. The total breakdown of installed grid connected capacity from all sources including large hydro was as follows:

Grid connected installed capacity from all sources as of April 30, 2016

Source	Installed Capacity (MW)
RES MNRE	42,849.38
Large Hydro	42,783.42
Coal	185,992.88
Gas	24,508.63
Diesel	918.89
Nuclear	5,780.00
Total	302,833.20

The first figure at the top of the table refers to the fast growing renewable energy sources under the responsibility of the Ministry for New and Renewable Energy and slightly exceeded the installed capacity of large hydro installations. This figure is targeted to reach 175 GW by 2022. Coal power currently represents the largest share of installed capacity at just under 186 GW. Total installed capacity as of April 30, 2016, for grid connected power in India stood at a little under 303 GW.

India's Renewable Energy Potential Remains Untapped

India has tremendous energy needs and an increasing difficulty in meeting those needs through traditional means of power generation. On July 30th and 31st, 2012 the world's largest blackout. The Great Indian Outage, stretching from New Delhi to Kolkata occurred. This blackout, due to failure of the northern power grid, caused nearly 700 million people – twice the population of the United States – to be without electricity.

A grid failure of such magnitude has thrown light onto India's massive demand for electricity, together with its struggle to generate as much power as it needs. India is aiming to expand its power-generation capacity by 44 percent over the next five years but recent problems indicate the scale of the challenge. Even before the blackout, in June of 2012, the country's power

Precision DC Calibrator : 2553A

Key Features :

- High basic accuracy
  * DC Voltage: ±75 ppm DC Current: ±120 ppm
- High stability and low noise
  * Stability: ±15 ppm/h Noise: 2 µVrms
- High resolution
  5.5 digits ±120000 count output resolution

AC Voltage Current Standard : 2558A

Key Features :

- High accuracy AC voltage:
  ±0.04% AC current: ±0.05%
- High stability AC voltage/current: ±50 ppm/h
- Wide generation range
  AC voltage: 1.00 mV to 1200.0 V
  AC current: 1.00 mA to 60.00 A
- Wide frequency range
  40 to 1000 Hz (Frequency accuracy: ±50 ppm)

Precision DC Calibrator : 2560A

Key Features :

- High accuracy : DC voltage:±50 ppm, DC current: ±70 ppm
  At 1 V and 1 mA range, for 180 days, 10 ppm = 0.001%
- High stability : DC voltage: ±10 ppm/h, DC current: ±20 ppm/h
  At 1 V and 1 mA range
- High resolution : 5.5 digits, ±120000 count display
  6.5 digits, ±1200000 count display*
  *In the high resolution mode
- Wide output range : DC voltage: −1224.00 V to +1224.00 V
  DC current: −12.2400 A to +36.720

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generation fell short by 5.8 percent when confronted with a peak-hour demand of 128 GW, according to Government data.

Electricity consumption in India has been increasing at one of the fastest rates in the world due to population growth and economic development. India's economy faces increasing challenges because energy supply is struggling to keep pace with demand, and there are energy shortages (as much as 15 percent daily) almost everywhere in the country. Such chronic lack of energy and unreliable supplies threaten India's economic growth.

For economic as well as environmental reasons India needs to shift to non-polluting renewable sources of energy to meet future demand for electricity. Renewable energy is the most attractive investment because it will provide long-term economic growth for India. Renewable energy also has the advantage of allowing decentralized distribution of energy – particularly for meeting rural energy needs, and thereby empowering people at the grass roots level. Solar electricity could also shift about 90 percent of daily trip mileage from petroleum to electricity by encouraging increased use of plug-in hybrid cars. For drivers in India this means that the cost per mile could be reduced by a quarter in today's prices.

India does not have an overarching energy strategy – instead it has a number of disparate policies. Rather than promoting an overarching energy strategy, to date India has developed a cluster of energy business models and policies that have not been productive. These policies are definitely affecting renewable energy expansion plans. The present business model needs to be changed from a centralized to a decentralized structure that allows all stakeholders including capital investment coming from state-owned investors, pension funds, and foreign countries.

Can Renewable Energy Work For India?

Solar is the prime free source of inexhaustible energy available to all. And, India is one of the sun's most favored nations, blessed with about 5,000 TWh of solar insolation every year. Even if a tenth of this potential was utilized, it could mark the end of India's power problems – by using the country's deserts and farm land to construct solar plants. Renewable energy has the potential to re-energize India's economy by creating millions of new jobs, allowing the country to achieve energy independence, reduce its trade deficits and propel it forward as a "Green Nation." In short, renewable energy offers too many benefits for India to ignore, or delay its development.

India should take full advantage of this golden opportunity because renewable energy has particular relevance in remote and rural areas, where there are around 289 million people who don't have access to reliable sources of energy. Solar energy is the most cost-effective option for India to reduce energy poverty without having to extend national grid services to provide power for individual homes and buildings.

India's present generation capacity is about 200,000 MW. The country could potentially increase grid-connected solar power generation capacity to over 200,000 MW and wind energy to over 100,000 MW by 2030 if the right resources (and more importantly, energy policies) were developed. India can develop massive commercial wind farms to harness the strong onshore costal area and offshore wind to boost the country's supply of clean renewable energy. But, to tap this vast resource, India must develop and implement smart business models and favorable policies as quickly as possible.

Future Perspectives For Renewable Energy In India

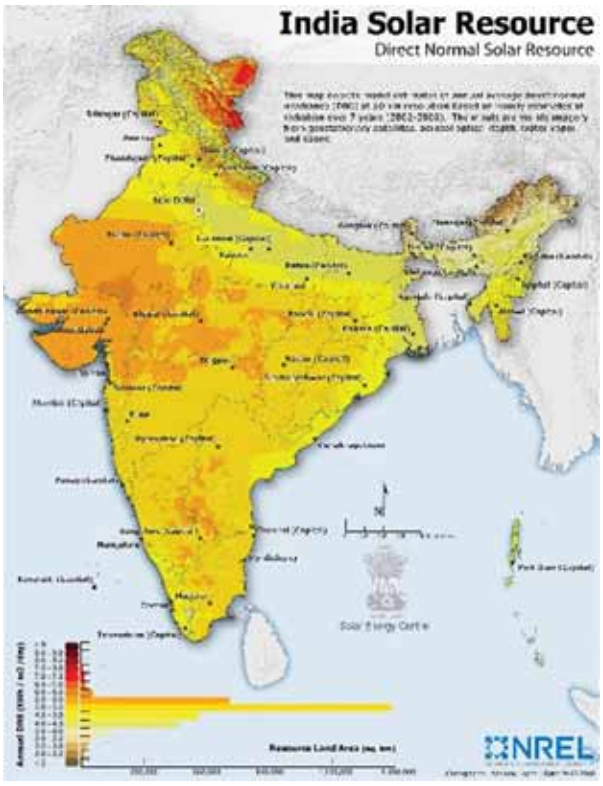
India is facing an acute energy scarcity which is hampering its industrial growth and economic progress. Setting up of new power plants is inevitably dependent on import of highly volatile fossil fuels. Thus, it is essential to tackle the energy crisis through judicious utilization of abundant the renewable energy resources, such as biomass energy, solar energy, wind energy and geothermal energy. Apart from augmenting the energy supply, renewable resources will help India in mitigating climate change. India is heavily dependent on fossil fuels for its energy needs. Most of the power generation is carried out by coal and mineral oil-based power plants which contribute heavily to greenhouse gases emission.

The average per capita consumption of energy in India is around 500 W, which is much lower than that of developed countries like USA, Europe, Australia, Japan etc. However, this figure is expected to rise sharply due to high economic growth and rapid industrialization. The consumption of electricity is growing on the worldwide basis. Energy is a necessity and sustainable renewable energy is a vital link in industrialization and development of India. A transition from conventional energy systems to those based on renewable resources is necessary to meet the ever-increasing demand for energy and to address environmental concerns.

A Glance At Renewable Energy Sources In India

Solar Energy

Solar power, a clean renewable resource with zero emission, has got tremendous potential of energy which can be harnessed using a variety of devices. With recent developments, solar energy systems are easily available for industrial and

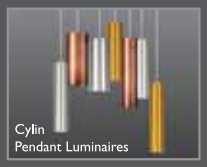


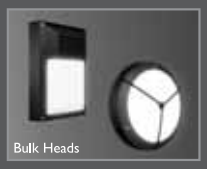
India's Lighting Company

Interior Luminaires

Landscape Luminaires

Environmental Luminaires





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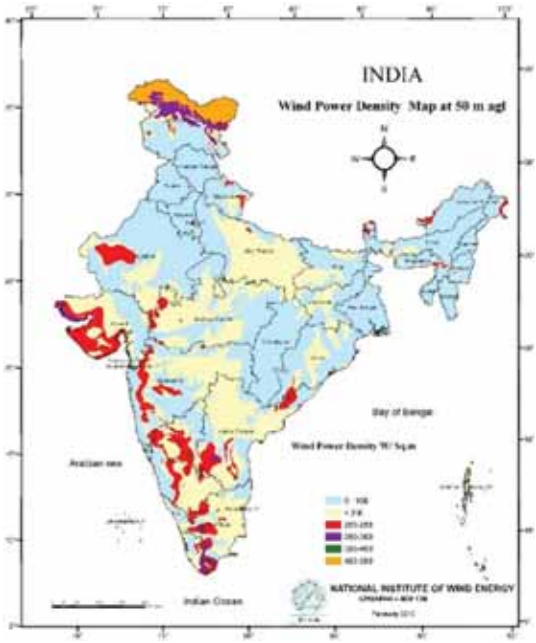
domestic use with the added advantage of minimum maintenance. Solar energy could be made financially viable with government tax incentives and rebates.

An exclusive solar generation system of capacity of 250 to kWh units per month would cost around Rs. 5 Lacs, with present pricing and taxes. Most of the developed countries are switching over to solar energy as one of the prime renewable energy source. The current architectural designs make provision for photovoltaic cells and necessary circuitry while making building plans.

Wind Energy

Wind power is one of the most efficient alternative energy sources. There has been good deal of development in wind turbine technology over the last decade with many new companies joining the fray. Wind turbines have become larger, efficiencies and availabilities have improved and wind farm concept has become popular. It could be combined with solar, especially for a total self-sustainability project.

The economics of wind energy is already strong, despite the relative immaturity of the industry. The downward trend in wind energy costs is predicted to continue. As the world market in wind turbines continues to boom, wind turbine prices will continue to fall. India now ranks as a 'wind superpower' having a net potential of about 45,000 MW only from 13 identified states.



Hydro Electric Power

India has a huge hydro power potential, out of which around 20 % has been realized so far. New hydro projects are facing serious resistance from environmentalists. Resettlement of the displaced people with their lands becomes major issue.

Biomass Energy

Biomass energy can play a major role in reducing India's reliance on fossil fuels by making use of thermo-chemical conversion technologies. In addition, the increased utilization of biomass-based fuels will be instrumental in safeguarding the environment, creating new job opportunities, sustainable development and health improvements in rural areas. Biomass energy could also aid in modernizing the agricultural economy. A large amount of energy is expended in the cultivation and processing of crops like sugarcane, food grains, vegetables and fruits which can be recovered by utilizing energy-rich residues for energy production. The integration of biomass-fuelled gasifies and coal-fired energy generation would be advantageous in terms of improved flexibility in response to fluctuations in biomass availability with lower investment costs.

Proposed Guidelines for Power Consumers in India

- Explore all possibilities to set-up an independent power plant making use of renewable resources like solar, wind and biomass.
- Use of government / utility electricity supply, only in case of emergency.
- Energy savings by using low wattage / high luminous lamps (LED).
- Use of power factor improves.
- Regular maintenance and servicing of electrical equipments.
- Avoidance of inverters and large storage batteries (except emergency).
- Intelligent power factor correctors to minimize energy losses in capacitor at lower load conditions.
- Frequent energy audits

Proposed Guidelines for Policy Makers in India

- Vigorous promotion of renewable energy by government agencies, corporate, public sector, academic institutions etc.
- Establishment of national-level body to increase awareness of renewable energy at grass-root level
- Financial support and sponsorship for research and development in renewable energy technologies.
- Ambitious goals and targets for power generation non-conventional sources.
- Installation of solar / wind / biomass power generation systems and energy saving in every government office to encourage and inspire people.
- Restriction on using large battery energy storage systems.
- Compulsory installation of solar water heating systems for all urban residential and commercial establishments.
- Mandatory renewable energy systems provision for new residential, commercial and industrial buildings.
- Attractive incentives and subsidies for installation and successful operation of renewable energy equipment.
- Abolishing duties / taxes on import of small-scale renewable energy generating equipment
- Cultivation of energy crops on marginal and degraded land
- Use of biofuels in vehicles.
- Soft loans for setting up renewable energy enterprises.
- Additional incentives for buyers and manufacturers of renewable energy equipments in rural areas.

Guidelines for Research Professionals

- Development of comprehensive educational and awareness modules for renewable energy systems.
- Development of cost-effective, high-efficiency and long-lasting photovoltaic cells.
- Development of high efficiency wind turbines, ranging from 300 W – 10 kW, to generate energy even at low wind velocity.
- Development of small-scale, low maintenance biomass gasifiers to make use of abundant biomass resources in rural areas for cogeneration

Benefits Of Renewable Energy

Renewable energy resources, such as wind and solar energy, are constantly replenished and never run out. Key benefits of renewable energy are:

Environmental	Renewable energy technologies are clean sources of energy that have a much lower environmental impact than conventional energy technologies
Energy for the future	Renewable energy never runs out. Other sources of energy are finite and will someday be depleted.
Jobs and the economy	Most renewable energy investments are spent on materials and workmanship to build and maintain the facilities, rather than on costly energy imports. Renewable energy investments are usually spent within the U.S.; frequently in the same state; and often in the same county. This means your energy dollars stay home to create jobs and to fuel local economies, rather than going overseas. Meanwhile, renewable energy technologies developed and built in the U.S. are being sold overseas, improving the U.S. trade deficit.
Energy security	In the last few decades, our nation has increased its dependence on foreign oil supplies instead of decreasing it. This impacts more than just our national energy policy. Our nationï¿½s energy security continues to be threatened by our dependency on fossil fuels. These conventional energy sources are vulnerable to: political instabilities; trade disputes; embargoes and other disruptions.
Save money	Once the initial cost of construction and setup of a renewable power source is covered, it can quite quickly begin to pay for itself. Some sources allow you to save money quicker than others. Solar, for example, requires a large investment up front, so the payoff is delayed when compared to other sources. However, proper storage decisions, such as the amount and quality of batteries used, can help reduce costs on a grand scale.
Stabilize Energy Prices	Switching to renewable energy sources also means steady pricing on energy. Since the cost of renewable energy is dependent on the invested money and not the increasing or decreasing or inflated cost of the natural resource, governments would only pay a small amount in comparison to the needlessly heavy pricing of the energy prices we are witnessing currently.

Conclusion

There is an urgent need for transition from petroleum-based energy systems to one based on renewable resources to decrease reliance on depleting reserves of fossil fuels and to mitigate climate change. In addition, renewable energy has the potential to create many employment opportunities at all levels, especially in rural areas. An emphasis on presenting the real picture of massive renewable energy potential, it would be possible to attract foreign investments to herald a Green Energy Revolution in India.

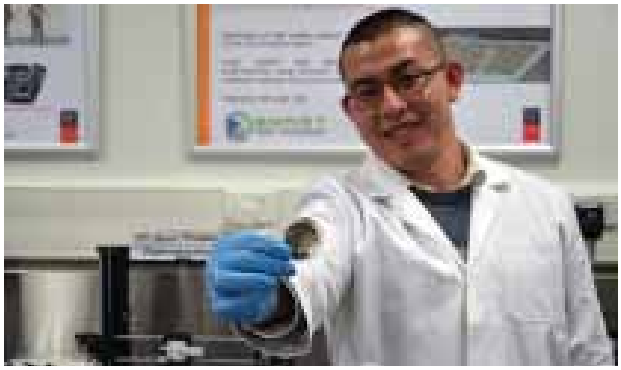
>> Supercapacitor

Scientists Develop Super Fast Supercapacitor

Large-scale production of the graphene that would be needed to produce these high-performance supercapacitors can be done by using low-cost solution-based film synthesis techniques and a laser 3D printer…

Whether it is for heavy duty or for micro level, use of battery is prevalent at almost all situations where power storage or stored power is essential. However, with the conventional storage batteries, there are always some challenges associated.

First of all, batteries take a long time to get charged. Their service life is short. Also, proper disposal of the batteries is a big challenge – as their constituent materials are not environment-friendly. These batteries sometimes pose the risk of explosion too, if not handled properly.



Dr Han Lin presented the new supercapacitor at Fresh Science Victoria 2016…

So, these challenges have compelled scientists to find out a better alternative. We all know that they have created supercapacitors or ultracapacitors, which hold great potential to overcome these challenges. However, still they are at the experimental stage.

A good news has come from the Swinburne researchers. They have developed a new type of battery, which is nothing but a supercapacitor that charges extremely fast. Literally, the environment-friendly supercapacitor charges within some seconds, and can be used millions of times. Dr Lin presented the new supercapacitor at Fresh Science Victoria 2016 earlier this year.

"After sales service becomes a very important point..."

KVTEK Power Systems Pvt. Ltd. designs and manufactures technically advanced and easy-to-use products for **High Voltage**, **High Current** and **High Power test systems and measurement instruments**. In an exclusive e-interview with **Electrical India**, **Anil Uppal** (**Managing Director cum CEO**) of the company is explaining to **PK Chatterjee** how the growth of their business is getting affected because of import of T&M equipment from China. Excerpts...

How is the electrical test & measurement instruments' market growing in India?

The market should be growing at a much faster pace but still nothing significant is happening because of the fluid economic condition – and as a result of that the industry is still reluctant to make any major capital investment.

What sort of competition are you experiencing these days?

The major competition in electrical test and measuring instrument industry is from Chinese companies only – as there is not much of competition in this field from within India. The main reason behind that is the Chinese government subsidizes the export of electrical test and measuring instrument very heavily. Thus, it is not a level playing

field for Indian manufacturers. The only way to counter this unfair practice adopted by the Chinese is – the Govt. of India should levy higher custom duty on these equipment when imported from China, failing doing that this industry in India will never develop.

Are you observing any kind of transformation in this segment?

The main transformation in this segment is that earlier on – largely these equipment were imported from US / Europe and now these are being imported mainly from China. Industry leaders for some reasons are willing to accept Chinese products, but not those made in India – even though the quality of products coming from China is not good. They are accepting the same as these are really cheap (not less expensive).

What are your offerings to the Indian power industry?

We are mainly offering High Voltage Test Equipment required by Power Equipment Manufacturers for their in house routine and type testing prior to shipment – and also by third party test labs mainly for type tests. Broadly range of products offered by us is as below:

- Impulse Test System
- HV AC Series Resonant Test Systems
- HV AC Test Transformers
- Partial Discharge Detection Systems
- Capacitance and Tangent Delta Test Systems
- Transformer Loss Measuring Systems
- Static Frequency Converter Systems
- Current and Voltage Seasoning Equipment for Vacuum Interrupters
- High Current Injection Systems
- AC/DC Kilo Voltmeters
- RF Shielded Labs.

What kind of R&D effort do you put to design new products?

We have a very dedicated R&D team comprising software, electronics, electrical and mechanical engineers – and as a result of their hard work, we are launching at least one new product every year. Besides, ours is a project-based business and every equipment requires customization to the specific requirement of every customer, which again is taken care of by our R&D team.

What kind of consultancy do you offer to develop new HV labs?

Our consultancy towards new HV Labs covers the following subjects:

1. General aspects of HV Lab for Testing of the specific device under test.
2. General requirements of HV Lab grounding:
   - Zero Potential System
   - Evaluation of soil resistivity
   - Evaluation of ground bed resistance
   - Measuring principle of ground bed resistance
   - Earthing rod design along with drawing
   - Cable ducts drawing
   - Impulse current return system (copper mesh) along with drawing
   - Connection of the current return system to the zero-potential ground system
   - Grounding/Isolation of the test area with drawing
   - Grounding connections in the test area.
3. General requirements of Laboratory Floor
   - Concrete Floor
   - Polymeric Floor coating.
4. General requirements on the laboratory shielding
   - Grounding / Isolation of the shielded laboratory
   - Attenuation design of the shielded laboratory
   - Influence of the metal plate bonding
   - Influence of perforated metal plate
   - Summary in regards of shielding design.
5. Insulation resistance of the shielded laboratory to the local factory ground.
6. General requirements on the transformer test laboratory acoustics.
7. General requirements on the heat extraction design in case of a power transformer test laboratory

   Total air flow circulation
   - Wave guide design calculation
   - Total transformer losses depending on the power rating
   - Summary ventilation requirements
8. General requirements on wall bushings in case of power transformer test laboratory.
9. General requirements on control room.
10. General requirements on the laboratory dimensions and main door.
11. General requirements of the laboratory lighting and electrical installation.

Is it worth upgrading old laboratories, or new installations are cost worthy?

It is a very subjective decision and also depends upon the condition of the specific lab that needs to be upgraded. Depending on what needs to be upgraded and its thorough on-site inspection only,

we can confirm which one will be a better option. It is not possible to generalize as this may vary from case to case basis.

How do you ensure safety through tactical design of electrical devices and components?

Since we are largely dealing with High Voltage Test Equipment, safety of the equipment and the personnel in vicinity when the equipment is in use – becomes absolutely essential to avoid potentially fatal accidents.

Besides building enough safety in electro-mechanical design of the equipment, we ensure that there are enough protections built into the electronics and software of the controlling part of the HV Test Equipment.

Which companies do mostly buy your T&M devices?

Companies manufacturing Power / Distribution Transformers, Instrument Transformers, Cables, Switchgear, GIS, Insulators. Basically anyone who is manufacturing any power equipment required to be used for a voltage higher than 11 kV can be our customer. Besides manufacturers; third party test labs and engineering colleges can also be our potential buyers. Our major customers are BHEL, Toshiba, Schneider, Siemens, Mehru, CPRI, ERDA, COER etc.

What is your suggestion to the potential buyers?

My suggestion to the potential buyers, especially the ones who are exploring either to buy locally in India or import from China, is that even though you are able to import from China at a cheaper price today – their inability to give efficient and cost effective after sales service will hurt you in the long run.

Indian manufacturers, on the contrary, can give you much more efficient and cost effective after sales service – and considering the fact that the test equipment once procured will be in use for next 20 to 30 years after sales service becomes a very important point to be considered while buying it.

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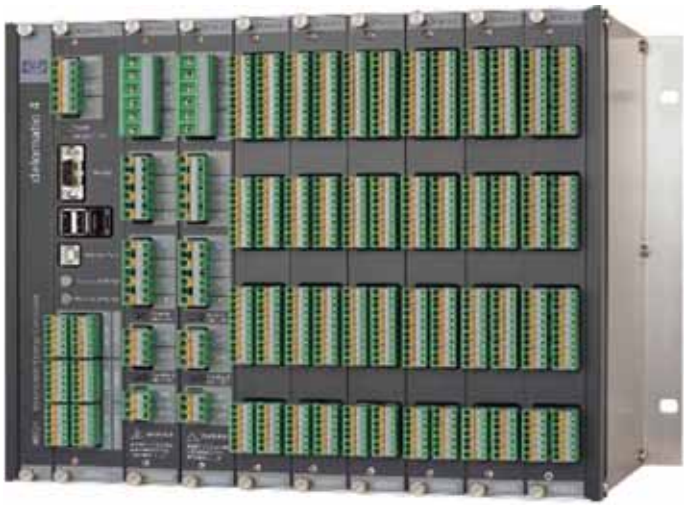
Hydro Turbine Control Solutions

Working as a part of your team, DEIF's process helps to define problems, identify solutions and develop ideas in a manner which will provide the most successful and appropriate end results...

DEIF, a company of Danish origin with global presence, is one of the world leaders in control solution for the power generation systems on land and marine segments. DEIF with its eight decade of experience has developed control solutions for hydro power, the largest and most economical source of renewable energy on Earth. In order to guarantee optimised power plant operations, increase safety and simplify maintenance; DEIF has developed integrated solutions that are capable of performing large number of functions compared to standard systems. Due to our integrated products and solutions we can reduce the maintenance costs to a minimum. DEIF India Pvt. Ltd., a subsidiary of DEIF A/S, Denmark,is the Centre of Excellence for Hydro Power applications. DEIF India develops and provides innovative solutions for power management and control of micro, mini and small hydro power generating sets for the whole world. Our systems have been installed successfully in large number of hydro power plants countrywide over a very short time span. Our product Delomatic, is used by numerous renowned OEMs and end users including Himachal Pradesh State Electricity Board Ltd., and Uttarakhand Jal Vidyut Nigam Ltd. – the states with maximum hydro power potential in India.

Globally local existence

Our 'glocal' approach combines leveraging global experience with strong local presence and expertise. Our local experts work hand-in-hand with you to meet your exact needs at every stage of the project. Working as a part of your team, DEIF's process helps to define problems, identify solutions and develop ideas in a manner which will provide the most successful and appropriate end results. DEIF HYDRO is supported by global sales and service setup, which gives us a global reach and the ability to serve our customers in any corner of the world. After completion of the project, DEIF offers an extensive local support network in order to ensure high availability of maintenance and other services. By doing so, we offer a highest degree of operational safety and efficiency.



Delomatic 4 Hydro...

Technology through innovative solutions

DEIF invests heavily in research and development globally, to provide state-of-the-art technology that meets customers' needs and stay at the

forefront of technological innovation. The expertise and vision of our designers and their partnership with different fields of power control equipment such as Marine, Steam, Gas and Diesel; allows us to consistently offer cutting-edge technology to our customers in Hydroelectricity generation sector as well.

Tailor-made solutions for specific requirements

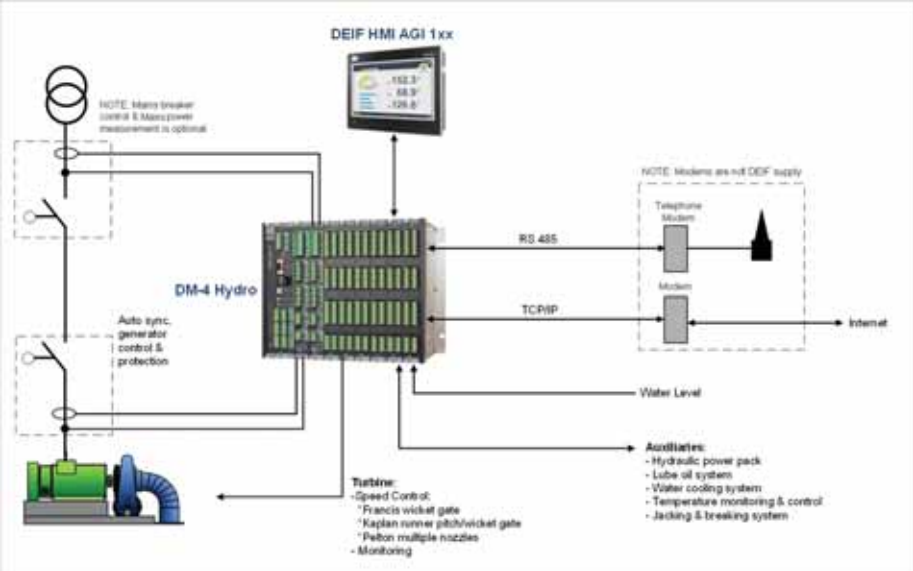
Every project is different in terms of challenges and requirements. Local conditions or budget limitations are also determining factors for hydropower projects. DEIF offers integrated and cost-efficient solutions of different scope according to customer-specific requirements and capabilities. In the development process, our goal is to maximize efficiency by customising our solutions to reach the best possible solution for each client, thus gearing up the customer's profit to a higher level.

Hydro turbine generator control

A customised solution, DEIF's integrated hydro turbine generator control solutions economizes installation costs significantly by using fewer components and lesser wiring compared to systems that require multiple units to provide synchronisation, protection and PLC functionality.

Delomatic 4 (DM-4) Hydro-controlled plants offer fully automated control for stable optimised operation and require less maintenance and fewer man-hours. The Delomatic 4 Hydro is compatible with all types of turbines and flexible and easy to adapt with simple parameter settings. Critical functions such as speed governing, generator protections and synchronising are fully integrated with password-protected features for maximum security.

The controller's Human Machine Interface (HMI) is easy to operate. Based on the graphic screens embedded in the DM-4 Hydro unit itself, the screens are uploaded to a PC like any other interactive webpage graphics using USB or TCP/IP communication, enabling simple password-protected remote control and monitoring.



Hydro turbine control and auxilary systems...

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

Delomatic hydro features

- Hydro Turbine Controller for Parallel with Mains or Stand-alone Generator
- Speed and Load Control
- Valve Controls (main/drain/fill)
- Water Level Control
- Turbine control, auxiliary control, protection and supervision
- Generator control, Auto synchronisation protection and supervision
- Dedicated HMI touch screen operator panel

DEIF's hydro control systems are not only suitable for new installations, but also can be used to upgrade existing plants that can give you following key benefits.

Featuresof Delomatic 4 Hydro	Types of hydro turbines		
	Francis	Kaplan	Pelton
Automatic Start-Stop control	✓	✓	✓
Sequencing Control (Auxiliaries Controls)	✓	✓	✓
Speed & Load Control	✓	✓	✓
Over speed protection with Redundant speed sensor input	✓	✓	✓
HMI with Mini SCADA	✓	✓	✓
Future proof communication (TCP/IP)	✓	✓	✓
Protection – Turbine & Generator	✓	✓	✓
Synchronisation – Auto & Manual	✓	✓	✓
Voltage & Power Factor control	✓	✓	✓
Site selectable CT & PT inputs	✓	✓	✓
Standalone (island) control	✓	✓	✓
Parallel with grid control	✓	✓	✓
Load sharing	✓	✓	✓
Water level control	✓	✓	✓

References

DEIF India has supplied control systems for hydro projects with total 150 MW of capacity all over the world for various types of hydro installations.

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Strengthening Power Distribution Systems

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If we look at the huge costs of maintenance, repairs & replacements for oil type transformers spent every year, then the differential cost between oil type and dry type transformers should not be a too big amount, if it helps reduce transformer failures…

Electricity is one of the vital infrastructures for economic development of the country. With government of India taking necessary steps to improve ease of doing business, the prospects of return of glorious days of high and sustainable growth of the country doesn't seem to be a distant dream. Infrastructure developments have already been planned in various sectors of economy viz. railways, highways, smart cities, renewable energy, electricity etc. However, a lot of this success would depend on reliability of our power distribution system. Power generation has kept pace with the growing needs of the economy by meeting the objectives of 12th Five-year plan, however transmission and distribution systems need to be strengthened further to enable sufficient evacuation of power from generating stations.

It is high time that the utilities should look into the other new options of technologies that are more sophisticated & advanced to keep pace with the growing needs of the country. Electricity would be one of the key deciding factors, if India could accelerate at the pace of growth that the world is expecting from it in the next decade & become an economic power of the world. We understand that many of the progressive and forward looking utilities are already on the lookout for new technological solutions – that can make them more efficient and improve their services – and in turn contributing towards progress of the country.

Issues in the distribution systems

Power distribution system in India is plagued with problems of high failures in distribution

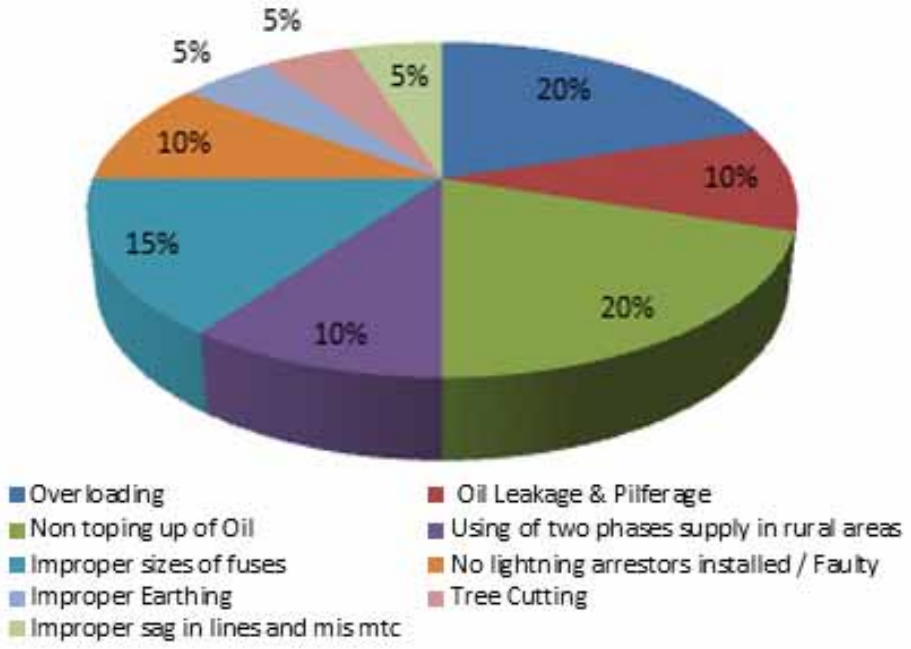


Figure 1: Failure Analysis of Distribution Transformers (Based on the survey of Utilities in India)…

transformers. There are more than 60 utilities in the country, considering failures in all the utilities, the amount of financial loss to the country is humongous. There are approximately 4.5 million distribution transformers installed in the country, out of which the average failure of the country is about 9.2%, while in some states it is as high as 25-30%. This is huge when compared with failure rates in developed world of less than 1%. As per the industry estimate, the failure in DTs puts total financial burden of close to 200 Cr. on the utilities per year towards replacements & repairs of transformers.

The cash strapped utilities have to allocate almost 15-20% of their annual budgets towards repairs and replacements costs in their systems. This is huge when we know that they are already in huge debts and such finances are not easy for them. These huge costs of failures also make introduction of new and innovative technologies difficult to make inroads in their systems. Government of India has already initiated steps to reduce debt burden of utilities (with UDAY scheme), which will also help them improve their operational performance by upgrading technologies in their distribution systems.

Key reasons for failures in Distribution Transformers (DTs)

As per our survey of more than 20 utilities in the country, the key reasons identified for high failures in distribution transformers are as given below –

1. Prolonged overloading
2. Oil pilferage or leakage
3. Non-topping up of oil
4. Single phasing
5. Improper size of fuses
6. No lightning arresters installed/faulty
7. Faulty earthing
8. Tree cutting
9. Improper sag in lines and miscellaneous maintenance reasons

Our analysis of all the reasons of failures in distribution transformers indicates that *60% of all failures are due to oil or related to insulation*. If we could address these causes for failures in distribution transformers, the total failure rate in distribution systems would come down drastically.

We have a case study conducted by an International Firm, Cedar Consulting, which has analyzed costs for repairs of transformers due to various causes. This study from the US is used here as a reference to highlight that the insulation failure leads to highest failures in transformers and has biggest cost impact.

Surprisingly, lightning caused transformer failures are rare. Insulation failure is the major cause.

Cause of Failure	Number	Total Paid
Insulation Failure	24	$ 149,967,277
Design /Material/Workmanship	22	$ 64,696,051
Unknown	15	$ 29,776,245
Oil Contamination	4	$ 11,836,367
Overloading	5	$ 8,568,768
Fire /Explosion	3	$ 8,045,771
Line Surge	4	$ 4,959,691
Improper Maint /Operation	5	$ 3,518,783
Flood	2	$ 2,240,198
Loose Connection	6	$ 2,186,725
Lightning	3	$ 657,935
Moisture	1	$ 175,000
	94	$ 286,628,811

Source: The Hartford Steam Boiler Inspection and Insurance Co. 2003

Figure 2: Transformer Insurance Loss Analysis for different types of failures...

The Indian Utilities can conduct a similar study for their systems. We expect that the study would reveal a grim scenario in India as the transformer failures in India are much higher than US.

The life of a distribution transformer is expected to be at least 25 years (as per CEA guidelines), however the utilities repair their transformers at least 2-3 times within this period. In most of the cases, distribution transformers don't even complete their expected life of 25 years in operation, and are discarded once cost of repairs become too high (generally >40% of new transformer's cost). Hence, an alternate technological solution needs to be looked into to solve the issue of high transformer failures with the utilities as the financial loss is exorbitant.

Assessing technological solutions in transformers

There are various solutions in the market, let's analyze all available solutions to come out with the best solutions:

1. Conventional Oil filled Transformers

The oil filled transformers have proved their performance over several decades, however there are limitations in this technology that can't be addressed by changing designs or just changing protection systems. The issues are related to oil which will still remain. Refer Table 1.

2. Nomex Engineered Dry Type Transformers

We had conducted a survey with more than 20 utilities across the country to understand the main concerns in their distribution systems. The surveys revealed that the biggest concerns of utilities are reducing failures, improving reliability and mitigating risks of fire in the oil type distribution transformers. We conducted failure analysis of oil type distribution transformers (as per Fig. 1) to understand the

Table 1: Conventional Oil filled Transformers

Sl.	Characteristics of Technology	Analyses
1	Periodic oil maintenance activity is a necessity	Needed to maintain life of the insulation and the transformer
2	Oil level checks and leakages, if any, need to be performed regularly	Impacts temperature rise which effects life of the insulation& hence transformer
3	Risk of fire hazards and explosion due to oil	Oil poses environmental risks
4	Peak loading is checked by cutting of at 80% rated capacity	Loading beyond rated load reduces life

Nomex® makes all the difference……

Nomex® aramid has been used as the primary insulating material for electrical equipment applications since the 1960's.

- Certified Long Term Stability up to 220°C
- Short term exposures up to 350°C is possible
- Will not Melt, Flow, or Support Combustion below 250°C
- Contains no toxic or corrosive off-gases
- Low Dielectric Constant enables better distribution of stresses
- Low Dissipation factor reduces potential of dielectric losses
- High Resistivity even up to 250°C makes it an superior insulator

Figure 3: Technical characteristics of Nomex Insulation…

main causes of the high failures of transformers.

Based on this understanding, DuPont worked on the technological solutions to address the concerns of the utilities. The Nomex engineered dry type transformer technology was developed by experts from DuPont. Technical experts applied their global knowledge & local understanding to develop this product with built-in features that can address the key issues in power distribution system. We will now see the details of the technology and benefits for power distribution companies.

Nomex engineered Dry Type transformers technology

The Dry Type Transformers technology that we are discussing here is also called "VPI (stands for Vacuum Pressure Impregnated)" transformer technology. It has lots of advantages for utilities as given below:

1. The transformers can be conveniently loaded beyond rated capacity as they can endure peak loading up to 140% for 3.5hours (120% continuously, 130% up to 8 hours & 140% up to 3.5 hours) without any effect on life of transformer. This is unlike oil transformers where the transformers are under-utilized by cutting off at about 80% rated capacity to provide buffer during peak loading.
2. There is flexibility in designing these transformers as per environmental conditions (Passed Class E2: Frequent condensation, high humidity and heavy pollution) & climatic conditions (Passed Class C2: Operating at ambient temperature of -25 °C) at site of operation.
3. The transformers are virtually maintenance free because there is no oil as such no need for any periodic maintenance.
4. The transformers are easily reparable at site. Although fails less, but in case of any failure, the coil(s) can be conveniently replaced at site. This reduces repair costs and delays when it gets repaired outside.
5. The Nomex engineered dry type transformers ensure fire safety (Passed Class F1: Highest safety against fire hazards) which is required in densely populated locations. As against Oil filled technology which has more than 50% inflammable materials, the dry type transformers have less than 5% total combustible material with respect to the total weight of transformer.
6. The dry type transformers can be installed closer to load which reduces transmission losses and costs of cabling.
7. All materials conform to the standards of UL, IEC, IS Standardsfor Dry Type Transformers.

Nomex has high Limiting Oxygen Index & high Optical Transmission Factor even at temp. up to 250 °C.

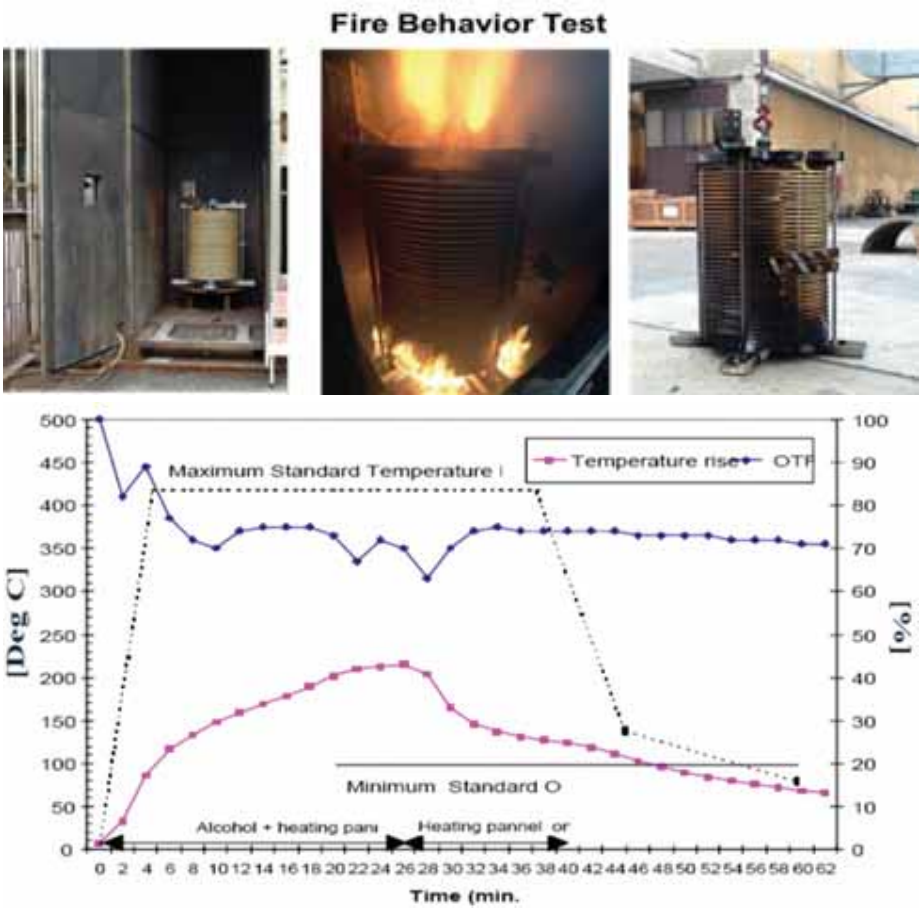
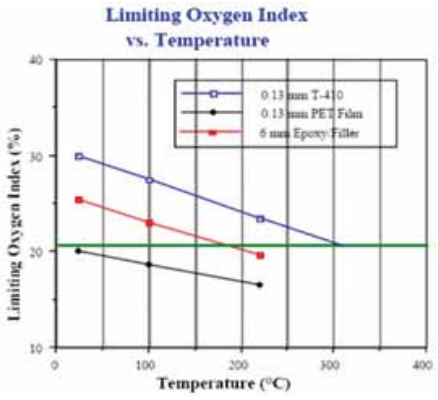


Figure 4: LOI and OTP for Nomex. Fire Behaviour test on Nomex engineered dry type transformer…



Economics of the Dry type transformers technology

The failure of transformers results in two main financial losses to the utility:

1. Repairs and replacement costs of distribution transformers

Transformer failure losses can be substantial, ranging from $24 million to $150 million per year over the 5 years analyzed. Average loss per incident of $3 million.

From a presentation given by Hartford Steam Boiler Inspection and Insurance Co. at an International Association of Engineering Insurers meeting in Stockholm in 2003.

CEDAR

Table 1 – Number and Amounts of Losses by Year

Table 1	Total # of Losses	Total Loss	Total Property Damage	Total Business Interruption
1997	19	$ 40,779,507	$ 25,036,673	$ 15,742,834
1998	25	$ 24,932,235	$ 24,897,114	$ 35,121
1999	15	$ 37,301,591	$ 36,994,202	$ 307,389
2000	20	$ 150,181,779	$ 56,858,084	$ 93,323,695
2001	15	$ 33,343,709	$ 19,453,016	$ 13,890,684
Grand Total	94	$ 286,628,811	$ 163,239,089	$ 123,389,722

* Total losses in 2000 includes one claim with a business interruption portion of over $86 million US

Table 1A – Number and Amounts of Losses by MVA and Year

Table 1 A	Total # of Losses	Losses w/data	Total MVA reported	Total PD (with size data)	Cost /MVA
1997	19	9	2667	$20,466,741	$7669
1998	25	25	5685	$24,897,114	$4379
1999	15	13	2433	$36,416,806	$14967
2000	20	19	4386	$56,364,680	$12849
2001	15	12	2128	$16,487,059	$7748
Total	94	78	17,199	$15,4611,400	

Source: The Hartford Steam Boiler Inspection and Insurance Co. 2003

Figure 5: Transformer Insurance Loss Analysis for total loss to business…

2. Loss of business due to supply disruptions

Repairs and replacement costs of distribution transformers

Every year utilities spend almost 15-20% of their annual budgets on repairs and replacement costs for failed equipment in their system, which is a significant amount.

The failures do not occur at all locations but generally in certain zones which are identified as high risks. If utilities can identify all locations with high failures, and address the problems with better technological solutions, it would bring down the huge costs of repairs and replacements.

Some of the possible locations where these trials can be conducted are mentioned below:

a. Remote locations that are difficult for maintenance of oil type transformers
b. Agricultural belts or locations that suffer during seasonal peak loading
c. Crowded areas where there are risks of fire hazards with oil type transformers

If we look at the huge costs of maintenance, repairs & replacements costs for oil type transformers spent every year, then the differential cost between oil type and dry type transformers should not be a too big amount, if it helps reduce transformer failures.

Loss of business due to supply disruption

Every failure in transformer results in business loss due to supply disruptions. Supply disruptions also lead to social costs due to public unrests.

We have another case study by International Firm, Cedar Consulting, on the business loss due to supply interruptions. This study from US, used here as a reference for our understanding, highlights the magnitude of loss to business due to transformer failures.

With much higher transformer failures in India than US, we expect the financial impact to be more severe in India.

Conclusion

Though oil type transformers technology is still considered the best technology for most of the applications, we need to appreciate a few limitations in this technology.

Every need in the market begets new solutions and innovations, which either address the problems or improve upon the performance from existing solutions.

Nomex engineered dry type transformers technology is developed after understanding the issues faced by the utilities and providing a solution to address them.

The lifetime cost of Nomex engineered dry type transformer is estimated to be at least 30-35% lower than oil type transformers.

This is due to lower failures, lesser need for maintenance, reduced repair costs and also capabilitsy to load beyond the rated capacity of transformer.

We are confident that many utilities would find the solution beneficial in the long run – and their progressive steps would take the country to a next level of growth and development for future.

Techniques For Battery Testing In Railways

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Fig 1: An Indian electric train...

In today's world, life without electricity is unimaginable. From a small light bulb to large motors and for many other major purposes, electrical energy is the main source. As the importance of electricity in everyone's life is increasing, it is in other way increasing the demand. As of 2016 May, 303GW is the installed capacity of utility sector in India. There is a shortage of 2.1% of total electricity in India. All this demand cannot be met alone by installing more generation. By reducing consumption, by reducing losses or by increasing private participation in energy generation, load on the utility can be decreased. By using regeneration, usage of renewable energy sources in the form of private power generation, cogeneration etc., power demand can be reduced. There is a scope for reduction of losses in many sectors, which use bulk electric supply. One such application of electric power is for batteries.

In railways, batteries play a vital role. The battery used in railways is lead acid battery, which is the most popular rechargeable battery worldwide. Both the battery product and manufacture process are proven economical and reliable. These are specially designed for railway application to withstand deep cycling.

There is a scope for reduction of losses in many sectors, which use bulk electric supply. One such application of electric power is for batteries...


Fig 2: Location of batteries in railway coaches...

Railway batteries are typically used for rolling stock or stationary applications. Rolling stock batteries are used for locomotive starting, lighting, on board auxiliary system in engines and coaches. Stationary batteries are used as emergency

Fig 3: Battery testing in railway workshop...

Fig 4: Control panel at railway workshop used for charging and discharging batteries...

backup power for railroad crossings, signal towers and signaling systems. Batteries are also used to provide illumination, fan, air conditioning, and other miscellaneous needs of electricity for travelling passengers. Hence, battery capacity, robustness, reliability and performance are important for their effective utilization. The batteries are received at railway workshop once in eighteen months to ensure the above said features. These features are ensured by conducting various tests. Discharge process which is one of the performance tests conducted on batteries to check its capacity and reliability.

In discharge test the batteries are charged and discharged for 3 cycles. Lead Acid battery uses constant current, constant voltage charge method. A regulated current raises the terminal voltage until the upper voltage limit is reached at which point current drops due to saturation. It is charged in three stages:

1. Constant current charge
2. Topping charge
3. Float charge

Battery gets fully charged when current drops to a set low level. Batteries that are used in deep cycling mode can be charged up to 14.7V for a 12V battery to get the highest charge rate.

A discharge/charge cycle is commonly understood as the full discharge of a charged battery with subsequent recharge, but this is not always the case. Batteries are seldom fully discharged, and manufacturers often use the 80 percent Depth-of-Discharge (DoD) formula to rate a battery. This means that only 80 percent of the available energy is delivered and 20 percent remains in reserve.

Fig 5: Battery discharging through resistive load...

Block diagram of existing methodology :

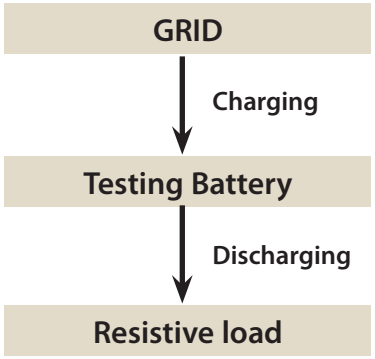

Fig 6 Discharging Process...

In the existing system, during the testing of batteries for maintenance, the batteries are unloaded from the coaches and initially fully charged. The power required to charge the batteries is obtained from the grid. After charging them for 10 hours with constant value of current, batteries are discharged to a minimum level of 1.75 volts at constant current. Discharging is done through the resistive loads, i.e., dissipated through the resistors. This power is wasted and is not being utilized for any other purposes.

In the proposed methodology, various techniques are explained in which power can be conserved. The first technique is, using solar energy to charge the batteries. As it is the renewable energy, it is one of the ways of saving energy. Here battery 1 or battery 2 can be charged using the solar panel when the solar voltage falls

Block diagram of the proposed technique

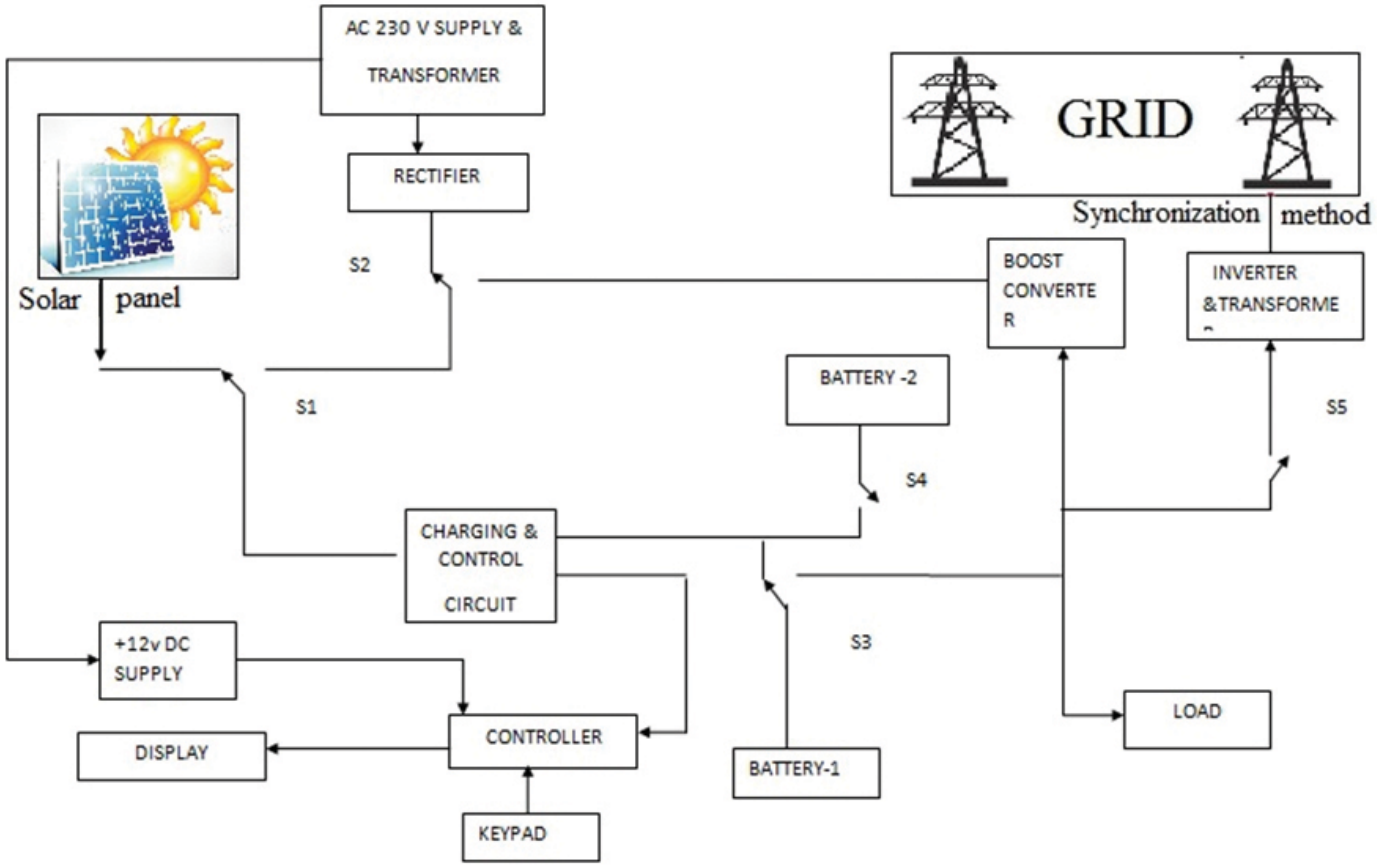

Fig. 7. Schematic diagram of the triple regenerative techniques...

below the set voltage automatically, it switches to the AC supply with help of the microcontroller and charges any one of the batteries. Here the switches S1 and S3 are closed. The second technique is charging a battery by the discharged power of another battery. In this technique, though the battery cannot be fully charged using another battery, remaining power can be taken from either solar or grid. Here the switches S1,S2,S3,S4 are operated. The third technique is pumping back the discharged power to the grid using synchronization technique. Microcontroller is used to control the switching operations. Keyboard and LCD display are used for better interaction of the operator with the system.

There are around 14,300 trains in INDIA and the no of batteries used in AC and NON-AC trains are 56 and 17 respectively per coach. Assuming the number of AC and NON-AC coaches in a train be 5 and 10, the capacity of the batteries used is calculated by assuming battery capacity to be minimum is 54,000Ah. Power required for one performance test is found to be 85536 kWh.

Hence for 14300 trains approximately 1.2231*e9 kwhr power can be saved.

Average commercial tariff per unit is Rs. 5.79/- and expecting a good rate as high as of 10 Rs / Unit depending upon the size of requirement by private participation. By adopting the above method, the approximate money that can be

Fig 8: Pilot model...

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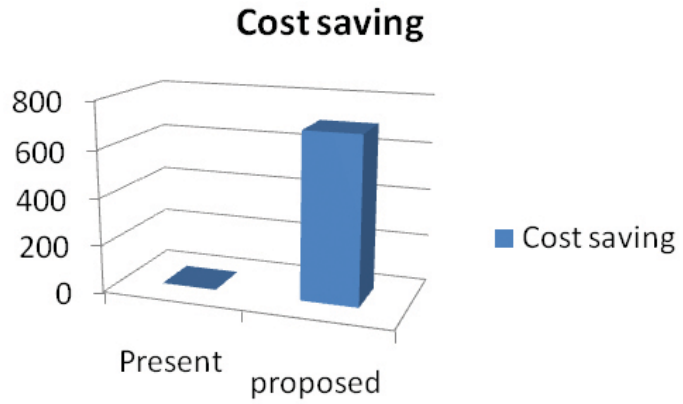
Contact Person : Kiran Kalal | E-mail : sales@axonelcorp.com

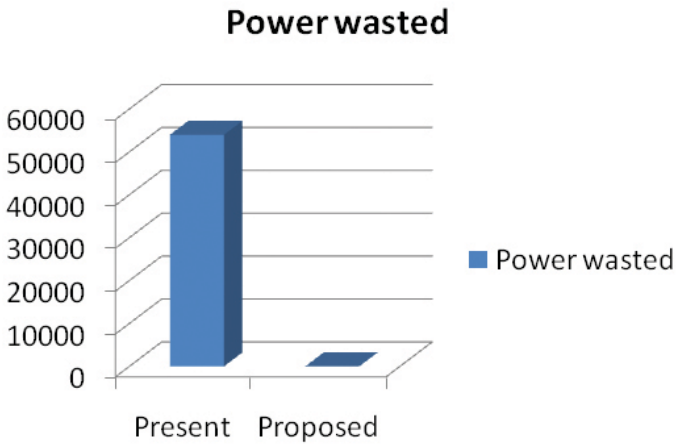
Contact Person : James Zhu | E-mail : james.zhu@lzgwe.com

www.axonelcorp.com

Graph which represents the cost saving in the present and proposed method...



Graph which represents the power wasted in the present and proposed method...



saved will be 700 crores for 18 months as the demand for installing new generating plants are also eliminated.

This Proposed method is successfully demonstrated using a pilot model:

Results of the triple regenerative techniques:

The results are tabulated as follows:

Parameters	Existing method	Proposed method
Battery charging	From grid	Both solar and grid
Battery discharging	Resistive load	Charge another battery or pump back the power to the grid
Automation	Manual	Semi-automatic
Power saving	Nil	54000Ah
Cost saving	Nil	Approximately Rs.700 crores
Initial investment	Nil	Required for initial setup
System efficiency	Less efficient	More efficient

Future scope

This method can be adopted in all fields where batteries are used in bulk. For example, it can be implemented in KPTCL as 56 batteries are used in each substation. According to KPTCL annual report 2010-2011, there are 945 substations in Karnataka. Approximately 5 crore 82 lakhs can be saved by adopting this method in KPTCL. This proposed method is semi automatic. In future, this can be made fully automatic reducing the man power and reducing the maintenance cost. This proposed work promotes the private participation as the excess solar energy can be pumped back to the grid.

Conclusion

Regenerative techniques for Railway battery efficiency testing using solarenergy can be thus used to save a large amount of energy. Thus, using the green energy, energy can be conserved and regeneration of power adds to the amount of energy saved. Hence, electricity used and thus the cost can be minimized. Energy conservation is the foundation of energy independence as:

- Energy efficiency saves money.
- It improves the economy.
- It is environmental friendly.
- It improves national security.
- It upgrades and enhances quality of life.

This method can be adopted in all fields where batteries are used in bulk. For example, it can be implemented in KPTCL as 56 batteries are used in each substation. According to KPTCL annual report 2010-2011, there are 945 substations in Karnataka.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Raveena D

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MGM brake motor main features

- TEFC 3-ph asynchronous brake motor (0.09kW-130kW)
- AC 3-ph brake (no rectifier) or DC brake on request
- Oversized brake disc for higher brake torque, longer life and reduced maintenance
- Fine and easy brake torque adjustment (as standard)
- Very quick brake reaction time
- Frequent START/STOP cycle applications
- Manual brake release (as standard)
- Hexagonal hole on non drive end of the shaft for manual rotation
- Single speed or two speeds motors
- All motors designed for inverter duty

VARVEL production lines

- RS-RT worm gearboxes: 28 to 150 mm centres.
  One stage worm, helical/worm and double worm.
- RD helical gearboxes: 50 to 2300 Nm. Two and three stages.
- RN parallel shaft gearboxes: 180 to 3300 Nm. Two and three stages.
- RO-RV bevel/helical gearboxes: 180 to 3300 Nm. Three stages.
- RG precision planetary gearboxes: 10 to 230 Nm.
  One and two stages.
- VR dry friction speed variators: IEC63 to IEC90
  1 to 5 stepless speed range, 300 to 1500 rpm.
- VS planetary speed variators: IEC71 to IEC112
  1 to 5 stepless speed range, 200 to 1000 rpm.

A new generation of electric motors and gearboxes for power transmission quality from the alliance of two dynamic italian companies.
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"Focus on cost, quality and return on investment..."

CG is one of the largest electrical capital equipment manufacturer with an impressive and diverse portfolio of products, solutions and services for Power and Industrial, addressing myriad needs. The multi-product, multi-solution and multiservice company has a very wide business periphery. In an exclusive interview with **Electrical India**, the company's **Vice President Sales and Marketing (India), Ramesh Kumar N** is describing various aspects of their business to **PK Chatterjee**. Excerpts…

How is the transformation happening in the Energy Sector?

While India has not been surplus country on energy, based on the government initiative on using alternative sources of energy focus is shifting more on green energy like solar and wind. These sources are widely distributed, clean and produces no gas emissions during operation. Solar energy has become a buzzword in industry in most of the states across India, significant investments are being done on building and utilizing solar energy. At the same time to become surplus as well as to give uninterrupted power to people in their states, most state governments are emphasizing on using energy efficient products to save energy with the support from EESL (Energy Efficiency Services Limited) and BEE (Bureau of Energy Efficiency) marking star rating on various products.

How has CG geared up to cater solutions to the emerging needs of this new (or evolving) Market?

At CG our endeavor is to produce and supply energy efficient products to market and we have been in the forefront in adopting new technologies to serve the purpose. We are the first in developing entire range of energy efficient IE3 Motors along with all approvals required from the approving bodies. Also, we are at the advanced stage of developing entire range of energy efficient IE4 Motors, most of these products are already marketed by us. While we are product selling company and customer are looking for solutions, we are customizing our products on the application base to help customers select products for their solutions rather than advising customers to use the existing range of products for all types of solutions.

How does CG differ from other Indian multi-product, multi-solution and multiservice companies?

As I said earlier, CG is the first and fast in adopting new technologies and we believe in 100% in-house manufacturing. All our products are made in our own state-of-the-art plants spread across India. At CG, we have complete testing facility as well. In addition, we also offer all kinds of third party test certificates (yet another unique feature) as compared to our competitors.

> CG is a clear leader in LV Motors. We produce and supply almost 1 lac machines per month in LV range, which is close to double as compared to the second largest manufacturer in India...

The product basket offered under CG umbrella is largest as compared to any of our competitors. Customers can choose from a wide array of customized products and solutions for various applications. CG is the only company in India to offer Motors from 0.25 KW to 12 MW Motors in various enclosures and voltage class, Generators up to 25 MVA and Drives up to 3 MW.

What are your shares in the Indian market for the major (capital) electrical equipment (Like Motors, Generators and Drives)?

CG is a clear leader in LV Motors. We produce and supply almost 1 lac machines per month in LV range which is close to double as compared to the second largest manufacturer in India. We are No. 2 in MV Motors with respect to volume and range. Drives, while we are a decade old in Indian market with a small share but we hold a little more than 30% share in European market where we are known with the brand name "Emotron by CG".

Which sectors or segments are you targeting on in 2017?

As I said we are clear no. 1, this is possible as we are penetrated to all the sectors. However currently irrigation & pharma is giving us good growth which will be continued in the year ahead. Among core sectors, cement is looking up. In steel small industries like rerolling mills have started investing. We enjoy good share with lots of OEMs (Original Equipment Manufacturers), who have good projects from overseas which will help us grow faster than market.

What kind of technical innovations are you doing in enhancing quality and reducing costs of your products?

We believe in in-house manufacturing so as to have a direct control on raw material cost and product quality. "We put all our energy to save yours" is our slogan, more than our cost we focus on making energy efficient products to save our customer's cost and to provide them a hassle free service.

What kind of post-sales service do you offer in India? How do you manage to do that on pan-India basis?

We are leveraging after sales services by repair & refurbishment, spares supply, diagnostic services, conditional monitoring and annual maintenance contract.

In the engineering industry, we are the first to launch call center with toll free number to register customer complaints a decade back, which is successfully being operated even today. Customer PIN code is linked to the nearest service station and our service contractor as well as nearest branch service engineer gets an text massage as soon as customer registers the complaint. Our endeavor is have the FIR (First hand information) within 24 hours and to close the complaint to the best satisfaction of our customer within 72 hours. Our service is backed by more than 350 service stations spread across the country and our toll free no can be accessed from any part of the county.

Complaint complete dash board is available to our service team and escalation matrix is fed in the system. All pending complaints are escalated by the system automatically. Product complaint analysis and improvement plans are done by quality team at respective plants by downloading data from system based on the complaints and service team fed back fed in the system.

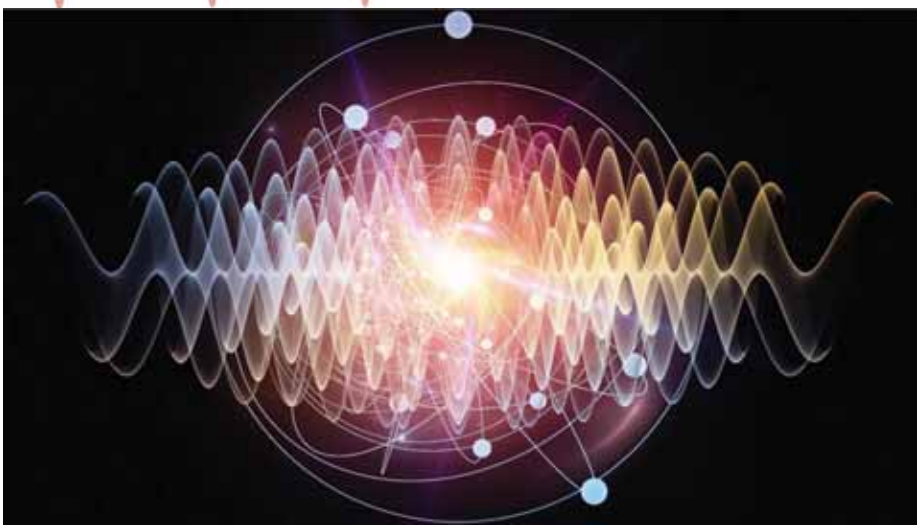
What is your advice to the potential customers?

While customer is always a king, of late customers expectation are going up drastically and it is their right to demand. However, focus on the initial cost has increased drastically rather than the long term benefits. My advice is to focus on both cost, quality & return on investment using more and more energy efficient products.

Analysis And Elimination Of Third Harmonics


Paresh Modha **Minesh Joshi**

Assistant Professors in Electrical Engineering department at ADIT, New Vidyanagar



This article discusses the power quality issues and how is the unwanted component (called harmonic) introduced. Consequence of harmonics according to their sequence will be different and most precarious also. Moreover, different strategies according to different cases are discussed. We have discussed four different cases. Whereever necessary, the mathematical analysis is shown with output waveform to prove the arguments...

Modern civilization has become reliant on the unremitting supply of clean electrical power. Poor quality of power causes financial losses, and also utility or consumer or distributor has to pay the loss, which we can say bonus burden. The society expects continuous and pure power quality. The higher magnitude of voltage for extremely short duration is called impulses/Transients. Where a steady state voltage rise lasts for several seconds, it is called over voltage, and if it dips then it is called under voltage. The so called harmonics is nothing but the non fundamental frequency components of a distorted power frequency waveform.

- Causes of Power Quality Problems or Sources of Power System Harmonics:

i. Modern internal causes like single and three phase converter also inverter, SMPS, PCs etc.
ii. External causes like single L-G fault and L-L-G fault are the major reasons for unbalanced voltage in the power supply system.
iii. Conventional devices like rotating machines, reactors, transformers, welding machines, variable speed drives.

Figure 1: Fundamental Component and Third Harmonics Component

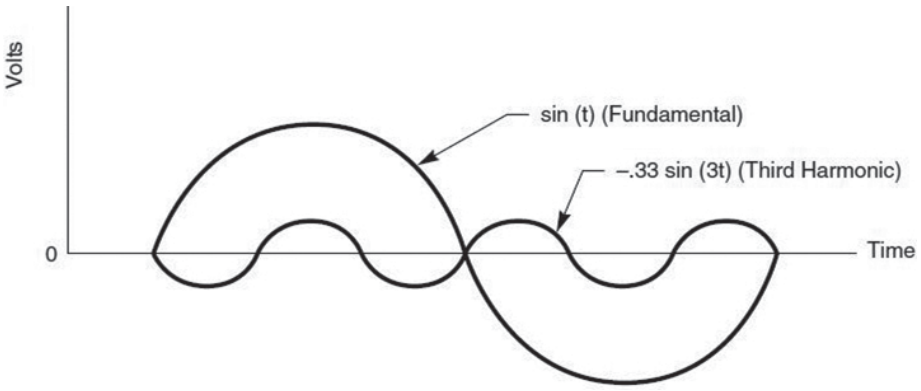
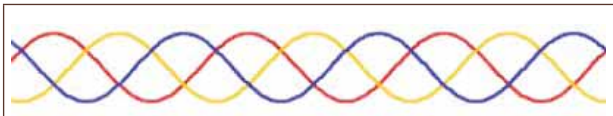
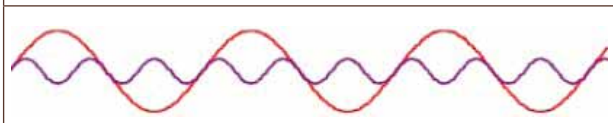
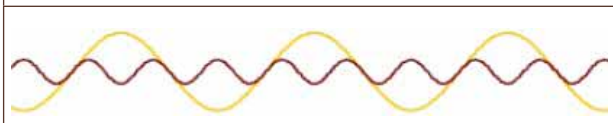
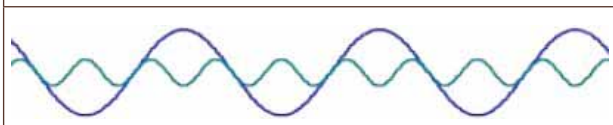
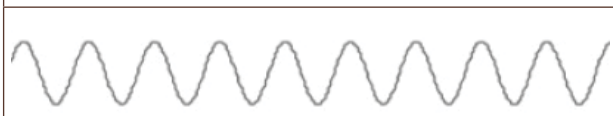


Table 1: Fundamental wave and R, Y, B with harmonic and Neutral Currents waveform

	Waveforms of a balanced three phase fundamental currents w.r.t. time
	R-Phase current with its 3rd harmonic component w.r.t. time
	Y-Phase current with its 3rd harmonic component w.r.t. time
	B-Phase current with its 3rd harmonic component w.r.t. time
	3rd harmonic currents of R,Y,B phases are in phase with each other adds in neutral.

iv. Modern electrical accessories like Air conditioners, Microwave ovens, printers, photocopiers, fluorescent Lamps.

As the harmonics are generated because of the above so called reasons, responsible for malfunction of circuit breaker, large neutral currents, skin effects, overheating of transformer, decrement in power factor, and distortion in voltages and extra losses in rotating machines.

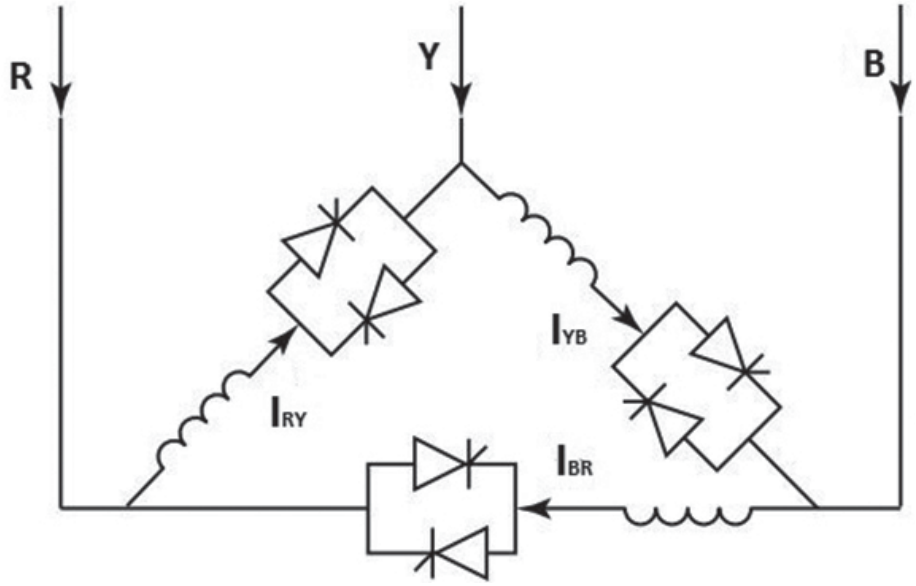
If the harmonics are related to circuit configuration then they are called characteristic harmonics. Whereas if the imbalance of the system occurs in voltage or in impedance and by frequency converter generates non -characteristics harmonics.

3rd Harmonics

The triplen harmonics most savior harmonics shown by 3(2N+1), where N=0, 1, 2...., i.e. 3, 9, 15, 21, etc. the triplen harmonics have zero sequence nature and it accumulates as neutral current.

The third harmonic currents of R,Y and B phases are in phase with each other and hence adds up, without cancellation in the neutral conductor.

Figure 2: Delta Configuration of TCR



Phase Sequence Harmonics

The Details of positive, negative and zero phase sequence harmonics are mention below.

Table 2: Phase Sequence Harmonics

Positive Sequence	Negative Sequence	Zero Sequence
Fundamental	2nd Harmonic	3rd Harmonic
4th Harmonic	5th Harmonic	6th Harmonic
7th Harmonic	8th Harmonic	9th Harmonic
10th Harmonic	11th Harmonic	12th Harmonic
3n+1	3n+2	3n+3
Divide by 3 Reminder 1	Divisible by 3 Reminder 2	Divisible by 3 Reminder 0

Consequences of Phase Sequence of Harmonics are different to any electrical system according to their sequence.

Positive Sequence: It causes over heating due to 'Skin Effect', aids with fundamental component, responsible for moderate heating and it is relatively less harmful.

Negative Sequence: It causes over heating due to 'Skin Effect', opposes the fundamental, responsible for excessive heating and most harmful.

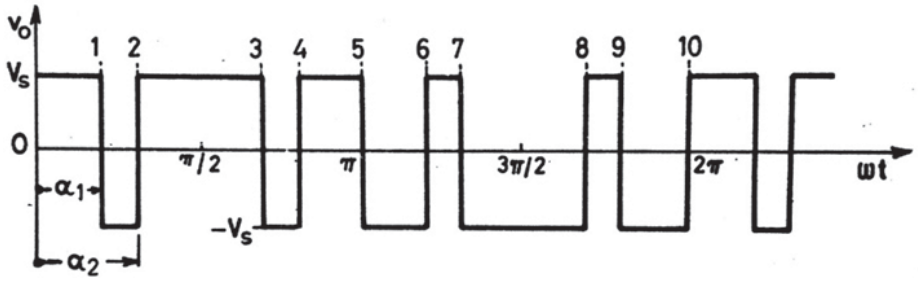
Zero Sequence: causes 'Skin Effect', accumulates in the neutral, also creates 'hot neutral', responsible for neutral to earth voltage and open neutral condition.

- CASE 1: A 3phase TCR Comprises Three Single Phase TCRs Connected in Delta
- CASE2: PWM Methods to Eliminate 3rd harmonic
- CASE 3: 3rd harmonic Reduction by Transformer Connection
- CASE 4: 3rd harmonic Injection Method

Case 1: A 3phase TCR Comprises Three Single Phase TCRs Connected in Delta

In the case of 3 phase, 6 pulse TCR compromises three single phase TCRs connected in delta configuration, the inductor is divided in to two halves and having thyristor connected in anti parallel combination. Only odd harmonics will be generated when all 3 phase supply voltages are in balanced condition, all thyristors

Figure 3: Harmonic reduction by PWM in Single Phase Inverter



are fired equally in each phase and also all inductors are identical then only the symmetrical current pulse having positive and negative half cycles are generated.

To prevent the 3rd harmonic from getting into transmission line the delta connection of the three single phase TCRs used. If IRn, IYn, IBn be the line current respectively for delta connected TCR and IRYn,IYBn, IBRn be the nth order harmonic phase current respectively in the delta branches, then

$I_{RY3} = A \cos(3\omega t + \emptyset_3)$ ..... (1)

$I_{YB3} = A \cos(3\omega t + \emptyset_3 - 3\frac{2\pi}{3})$

$= A \cos(3\omega t + \emptyset_3 - 2\pi)$ ..... (2)

$I_{BR3} = A \cos(3\omega t + \emptyset_3 - 3\frac{4\pi}{3})$

$= A \cos(3\omega t + \emptyset_3 - 4\pi)$ ..... (3)

Thus IRY3, IYB3, IBR3 all have the same magnitude. So, IRY3= IYB3 = IBR3. Now all the three currents are in phase and circulate to the thyristor delta, forming a zero sequence system. It follows that the third harmonic line currents reduce to zero, as shown below:

IR3= IRY3-IYR3 = 0

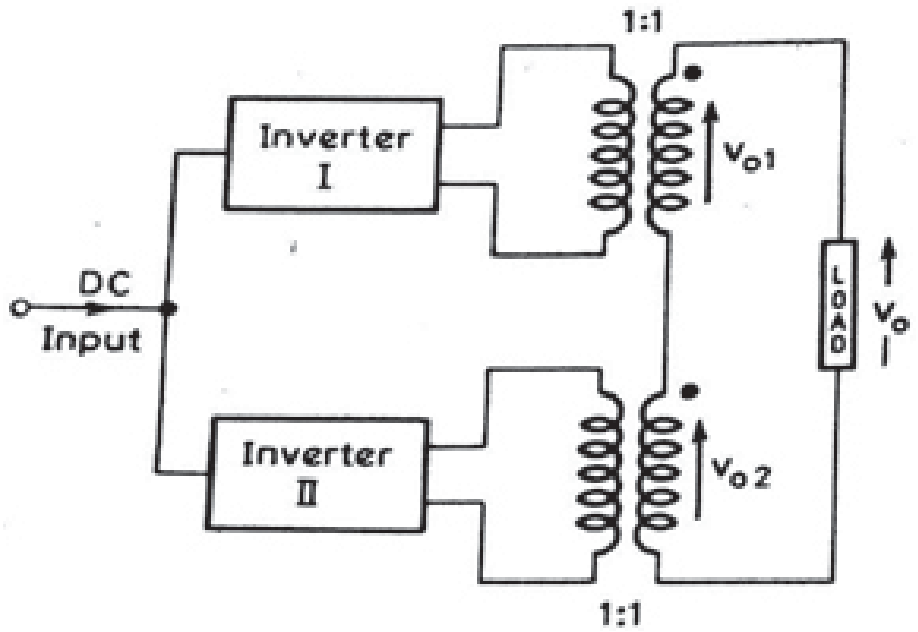
Similarly, Iy3 = 0 and IB3=0

In short not only the 3rd harmonic will be canceled out, but also all the harmonic of the order 3N+3, where N=0,1,2,…….. (3,9,15,21,27) cannot flow through the lines during balanced operation.

Case 2: PWM Methods to Eliminate 3rd Harmonic

When there are several pulses per half cycle, lower-order harmonics are eliminated. Here, the figure given illustrates output voltage waveform that can be attained from a single phase full-bridge inverter. This waveform can also be obtained from a single phase half-bridge inverter, but then the amplitude of voltage wave would be $V_s/2$. The waveform of figure needs ten commutations per cycle (=360°) instead of two in an unmodulated wave. The voltage waveform in the figure is symmetrical about π as well as π/2.

Figure 4: Harmonic reduction by transformer connections



As this voltage waveform has quarter-wave symmetry, $a_n=0$.

$b_n = \frac{4Vs}{\pi}\left(\int_0^{\propto 1} sinnwt.dwt - \int_{\propto 1}^{\propto 2} sinnwt.dwt + \int_{\propto 2}^{\pi/2} sinnwt.dwt\right)$

$= \frac{4Vs}{\pi}\left[\frac{1-2cosn\propto 1+2cosn\propto 2}{n}\right]$ ..... (4)

If third and fifth harmonics are to be eliminated, then from the equation:

$b_3 = \frac{4Vs}{\pi}\left[\frac{1-2cos3\propto 1+2cos3\propto 2}{3}\right]$ ..... (5)

and $b_5 = \frac{4Vs}{\pi}\left[\frac{1-2cos5\propto 1+2cos5\propto 2}{5}\right]$ ..... (6)

or $1\text{-}2\cos 3\alpha_1 + 2\cos 3\alpha_2 = 0$

and $1\ 2\cos 5\alpha_1 + 2\cos 5\alpha_2 = 0$

The above two simultaneous equations can be solved numerically to calculate α_1 and α_2 under the condition that $0 < \alpha_1 < 90°$ and $\alpha_1 < \alpha_2 < 90°$. This gives $\alpha_1 = 23.62°$ and $\alpha_2 = 33.304°$.

Case 3: 3rd Harmonic Reduction by Transformer Connection

Output voltage from two or more inverters can be combined by means of transformers to get a net output voltage with reduced harmonic content. The essential condition of this scheme is that the output voltage waveforms from the inverters must be similar but phase-shifted from each other. Here, figure given illustrates two transformers in series with their output voltages V_{01} from inverter 1 and V_{02} from inverter 2. Here V_{02} waveform is taken to have a phase shift of π/3 radians with respect to V_{01} waveforms as shown in given figure. The resultant output voltage V_0 is obtained by adding the vertical coordinates of V_{01} and V_{02}. It is seen that V_0 has amplitude of $2V_s$ from π/3 to π, 4π/3 to 2π and so on. Here, the shape of V_0 is quasi square wave.

The Fourier analysis of waveforms V_{01} and V_{02} gives:

$V_{01} = \frac{4Vs}{\pi}(sinwt + \frac{1}{3}sin3wt + \frac{1}{5}sin5wt + \cdots)$ ..... (7)

$V_{02} = \frac{4Vs}{\pi}(\sin(wt - \frac{\pi}{3}) + \frac{1}{3}sin3(wt - \frac{\pi}{3}) + \frac{1}{5}sin5(wt - \frac{\pi}{3}) + \cdots)$ ..... (8)

The resultant output voltage $V_0 = V_{01} + V_{02}$

$V_0 = \frac{4Vs}{\pi}\sqrt{3}(\sin(wt - \frac{\pi}{6}) + \frac{1}{5}sin5(wt + \frac{\pi}{6}) + \cdots)$ ..... (9)

The resultant of V_{01} and V_{02} must be $\sqrt{3}$ times V_{01} or V_{02} and also V_0 lags V_{01} by 30°. To remove the 3rd harmonic V_{02} must be lags V_{01} by 180°.

Thus the 3rd and other triplen harmonics are eliminated from net output voltage and the fundamental component of output voltage V_0 is

Fundamental Component of $V_{01m} = 4\frac{\sqrt{3}*Vs}{\pi}$ ..... (10)

Case 4: 3rd Harmonic Injection Method

The PWM technique is the simplest technique to understand the modulation operation, but to utilize the full DC supply voltage for inverting

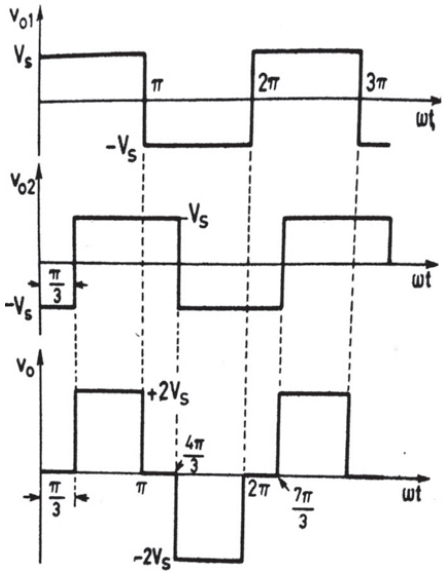


Figure 5: Waveforms of elimination of 3rd and other triplen harmonics

operation 3rd harmonics techniques will be better. To go in depth, let's consider a fundamental component of sine wave which contained triple frequency component, so it is denoted by:

$X = \sin\emptyset + A\sin 3\emptyset$ ..... (11)

To get the maximum value of X let's take its derivative and equate to zero, Thus:

$\frac{dX}{d\emptyset} = \cos\emptyset + 3A\cos 3\emptyset = \cos\emptyset(12A\cos^2\emptyset - (9A-1)) = 0$. ..... (12)

Thus, the minimum and maximum of the waveform therefore occur at:

$\cos\emptyset = 0$

$12A\cos^2\emptyset - (9A-1) = \cos^{-1}0 = 1$

$\cos\emptyset = \sqrt{\left[\frac{9A-1}{12A}\right]}$ and therefore $\sin\emptyset = 1$ and so $\sin\emptyset = \sqrt{\left[\frac{1+3A}{12A}\right]}$

Using the Trigonometric Identity,

$\sin 3\emptyset = 3\sin\emptyset - 4\sin^3\emptyset$, thus the value of x can be modify as

$X = (1+3A)\sin\emptyset - 4A\sin^3\emptyset$

If $\sin\emptyset = 1$ then, $X_{max} = 1-A$ ..... (13)

and also

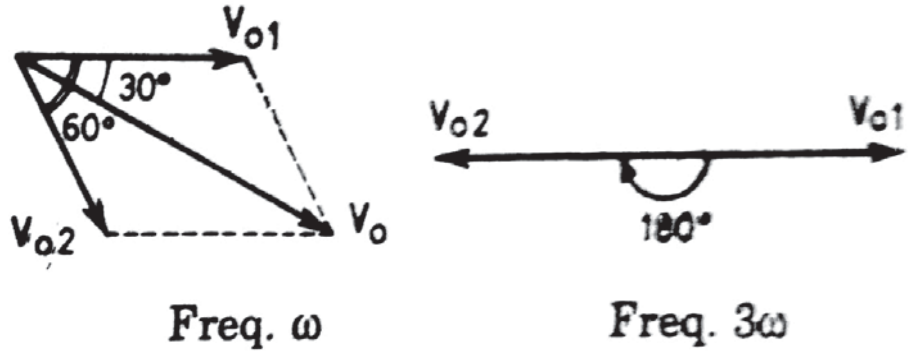


Figure 6: Resultant output voltage and phase difference between V_{01} and V_{02}

If $\sin\emptyset = \sqrt{\left[\frac{1+3A}{12A}\right]}$ then, $X_{max} = 8A\sqrt{\left[\frac{1+3A}{12A}\right]}$ ..... (14)

Thus, using the equation (13) and (14) the optimum value of A is obtain when the value of X is minimum, by taking differentiation of X with respect to A, we get A= -⅓ and A= -⅙.

By putting the negative value of A makes X greater then unity. So A= ⅙ will be preferable. And thus the equation of X can be modified as

$X = \sin\emptyset + \frac{1}{6}\sin 3\emptyset$ ..... (15)

By substituting the value of A= ⅙ we get the value of cosØ= (1/2), i.e. Ø will be π⁄3, 2π⁄3, etc. All triplen harmonics pass through zero will have maximum amplitude of $X_{max} = \pm\frac{\sqrt{3}}{2} = \pm 0.866$.

Thus, by injecting third harmonic with the maximum magnitude of one sixth the modulation waveform reduces the peak value of output by a factor of $\frac{\sqrt{3}}{2}$ without making any change in the fundamental. Thus, if we increase the amplitude of the modulating waveform by a factor M, so that the equation can be articulated as

$X = M[\sin\emptyset + \frac{1}{6}\sin 3\emptyset]$ ..... (16)

Thus, the required value of M for a peak value of unity should satisfy the constraint is:

$1 = M\frac{\sqrt{3}}{2}$ and therefore, $M = \frac{2}{\sqrt{3}}$.

Therefore for $V_{RN} = \frac{2}{\sqrt{3}}[\sin\emptyset + \frac{1}{6}\sin 3\emptyset]$ where Ø= wt.

V_{YN} and V_{BN} lags from V_{RN} by 120° and 240° respectively.

By adding the third harmonics we can increase up to 15.5% of the amplitude of the fundamental phase voltage.

Conclusion

This article has included the details of harmonic and the sequence also and their hazardous effect in Electrical System. Moreover different techniques also discussed in Power System as well as Power electronics techniques to suppress the argument the mathematical analysis discussed to remove 3rd harmonics.

- In TCR using Delta configuration we can eliminate 3rd harmonics.
- Using PWM techniques by providing proper phase shift we can eliminate 3rd and other triplen harmonics.
- By injecting 3rd harmonic component to the sinusoidal modulating wave, the fundamental amplitude increase by 15.5%, and hence DC power supply utilize very well.

For future works further simulation should be performed for all the technique as mentioned above. Moreover, using different modulating techniques in different level to improve switching frequency of Inverters.

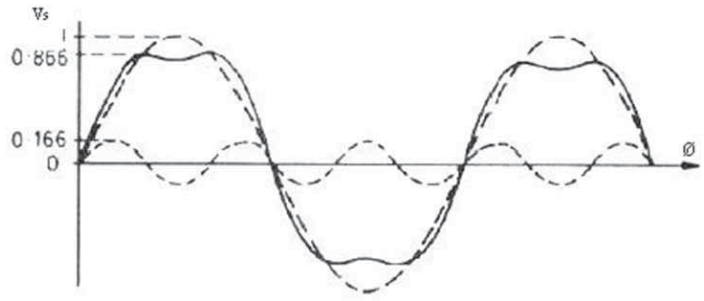


Figure 7: Fundamental wave, 3rd harmonic in R-phase, addition of 3rd Harmonics

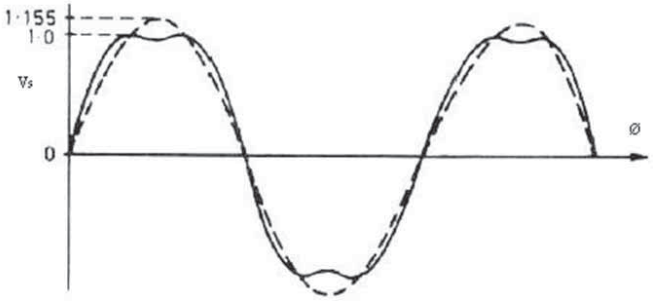


Figure 8: Improvement in Fundamental wave by injecting 3rd harmonic in R-phase

CAT-IV Digital Multimeter

Pravin Khisti
Asst. Manager (Research and Development)
Rishabh Instruments Pvt. Ltd.

If you are working in CAT IV environment, high voltage and high energy transients or spikes caused by motors, lightning, variable frequency drives, discharging of capacitors etc., can run through your multimeter without any warning...

If you are planning to travel on a bike or a car it's necessary for your safety to wear the helmet or wear seat belt. Helmet will protect you from impacts and mechanical shocks. Seat belt saves your head from making impact on steering wheel. Air bags installed in car will be inflated in an accident situation.

What If you are taking voltage or current measurements in electrically hazardous environment?

Will you Just pick up any multimeter with any random specifications? NO !!! you must not. Then what should you do to keep yourself safe? Let's first understand the working environment in which you are going to use the multimeter.

Your measurement area may vary from a simple battery voltage measurement, to the MCB or fuse protected sockets or at the utility incomer of your factory or house or you may be measuring directly on electrical pole.

Naturally a question may arise in your mind that voltage is a voltage, may it be at my household socket or it is at electrical pole, what difference it makes to me, as multimeter is designed to measure voltages up to 1000V.

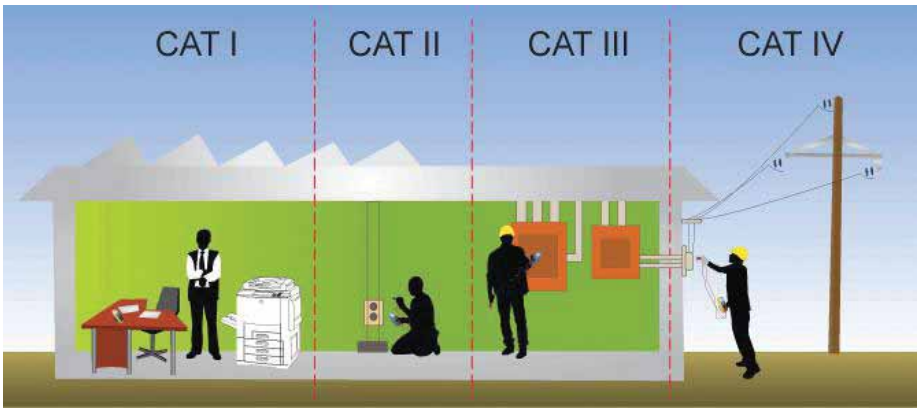
How will the location of the measurement affect me? Can I select any multimeter to use at any locations described above. To find the answer to this question, let's take a look at what makes these various locations or working environments, different than each others even though voltage levels may be the same.

The answer is energy levels i.e., ability to deliver the current at high voltages. As energy level increases, threat to life increases exponentially. Your multimeter must be designed to protect you in that particular energy environment. The energy levels at CAT IV are higher compared to CAT III or CAT II or CATI.

Depending upon the energy levels, these working environments are referred as installation categories, and are divided into four categories i.e., CAT I, CAT II, CAT III, CAT IV. As energy level increases installation category increases – hence the risk level also increases.

Below are the examples of installations categories:

1. **CAT I**: A battery or protected (by fuse or other means) electronic equipment or any high voltage low energy sources like 1000V in photocopier machine.
2. **CAT II**: The appliances connected to wall sockets.
3. **CAT III**: Installations, lighting loads inside the buildings. Loads separated from utility through at least one isolation transformer.



RISHABH 601X Bluetooth and USB series...

Fixed or permanent installations directly connected to building mains supply.

4. **CAT IV**: Origin of installations, Panels at entry (source) level of the buildings, cables running between electrical pole to building. The connections to the meters at utility inputs 'bus and feeders', distribution panels.

If you are working in CAT IV environment, high voltage and high energy transients or spikes caused by motors, lightning, variable frequency drives, discharging of capacitors etc., can run through your multimeter without any warning. If your multimeter is not designed and tested for CAT IV, your life is at risk. CAT IV 600V (or CAT III 1000V) multimeter should withstand 7.8kV transient, CAT III 600V multimeter should withstand 6.1kV transient according to IEC-61010 safety standard. Otherwise, it can be dangerous to user's life as shown below:

Lightning strike causes a transient on electrical line, which can form an arc between input terminals of the multimeter. If proper clearance is not maintained during design – or protection components are not used, this will lead to a high short circuit current in terms of few kilo ampere for a momentary time. This can lead to the blast or burning of multimeter. Very high temperature will result from such arcs. This can cause burns to the user and cost his life.

One more reason for high current flow through multimeter is using multimeter in wrong way. For example an electrician is measuring current. For this, he should insert the leads in mA or A sockets. In a measurement mode, input resistance is 10 mΩ. If now the user wants to measure voltage but forgets to change the leads to V sockets even though the function selector knob is changed to Voltage function, then voltage source will be short circuited, leading to a heavy current flow. Here, the high quality fuses will come into picture to protect the user. These fuses should be ultra fast acting so that before current exceeds dangerously high level fuse should blow.

Always choose the multimeters with proper category and voltage you are working in.

Tips to select right multimeter for appropriate installation category:

1. If you are working in CAT IV environment having working voltage 440V AC choose CATIV 600V multimeter.
2. While choosing mulitmeter category and voltage, always choose category first and then voltage.

For example: CAT IV 600V multimeter is safer than CAT II 1000V.

3. Voltage ratings, of the fusesused, should be equal to or greater than maximum voltage measured by multimeter.
4. Fuses should be ultra fast acting.
5. Multimeter housing and probes should be double insulated.

Rishabh Instruments provides Multimeters with additional safety feature to eliminate accidents due to wrong connections. This feature is called as ABS i.e., Automatic Blocking System. When you turn the function selector knob to voltage position, mA and A sockets are blocked by ABS plate – so that the user cannot insert test leads in wrong sockets. When function selector knob is placed on mA or A position, mA or A socket will be opened respectively and voltage socket will be blocked. So at any point of time only correct socket is available to insert the test leads.

Rishabh Instruments CATIV Multimeters and Clamp meters:

- Rishabh Multimeters: RISHABH 6016,6015,6012 (USB and Bluetooth) / RISHABH 616,615,612 / Rish Multi 12s, 14s, 15s, 16s, 18s, 20 are CAT IV 600V multimeters
- Clamp meters: Rish Clamp 1000 A/300A AC, 1000A/300A ACDC, Rish Clamp Power
- 1000A/400A ACDC are CAT IV 600V Clamp meters.
- RISHABH 601X Bluetooth and USB series
- RISHABH 61X series
- RISH CLAMP 100/300 ACDC,RISH CLAMP POWER 1000A/400A ACDC, RISH CLAMP ES
- 1000/400AC

All the above mentioned multimeters and clamp meters are designed and tested to fulfill the safety requirements according to IEC-61010 safety standard. Protection devices like PTCs, surge resistors, VDRs, spark gap are used to keep you safe in electrically hazardous environment.

Fuses used in the multimeters are ultra fast acting with 1000V ratings and 30kA rupture capacity. Housings are double insulated, so that your hand remains electrically isolated in hazardous conditions. Multimeters are provided with Automatic blocking system as described earlier to avoid accidental misuse.

Remember: Just knowing the safety is not enough, but practicing it is the key to total safety!!!

Influence Of The Joint Design

Diego Cisilino
Product Manager
HV Accessories
Business Unit Power Accessories

With the steady increasing demands of electric power in major cities around the globe combined with the challenge for much greater system reliability of supply, utilities throughout the world are grappling with the inevitable increase in demand for undergrounding high voltage cable transmission lines and the need to improve the overall performance of this expensive asset. The challenge is how to perform cable underground installations in the most cost effective manner.

The total costs of underground cable systems can vary widely even for the same voltage, power and length, making it difficult to generalise. Using modern cable techniques, it still costs approximately 4 to 15 times more compared to an equivalent overhead line through normal / urban terrain. A major element of this cost differential is accounted by the cable itself. On the other hand around 60% of the installation costs result from the civil works required for the cable installation, while cable accessories themselves represent less than 2% of the total costs of the cable transmission lines.

For most installations, joints are required at intervals along the route. This is because cable is supplied in fixed lengths given by the cable drum diameter and weight. The amount of cable on a drum is in turn dictated by the cable diameter and transport options for the cable drum. For these reasons joints are required approximately every 500 m to 800 m of cable length. For long cable transmission lines then the number of joints and resulted joint bay infrastructure is considerable. The trenching work and joint bay construction of underground transmission lines

The challenge is how to perform cable underground installations in the most cost effective manner. The total costs of underground cable systems can vary widely even for the same voltage, power and length, making it difficult to generalise...

Picture 1: cable and joint installations in open trench...

Picture 2: horizontal directional drilling and pre- fabricated joint bay...

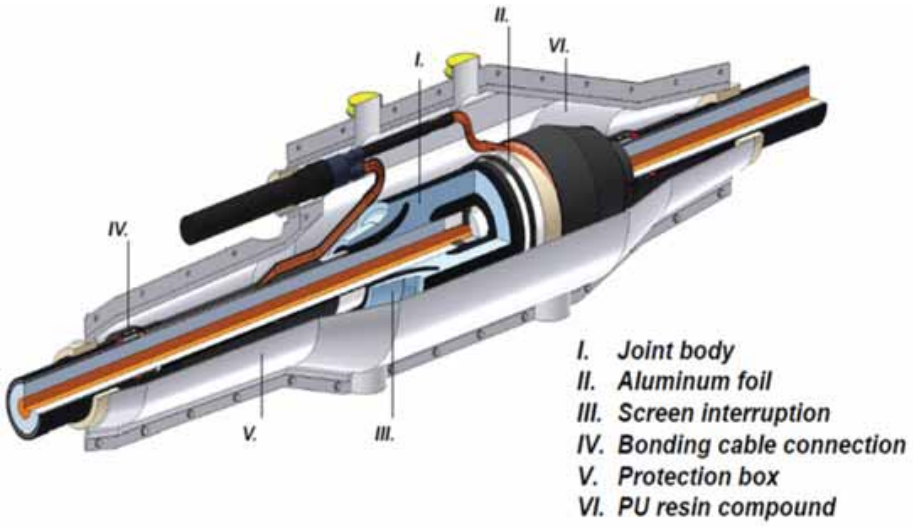
causes great soil disturbances. In suburban and rural areas where no space restrictions are a major problem, direct burial result the most economical option. In such cases the joint bay size normally play no a major infrastructure role in the total cost (Picture 1).

In contrast installations in urban or central city areas, where there is a requirement to cross major roads or go through high density populated areas, the costs of major excavation work in terms of traffic management and construction can be considerable. Further limitations for construction activities that are imposed for reasons of noise, dust and traffic impacts must also be considered since often derive in further increase of the total cost as well as delays in project execution plans. For these reasons, power utilities and contractors are striving for compact joint bays able to considerably reduce the civil work costs as well as to reduce the total installation time of high voltage cable transmission lines. In order to minimize excavation and trenching work horizontally directed drilling and cable installation in pipes represent a cost effective alternative. The necessary joint bay infrastructure can then be performed on site or preferable today be pre-fabricated type (Picture 2). The advantage of the latter solution is that the total execution time for civil work as well as disturbances to public traffic, dust and noise are drastically reduced.

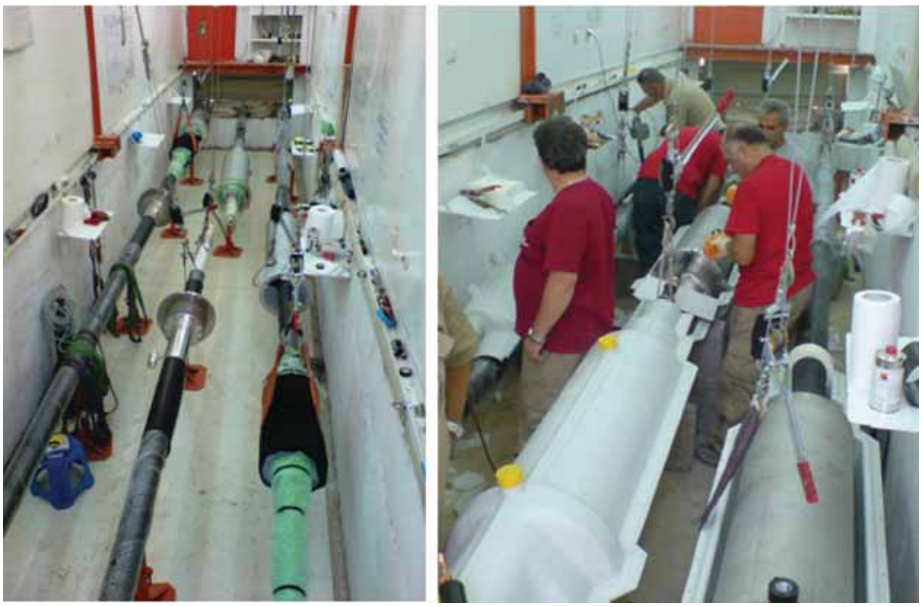
For further cost optimizations for transportation and installation work, the size of the joint bay becomes the dominant improvement factor. To solve the problem Brugg has developed a new innovative vertical split-box outer protection design, which, combined with existing the gas cushion installation system for pre moulded joint bodies, allows up to 50% reduction of the necessary infrastructure and therefore direct costs for the joint bay infrastructure. A practical comparison illustrates the advantages of the new joint type as well as presents a recommendation to a standard joint bay for cables systems up to 245 kV.

Impact of joint outer protection design in the size of a joint bay

For underground cable projects the joint bay location is selected in order to maximize each section length of cable. The size of the joint bay will be determined by the density of existing services, likely disruption to traffic and space requirements for cable drums and cable pulling equipment. Therefore, are normally located within or adjacent to public roads. The ultimate



Picture 3: Joint type MPFP with vertical split-box design...



Picture 4: Installation space for joint type MPSP with cylindrical metal casing and horizontal split-box design...

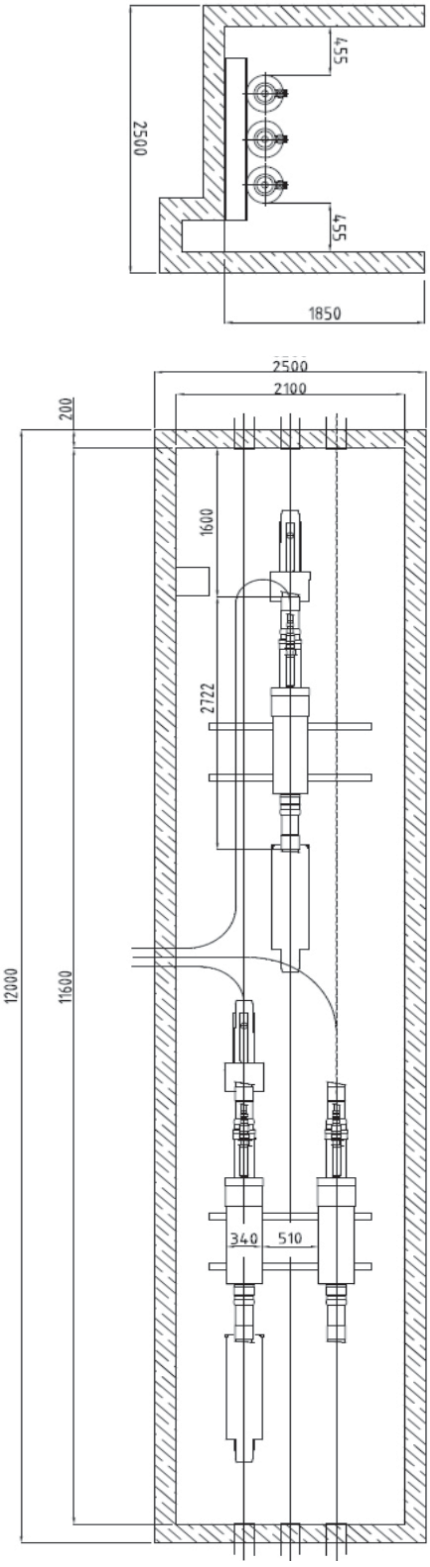
dimensions of a joint bay infrastructure are majorly governed by the space requirement of the joints to be constructed within the bay and the minimum bending radius of the cables. As a consequence, the joint design has a direct impact in the final join bay size – and therefore direct impact in the costs of the necessary civil work. While the joint bay width and depth are determined by the necessary minimum clearance distances required for installation and safety operational reasons, a particular attention is to be made to the necessary length for positioning major components of the joint outer protection system in a parking positon as well as installation tools along the cable prior the final joint assembly. As a result the total free length required for the final joint assembly and therefore for the joint bay is majorly affected by the joint outer protection design. A new vertical split-box design demonstrates to be advantageous while eliminating the problem (Picture 3).

For a better understanding and quantification a comparison between two types of joint outer protection is presented in the case of a 245 kV cable circuit joint bay installation. A traditional joint type with cylindrical metal casing and horizontal split-box design filled compound (Picture 4) is considered.

During the assembly this joint outer protection design requires first to bring the metal casing as well as the split-box joint outer protection into a parking position along the cable – and therefore the joint bay. After the assembly of the main joint body over the prepared cable distance, the metal casing as well as split-box is then assembled to its final position over the joint area. Considering a total joint length of approx. 2.8 meters, the necessary space to assemble the joint results approx. 6 meters considering necessary space for final cable fixing into the joint bay with a cable clamp. Considering the installation of 3 joints per bay, a total length of at least 12 meters resulted minimum necessary (Pictures 5).

The new joint outer protection concept presents as improvement a simpler innovative vertical split-box design for the joint outer protection, which does not require any parking position at all. The total joint installation length required in this case is determined mainly by the necessary cable preparation distances. As a result, the necessary total installation length per joint is reduced to practically the joint length of about only meters considering necessary space for final cable fixing after the joint assembly (Picture 6).

Accordingly, the total joint bay length can then be reduced to only 6 meters, thus



Picture 5: Joint bay dimensions for joint with metal casing and horizontal split-box design...

Forthcoming Events At A Glance

NATIONAL

Energy Storage India
Venue: Nehru Centre, Mumbai
Date: January 11th to 13th, 2017
Website: www.esiexpo.in

Ieema
Venue: India Expo Centre, Greater Noida, India
Date: January 23rd to 25th, 2017
Website: http://ieema.org/

ElAsia
Venue: BEC, Mumbai
Date: April 12th to 14th, 2017
Website: www.elasia-expo.com

intec
Venue: Codissia Trade Fair Complex, Coimbatore
Date: June 1st to 5th, 2017
Website: www.intec.codissia.com

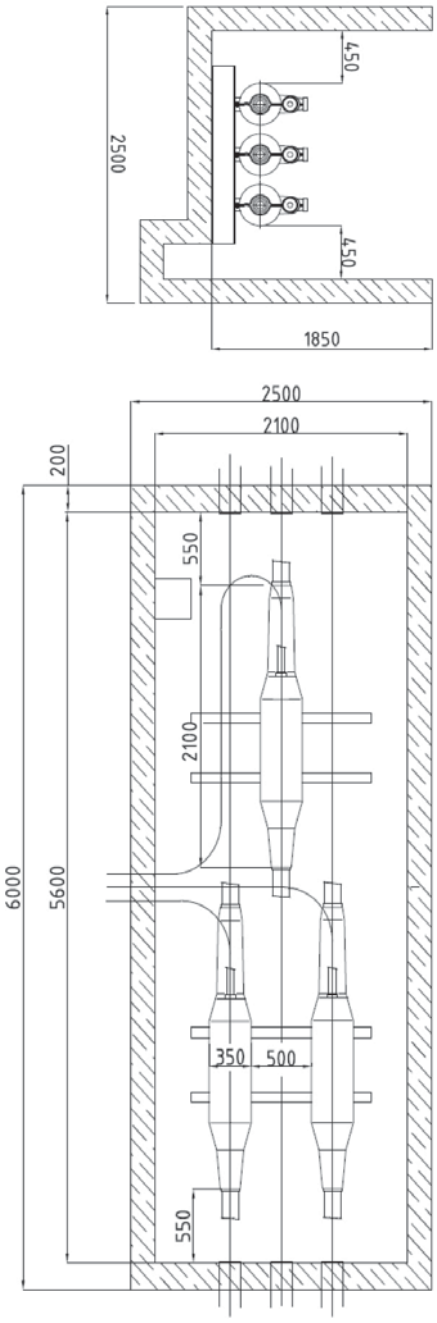
INTERNATIONAL

Middle East Electricity
Venue: Dubai World Trade Centre, UAE
Date: February 14th to 16th, 2017
Website: www.middleeastelectricity.com

GeoTHERM - expo & congress
Venue: Messe Offenburg
Date: February 15th to 16th, 2017
Website: www.geotherm-offenburg.de

ENEX
Venue: Kielce Trade Fairs, Poland
Date: March 1st to 2nd, 2017
Website: www.enex.pl

PV System Expo
Venue: Tokyo Big Sight, Japan
Date: March 1st to 2rd, 2016
Website: www.pvs-expo.jp



Picture 7b: Joint bay dimensions for a joint with vertical split-box design...

representing a 50% length reduction compared to the previous outer protection design (Picture 7)

Based on the joint pit dimensions presented above, the volume saving of the joint bay is approximately 27 m^3 per joint bay. As a result and proportional to this volume difference the new vertical split-box design offers further considerable installation and infrastructure costs

Picture 6: Installation space for joint type MPFP with vertical split-box design...

Picture 7: Joint pit cabin made by 20 feet container...

savings due to less soil excavation work and its transportation, less necessary reinforced concrete for the joint bay, less back filling material as well as less collateral damage to public pavements. Further advantages are presented the state of the art installation techniques without needing time consuming plumbing or soldering work, allowing further faster and easier installations. This is particularly important in view of maintenance and repairmen work in case of unexpected failure of the cable network.

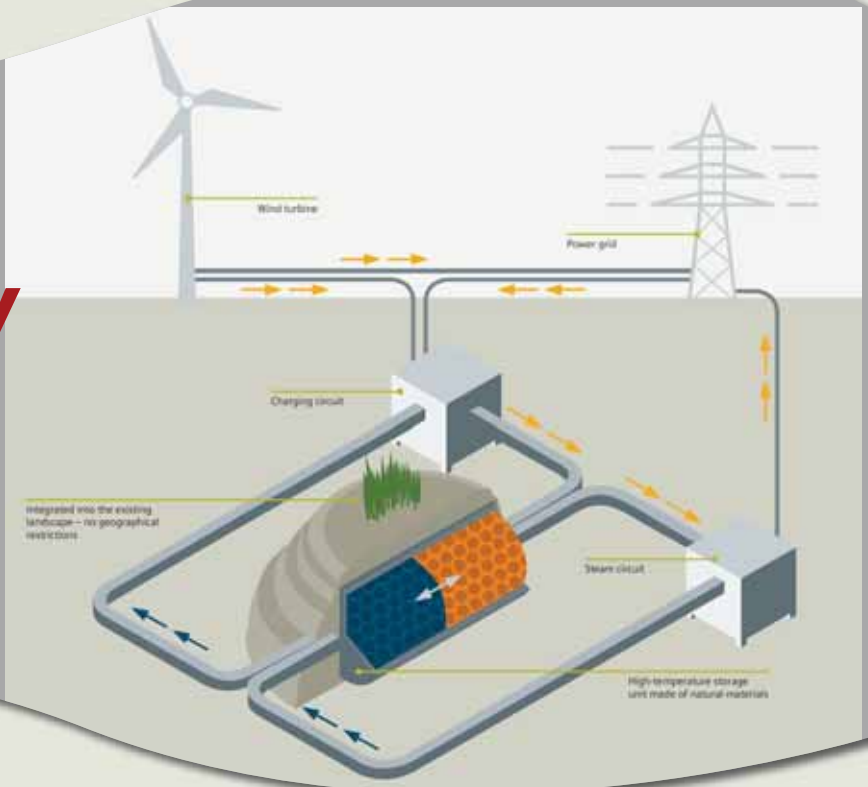
For the joint installation, suitable clean conditions must be established at the joint bay location, including temporary power supplies conditioning. For this purpose a 20 feet container can easily be adapted to the joint bay cabin thus creating a protective dust and rain protection to the joint bay. The container is then transported to site and placed above the joint bay with help of a crane (Picture 7). The advantage of the joint pit size optimization, combined with pre-fabricated joint pit technic, is that the container joint pit cabin fits perfectly to the suggested joint bay dimensions.

Conclusions

The new vertical split-box design offers further cost savings in infrastructure and installation times compared to traditional horizontal outer protection designs. In future, this innovative design will majorly influence the execution of underground high voltage transmission lines. In view of the highly compact dimensions, a future standardization of a pre-cast joint bay is possible for voltages systems from 72.5 kV and up to 245 kV.

Storing Wind Energy

The thermal store for wind energy, which is being developed in Hamburg, is a joint project between Siemens, Hamburg Energie and TUHH. The German Federal Ministry for Economic Affairs and Energy is funding the project…



Siemens is developing economic storage technology: alongside Technical University Hamburg Harburg (TUHH) and urban utility company Hamburg Energie, Siemens is researching a storage solution in the Northern German city that will set a future standard in efficiency. After having been converted to heat in rock fill, excess wind energy is stored and protected with an insulated cover. When there is a need for additional electricity, a steam turbine converts the heat energy back to electricity. The simple principle of this store promises an extremely low-cost set-up. The project has therefore received research funding from the German Federal Ministry for Economic Affairs and Energy.

Siemens is currently operating a test set-up for the storage solution, named Future Energy Solution (FES), at Hamburg-Bergedorf. Alongside scientists from the TUHH Institute for Thermofluid Dynamics, the company is researching how to make charging and discharging the store particularly efficient. The arrangement of the rock fill and the form of the surrounding insulating container are crucial. The store is being tested at temperatures over 600 degrees Celsius. Just like a hot air gun, a fan uses an electrically-heated air flow to heat the stones to the desired temperature. When discharging, the hot stones in turn heat the air current, which then heats a steam boiler; its pressure drives a generator via a steam turbine.

As the current test set-up only tests the thermal requirements for the storage process, no reverse current is generated. However, researchers wish to test the complete energy conversion in spring 2017: from electricity to heat storage in the rock fill and back to electricity. They are establishing a complete thermal store on the Trimet aluminium smelter site in Hamburg-Altenwerder to the south of the River Elbe on the German A7 highway. The full-size FES will be able to store around 36 megawatt hours (MWh) of energy in a container with around 2,000 cubic meters of rock. Via a boiler, the heat it contains will generate so much steam that a Siemens compact steam turbine can generate output of up to 1.5 megawatts of electricity for up to 24 hours a day. The researchers expect to generate effectiveness of around 25% even in this early development phase. In the future, the concept has the potential for an effectiveness of around 50%. Partner Hamburg Energie will investigate appropriate marketing options for the stored energy.

"The technology of our FES store deliberately uses mainly tried and trusted technology. Because we are working here with tested thermal components and a series-ready steam turbine, we will be able to offer a practical solution within a few years. Our complete experimental system will be operational in just around 15 months," says Till Barmeier, Siemens' Project Manager.

Whereas many other stores generate high costs or only permit limited storage capacities, the FES technology can be used in the most varied of sizes and output classes, and therefore always remains extremely economical. The only limit to the concept is the space required for the rock-filled insulated container.

Transform the potential of your Transformer Reference Materials

To aid in the organization of a corporate or personal library, Megger is introducing a comprehensive series of Transformer Life Management bulletins that broadly cover the fundamentals of managing the life of a transformer

The Value of a Technical Library

Enter the office of most engineering types and there, on the shelf, you are likely to find a collection of prized reference materials. When pressed to share, often follows the tale of beloved resources never returned justifying heavy reluctance to lend out again. This valued labour segment (of which I proudly number) are the natural born problem solvers. Often and aptly characterized as incredibly resourceful, when left to their own devices, they figure things out.

A meaningful part of an engineer's arsenal is a carefully constructed library of references that are time-vetted supports for doing their job well (even if that support comes only from the reassuring presence and availability of these materials should the need arise to reference them). In many cases, personal financial investment has grown these libraries, of which university text books among others, number. So of no surprise, when these valued employees move on, often these treasure troves follow.

This highlights an interesting aspect to succession planning; that is, the advantages of establishing and maintaining a protected corporate library, accessible to all. In fact, a corporate library serves important roles, including:

- Spreading knowledge within the organization;employees value education and it will help build individual libraries
- Aiding with succession planning – an additional way to pass knowledge

What you can do:

- While most companies have employees who know a lot, it is unlikely that they have time to write it all down. A better solution may be to build a library and have these internal subject matter experts validate the collection you assimilate and supply what is missing. Annotating key materials as they relate specifically to the company is another invaluable service these employees may provide.
- Materials are all around though they do need to be collected, thoughtfully selected(you may not want to keep everything)and organized.

> A meaningful part of an engineer's arsenal is a carefully constructed library of references that are time-vetted supports for doing their job well.

Introducing Transformer Life Management (TLM) Bulletins – their place in your library

To aid in the organization of a library(corporate or personal), Megger is introducing a comprehensive series of Transformer Life Management (TLM) bulletins that broadly cover the fundamentals of managing the life of a transformer. These are provided by Megger

subject matter experts delivering confidence that the material is current. The bulletins span topics from moisture in transformers to each of the many electrical tests available to assess the condition of a transformer or instrument transformer. Moisture in transformers, for example, is a huge subject so there is value in overview summary publications that introduce the topic. If you collect all publications you can find on atopic, Megger TLM bulletins would be suitable to place at the front of each collection to introduce and frame that subject.

> TLM bulletins span topics from moisture in transformers to each of the many electrical tests available to assess the condition of a transformer or instrument transformer.

The Mature Library and the importance of maintenance

Of special note are mature libraries. Their value is already recognized but the risk here is failure to maintain. A champion must nurture it for while some material may be timeless, the most recent understanding of a subject must also be housed therein. Electrical testing, for example, has advanced – if you have material, when was the last time you updated it?

Megger TLM bulletins include more recent developments in the electrical test domain, including:

- Dynamic winding resistance (the variations of and differences in dynamic measurements)
- Individual temperature correction (ITC)
- Dielectric frequency response (DFR) for transformers and bushings
- How to increase the efficiency of testing through test lead management solutions like "One-time Connection" and a true transformer test van
- Demagnetizing procedures – different approaches

> **Download a newly featured TLM bulletin each month free of charge.**

These advancements are significant. Some examples of what a student subscribing to an out-of-date library would be at risk to miss include the following:

Dynamic measurements on OLTCs

Assessment of on-load tap changers include traditional static measurements (e.g., exciting current, turns ratio, winding resistance, and SFRA tests) and measurements made during the execution of a tap change, including continuity tests, dynamic current (a.k.a., "ripple") tests that are sometimes passed off as dynamic resistance tests, dynamic voltage tests (used to calculate dynamic resistance) and finally, true dynamic resistance measurements. Grab a Megger TLM on dynamic measurements to learn the differences between these. For example (but stripping detail):

A dynamic current test is similar to continuity testing. However, in addition to detecting discontinuity, the test current is measured and the result is presented in a current-time diagram or as a percentage ripple value. Ripple is the magnitude by which the test current decreases during the tap change and is expressed as a percentage of the test current. The challenge with this method is the inconsistency of the results given differing variables (e.g., test currents and connections).

For a dynamic voltage test, a relatively small test current (0.1 to 1A) is injected through the tap changer using a high-impedance current source and the LV windings (or HV, i.e., opposite windings of that under test) of the transformer are short-circuited. The voltage over the test circuit is measured and resistance versus time can be calculated.

A new, patented method is to measure dynamic resistance in the tap-changer by simultaneously measuring the test current together with voltages on both HV and LV windings and combine the results with transformer modelling. The difference in this test setup and that for the previous method is that the LV winding is left open.

Individual Temperature Correction (ITC)

Line frequency power factor[1] has been one of the preferred tools used to evaluate the condition of the insulation in substation electrical equipment for a long time. This testing tool relies on comparison with benchmark or previous results, whereby deterioration or contamination is detected by a change in power factor. The success of a comparative analysis is based on assurance that the results being compared are representative of the state of the insulation and not changeable test variables present. Otherwise, a change in power factor may be attributed to a test variable(s) and not an actual change in the condition of the insulation.

One notable test variable in power factor testing is (top oil) temperature. Therefore, for a meaningful comparison between tests, all power factor results need to be converted (or corrected) to equivalent 20° C power factor values that adjust for the influence of temperature. However, IEEE standards now acknowledge that the long-used corrections tables provided for this purpose are not reliable and no longer endorse their use. Dielectric frequency response (DFR) testing, which involves performing approximately 20 measurements from 1 kHz down to typically 1 mHz, has given operators a new alternative to determine the Individual Temperature Correction (ITC) factor for the line frequency power factor value measured at any temperature between 5 and 60° C, so that it can be accurately normalized to 20° C for trending analysis. Megger's TLM bulletin on ITC describes how this is done.

Dielectric Frequency Response (DFR) for transformers and bushings

Dielectric Frequency Response (DFR/FDS) measurements (narrow band, NB, and wide band, WB) are techniques/ methodologies for general insulation testing and diagnostics. It is recommended to routinely perform narrow band DRF measurements (1 – 500 Hz) in addition to single (line) frequency power factor tests. In comparison with 50/60 Hz power factor(PF) measurements, DFR measurements provide the following advantages:

- Capability of performing individual temperature correction of measured 50/60 Hz dissipation factor at various temperatures to values at reference temperature, 20 °C (NB and WB)

[1] Also dissipation factor or Tan δ

- Capability of estimating temperature dependence in an object; from a measured dissipation factor at a certain temperature calculate the dissipation factor at a different temperature (WB)
- Capability of estimating the moisture content of oil-immersed cellulose insulation in power and instrument transformers and bushings (WB)
- Capability to verify if seemingly good PF values actually are, and reveal when seemingly good PF values actually are not, thereby providing for earlier detection of problems (NB and WB)
- Capability of generally investigating causes for increased power factor in power components (NB and WB)

Megger TLM bulletins will describe how DFR fits into a transformer and bushing test program, including for example, why reliance on a line frequency power factor alone does not provide a full picture of insulation health.

Increasing the efficiency of testing through lead management solutions

Lead management, including quality of connection and correct lead placement, is an important part of testing. The time required to perform electrical testing is mostly influenced by the time involved for test set-up and breakdown.[2] Therefore improving test efficiency largely becomes a matter of improving lead management. The one-time connection concept reduces the number of connections required to execute electrical tests, such as transformer turns ratio and winding resistance tests, and eliminates the possibility of incorrect test connections. Another innovative solution is a true transformer test van. Megger's TLM bulletin on lead management solutions explains these concepts.

Visit megger.com/TLMBulletin to learn more and start updating your library

With improved lead management solutions, in addition to the time savings, safety hazards are minimized. Less required connections and connection changes means less ladder climbs to the top of the transformer. For some tests particularly, touching each bushing terminal with a grounding stick before removal of a test lead prevents risk of shock. Minimizing the number of disconnects lowers the chance that a tester becomes complacent and neglects this recommended safety measure.

> Every month you will receive an alert as soon as the latest bulletin becomes available.

Demagnetizing procedures

Though not necessarily a failure, a magnetized core may result in potentially damaging in-rush currents (which exceed the transformer's rated current by an order of magnitude and more) when the transformer is energized. This carries multiple implications but to the transformer itself, the high mechanical forces and resulting vibrations due to these currents may cause increased wear on the insulation of transformer windings. For the power system, protective relays cannot distinguish between causes of high current (e.g., a transformer fault or a magnetized core) and will trip until this condition is corrected. A magnetized core may also influence certain off-line, diagnostic test results such that meaningful conclusions about the condition of the transformer cannot be accessed.

Residual magnetization leads to lower magnetizing inductance. Results from tests in which none of the transformer windings are short-circuited may be notably impacted, particularly exciting current and SFRA tests.

There are a couple of demagnetization approaches. With an alternating direct current method, the magnetic alignment of the core iron is neutralized by applying a direct voltage of alternate polarities to the transformer winding for decreasing intervals. A variant of this is a Constant Voltage Variable Frequency method (CVVF). The effectiveness, efficiency, and safety of automated demagnetization features can vary; Megger's TLM bulletin on core demagnetization will aid in your understanding of this topic.

Accessing Transformer Life Management (TLM) Bulletins

In appreciation for your support through the years and because a more informed individual is our best customer, Megger invites you to download a newly featured TLM bulletin each month at no charge to you – every month you will receive an alert as soon as the latest bulletin becomes available on megger.com/TLMbulletin.

For further information mail to Pratyush.Sinha@megger.com

[2] With the exception of dielectric frequency response measurements where the actual measurements time may take on the order of twenty plus minutes

Mr.Kadappa K Mysore Born in Belligatti village, Kundgol Taluka, Dharwad District of Karnataka state in January 1971. Mr. Kadappa K Mysore became a qualified professional in 1995 with a Graduate Degree in Instrumentation Engineering from Siddaganga Institute of Technology, Tumkur, Bangalore University. Mr. Kadappa started his career with employment as a Test Engineer at ELTEL industries in Bangalore. After working three and half year he ventured in to Testing of power equipment at site. He tested and diagnoses the power equipment near to failure and saved the failure with this customer helped him to developing Testing lab in large scale. Mr.Kadappa K Mysore Honorable with Best Small Scale Entrepreneur in the Year-2005 by Govt. of India.

"About Shanthala":

Shanthala Engineering was established in 18th Feb 1999 at Bangalore, in the year-2000. The Shanthala Laboratory was established in Hubli in the year-2003 both firm are merged in to become a Shanthala Power Research Corporation and shifted to New own building in Hubli, Shanthala become NABL and ISO certified company in the year-2004.

In the year 2008 Shanthala become Public Limited Company. Now, Shanthala Operates the services in all over India and abroad with 250 Highly qualified staff and 35,000Sq.ft of laboratory and has purchased 40 acres of land in NH4 highway, for all Testing Facility under one roof in Hubli.

Shanthala Power Limited" since inception has achieved many milestones. I take pride in showcasing the achievement of Shanthala Power Limited.,

2003 - Certified with ISO-9001:2008.

2004 - Accredited with NABL.

2005 - National Award for Small Scale Entrepreneurs to Mr.Kadappa K Mysore.

2008 - Honored with Rajiv Gandhi National Quality Award.

2010- Branch offices were set up across India & Honored with Rajiv Gandhi National Quality Award.

2012 - Special Commendation for the Golden Peacock HR Excellence Award.

2013- Rajiv Gandhi Excellence Award & Mahila Jyoti Award.

2014 - Avva Prashasti at Hubli.

- International Star for Leadership in Quality Award at Paris.
- Electro-Technical Calibration NABL Accredited Laboratory at Hubli.
- Best Quality Leadership Award in the Gold Category at Las Vegas, the United States of America.

"Our Transformer Oil Testing" Facilities Available at Shanthala

We collect the Transformer oil sample at customer's site. Our sample collection team centralizing, 6 dedicated mobile vans, 15 Technicians. We are having 30 dedicated Testing Engineers, 5set of equipments and online reporting system and large data bank of more than 1,00,000 Transformers testing from last 15 years. It will help our customers to advice on Tested results. We provide trend analysis on Transformers, so, that you can monitor, Repair, Recondition of the Transformers and also plan for the shutdown.

Transformer Oil plays a vital role in deciding the life of the Transformer and its performance during operation. The condition of the transformer winding is also largely dependent on the quality of Oil i.e. used in the transformer. On many occasions the transformers have failed prematurely because of not maintaining the quality, standards of the oil. To assess the transformer as a whole and to predict its condition, assessment has to be done in all the areas of the transformer i.e. oil, paper and conductor.

Tests on Transformer Oil ;

S.No.	Types of Tests	Information provided by Tests
1.	Breake down Voltage (BDV)	Indicated conductivity contaminants present in the oil such as particle, free water.
2	Moisture Content	Indicates the total dissolved water in the oil.
3	Interfacial Tension (IFT)	Indicates the presence of Sludge and excessive polar contaminants from the cellulosic materials.
4	Neutralization Number (Acidity)	Indicates the Acid contents in the Oil.
5	Die electric Dissipation Factor (Tan Delta)	Indicates the presence of soluble varnish, resins and others polar contaminants and aging of oil.
6	Resistivity(Specific Resistance)	Indicates the fitness of the Oil.
7	Flash Point	Indicates the presence of lower Hydro-carbons.
8	Sludge/Sediments	Indicates Deposition of fibrous particles, dust contaminants etc..
9	Dissolved Gas Analysis (DGA) **a.** Methane **b.** Ethane **c.** Ethylene **d.** Acetylene **e.** Carbon Dioxide **f.** Carbon monoxide **g.** Hydrogen **h.** Total Gas Content	Monitors internal condition of the transformer.
10	Furan Analysis a. 5 Hydroxymethyl-2 Furaldehyde b. Furfuryl alcohol c.2-Furaldehyde d. 2-Acetyl Furan e.5-Methyl-2-Furaldehyde	Periodical evaluation of Furan compounds in transformer oil help to know the condition of the solid insulation.
11	PCB Analysis	Indicates the polychlorinated biphenyl compound in Oil.
12	DBPC	Indicates the Anti-oxidant level.
13	Kinematic Viscosity	Indicates Heat removal efficiency of oil.
14	Pour Point	Indicates freezing point of oil.
15	Density	Indicates Heat dissipation characteristic.










Power Scenario Of Uttarakhand

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Power sector plays a vital role in infrastructure and growth of economy of every state. Uttarakhand has grown at a faster rate in order to eliminate the differences between it and other existing states. An efficient and financially sound power sector is a prime factor for growth as well as poverty reduction. This article presents various power related aspects of Uttarakhand...

Uttarakhand was introduced to the Map of India on 9th November 2000 after the bifurcation of Uttar Pradesh. It faced expectations related to the development and infrastructure needs of the state. Dehradun was declared the capital of Uttarakhand and stood as prime focus to meet the increasing economic and political activities.

All these also resulted in an increase in power demand and supply. Uttarakhand has a total area of 53,483 km^2 of which 86% is mountainous and 65% is covered by forest and northern part of the state is covered by high Himalayan peaks and glaciers. Agriculture is one of the most significant sectors of the economy along with tourism and hydropower as key industries.

Power sector background

Uttar Pradesh State Electricity Board (UPSEB) was founded on 1st April 1959. However on 14th January 2000, the functions of UPSEB were transferred to the follwing three Corporations registered under Indian Companies Act, 1956 :

1. **Uttar Pradesh Jal Vidyut Nigam Limited (UPJVNL)** : it own and operate the existing and under construction hydro power stations of UPSEB.
2. **Uttar Pradesh Rajya Vidyut Utpadan Nigam Limited (UPRVUNL)** : it owns and operates the existing Thermal Power Stations of UPSEB.
3. **Uttar Pradesh Power Corporation Limited (UPPCL) :** it operates for Transmission and Distribution of electricity in Uttar Pradesh.

Uttarakhand was introduced with UPCL & PTCUL as the functional bi-furcated Utilities responsible for the Electricity Distribution & Power Transmission within the State. The Company consists of 3,487 Human Capital Workforce , committed to provide 24X7 High Reliability and Quality Power Supply to 1.89 million electricity consumers spread across the 13 Districts in the State of Uttarakhand viz. Dehradun, Uttarkashi, Pauri, Tehri, Chamoli, Rudraprayag, Haridwar, Nainital, U.S.Nagar, Almora, Bageshwar, Pithoragarh & Champawat respectively. UPCL aims to reduce the AT&C Losses of the Company for FY 2015-16 to around 17% and set target to further reduction to 14% by March 2020. The company operates and maintains following substations:

a. 295 Substations of 33/11 KV with capacity - 3122 MVA.
b. 66/33/11 KV -48 MVA.
c. 4526 Km -33 KV, 38204 Km -11 KV lines and 59401 Km LT Lines spread across the State periphery.
d. 60298 Distribution Substations of 11/0.4 KV-3602 MVA capacity with a Sub-Transmission & Distribution System Network of 211 Km - 66 KV.

The On-going schemes for the Distribution System Improvement works entails an investment of Rs.715 Crores during the FY 2015-

Table 1: Hydro Plants

S. No.	Project Details	Installed Capacity (MW)
1.	Projects in Alaknanda River Basin	
	Total	455.45
2.	Projects in Bhagirathi River Basin	
	Bhagirathi Total	1850.9
3.	Projects in Ganga River sub basin downstream of confluence of Bhagirathi and Alaknanda	
	Ganga sub basin Total	173.7
4.	Projects in Ramganga basin	
	Ramganga Total	210.5
5.	Projects in Sharda River Basin	
	Sharda Total	426.15
6.	Projects in Yamuna River Basin	
	Yamuna Total	478.15
	Grand Total	3594.85

16. The company introduced following two new schemes for 24X7 working:

1. POWER FOR ALL (PFA) of the Ministry of Power for the State, the Deen Dayal Upadhyay Gram Jyoti Yojana – DDUGJY estimated to the tune of Rs. 3332.37 Crores additionally replacing the completed RGGVY aimed for providing better supply to the rural consumers and ensuring last – mile connectivity and access of electricity to rural households
2. The Integrated Power Development Scheme - IPDS, which is a way forward to the on-going R-APDRP with an additional investment of about Rs. 233.54 crores for implementation during the 12th Five Year Plan (FYP 2012-17) and upcoming 13th Five Year Plan (FYP 2017-22) aimed to provide 24X7 Reliable, Secure & Safe electricity and access to all the rural, semi-urban & urban households and ultimately reducing the AT&C Losses of the Company to below 14% by 31st March 2020 under the Schemes .

Table 1: Power Capacity of state

S.No.	Type of Plant	Capacity In Mw
1.	Coal	399.50
2.	Gas	69.35
3.	Nuclear	22.28
4.	Hydel	2441.80
5.	Other Renewable Sources	244.32

Hydro power

Uttarakhand is estimated to have a hydropower potential to the tune of 20,236 MW against which around 3594.85 MW has been harnessed so far through hydroelectric projects. The State is gifted by nature with rivers like Ganga, Yamuna, Kosi. So provides an ideal location for hydropower development. Some of them are listed in Table 1.

> Uttarakhand is estimated to have a hydropower potential to the tune of 20,236 MW against which around 3,594.85 MW has been harnessed so far through hydro-projects...

In Uttarakhand, operation and execution of various schemes based on non-conventional energy resources is handled by Uttarakhand Renewable Energy Development Agency (UREDA) through local Panchayat, volunteer organizations and district administration.

Solar power

In order to promote solar power generation in the state, the Uttarakhand Renewable Energy Development Agency (UREDA) has decided to set up over 2,000 units, which will produce 44 MW of electricity using solar energy. As per the new rule, Uttarakhand will have to purchase 8% power generated through solar plants. Earlier, the state was required to purchase just 3% power generated by such plants. It has 23 solar power generation plants and these are sufficient to fulfil the mandatory power purchase of 3%. New solar power generation options have been worked out for all states and under this campaign young entrepreneurs will be involved to enhance the total power generation capacity. In order to match the criteria laid out by the Union Ministry, the state will have to work towards setting up new power infrastructure. For this, over 2000 plants of varying capacity will be set up at different places. All infrastructure will be funded under central government schemes.

Factors causing set back

Uttarakhand has certainly showed signs of growth for the last few years but the growth has not been uniform. The growth process in Uttarakhand has been limited to the plain districts excluding the hilly areas, which is due to location of manufacturing units in the plain districts. However, 40% of the population of the state still lives below poverty line ,despite a very low rate of unemployment. It is due to the low wage and income rate in the state, which leads to the problem of the poor working. So, there is need for the productive employment demands of the rural population in the state, which can be achieved through an efficient and reliable access to energy. The development approaches are dependent on the old energy sources that worked for the plains, which are not much effective in the hills due to the associated difficult terrain. Many thermal power plants also contribute towards power demand in Uttarakhand. But renewable energy sector is the main focus due to various factors now a days.

Conclusion

Power sector of Uttarakhand is rising at a very good pace and will definitely contribute towards a large part on overall energy demand of our country, which requires such contribution to be the top developed country.

Power Scenario Of Chhattisgarh

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Electricity utilization is a vital index that decides the progress level of a state. The 'Power for All' programme is a foremost stride in this way. This cooperative project of Government of India and Government of Chhattisgarh aims to augment the satisfaction levels of the consumers and perk up the quality of people's life via 24x7 power supply. This would result in swift inclusive development of the state...

Power sector is a crucial infrastructure ingredient for expansion of an economy. The accessibility of dependable, quality and inexpensive power is imperative for brisk growth in crop growing, manufacturing and for overall fiscal expansion of a state. For this a well-organized, pliant and monetarily vigorous power sector is an indispensable prerequisite for development of a state and financial empowerment of the common man. Under the Indian Constitution, electricity is a concurrent subject. As per Electricity Act 2003, it is the obligation of a distribution licensee to extend and preserve an efficient, synchronized and cost-effective distribution system in the mandated area of supply as well as to furnish electricity in agreement with the provisions contained in the Act. The State Electricity Regulatory Commission (SERC), as per the provisions of the act, specifies and enforces the standards with respect to quality and reliability of supply by licensees and also monitors the performance of distribution companies (Licensees) on the basis of notified Performance of Standards.

Chhattisgarh Power Sector

Power sector can be divided into three verticals having Generation, Transmission and Distribution business. In Chhattisgarh, state electricity board, which was undertaking all the above functions, after the streamlining procedure undertaken in December 2008, was unbundled into five independent companies, as given hereafter.

Figure 1: Statistics of Chhattisgarh at a glance

Area	1,35,191 Sq. Km.
No. of Districts	27
No. of Villages	19,576
Households	56,22,850 (Census 2011)
Electrified Villages	18468 out of 19567 (95%)
Population	2.55 Crores
Forest Cover	55,674 sq. km. (41%)
Minerals	17% of coal
Installed Capacity	19,827 MW March 2015
Maximum demand	3817 MW (FY 2014-15)
Number of Consumers	42,94,606 (March 2015)
Number of domestic consumers	35,57,748 (March 2015)

Table 1: CSPGCL

Particulars	November 2001	March 2015	Increase/Decrease (%)
Installed Capacity (MW)	1,360	2,424	78
Power Generation (MU)	7,138	15,592	118
PLF (%)	65.72	78.07 (64.5)*	18.79
Auxiliary Consumption (%)	10.35	8.57	17.20
Specific Oil Consumption (ml/Kwh)	2.14	0.804	62.43
Specific Coal Consumption (Kg/Kwh)	0.79	0.770	2.53

*National average

Table 2: Export Capacity in Chhattisgarh

Export Capacity towards (MW)	Existing Capacity	Under Construction	Under Consideration	Total
East	10,000	6,300	–	16,300
North / West	7,138	15,592	118	6,000
South	65.72	78.07 (64.5)*	18.79	48,700

Table 3: CSPTCL performance

Particulars	November 2001	March 2015	Change (%)
400 kV (ckt. km)	277	1538	455%
220 kV (ckt,km)	1594	3314	108%
132 kV (ckt.km)	2974	5476	84%
400/220 kV S/s	1	2	100%
220/132 kV S/s	5	19	280%
132/33 kV S/s	20	69	245%

Table 4: CSPTCL performance

Particulars	Position as on		Percentage & Growth
	December 2000	May 2015	
Maximum Demand (in MW)	1,334	3950	196%
LT consumers (In Lakhs)	18.9	43	128%
Agriculture pumps (In Lakhs)	0.73	3.46	372%
BPL Connection (In Lakhs)	6.3	15.95	153%
HT Consumers	530	2,336	340%
Connected load (in MW)	1,976	7,102	259%
Agriculture load (in MW)	191	936	390%

1. Chhattisgarh State Power Generation Company Limited (CSPGCL),
2. Chhattisgarh State Power Transmission Company Limited (CSPTCL),
3. Chhattisgarh State Power Distribution Company Limited (CSPDCL),
4. Chhattisgarh State Power Trading Company Limited (CSPTrCL), and
5. Chhattisgarh State Power Holding Company Limited (CSPHCL).

The function of power generation to meet the demand of the state was given to CSPGCL. The function of intra state transmission of power was given to CSPTCL and distribution of power to end consumers was given to CSPDCL.

Power Generation

The existing installed power generation capability of the state is 19,827 MW. The state is expected to witness a capacity accumulation of 22,000 MW at some stage in the end of 12th Five year plan which is principally for meeting the demand of other states.

CSPGCL at present has an installed capacity of 2,424 MW, out of which 2,240 MW is from coal based power plants. CSPGCL will also append an extra capacity of 1,000 MW (2 x 500 MW Marwa) which will boost the installed capacity of CSPGCL to 3,424 MW by the end of FY 2016. Some of the changes in key parameters after the formation of Chhattisgarh state have been shown in Table 1.

Power Transmission

Chhattisgarh has total interstate transformation capacity of 23,205 MVA. The bulk of the network is designed for exporting power outside Chhattisgarh. The transmission export capacity in the state to other parts of the country has been shown in Table 2.

To meet the demand of Chhattisgarh, intra state transmission network has been developed by CSPTCL which provides connectivity to CSPDCL customers. A capacity of 6030 MVA has been developed by CSPTCL to meet the demand. A summary of capacity expansion has been shown in the Table 3.

Power Distribution

The task of power distribution in the state is undertaken by CSPDCL. The comparative of expansion in key parameters is shown in Table 4.

Electrification

According to the census 2011, Chhatisgarh has a populace of 2.55 crores with 40% of population concentrated in Raipur, Durg and Bilaspur districts. Chhattisgarh domestic electrification had reached a level of 75% (94% in urban and 70% in rural areas respectively) as per the census 2011, which is reasonably superior than the overall India average of 67%.

Reference: All literature, figure and data used from document on "24x7 Power for All Chhatisgarh".

Hydro Power Scenario In Tamilnadu

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Tamil Nadu has been a pioneer State in the field of hydro power development in India. It is the only State in India where all of its economically exploitable hydro power potential has been harnessed. The State has the highest head hydro power plant in India and has developed every type of hydro power schemes: run off river & storage based schemes, surface & underground power houses, high head & low head plants, base load & peak load stations, single & multi-purpose schemes, conventional & pumped storage schemes, schemes in cascade development, inter-basin transfer of water for power generation etc...

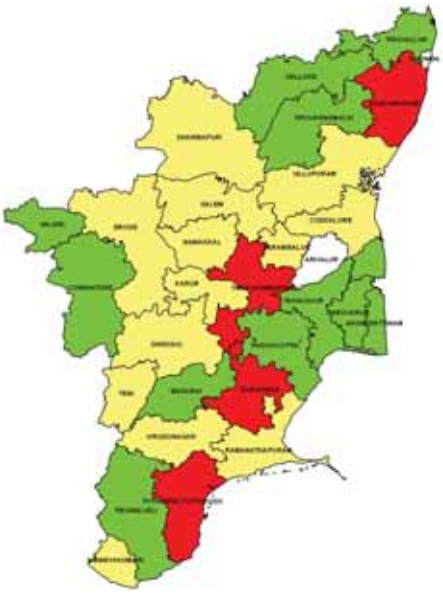
Tamil Nadu (the Lands of Tamils or Tamil Country) is the southernmost part of Indian Peninsula. It is bordered by union territory of Pondicherry and States of Kerala, Karnataka and Andhra Pradesh. It is bounded by Eastern Ghats on north; by Nilgiri Hills, Anamalai Hills and Kerala on west; by Bay of Bengal in east; by Gulf of Mannar and Palk Strait on southeast and by Indian Ocean on south. It has country's second longest coastline of about 1,076 km in length. It shares a maritime border with Sri Lanka. Chennai (formerly known as Madras) is the State Headquarters.

Tamil Nadu is the eleventh largest state in India by area and the sixth most populous one. It has a population of 7,21,47,030 as per Census 2011, and covers an area of 1,30,058 sq.km. Its 48.4 % population live in urban areas. It is divided into 32 districts. According to Human Development Index in 2011, Tamil Nadu ranked sixth among Indian States and is second-largest State economy.

Western, southern and north-western parts are hilly and rich in vegetation. Western and Eastern Ghats meet at Nilgiri hills. Western Ghats traverse the entire western border with Kerala, effectively blocking much of rain bearing clouds of south west monsoon from entering State.

Tamil Nadu is mostly dependent on monsoon rains and thereby is prone to droughts when monsoons fail. It has two distinct periods of rainfall: south-west monsoon from June to September with strong southwest winds and north-east monsoon from October to December with dominant north east winds. Annual rainfall of the State is about 945 mm of which 48% is through north-east monsoon and 32% through south-west monsoon.

About 28 dams have been constructed in Nilgiri Hills for impounding, diverting and regulating the water resources for hydro power generation. Nilgiri Plateau is the meeting point of Western and Eastern Ghats. Famous



Madumalai Wild Life Sanctuary is in these hills. Kundah forested hills are in broad valley surrounded by steep sided hill ranges/ basin. Whole of this Kundah basin has a number of reservoirs like Mukurthi, Pykara, Parson's Valley, Emarald, Upper Bhavani etc.

Anamalai forested hills lie in southern portion of Coimbatore district of Tamil Nadu. These are in continuation of Western Ghats and have a good amount of annual rainfall of more than 250 cm. Nature has endowed Anamalai Hills with a rich hydro power potential.

This article deals with State level power organisations, power supply position, sources of electricity, major river systems, hydropower potential, hydropower projects in operation and renovation & modernisation of old generating units of hydro power plants in Tamil Nadu.

State Level Power Organisations

Electricity Department, under Department of Power of Government of Madras was created in 1927 for dealing the matters related to power. Madras State Electricity Board was formed on 1st

Table 1

Year/ Period	Energy Supply Position (MU)				Peak Demand/ Peak Met (MW)			
	Requirement	Availability	Deficit (-)	Deficit (%)	Peak demand	Peak Met	Deficit (-)	Deficit (-)(%)
April- Sep., 16	54,428	54,419	-9	0.0	14,823	14,823	0.0	0.0
Sept., 2016	8,675	8,674	-1	0.0	14,424	14,385	-39	0.3

July 1957 in accordance to Electricity Supply Act of 1948 as successor of Electricity Department. It was responsible for electricity generation, distribution and transmission. It also regulated electricity supply in Tamil Nadu. Later on this Board was renamed as Tamil Nadu Electricity Board (TNEB).

With effect on 1st November 2010, TNEB was re-organised in to Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO) (responsible for power generation and Tamil Nadu Transmission Corporation Limited (TANTRANSCO) (responsible for power transmission) under section 131 of the Electricity Act of 2003.

Tamil Nadu Electricity Regulatory Commission (TNERC) was established in 1999 under Electricity Regulation Commission Act, 1998 mainly to deal tariff related matters. Tamil Nadu Energy Development Agency (TEDA) acts as a nodal agency to State and Central government, promotes/ develops renewable energy schemes, implements schemes sanctioned by State/Central Government, promotes energy conservation activities and encourages research and development on renewable sources of energy.

Tamil Nadu Electrical Inspectorate (TNEI) is under the control of Energy Department and is responsible for ensuring electrical safety in the State. It is also a nodal agency for energy efficiency and conservation. Tamil Nadu Power Finance and Infrastructure Development Corporation (PowerFin) mobilizes funds for financing power and infrastructure projects. Indian Renewable Energy Development Agency (IREDA) under MNRE provides funds for renewable energy projects.

Power Supply Position

In Tamil Nadu, energy and peak demands have almost been met during April 2016 and the period April 2016 to September 2016. Requirements vis-à-vis availabilities of electricity and peak power demands in Tamil Nadu during these periods are given in Table 1.

Sources Of Electrical Energy

Sector-wise

Tamil Nadu has the third largest installed power generation capacity in India. Total installed capacity of electricity in the State as on 31.08.2016 was 26,260 MW. Sector-wise distribution of installed capacity in the State is indicated below:

Sector	Total Installed Capacity (MW)
State Sector	7598.98
Private Sector	13519.36
Central Sector	5141.60
Total	26259.94

Category-wise

Major sources of electricity in Tamil Nadu are thermal power power plants, natural gas power plants, diesel power plants, nuclear power plant, wind mill power plants and hydroelectric power plants. Category-wise installed capacity in Tamil Nadu as on 31.08.2016 is given in Table 2.

Table 2

S. No.	Category of Installation	Total Installed Capacity (MW)	% Contribution to Total Installed Capacity
1	Thermal		
i)	Coal	11875.10	45.2
ii)	Gas	1027.18	3.9
iii)	Diesel	411.66	1.6
	Sub-Total (Thermal)	13313.94	50.6
2	Nuclear	986.50	3.8
3	Hydro (Renewable)	2212.20	8.4
4	RES (MNRE)	9777.30	37.2
	Total	26282.94	100

From Table 2, it seen that contribution of hydro installation to total installation in Tamil Nadu is 8.4%.

Major River System

Most of the hydropower development in Nilgiri Hills is covered by east-flowing rivers, namely Bhavani, Kundah and Moyar. Most of east flowing rivers have their origin in eastern slopes of Western Ghats and traverse their course through plains of Deccan Plateau and drain in to Bay of Bengal. Rivers are generally perennial with large variation in flows during monsoon and non-monsoon periods. Because of large variations in river flows, this basin is generally suitable for development of storage type schemes.

Bhavani river is the main tributary of Cauvery and joins it on right bank about 45 km below Metture reservoir. It rises in Salient Valley forests of Malabar (in Kerala) and after traversing in south-easterly direction, it swings round the hill and flows in north-eastern direction before entering in Tamil Nadu. It drains an area of 7,144 sq. Km and flows a distance of 216 km before joining Cauvery at Bhavani. Kundah and Moyar are its important tributaries. Pykara, Sandynallah, Melkodmund and Lone Valley streams are tributaries of Moyar river.

Pykara river rises on Mukurthi peak. After winding through the plateau for 24 km, it plunges down to plain in two falls and a series of cataracts making up in all a total drop of 914.4m in a few kilometres of length offering great potentialities of hydro power generation. Porthimund and Parson's Valley streams are its tributaries.

Total hydro power development in Anamalai Hills is covered by seven rivers, namely, Nirar, Sholayar, Parambikulam, Thunnakavadu, Peruvaripallam, Aliyar and Oliyar. About 8 dams

have been constructed in Anamalai Hills for impounding, diverting and regulating the water resources for hydro power generation and irrigation.

Aliyar and Oliyar rivers flow on eastern side, while remaining five rivers flow on western side of Western Ghats. These rivers have their sources at various elevations ranging from 1158m to 320m. Advantage of the difference in elevations has been taken to generate hydro power by constructing dams across each of these rivers. Parambikulam river, which originates from and traverses Anamalai in Coimbatore district is a tributary of Chalakudi river (Kerala), which ultimately empties in to Arabian Sea.

Hydropower Potential And Status Of Development

In terms of installed capacity, the total hydro power potential identified for Tamil Nadu as per reassessment studies is 1918 MW including station capacity up to 25 MW and is 1693 MW excluding station installed capacity of 25 MW. All the conventional hydro power potential in Tamil Nadu has been harnessed.

Hydro Power Schemes In Operation

Pre-Independence Power Scenario

Tamil Nadu has been one of the earliest States in Indian Union, where water was utilized for power generation.

Until about 1908, hydro electricity generation in Madras State was confined to a few tiny hydro plants in tea estates utilising waters of mountain streams and to small hydroelectric installation of Kattery in Nilgiris. The first river tapped for power development by Government of Madras was Pykara in Nilgiri Hills (first 3 units of 6.65 MW each) in 1932 and 1933. Fourth and fifth units of 11 MW each of this plant were commissioned in 1939. Thus, pre-Independence hydro power capacity in Nilgiri Hills and hence in Madara State was 41.95 MW.

Post-Independence Power Scenarios

After Independence of India, hydro power capacities were added during various Five Year and Annual Plans in Tamil Nadu. At present total hydro installed capacity of Tamil Nadu is 2,283.55 MW, 2,212.20 MW from stations having individual station capacity over 25 MW and 71.35 MW from stations having individual station capacity up to 25 MW.

Tamil Nadu has developed almost all type of hydro power schemes: run off river & storage based schemes, surface and underground power houses, high head and low head plants, base load and peak load station, single and multi-purpose schemes, conventional and pumped storage schemes, cascade development, inter-basin transfer of water etc.

Major/ Medium Stations (Station Capacity over 25 MW)

There are 29 hydro power schemes having individual station capacity over 25 MW aggregating to an installed capacity of 2,212.2 MW in operation in Tamil Nadu as on 31.08.2016. These schemes include 28 conventional hydro power schemes aggregating to an installed capacity of 1,812.2 MW and one pumped storage scheme, namely Kadamparai PSS of 400 MW.

Hydroelectric schemes in operation in Tamil Nadu as on 31.08.2016 are listed in table 3.

All hydro power stations in Tamil Nadu are conventional except, one station, viz. Kadamparai, which is pumped storage scheme having reversible generating units. This station adds valuable peaking power capacity to the grid and enables better utilization of thermal/ nuclear energy generation capacities in the State. In addition, it affords conventional energy generation of 77 MUs per annum on an average.

Table 3

S. No.	Name of Hydro Power Scheme	Nos. of Units x MW	Installed Capacity (MW)
1	Aliyar	1x60	60
2	Bhavani Kattalai Barrage-I	2x15	30
3	Bhavani Kattalai Barrage-II	2x15	30
4	Bhavani Kattalai Barrage-III	2x15	30
5	Kodayar -I	1x60	60
6	Kodayar -II	1x40	40
7	Kundah -I	3x20	60
8	Kundah -II	5x35	175
9	Kundah -III	3x60	180
10	Kundah -IV	2x50	100
11	Kundah -V	2x20	40
12	Kundah - VI	1x30	30
13	Lower Mettur - I	2x15	30
14	Lower Mettur - II	2x15	30
15	Lower Mettur - III	2x15	30
16	Lower Mettur - IV	2x15	30
17	Mettur Dam	4x12.5	50
18	Mettur Tunnel	4x50	200
19	Moyar	3x12	36
20	Papanasam	4x8	32
21	Parson`s Valley	1x30	30
22	Periyar	4x35	140
23	Pykara	3x7+2x13.6+1x11	59.20
24	Pykara Ultimate	3x50	150
25	Sarkarpathy	1x30	30
26	Sholayar- I	2x35	70
27	Sholayar - II	1x25	25
28	Suruliyar	1x35	35
29	Kadamparai	4x100	400
	Total		2212.2

Note: Above capacities do not include up-rated capacities after renovation and modernisation of generating units of some of the hydro power stations.

In Generation Mode, machines of Kadamparai PSS operate to cater peak hour power demand for full load depending on level of Kadamparai reservoir and level of Upper Aliyar dam. In Pump Mode, machines of this station operate as pump mode to pump the water from upper Aliyar dam to Kadamparai reservoir during night hours on grid frequency above 49.4 Hz utilizing off peak energy.

Small / Mini / Micro Stations (Station Capacity up to 25 MW)

At present, there are 16 small/ mini/ micro hydroelectric schemes aggregating to an installed capacity of 71.35 MW in operation in Tamil Nadu. These schemes are listed in Table 4.

Future Hydroelectric Schemes

As already has been stated, all economically viable hydro power potential in Tamil Nadu has been exploited. There is no conventional hydroelectric scheme under construction in Tamil Nadu. Also, there is no hydroelectric scheme in Tamil Nadu cleared by central Electricity Authority and yet to be taken for implementation. No hydroelectric scheme in Tamil Nadu is under examination in central Electricity Authority for accord of techno-economic clearance.

One pump storage scheme viz. Kundah of 500 MW envisaged for peak power generation was received in Central Electricity Authority. The same was examined and returned in December, 2007 for resubmission after resolution of inter-State aspect.

Renovation And Modernisation Of Hydro Generating Units

Renovation and Modernisation Works Completed

For optimization of resources and to tide over the shortage of electricity in the country, renovation & modernisation, up-rating and life extension (RMU&LE) of the existing old hydroelectric power projects is considered a cost effective option to ensure efficiency, better availability and also to augment capacity addition.

Renovation & modernisation, up-rating, life extension (RMU&LE) and restoration of capacity of the following generating units of hydro power plants in Tamil Nadu have been completed up to 12th Five Year Plan:

- Units 3 & 4 of Kadamparai PSS (100 MW each): Works included Renovation & Modernisation + restoration.
- Units 1&2 of Kundah– III (60 MW each): Works included Renovation & Modernisation
- All the 3 units of Moyar (12 MW each): Works included Renovation & Modernisation + + Life extension.
- Sholayar-I (1x30 MW): Works included Renovation & Modernisation
- All units of Pykara (3x6.65+ 1x11+2x 14): Works included Renovation & Modernisation + Life extension.
- All the 4 units of Papanasam (4 MW each): Works included Renovation & Modernisation + Life extension + up-rating of each unit by 1 MW (Total addition in capacity: 4 MW).
- All units of Mettur Dam (4x10 MW): Works included Renovation & Modernisation + Life extension + up-rating of each unit by 2.5 MW (Total addition in capacity: 10 MW).
- Generating units of Periyar PH (4x35 MW) (Original) have been up-rated from 35 MW each to 42 MW each. Total addition in capacity is 28 MW

Ongoing Renovation and Modernisation Works

- Sholayar PH-1 (2x35 MW): Each unit to be uprated to 42MW (Total addition in capacity:14MW)
- Kodayar PH-II (1x40 MW): Unit would be up rated to 46 MW (Total addition in capacity: 6 MW)
- Moyar PH (3x12 MW): Each unit would be up rated to 14MW (Total addition in capacity: 6 MW)
- Kodayar PH-I (1x60 MW): Unit would be up rated to 70 MW (Total addition in capacity: 10 MW)

In addition to above, some of the generating units of hydro power plants in Tamil Nadu are programmed for Renovation & Modernization & Life Extension and up-rating during the period 2017-22.

Table 4

S. No.	Name of Hydro Power Scheme	Nos. of Units x MW	Installed Capacity (MW)
1	Pykara Micro PH	2x1	2
2	Maravakandy PH	1x0.75	0.75
3	Mukurthy Micro PH	1x0.35	0.70
4	PU Micro PH	3x0.05	0.15
5	Aliyar Mini PH	2x1.25	2.50
6	Thirumurthy Mini PH	3x0.65	1.95
7	Poonachi Mini PH	2x1	2
8	Amaravathi PH	2x2	4
9	Sathanur	1x7.5	7.5
10	Lower Bhavani -1 Micro Hydel PH	4x2	8
11	Lower Bhavani RBC	2x4	8
12	Servalar Power House	1x20	20
13	Vaigai Power House	2x3	6
14	Perunchani PH	2x0.65	1.30
15	Periyar Vagai Mini - I	2x2	4
16	Periyar Vagai Mini - II	2x1.25	2.50
	Total		71.35

Conclusions

Tamil Nadu has been a pioneer State in the field of hydro power development in India. It has harnessed of all its economically exploitable conventional hydro power potential. To meet their power requirements, hydro potential at the existing irrigation dams is being exploited. To meet long term peaking requirements, provision of additional peaking capacity at the existing projects (operating at a very high load factor) is being given consideration.

Gaya Residents Enjoy Smart Metering

Bihar's first set of 100 smart electric meters have been successfully installed in Gaya. What does the first lucky consumer of the smart meter Kumar Kanishk from Shivpuri Colony say?

A smart meter is an electronic device that records consumption of electric energy in intervals of an hour or less and communicates that information at least daily back to the utility for monitoring and billing. Smart meters enable two-way communication between the meter and the central system. Unlike home energy monitors, smart meters can gather data for remote reporting. Such an Advanced Metering Infrastructure (AMI) differs from traditional Automatic Meter Reading (AMR) in that it enables two-way communications with the meter. Installation of Smart Meter is the step towards Government's Smart Grid Initiative.

Since the inception of electricity deregulation and market-driven pricing throughout the world, utilities have been looking for a means to match consumption with generation. Traditional electrical meters only measure total consumption, and so provide no information of when the energy was consumed at each metered site, Smart meters provide a way of measuring this site-specific information, allowing utility companies to introduce different prices for consumption based on the time of day and the season.

Utility companies propose that from a consumer perspective, smart metering offers potential benefits to householders. These include:

- **More accurate bills**: Smart meters mean the end of estimated bills, the end of having to remember to provide meter readings and/or have a stranger come into your home to read your meter
- **Better understanding of your usage**: With the in-home display, you can see immediately and directly how your habits and lifestyle impact your energy usage and ultimately your energy bill. By making your energy usage more easily understood, you can make smarter decisions to save energy and money, including feeling more comfortable switching energy supplier
- **Bringing energy system into the 21st century**: The future is smart, and smart meters are part of the effort to create a smart grid, which is part of providing low-carbon, efficient and reliable energy to Britain's households
- **Innovative energy tariffs**: Using the data collected on when and how households are using energy, suppliers can create more competitive time-of-use tariffs with cheaper prices for off-peak use.

Electricity pricing usually peaks at certain predictable times of the day and the season. In particular, if generation is constrained, prices can rise if power from other jurisdictions or more costly generation is brought online. Proponents assert that billing customers at a higher rate for peak times will encourage consumers to adjust their consumption habits to be more responsive to market prices and assert further, that regulatory and market design agencies hope these 'price signals' could delay the construction of additional generation or at least the purchase of energy from higher priced sources, thereby controlling the steady and rapid increase of electricity prices. The Smart Meter will report back electricity issues (such as periods of low voltage) to deliver better quality of supply.

An academic study based on existing trials showed that homeowners' electricity consumption on an average is reduced by approximately 3-5%.

The ability to connect/disconnect service and read meter consumption remotely are major labour savings for the utility.

Bihar's 1st set of 100 smart power meters are already being installed in Shivpuri Colony and Aliganj localities of Gaya town by India Power Corporation (Bodhgaya) Ltd.

The new-generation smart meters are well ahead of the electronic meters besides dispensing with the necessity of manual reading, alert power supply officials to snags with precise location and other details. Smart meter users will no longer be required to register complaints as the meters will send signals to the main server, thereby ensuring prompt fault repair. 1200 meters are being installed on pilot basis and based on the adaptability; larger quantity installation is being planned. India Power Corporation (Bodhgaya) Ltd. (IPCBL) has about 1,10,000 power consumers in Gaya town, Bodhgaya and Manpur areas. IPCBL has undertaken the task of replacing old and exposed LT wires with aerial bunch cable with five wires bunched together. Three of five wires carry current provided by the three phases emanating from distribution

transformer and the two remaining wires are used for earthing and street light purposes respectively.

Once the smart meters are installed, power executives will no longer have to climb atop poles for disconnection purposes. Power supply to the defaulters will be disconnected from the main server itself and reconnection too will be instantly done once the bill is paid. These smart meters will be beneficial for both the consumers as well as India Power because the consumer will be getting quality power (aerial bunch cable will minimize voltage fluctuation). India Power Corporation (Bodhgaya) Ltd. will benefit as the systems seals the leakages that cause power theft.

The priority to replace the old mechanical meters with the smart meters will be based on a disciplined system. The smart meters will provide the consumers with different facilities such as automated meter reading, six-month data storage, online fault detection in distribution line, location and quantity of power theft amongst others. The company would not charge anything from consumers during the pilot project.

The first lucky consumer of the smart meter – Shivpuri Colony resident Kumar Kanishk said, "The company told us about benefits of the smart meters. If the family goes somewhere outside and the house is locked, the consumer will have to inform the company office. During this period, meter will not show any reading and if someone uses or steals power, the company will get a report and take action immediately."

"We had a mechanical meter at home and later replaced it with a digital one. Now India Power has installed a smart meter. In the digital meter, there were complaints of excess reading but that was sorted out. Only time will tell the performance of these smart meters, added Kanishk.

Union Energy Minister Piyush Goel has directed power companies to ensure 100% smart meter coverage by the year 2020. IPC(B)L is likely to complete the job well ahead of the 2020 deadline.

Source: India Power Corporation Limited

Demand Estimation & Power Distribution

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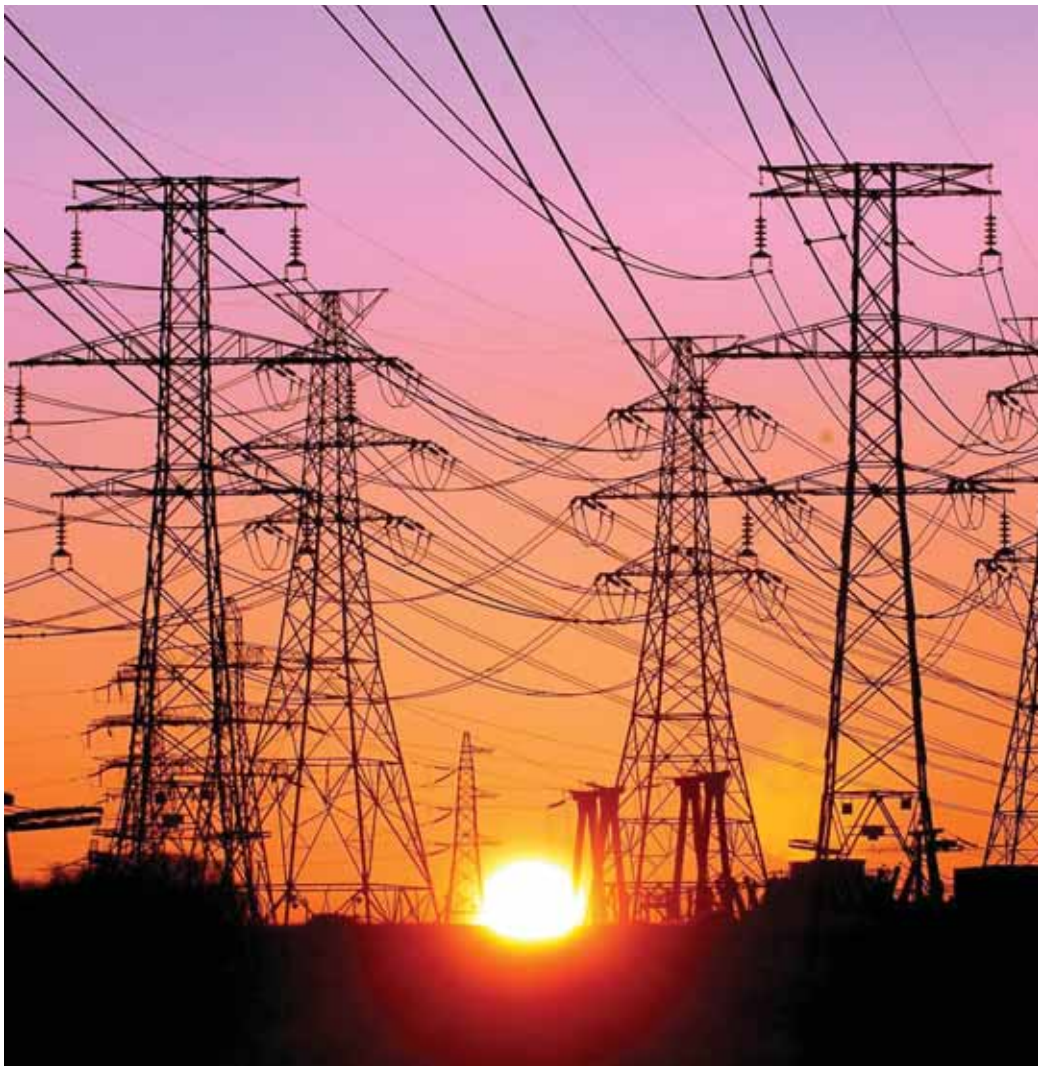


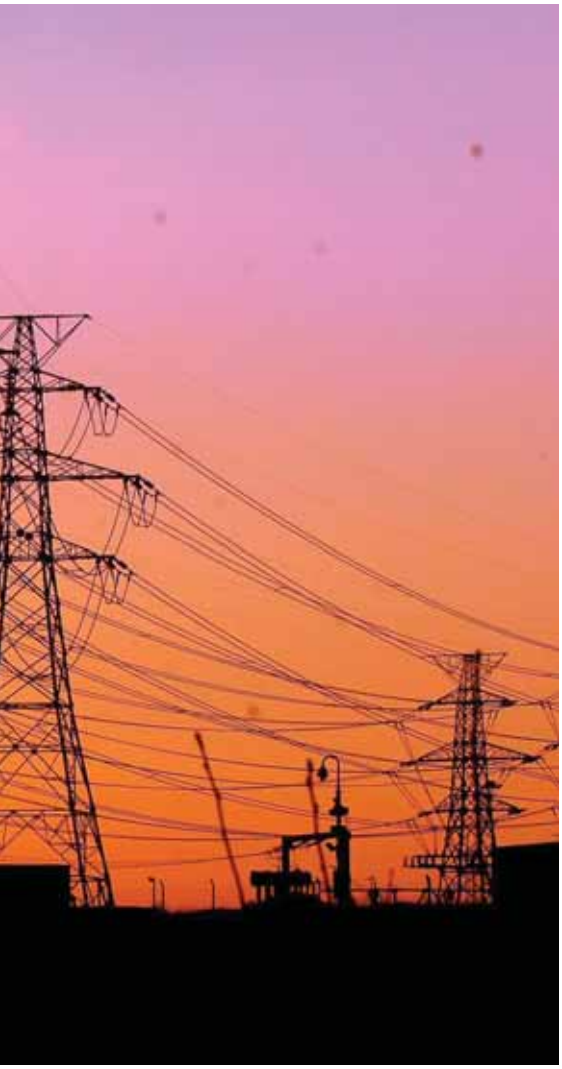
'Assured and quality electric supply' is one of the core infrastructure elements of the smart city. The backbone to drive this objective is to implement an efficient and intelligent power distribution system. The trigger for an efficient power distribution network begins with the demand assessment. The methodology for arriving at the optimum demand assessment and planning of power distribution network for a smart city is deliberated in this article...

Government of India has a vision of developing 100 smart cities across the country aiming at higher economic growth and improved quality of life.

Smart cities are considered to build a strong and intelligent infrastructure with sustainable environment. The core infrastructure elements expected out of a smart city would include 24x7 water and power supply, robust transport system, efficient water & waste management system, reliable IT network, smart buildings, state-of-the-art health care & education facilities, e-Governance, safety & security, etc. It is evident that to build these infrastructure elements efficiently, electricity plays a vital role. It would be impossible to build an efficient infrastructure without reliable energy source.

To ensure 24x7 reliable and energy efficient power to the smart city, it is imperative that the electric services should be of best quality, continuous and economic. Thus, the most significant and crucial design goals would be

optimal demand assessment followed by establishment of an efficient power distribution system. For building a new smart city, accurate prediction of the demand is a challenging task due to the diversified and varying pattern of the load. This requires a holistic approach through a diversified and optimized load model.



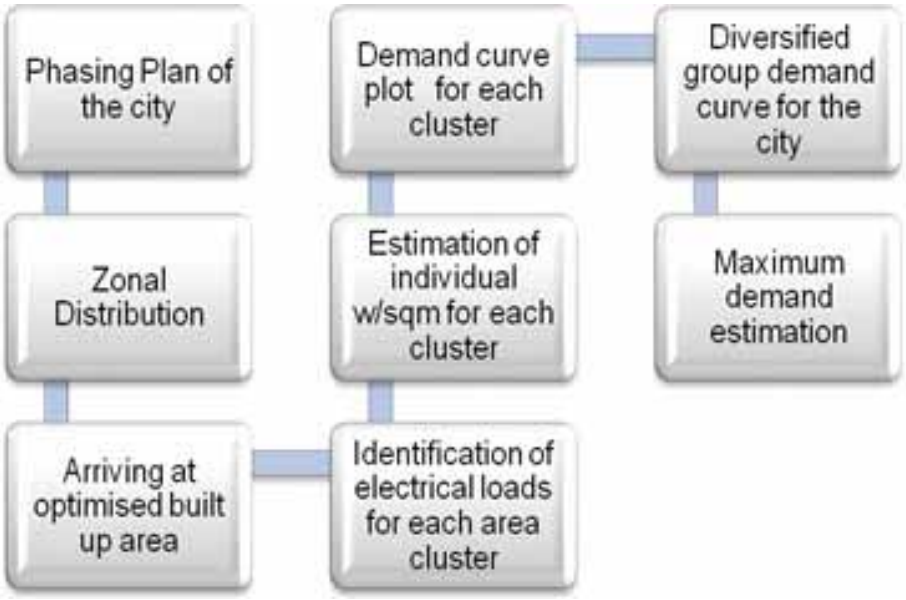
Demand Estimation

Usually for a city development, historical and statistical load pattern and recorded load data will be used to estimate the maximum demand.

This normally includes monthly energy billing data for domestic consumers and hourly meter recordings of the maximum demand values for bigger customers, generally HT consumers.

Development of a new smart city which aims at high reliability necessitates an advanced model. Generally, the models adopted till date in many countries are, objective based models, identification based models on spatial coverage, classification based modeling approach. In a smart city, more focused demand estimation is required in order to meet the criteria of optimal, energy efficient and economic demand estimation.

Figure 1: Stages of Demand Estimation



As per UN estimate, cities are responsible for 75% of global primary energy and contribute to 70% of global carbon emissions. The situation in Indian cities is still severe, the energy demand is rising each year, according to British Petroleum's energy forecast, energy demand in India is expected to increase by 132% by 2035 while the growth in production will be about 112%. Thus, to build a smart city, it is vital that low carbon foot print and energy efficient power should be considered as major factors.

To enhance the sustainability and energy security of the city and to ensure that the city remains an attractive destination for investment, renewable energy becomes a significant component of energy mix. It is crucial to supplement energy produced by burning fossil

Figure 2: Typical Zonal Classification

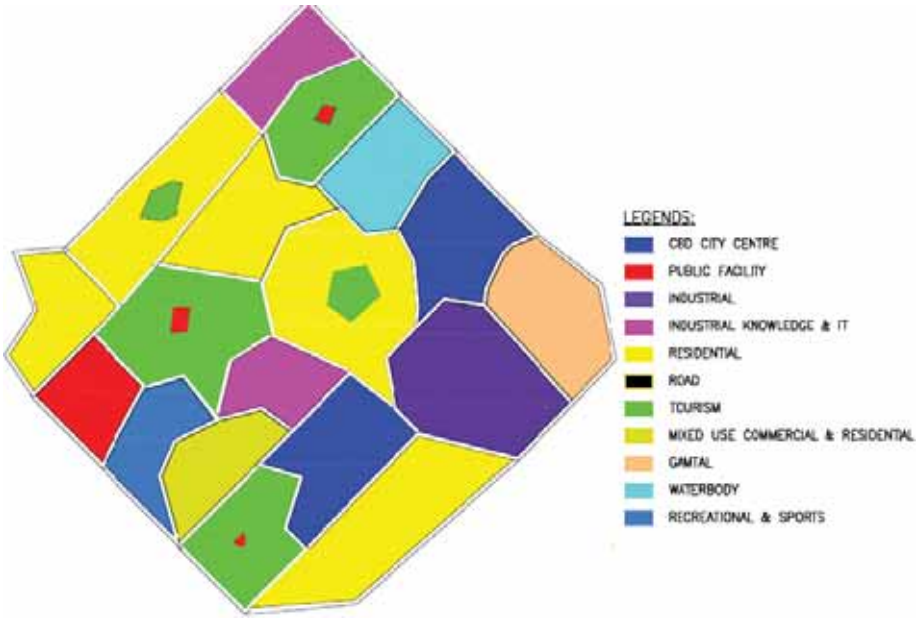
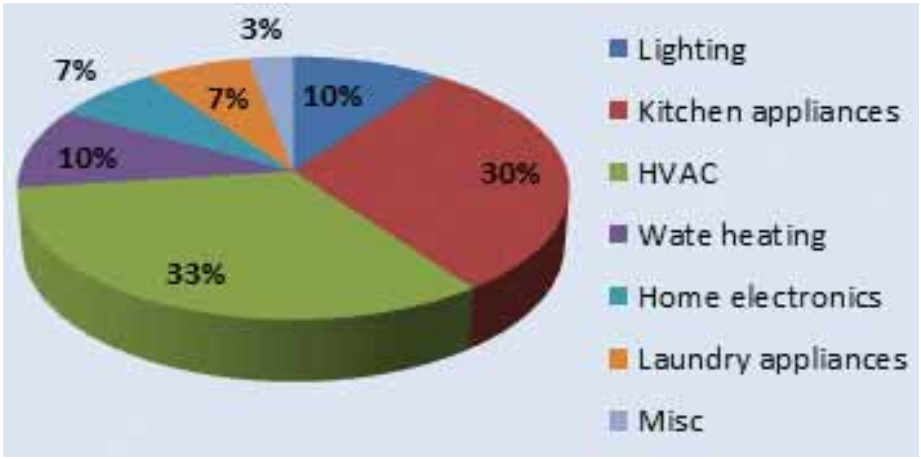


Figure 3: Energy Usage Pattern



fuels with clean renewable energy.

In addition, demand should meet the different types of load clusters with varying load pattern. Electrical load varies with time, place and climate. Therefore, a diversified demand estimation using weighted arithmetic mean model is considered. This model involves series of strategic planning and scrupulous forecasting of load demand. The various steps involved in this model are depicted in Figure 1.

a. Phasing Plan and Zonal Distribution of the City

Based on the city developmental plan and with consideration of environmental and sustainability objectives, zonal classification is done. Generally in any smart city, different types of zonal plot areas are envisaged. Few typical classifications are: Residential, High Access Corridor, City Center, Industrial, Knowledge & IT., Commercial, Recreation, Sports & Entertainment, Utilities, Public Facility Zone, etc. A typical zonal classification for a city is depicted in Figure 2.

b. Built-up Area Estimation

The optimized built-up area for each type of land use and plot area is derived based on resident population, floor space index norms, urban and regional developmental plan formulations and guidelines (UDPFI) and National Building Code (NBC). The built-up area considering growth plans & population density of various clusters are used in the assessment of the power demand and infrastructure planning of electrical power system.

c. Identification of Electrical Loads for Each Cluster

The electric loads are influenced by various factors i.e., application factor, area classification factor, climatic factor and time factor. Considering these factors, broad load classification are worked out which are further framed into micro level classifications. Various typical loads envisaged are lighting & receptacles, air conditioning & ventilation, workstations & servers, electronic appliances, elevators & escalators, heaters, water treatment loads, sewage treatment loads, etc.

d. Estimation of Individual Watt/Sq.m for Each Cluster

Precise estimation of Watt/Sq.m of individual loads is carried out considering the important objective of load optimization. Being a smart city, energy efficient, renewable energy source and adoption of smart & advanced technologies are the key factors which influence the load estimation. Optimum estimation on Watt/load is worked out considering the following energy conservation aspects adopted in a smart city.

- All commercial (IT/office) buildings are LEED certified
- Energy efficient lighting system for commercial buildings, street lighting and common area lighting
- Energy conservation measures in HVAC design
- Smart & Intelligent lighting controls for all road lighting
- All motors employed in utility area (WTP, STP, ETP, pumping stations, gas & fire stations, etc.) and industries are energy efficient motors.
- Usage of Variable Frequency Drives (VFD) for process motors
- Smart homes with smart metering system
- Integrated, smart and intelligent power system automation for complete city
- Renewable energy source like solar for all commercial and official buildings

In a typical city, major energy contributors are residential sector, industries and commercial buildings which require substantial consideration of energy efficient measures.

Residential Zone: Various surveys conducted across Indian cities reveal that residential sector contributes around 25% of the total power consumption. Major loads which contribute to this includes lighting, kitchen

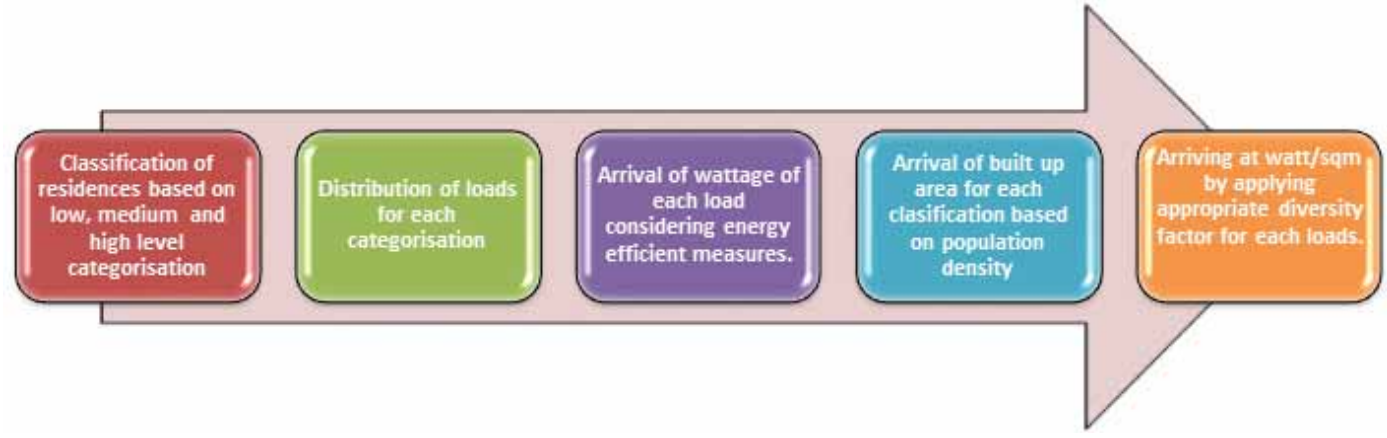


Figure 4: Steps Involved in Estimation of Watt/Sq.m

appliances, air conditioners and space heating. Typical energy usage pattern of residential loads are depicted in Figure 3.

Due to the significant proportion of energy consumption of residential sector, optimum energy demand estimation should necessarily take into consideration the various energy conservation measures. In general, residential energy pattern is influenced by variant factors such as number of occupants, time of occupancy, occupant behaviour and standard of appliances used. There are various models used for residential demand estimation such as statistical model, top down approach, bottom up approach, etc. The methodology adopted in this context is bottom up engineering approach which is based on end use energy model and this model has an advantage of identifying potential energy efficient measures. The major steps involved in this approach is depicted in Figure 4.

Commercial Buildings: Predominant loads envisaged in this zone are lighting (interior and exterior), HVAC, workstations and datacenters. Similar to residential, bottom up engineering end use model is adopted where Watt/Sq.m is arrived considering the energy wattage of individual end use load with due consideration of energy efficient measures.

As per ASHRAE standard, the lighting power density using building area method for office buildings is 0.9. However, in smart city, considering energy efficient measures such as efficient lighting, efficient lighting controls, the value is further optimised to less than 0.9. In a smart city, most of the official and IT buildings are expected to be LEED certified. Therefore, as per LEED norms, minimum of 3-5% renewable energy source is considered while arriving at the respective building Watt/Sq.m. While arriving at Watt/Sq.m, diversity factor plays a significant role as in commercial buildings, the power consumption varies with occupancy of the building and the work profile of the building.

Industrial Zone: Contribution of industrial zone is equally substantial and more complex to estimate the load. Due to varying industry types with diversified and unique load pattern, statistical energy data approach is considered in this zone.

e. Watt/Sq.m for Mixed Type Plot

In a smart city, normally a mixed type of plot is envisaged. In a mixed type of plot, identifying the exact load model to be adopted is complicated. For example, residential zone comprises residences, commercial offices/retail, leisure/hospitality, community facilities, local public open space, roads & utilities. Standard Watt/Sq.m model cannot be applied for this plot type. Thus, average load is worked out for these types of plots by applying a Weighted Arithmetic Mean (WAM) model by determining the percentage of different mix available.

Table 1. Weighted Arithmetic Mean Model Of A Typical Residential Area

Residential Area (Mixed Plot)		
Area under consideration	% area occupation	Watt/ Sq.m
Residences	A1%	W1
Commercial Offices	A2%	W2
Leisure/Hospitality	A3%	W3
Community Facilities	A4%	W4
Local Public Open Space	A5%	W5
Local Roads	A6%	W6
Utilities & ICT Devices	A7%	W7

Uniform Watt/Sq.m by means of Weighted Arithmetic Mean (WAM) of the area cluster = $\Sigma(A\% \times W \times Y) / Y$ where Y is the total built up area of residential area.

f. Maximum Demand Estimation

Maximum demand for each load cluster is determined by applying hourly diversified factor to the Watt/Sq.m arrived by means of WAM. Hourly diversity factor varies with time, application and climate.

Hourly Max Demand (MW) = Watt/Sq.m x BUA (Built Up Area) x hourly group diversity factor.

Thus, the maximum demand of the city is derived from the peak demand of the hourly demand curve. A typical hourly energy demand curve is shown in Figure 5.

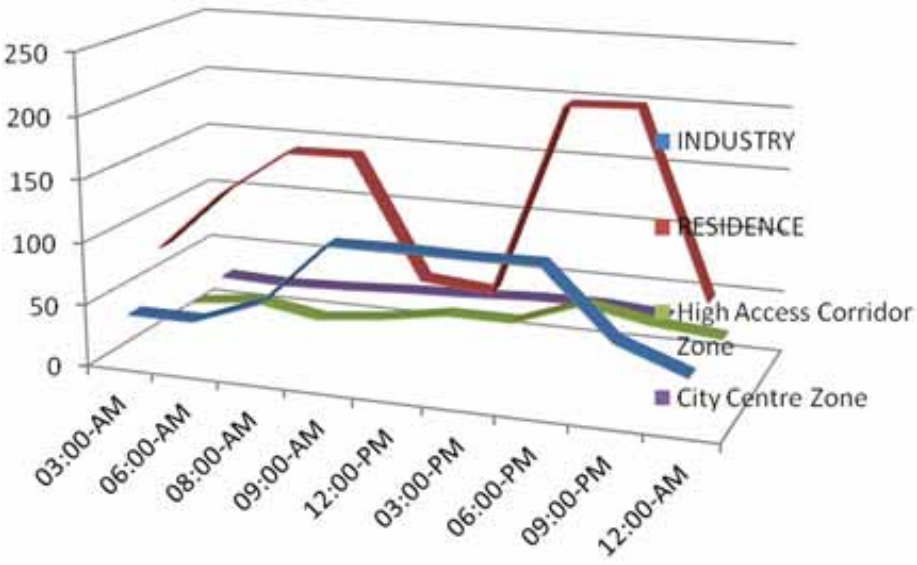


Figure 5: Typical Hourly Energy Demand Curve

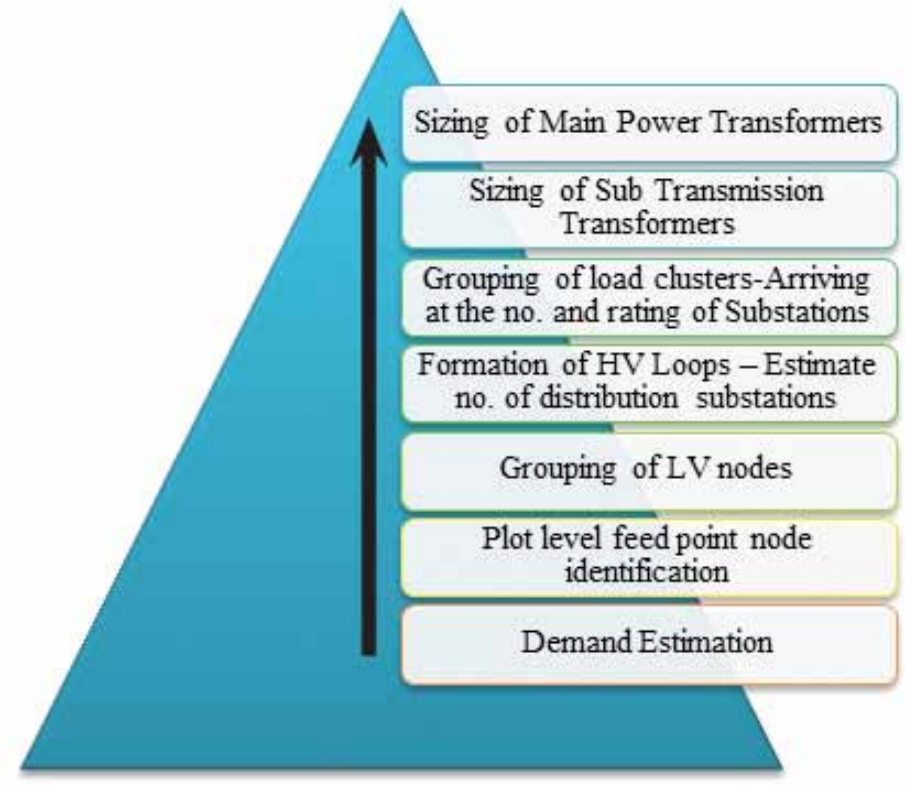
Power Distribution

The distribution network is the most extensive part of electrical power supply system, therefore optimization plays a vital role in the distribution system design. General design criteria include:

- Statutory rules applicable for particular location
- Power reliability and redundancy
- Minimum T & D losses
- Optimal selection of incoming power supply voltage level
- Optimal selection and close proximity location of distribution equipment
- Optimal sizing of main transformers and other distribution transformers
- Implementation of integrated and efficient automation system for the complete power distribution system
- Quick fault isolation and restoration
- Security and safety

To meet the aforementioned criteria and to design an optimized power distribution system,

Figure 6: Stages Involved in a Bottom up Nodal Methodology



bottom up nodal methodology is adopted.

Figure 6 in next page indicates the different stages involved in a bottom up nodal methodology.

Normally, the plot level feed points will be allocated based on the kVA versus voltage level identified by respective statutory norms. Based on the above criteria, the total no. of LV and HV customer feed points is arrived at for each voltage level. Grouping of individual plot level feed nodes (LV nodes and HV nodes) and formation of distribution substation loops based on zoning philosophy i.e., grouping within load clusters and particular type of land like residential, commercial, etc. is performed based on the circuit loop kVA limitation imposed. Point to be noted is, grouping should be within close proximity and meeting the voltage drop limit criteria. Further grouping of various load clusters is done and this grouping will be based on the limitation of HV equipment capacity.

In the design of main transformer and other intermediate step down transformers, key point to be noted are is ensuring continuity of power supply till end customer. Thus, redundant or n+1 transformer design is normally considered. As these transformers loading varies with time and climatic factors, optimum loading factor and diversity factor are chosen such that transformer is neither overloaded during peak utilization nor under loaded during off peak conditions and transformer losses are kept minimal.

Continuity of supply is achieved by means of Ring Main Units (RMU) looped to form a ring network. Ring network is designed with self-healing technology, which is achieved through fault passage indicators and auto sectionalisers for quick identification of fault and restoration of supply.

Selection of incoming voltage level and other intermediate voltages play a significant aspect in the design which influences the distribution network topology. Incoming voltage levels are normally selected based on the total demand requirement, and proximity of the source substations.

Power Distribution Automation

In order to achieve energy efficient power supply system with high quality and reliability, real time centralized control and monitoring is of paramount importance. They are met by means of integrated and intelligent power distribution automation. Thus, following automation facilities are provided for the power distribution of the city:

- Main receiving substation automation through IEC 61850 compatible SCADA system
- Sub transmission substation automation by means of micro SCADA with IEC 61850 compatibility
- Distribution automation through fault passage indicators, self healing system and smart RTUs
- LV distribution automation through smart panels
- Utility automation through intelligent MCCs and smart panels
- Home automation through Automated Metering Infrastructure (AMI)
- Smart lighting controls.

Conclusion

Development of Smart Cities is an ambitious plan rolled out by the Indian Government with an aim to improve the quality of life of people and improve the growth of the nation.

To fulfill the smart city mission, the key challenge for power providers/distributors would be to create a balance between the supply and demand of electric power. Robust demand estimation techniques, efficient power distribution system with energy efficient technologies are essential for implementing an economical and stable power supply system in smart cities.

Wireless Charging Is A Reality Now

The D-Broad system also improves system reliability and reduces total cost of ownership by eliminating trouble prone charging connectors and cables...

In contrast to conventional plug-in charging systems that require human operators to take Automatic Guided Vehicles (AGVs) out of service to re-charge, AGVs equipped with DAIHEN's D-Broad can autonomously re-charge and work around the clock. DAIHEN will supply the system on an OEM basis to AGV and mobile robotics manufacturers, and directly to advanced manufacturing engineers for custom factory automation projects. In addition to streamlining the AGV charging process, the D-Broad system also improves system reliability and reduces Total Cost Of Ownership (TCO) by eliminating trouble-prone charging connectors and cables.

In fact, WiTricity, has announced that DAIHEN Corporation, a global leader in power electronics and industrial robotics, has begun commercial shipments of its Wireless Power Transfer (WPT) system for AGVs. The DAIHEN system, D-Broad, is powered by WiTricity's patented magnetic resonance technology. D-Broad is poised to streamline factory automation by enabling fast, automatic charging at multiple locations along an AGV's route through a factory, as it transports materials and parts.

D-Broad will also serve as the basis for DAIHEN's own materials handling robot, called the AI Transfer Robot. DAIHEN developed the robot that can autonomously travel through a factory floor using sophisticated navigation and control systems, rather than relying on inflexible traditional underground wire guidance. WiTricity technology enabled the wireless charging over distance from a simple charging pad mounted to the front of the AI Transfer Robot – and without requiring precise alignment or docking to the charging source. The DAIHEN AI Transfer Robot can be deployed without expensive installation of docking stations, or continuous power rails buried beneath the floor.

"To be effective in factories, AGVs need to operate as efficiently and flexibly as possible – and that means working without interruption. We aim to expedite factory processes and reduce running costs by delivering wireless power transfer systems that enable automatic re-charging. With its magnetic resonance technology, WiTricity uniquely enables us to create highly flexible and efficient solutions," says Ryohei Tanaka, General Manager/Chief Engineer, Research and Development Division, DAIHEN.

"DAIHEN is leading the pack when it comes to applying revolutionary wireless power transfer to next-generation industrial power electronics and robotics solutions. WiTricity is excited to help DAIHEN achieve its mission of better factory automation in the emerging robotics space. We are only at the beginning of many WiTricity-powered solutions that will be hitting the market in a variety of applications," says David Schatz, WiTricity Vice President of Business Development.

Electricity Initiated Fire Hazard

Ritabrata Sanyal
Accredited Energy Auditor
Department of Power
Govt. of West Bengal

The object of the study is to examine efficacy of the prevailing safety regulations with regard to easing out incidences of electricity initiated fire hazard in electrical installations, and effectiveness of enforcing mechanism to curb thereof...

The reported news in ' The Telegraph ' on 22nd March 2016 about an incidence of fire, thought to be an electricity initiated fire, ravaging the heritage Zoology Laboratory of the Ballygunge Science College of the Calcutta University entailing property loss of about rupees 2 cr., besides irretrievable work of research scholars and priceless museum specimens of nearly extinct animals came under public domain .

Following that, on 29th March 2016, there has been an incidence of fire, thought to be a fire initiated by short circuit in LT installation, in a newly constructed commercial complex at Salt Lake, Kolkata in sector V – requiring more than one hour to put it out. The loss of property here also is reportedly significant.

On April 7, 2016, an electricity initiated fire from AC machine broke out in a Central Govt. establishment situated at Salt Lake, Kolkata in sector V points toward maintenance lapse calling for all time stricter vigilance cover as the Regulations of CEA contemplate (Anandabazar Patrika, 8th April'16).

The above news have saddened every one because of consequential damage of such enormity – and obviously throws open the door for relooking the sufficiency of the prevailing Safety Regulations of the Central

Electricity Authority with regard to restricting / mitigating electrically initiated fire in domestic and commercial premises.

The picture of electrical wiring in the University building, as appeared in the above stated edition of 'The Telegraph', distinctly speaks of weakness in the maintenance vigilance thereof.

The object of the study is to examine efficacy of the prevailing safety regulations –

with regard to easing out incidences of electricity initiated fire hazard in electrical installations, and effectiveness of enforcing mechanism to curb thereof.

To understand the basic essentials leading to triggering of fire from electricity causes, primarily, in short circuit, earth fault and overload situations, the probable factors correspond to ignition of fire need to be scanned. The factors are :

1) Carbonization of insulation
2) Short circuit / earth fault / gross overload
3) Excessive 'ohmic' heating ('hot-spot' situation)
4) Inconsistently performing installed equipment.

It is an accepted fact that the risk probability, under unfavourable operating circumstances, on account of carbonization of wire /cable insulation, primarily PVC, in installations using substandard insulated wires /cables is distinctly high. Despite that, in reality, high initial cost of PVC insulated wire / cable conforming to IS specifications, and lack of awareness about the potential hazard on usage of substandard wire / cable generally prompt one to use it in LV /MV installations.

The study, carried out on the subject of cable-insulation failures by different research organizations, has since identified the causes of breakdown as carbonization of insulation and, as a result, ignition of PVC insulation of wires / cables occurs. The factors are: gross overloading of wire / cable, localized heating due to conductor-strand breakage or loose terminal connection.

The poor insulation quality of substandard wires / cables, in the above stated circumstances, creates a semi-conductive path in insulation for leakage current even at 230 V and that ends up in electric arcing. The present trend of using PVC insulated wires / cables in installations without paying any heed to their quality corresponding to the locations of use makes the situation critical since PVC insulation, on exposure to temperature beyond the allowable limit, hastens its failure.

As to short circuit, the sudden flow of a very high magnitude of current through a very low resistance path is the manifestation of short circuit in an installation. Conductor to conductor contact in such an unwarranted situation creates a low resistance conducting path for the fault current. Sparking may appear as the conductors go apart. The arc, so formed, may lead to ignition of combustible materials in close vicinity.

The similar situation is also developed on occurrence of earth fault in an installation connected to earthed system of supply. Here, a very high amount of earth fault current flows through the faulty circuit to earth for ultimate dissipation. The contact of live conductor with earth conductor / earthed non-current carrying fittings in the installation constitutes the earth -fault path. Electric arcing may also appear on such a situation.

With regard to excessive heating under hot-sport situations, loose connection in the electrical installation is the real offender since the situation creates a localized high resistance path for the current and results in overheating. Continuance of the abnormality for a short time, because of high ohmic resistance, may ultimately show up as glowing connection and may lead to ignition of nearby combustible materials.

Inconsistently performing installed equipments may also create situation conducive to fire-risk.

Analysis of the attendant circumstances leading to electric fire with reference to Safety Regulations of CEA

Since, in reality, the use of substandard installation materials and apparatus has been rampant, watchfulness against their use in the installations is the desired administrative step. Here, the role of the owner of the installation is pertinent, since he himself is affected in consequence of accident in his electrical set-up. The role of the Licensed Electrical Contractor and the Supplier is equally vital (regulations 29(1) & 33(1)). The knowledgeable circle believes that, very often, their relaxed approach in discharging the assigned obligations under the Regulations of CEA, in most cases, leads to electricity initiated fire on consumers' premises.

The matters regarding general safety requirements in electrical installations have been the subject of regulation (12) of the Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2010. The provision makes specific reference to the matters pertinent to electrical safety during construction of electrical installation and safe use of electricity thereafter. The stipulation is also critical about the quality, current and voltage ratings of the installation materials corresponding to locations of their use.

The distinctive qualities of installation materials for the installations have been laid down in regulation 33(6). The provision lays emphasis on the use of insulating materials suitable for the proposed use and also maintenance of their qualities on all working conditions, such as temperature and moisture. The cable insulation, it is felt, also comes under its purview.

It is felt that, to have an installation operating consistently without any reasonable threat of malfunction therein, the selection of installed materials and apparatus conforming the relevant specifications of IS code is the prerequisite. It is evident, therefore, the fire- risk- factor due to carbonization insulation of wires / cables would appreciably come down upon use of installation materials without making any compromise to their quality.

As regards short circuit or like situations in electrical installations, inadequacy of the protective arrangements therein comes to the fore. The CEA Regulations, with an eye to plug up such eventuality, involve the Supplier in the matter and recognize the Supplier's satisfaction as to right compliance with laid down safety requirements by the owner of the installation prior to effecting the supply (regulation 33) . The measure proves effective in detecting inconsistency in the installations awaiting for the supply.

On top of that, in 2015 by an amendment of regulation (43), electrical installations, based on the notified voltage, are sub-divided into two categories. The installations, having voltage up to and including the notified one, are put under self-certified category and that above the notified voltage are placed under the inspection ambit of the Electrical Inspector. This means that the Electrical Inspector would only be competent to accord pre-energization approval of the installations of the voltage class above the notified voltage. However, for installations under self-certified category, the owner's certificate in lieu of approval of Electrical Inspector is considered adequate for the purpose enjoying the supply of electricity from the Supplier.

As to hot- spot situations, one is inclined to put blame on the Electrical Contractor for poor execution of installation work .

It is evident, therefore, that the 2010-Regulations of CEA, as amended up to date, not only ensure regulatory watchfulness on maintenance of protective qualities in installations but also on safe use of electricity.

The Regulations are critical also about the role of the persons, on whom inspection and testing for electrically safe installation rest .

Safety Regulations of the Central Electricity Authority

The Regulations, concerning measures relating to safety and electric supply, framed by the Central Electricity Authority (CEA) pursuant to the Electricity Act, 2003, took effect in 2010 vide Notification No. CEI/1/59/CEA/EI dated the 20th September, 2010. The regulations hold pertinence to ensuring electrical safety, not during erection stage but in-service situations also, and make specific reference to the role of the enforcing mechanism to carry into effect of the safety provisions in right spirit.

Understandably, there is scope for viewing the reported incidences of electric initiated fire as an effect of deficient upkeep of the installations, primarily by owners. But, the role of the supplier or the designated officials responsible for over-seeing safe maintenance thereof as per the said regulations needs scanning since the matters relating to electrical safety during their construction, installation, protection, operation and maintenance come under the jurisdiction of regulation 12 of the 2010 - Regulations of CEA .

Visualizing escapist mind-set of owners of the installations in generality, the Central Electricity Authority amended regulations 30 (2) to (5) of the 2010-Regulations in 2015 with a view to make the periodic inspection of electrical installations more meaningful...

Generally, an electrical set-up, be it at domestic or commercial premises, before being ready to receive the supply, passes through the following procedural- sequences :

1. Design of installation by keeping with a view to the mandatory protective features under the said regulations along with the recommendations of relevant IS standards .
2. Selection of installation materials and apparatus without making compromise to their qualities, both in respect of specifications and rating, and also their suitability for the operating environment [regulation 12(3)] .
3. Entrusting the State Govt. Licensed Electrical Contractor to carry out the installation work under direct supervision of a person holding the competency certificate for the type of work undertaken (regulation 29).
4. Pre- energizing inspection and testing of the prospecting consumer's installation by the Supplier before connecting it with his system of supply has been made obligatory (regulation 33(1)).
5. Mandatory inspection of installations of voltage-class exceeding the notified voltage by the Electrical Inspector prior to commencement of the supply [regulation 43(2)].
6. Self- certification by the owner of installation of notified voltage or below, awaiting for the supply [regulation 43(1)].

Regarding safe maintenance of the installation in – service situation, regulation 30(2) is very specific. The provision vests the responsibility of periodical testing and inspection thereof either in the Electrical Inspector or in the owner /consumer / supplier in respect of electrical installations based on the notified voltage, meaning the notified supply voltage.

Hence, installations of voltage above the notified voltage and that equal to or below are put under separate slot. Accordingly, installations above the notified voltage come under the inspection ambit of the Electrical Inspector [regulation 30(3)] and the rest are put under self-certified cover of the owner /consumer / supplier [regulation 30(2)].

It is confusing that regulation 30(1) speaks of involving either the Electrical Inspector or the Supplier, as may directed by the State Govt., for periodical inspections and testing of electrical installations. The provision is silent about legitimizing the owner's certification as the testimony to safe up-keep of his electrical set-up.

Visualizing escapist mind-set of owners of the installations in generality, the Central Electricity Authority amended regulations 30 (2) to (5) of the 2010-Regulations in 2015 – with a view to making the periodic inspection of electrical installations more meaningful.

By a substitution in regulation 5 ibid, a basic change in the compliance mechanism at pre-energizing stage or during periodical inspection of installations was brought about by authorizing Chartered Electrical Safety Engineers, having requisite qualification and experience as of

Electrical Safety Officer, to aid suppliers or consumers in the matters of testing, and observance of safety regulations (regulation 5A).

To make the arrangement rationally workable, CEA, based on the notified voltage, divides installations of voltages above 650V into two groups. However, no mention has been made with regard to periodical inspection coverage of installations below 650V. It is reasonably presumed that the self-certification by the owner the installation would prevail.

Regardless of installations of voltage equal to and below the notified voltage and having load demand of above 250 kW, the regulation 5(4) IBID makes it incumbent upon the owner thereof to appoint an Electrical Safety Officer to look into adherence of safety provisions.

But, the facts remains that the owner of installation having load demand of above 250 kW at or below the notified voltage (necessarily of voltage above 650 V) may not have any duly qualified engineer for appointment as electrical safety officer.

The unworkable obligation needs to be attended to with reference to ground reality to make the provision effective in achieving the desired objective of electrical safety. It is felt that, a prudent remedy to the said limitation would be to allow the owner of the installation to hire the service of a Chartered Electrical Safety Engineer form a panel, to be notified by the Sate Govt., for the purpose of inspection and testing of his installation. The matter calls for consideration of CEA.

The administering mechanism under the CEA Regulations, making Electrical Inspector, Electrical Safety Officer, Inspecting Officer or Supplier responsible for overseeing right implementation of electrical safety regulations both during and after commissioning of the installation, will ensure vigilance cover for electrically safe installation.

Therefore, one is inclined to take the view that, for identification of the weakness in the electrical installations, the periodical inspection of the electrical set-ups at a regular interval bears great relevance. The knowledgeable circle believes that timely detection of inconsistencies in the electrical installation would keep down the incidences of electric fire to a substantial extent.

Therefore, periodical inspection and testing of the installations by a duly qualified engineer at an interval of at least once in a year, as set under regulation 5 ibid, it is felt, is the right remedy.

However, for installations of the multi-storeyed buildings and important residential and commercial complexes, because of complexity of the electrical set-up both in terms of load demand and utility voltage, the right compliance with the safety stipulations should be put mandatorily under the superintending – cover of the Electrical Inspector, who gets a copy of the self-certified periodical inspection report from the owner of the installation.

Again, the submission of self–certified report in terms of regulation 30(3) ibid by the owners of the installation equal to or below the notified voltage without ratification of the information furnished therein by the Chartered Electrical Safety Engineer would, it is believed, defeat the very objective of achieving electrical safety since, in reality, the owners may not have the right competence as the provision of the regulation 30 contemplates.

Conclusion

There is no denying that regulatory-appropriateness is a necessity. The administering mechanism under the said Regulations, however, has not shown enough activism to prevent incidences of electric fire, even in important establishments as mentioned above.

The weakness needs to be set right to make the mechanism appropriately responsive with regard to consumers' observance of safety measures, particularly, under in-service situations.

Recommendations

In view of the facts as stated above, it is felt that the inspection report in form I, II & III of Schedule IV, as the case may be, under regulation 30(3) of the CEA (Measures Relating to Safety and Electric Supply) Amendment Regulations, 2015 be considered for revision to bring in the ratification of the information contained in the owner's self – certified report by Chartered Electrical Safety Engineer obligatory, since the owner may not have the right competence to carry out inspection and testing of his installation as the regulations contemplate.

Periodical inspection report of important installations with considerable load demand under owners' self-certification cover be put through subsequent scrutiny by the Electrical Inspector to exercise closer watchfulness on safe maintenance thereof, since the owners' maintenance lapse, as it appears, had been the prime initiator of electrical accidents leading to electric fire.

The appropriate government should be empowered to prepare a panel of Chartered Electrical Safety Engineers of requisite qualifications and experience to aid the owner of the installation falling under self-certified category to carry out inspection and testing for ratification of the owner's Inspection Report in terms of regulation 30(3) of the CEA (Measures Relating to Safety and Electric Supply) Amendment Regulations, 2015.

Power Generation Scenario In India

Electricity generation capacity in India is increasing fast. During the current year 2016-17 (Up to 31.10.2016), the Peak Demand is about 159 GW and the Installed Capacity is 307.3 GW with generation mix of Thermal (69.1%), Hydro (14.0%), Renewable (14.9%) and Nuclear (1.9%). The following sets of figures from the Central Electricity Authority (CEA) reveal our present generation capacity…

All India Installed Capacity (In Mw) of Power Stations

(As On 31.10.2016) (Utilities)

Region	Ownership/ Sector	Modewise breakup							Grand Total
		Thermal				Nuclear	Hydro	RES * (MNRE)	
		Coal	Gas	Diesel	Total				
Northern Region	State	16598.00	2879.20	0.00	19477.20	0.00	7632.55	662.06	27771.81
	Private	17926.00	333.00	0.00	18259.00	0.00	2478.00	8314.38	29051.38
	Central	12000.50	2344.06	0.00	14344.56	1620.00	8266.23	0.00	24230.79
	Sub Total	46524.50	5556.26	0.00	52080.76	1620.00	18376.78	8976.44	81053.98
Western Region	State	22500.00	2993.82	0.00	25493.82	0.00	5480.50	311.19	31285.51
	Private	36725.00	4676.00	0.00	41401.00	0.00	447.00	15507.30	57355.30
	Central	12898.01	3533.59	0.00	16431.60	1840.00	1520.00	0.00	19791.60
	Sub Total	72123.01	11203.41	0.00	83326.42	1840.00	7447.50	15818.49	108432.40
Southern Region	State	16882.50	791.98	287.88	17962.36	0.00	11668.03	512.55	30142.94
	Private	8270.00	5322.10	554.96	14147.06	0.00	0.00	19765.27	33912.33
	Central	11890.00	359.58	0.00	12249.58	2320.00	0.00	0.00	14569.58
	Sub Total	37042.50	6473.66	842.84	44359.00	2320.00	11668.03	20277.82	78624.85
Eastern Region	State	7540.00	100.00	0.00	7640.00	0.00	3177.92	225.11	11043.03
	Private	8731.38	0.00	0.00	8731.38	0.00	195.00	339.28	9265.66
	Central	14221.49	0.00	0.00	14221.49	0.00	1005.20	0.00	15226.69
	Sub Total	30492.87	100.00	0.00	30592.87	0.00	4378.12	564.39	35535.38
North Eastern Region	State	60.00	445.70	36.00	541.70	0.00	382.00	259.25	1182.95
	Private	0.00	24.50	0.00	24.50	0.00	0.00	9.47	33.97
	Central	250.00	1253.60	0.00	1503.60	0.00	860.00	0.00	2363.60
	Sub Total	310.00	1723.80	36.00	2069.80	0.00	1242.00	268.72	3580.52
Islands	State	0.00	0.00	40.05	40.05	0.00	0.00	5.25	45.30
	Private	0.00	0.00	0.00	0.00	0.00	0.00	5.85	5.85
	Central	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sub Total	0.00	0.00	40.05	40.05	0.00	0.00	11.10	51.15
ALL INDIA	State	63580.50	7210.70	363.93	71155.13	0.00	28341.00	1975.40	101471.53
	Private	71652.38	10355.60	554.96	82562.94	0.00	3120.00	43941.55	129624.49
	Central	51260.00	7490.83	0.00	58750.83	5780.00	11651.43	0.00	76182.26
	Total	186492.88	25057.13	918.89	212468.90	5780.00	43112.43	45916.95	307278.28

Figures at decimal may not tally due to rounding off

Abbreviation: SHP=Small Hydro Project (≤ 25 MW), BP=Biomass Power, U&I=Urban & Industrial Waste Power, RES=Renewable Energy Sources

Note: 1. RES include SHP, BP, U&I, Solar and Wind Energy. Installed capacity in respect of RES (MNRE) as on 30.09.2016 (As per latest information available with MNRE)

*Break up of RES all India as on 30.09.2016 is given below (in MW) :

Small Hydro Power	Wind Power	Bio-Power		Solar Power	Total Capacity
		BM Power/Cogen.	Waste to Energy		
4323.37	28082.95	4882.33	115.08	8513.23	45916.95

1. Durgapur TPS Unit-3 (130MW) has been removed from central sector of DVC.; 2. Parli TPS Unit-3 (210 MW) has been removed from the state sector of Maharshtra.; 3. CSTPS Chandrapur Unit 1&2 (2x210 MW) have been removed from the state sector of Maharshtra.

Installed Capacity (In Mw) Of Power Utilities In The States/Uts Located In Northern Region Including Allocated Shares In Joint & Central Sector Utilities

(As On 31.10.2016)

State	Ownership / Sector	Modewise breakup							Grand Total
		Thermal				Nuclear	Hydro (Renewable)	RES (MNRE)	
		Coal	Gas	Diesel	Total				
Delhi	State	135.00	1800.40	0.00	1935.40	0.00	0.00	0.00	1935.40
	Private	445.50	108.00	0.00	553.50	0.00	0.00	39.87	593.37
	Central	4421.37	207.61	0.00	4628.98	122.08	762.64	0.00	5513.70
	Sub-Total	5001.87	2116.01	0.00	7117.88	122.08	762.64	39.87	8042.47
Haryana	State	2720.00	150.00	0.00	2870.00	0.00	884.51	59.30	3813.81
	Private	2165.50	0.00	0.00	2165.50	0.00	0.00	74.89	2240.39
	Central	1202.03	535.29	0.00	1737.32	109.16	610.13	0.00	2456.61
	Sub-Total	6087.53	685.29	0.00	6772.82	109.16	1494.64	134.19	8510.81
Himachal Pradesh	State	0.00	0.00	0.00	0.00	0.00	523.60	256.61	780.21
	Private	0.00	0.00	0.00	0.00	0.00	1748.00	542.40	2290.40
	Central*	152.02	61.88	0.00	213.90	34.08	1288.94	0.00	1536.92
	Sub-Total	152.02	61.88	0.00	213.90	34.08	3560.54	799.01	4607.53
Jammu & Kashmir	State	0.00	175.00	0.00	175.00	0.00	1230.00	106.53	1511.53
	Private	0.00	0.00	0.00	0.00	0.00	0.00	51.00	51.00
	Central	329.32	129.14	0.00	458.46	77.00	1044.35	0.00	1579.81
	Sub-Total	329.32	304.14	0.00	633.46	77.00	2274.35	157.53	3142.34
Punjab	State	2630.00	150.00	0.00	2780.00	0.00	2230.23	127.80	5138.03
	Private	5014.00	0.00	0.00	5014.00	0.00	0.00	780.05	5794.05
	Central	660.88	263.92	0.00	924.80	208.04	921.65	0.00	2054.49
	Sub-Total	8304.88	413.92	0.00	8718.80	208.04	3151.88	907.85	12986.57
Rajasthan	State	5190.00	603.80	0.00	5793.80	0.00	987.96	23.85	6805.61
	Private	3196.00	0.00	0.00	3196.00	0.00	0.00	5531.25	8727.25
	Central	1014.72	221.23	0.00	1235.95	573.00	741.53	0.00	2550.48
	Sub-Total	9400.72	825.03	0.00	10225.75	573.00	1729.49	5555.10	18083.34
Uttar Pradesh	State	5923.00	0.00	0.00	5923.00	0.00	524.10	25.10	6472.20
	Private	7006.00	0.00	0.00	7006.00	0.00	0.00	1024.50	8030.50
	Central	2909.95	549.97	0.00	3459.92	335.72	1660.65	0.00	5456.29
	Sub-Total	15838.95	549.97	0.00	16388.92	335.72	2184.75	1049.60	19958.99
Uttrakhnad	State	0.00	0.00	0.00	0.00	0.00	1252.15	62.87	1315.02
	Private	99.00	225.00	0.00	324.00	0.00	730.00	263.61	1317.61
	Central	300.50	69.35	0.00	369.85	22.28	469.24	0.00	861.37
	Sub-Total	399.50	294.35	0.00	693.85	22.28	2451.39	326.48	3494.00
Chandigarh	State	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Private	0.00	0.00	0.00	0.00	0.00	0.00	6.81	6.81
	Central	32.54	15.32	0.00	47.86	8.84	62.74	0.00	119.44
	Sub-Total	32.54	15.32	0.00	47.86	8.84	62.74	6.81	126.25
Central - Unallocated		977.19	290.35	0.00	1267.54	129.80	704.36	0.00	2101.70
Total (Northern Region)	State	16598.00	2879.20	0.00	19477.20	0.00	7632.55	662.06	27771.81
	Private	17926.00	333.00	0.00	18259.00	0.00	2478.00	8314.38	29051.38
	Central	12000.50	2344.06	0.00	14344.56	1620.00	8266.23	0.00	24230.79
	Grand Total	**46524.50**	**5556.26**	**0.00**	**52080.76**	**1620.00**	**18376.78**	**8976.44**	**81053.98**

Installed Capacity (In Mw) Of Power Utilities In The States/Uts Located In Western Region Including Allocated Shares In Joint & Central Sector Utilities

(As On 31.10.2016)

State	Ownership/ Sector	Modewise breakup							Grand Total
		Thermal				Nuclear	Hydro (Renewable)	RES (MNRE)	
		Coal	Gas	Diesel	Total				
Goa	State	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05
	Private	0.00	48.00	0.00	48.00	0.00	0.00	0.00	48.00
	Central	338.60	0.00	0.00	338.60	25.80	0.00	0.00	364.40
	Sub-Total	338.60	48.00	0.00	386.60	25.80	0.00	0.05	412.45
Daman & Diu	State	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Private	0.00	0.00	0.00	0.00	0.00	0.00	4.00	4.00
	Central	43.38	4.20	0.00	47.58	7.38	0.00	0.00	54.96
	Sub-Total	43.38	4.20	0.00	47.58	7.38	0.00	4.00	58.96
Gujarat	State	5220.00	2321.82	0.00	7541.82	0.00	772.00	8.00	8321.82
	Private	8642.00	4060.00	0.00	12702.00	0.00	0.00	5428.53	18130.53
	Central	2888.62	424.27	0.00	3312.89	559.32	0.00	0.00	3872.21
	Sub-Total	16750.62	6806.09	0.00	23556.71	559.32	772.00	5436.53	30324.56
Madhya Pradesh	State	4080.00	0.00	0.00	4080.00	0.00	1703.66	83.96	5867.62
	Private	5389.00	0.00	0.00	5389.00	0.00	0.00	3140.07	8529.07
	Central	2490.05	257.18	0.00	2747.23	273.24	1520.00	0.00	4540.47
	Sub-Total	11959.05	257.18	0.00	12216.23	273.24	3223.66	3224.03	18937.16
Chhattisgarh	State	3280.00	0.00	0.00	3280.00	0.00	120.00	11.05	3411.05
	Private	10898.00	0.00	0.00	10898.00	0.00	0.00	473.31	11371.31
	Central	1574.54	0.00	0.00	1574.54	47.52	0.00	0.00	1622.06
	Sub-Total	15752.54	0.00	0.00	15752.54	47.52	120.00	484.36	16404.42
Maharashtra	State	9920.00	672.00	0.00	10592.00	0.00	2884.84	208.13	13684.97
	Private	11796.00	568.00	0.00	12364.00	0.00	447.00	6461.39	19272.39
	Central	3712.26	2623.93	0.00	6336.19	690.14	0.00	0.00	7026.33
	Sub-Total	25428.26	3863.93	0.00	29292.19	690.14	3331.84	6669.52	39983.69
Dadra & Nagar Naveli	State	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Private	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Central	54.22	27.10	0.00	81.32	8.46	0.00	0.00	89.78
	Sub-Total	54.22	27.10	0.00	81.32	8.46	0.00	0.00	89.78
Central - Unallocated		1796.35	196.91	0.00	1993.26	228.14	0.00	0.00	2221.40
Total (Western Region)	State	22500.00	2993.82	0.00	25493.82	0.00	5480.50	311.19	31285.51
	Private	36725.00	4676.00	0.00	41401.00	0.00	447.00	15507.30	57355.30
	Central	12898.01	3533.59	0.00	16431.60	1840.00	1520.00	0.00	19791.60
	Grand Total	72123.01	11203.41	0.00	83326.42	1840.00	7447.50	15818.49	108432.40

Installed Capacity (In Mw) Of Power Utilities In The States/Uts Located In Southern Region Including Allocated Shares In Joint & Central Sector Utilities

(As On 31.10.2016)

State	Ownership/ Sector	Modewise breakup							Grand Total
		Thermal				Nuclear	Hydro (Renewable)	RES (MNRE)	
		Coal	Gas	Diesel	Total				
Andhra Pradesh	State	3085.91	235.40	0.00	3321.31	0.00	1758.87	89.50	5169.68
	Private	2990.00	3074.11	16.97	6081.08	0.00	0.00	3395.79	9476.87
	Central	1473.30	0.00	0.00	1473.30	127.16	0.00	0.00	1600.46
	Sub-Total	7549.21	3309.51	16.97	10875.69	127.16	1758.87	3485.29	16247.02
Telangana	State	4806.59	0.00	0.00	4806.59	0.00	2245.66	0.00	7052.25
	Private	270.00	1570.89	19.83	1860.72	0.00	0.00	947.54	2808.26
	Central	1721.88	0.00	0.00	1721.88	148.62	0.00	0.00	1870.50
	Sub-Total	6798.47	1570.89	19.83	8389.19	148.62	2245.66	947.54	11731.01
Karnataka	State	4220.00	0.00	127.92	4347.92	0.00	3599.80	155.33	8103.05
	Private	2060.00	0.00	106.50	2166.50	0.00	0.00	5310.16	7476.66
	Central	1628.46	0.00	0.00	1628.46	475.86	0.00	0.00	2104.32
	Sub-Total	7908.46	0.00	234.42	8142.88	475.86	3599.80	5465.49	17684.03
Kerala	State	0.00	0.00	159.96	159.96	0.00	1881.50	145.02	2186.48
	Private	0.00	174.00	0.00	174.00	0.00	0.00	116.55	290.55
	Central	1038.69	359.58	0.00	1398.27	228.60	0.00	0.00	1626.87
	Sub-Total	1038.69	533.58	159.96	1732.23	228.60	1881.50	261.57	4103.90
Tamil Nadu	State	4770.00	524.08	0.00	5294.08	0.00	2182.20	122.70	7598.98
	Private	2950.00	503.10	411.66	3864.76	0.00	0.00	9995.20	13859.96
	Central	4155.10	0.00	0.00	4155.10	986.50	0.00	0.00	5141.60
	Sub-Total	11875.10	1027.18	411.66	13313.94	986.50	2182.20	10117.90	26600.54
NLC	State	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Private	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Central	100.17	0.00	0.00	100.17	0.00	0.00	0.00	100.17
	Sub-Total	100.17	0.00	0.00	100.17	0.00	0.00	0.00	100.17
Puducherry	State	0.00	32.50	0.00	32.50	0.00	0.00	0.00	32.50
	Private	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03
	Central	249.32	0.00	0.00	249.32	52.78	0.00	0.00	302.10
	Sub-Total	249.32	32.50	0.00	281.82	52.78	0.00	0.03	334.63
Central - Unallocated		1523.08	0.00	0.00	1523.08	300.48	0.00	0.00	1823.56
Total (Southern Region)	State	16882.50	791.98	287.88	17962.36	0.00	11668.03	512.55	30142.94
	Private	8270.00	5322.10	554.96	14147.06	0.00	0.00	19765.27	33912.33
	Central	11890.00	359.58	0.00	12249.58	2320.00	0.00	0.00	14569.58
	Grand Total	37042.50	6473.66	842.84	44359.00	2320.00	11668.03	20277.82	78624.85

Installed Capacity (In Mw) Of Power Utilities In The States/Uts Located In Eastern Region Including Allocated Shares In Joint & Central Sector Utilities

(As On 31.10.2016)

State	Ownership/ Sector	Modewise breakup							Grand Total
		Thermal				Nuclear	Hydro (Renewable)	RES (MNRE)	
		Coal	Gas	Diesel	Total				
Bihar	State	210.00	0.00	0.00	210.00	0.00	0.00	70.70	280.70
	Private	0.00	0.00	0.00	0.00	0.00	0.00	133.52	133.52
	Central	2531.24	0.00	0.00	2531.24	0.00	129.43	0.00	2660.67
	Sub-Total	2741.24	0.00	0.00	2741.24	0.00	129.43	204.22	3074.89
Jharkhand	State	1190.00	0.00	0.00	1190.00	0.00	130.00	4.05	1324.05
	Private	900.00	0.00	0.00	900.00	0.00	0.00	16.19	916.19
	Central	314.93	0.00	0.00	314.93	0.00	70.93	0.00	385.86
	Sub-Total	2404.93	0.00	0.00	2404.93	0.00	200.93	20.24	2626.10
West Bengal	State	5720.00	100.00	0.00	5820.00	0.00	986.00	91.95	6897.95
	Private	1781.38	0.00	0.00	1781.38	0.00	0.00	44.32	1825.70
	Central	922.45	0.00	0.00	922.45	0.00	431.30	0.00	1353.75
	Sub-Total	8423.83	100.00	0.00	8523.83	0.00	1417.30	136.27	10077.40
DVC	State	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Private	1050.00	0.00	0.00	1050.00	0.00	0.00	0.00	1050.00
	Central	7080.66	0.00	0.00	7080.66	0.00	193.26	0.00	7273.92
	Sub-Total	8130.66	0.00	0.00	8130.66	0.00	193.26	0.00	8323.92
Odisha	State	420.00	0.00	0.00	420.00	0.00	2061.92	6.30	2488.22
	Private	5000.00	0.00	0.00	5000.00	0.00	0.00	145.25	5145.25
	Central	1683.04	0.00	0.00	1683.04	0.00	105.01	0.00	1788.05
	Sub-Total	7103.04	0.00	0.00	7103.04	0.00	2166.93	151.55	9421.52
Sikkim	State	0.00	0.00	0.00	0.00	0.00	0.00	52.11	52.11
	Private	0.00	0.00	0.00	0.00	0.00	195.00	0.00	195.00
	Central	92.10	0.00	0.00	92.10	0.00	75.27	0.00	167.37
	Sub-Total	92.10	0.00	0.00	92.10	0.00	270.27	52.11	414.48
Central - Unallocated		1597.07	0.00	0.00	1597.07	0.00	0.00	0.00	1597.07
Total (Eastern Region)	State	7540.00	100.00	0.00	7640.00	0.00	3177.92	225.11	11043.03
	Private	8731.38	0.00	0.00	8731.38	0.00	195.00	339.28	9265.66
	Central	14221.49	0.00	0.00	14221.49	0.00	1005.20	0.00	15226.69
	Grand Total	30492.87	100.00	0.00	30592.87	0.00	4378.12	564.39	35535.38

Installed Capacity (In Mw) Of Power Utilities In The States/Uts Located In North-Eastern Region Including Allocated Shares In Joint & Central Sector Utilities

(As On 31.10.2016)

State	Ownership/ Sector	Modewise breakup							Grand Total
		Thermal				Nuclear	Hydro (Renewable)	RES (MNRE)	
		Coal	Gas	Diesel	Total				
Assam	State	60.00	276.20	0.00	336.20	0.00	100.00	30.01	466.21
	Private	0.00	24.50	0.00	24.50	0.00	0.00	4.10	28.60
	Central	127.00	435.60	0.00	562.60	0.00	329.72	0.00	892.32
	Sub-Total	187.00	736.30	0.00	923.30	0.00	429.72	34.11	1387.13
Arunachal Pradesh	State	0.00	0.00	0.00	0.00	0.00	0.00	104.61	104.61
	Private	0.00	0.00	0.00	0.00	0.00	0.00	0.27	0.27
	Central	12.35	46.83	0.00	59.18	0.00	97.57	0.00	156.75
	Sub-Total	12.35	46.83	0.00	59.18	0.00	97.57	104.88	261.63
Meghalaya	State	0.00	0.00	0.00	0.00	0.00	282.00	31.03	313.03
	Private	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Central	17.70	109.79	0.00	127.49	0.00	74.58	0.00	202.07
	Sub-Total	17.70	109.79	0.00	127.49	0.00	356.58	31.03	515.10
Tripura	State	0.00	169.50	0.00	169.50	0.00	0.00	16.01	185.51
	Private	0.00	0.00	0.00	0.00	0.00	0.00	5.00	5.00
	Central	18.70	338.96	0.00	357.66	0.00	62.37	0.00	420.03
	Sub-Total	18.70	508.46	0.00	527.16	0.00	62.37	21.01	610.54
Manipur	State	0.00	0.00	36.00	36.00	0.00	0.00	5.45	41.45
	Private	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Central	15.70	71.61	0.00	87.31	0.00	80.98	0.00	168.29
	Sub-Total	15.70	71.61	36.00	123.31	0.00	80.98	5.45	209.74
Nagaland	State	0.00	0.00	0.00	0.00	0.00	0.00	30.67	30.67
	Private	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Central	10.70	48.91	0.00	59.61	0.00	53.32	0.00	112.93
	Sub-Total	10.70	48.91	0.00	59.61	0.00	53.32	30.67	143.60
Mizoram	State	0.00	0.00	0.00	0.00	0.00	0.00	41.47	41.47
	Private	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10
	Central	10.35	40.54	0.00	50.89	0.00	34.31	0.00	85.20
	Sub-Total	10.35	40.54	0.00	50.89	0.00	34.31	41.57	126.77
Central - Unallocated		37.50	161.36	0.00	198.86	0.00	127.15	0.00	326.01
Total (North- Eastern Region)	State	60.00	445.70	36.00	541.70	0.00	382.00	259.25	1182.95
	Private	0.00	24.50	0.00	24.50	0.00	0.00	9.47	33.97
	Central	250.00	1253.60	0.00	1503.60	0.00	860.00	0.00	2363.60
	Grand Total	310.00	1723.80	36.00	2069.80	0.00	1242.00	268.72	3580.52

Efficient, Reliable, And Scalable Electrical Distribution

Let's write the future together...

ABB is a pioneering technology leader that is writing the future of industrial digitalization. For more than four decades, we have been at the forefront, innovating digitally connected and enabled industrial equipment and systems with an installed base of more than 70,000 control systems connecting 70 million devices.. Every day, we drive efficiency, safety and productivity in utilities, industry, transport and infrastructure globally. With a heritage spanning more than 130 years, ABB operates in more than 100 countries and employs around 135,000 people.

ABB's operations are organized into four global divisions (Electrification Products, Discrete Automation and Motion, Process Automation and Power Grids), which in turn are made up of specific business units focused on particular industries and product categories.

ABB is now advancing the technology further to extend the capabilities of the IoT (Internet of Things) for greater use in energy distribution, industry and infrastructure - like transportation and buildings. For ABB, this expansion extends the concept of IoT to include Services and People in the IoTSP. These elements are important for ABB because services make use of actionable information derived from data gathered from the IoT and enable people, through the analysis of that data, to be more productive and make better decisions.

ABB Electrification Products Division offers a full range of low and medium voltage solutions to connect, protect, control and measure a wide range of electrical systems for all major industries, including the residential sector. The business improves the reliability and efficiency of electrical installations through modular substation packages, distribution automation products, switchgear, circuit breakers, measuring and sensing devices, control products, wiring accessories, enclosures and cabling systems, including KNX systems designed to integrate and automate a building's lighting, ventilation, heating, security and data communication networks.

Main distribution switchboards up to 6300A

ABB keeps a commitment to support customers and energy distribution segment with modern reliable and proven equipment. We follow the markets' trends and we create the benchmark. Fully tested systems according to IEC61439 guarantee the best performance and quality. The

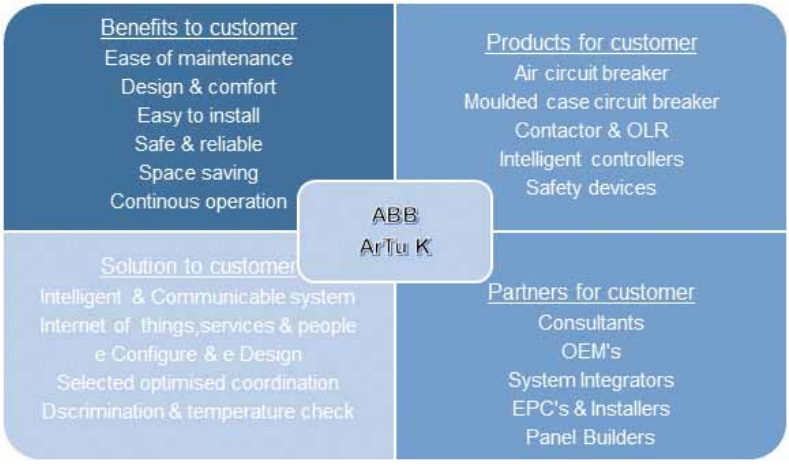


ABB ArTu K low voltage panels are synonymous with safety, quality and greater aesthetics. The panels are certified for latest global standards IEC 61439 by external independent organizations. ABB's electrical distribution solution is smart & user friendly. ABB Devices can be connected to supervise, monitor and control them centrally and automatically via communication network.

main target for us, is to propose and support customers to have a right solution in any possible industrial or commercial application.

Finding the best technology solution for electrical system designs is easy with ABB's comprehensive selection tools and exclusive technical documentation.

We offer highly functional and easy to deploy products to support a wide range of projects. And we want to support customers at every stage of projects, with design software, training materials, configuration and product selection tools. Whether customer is looking for energy efficiency, space savings, easily maintained systems or overall project cost reduction, ABB offerings can deliver customized solutions to meet project goals and streamline engineering processes.

With a network that spans the world, ABB is dedicated to addressing your service needs.

Customers' needs are our biggest opportunity and low-voltage products and services plays a proactive role in driving change that generates value for customers, by keeping their assets reliable and extending life cycles, while protecting customers' investments.

Technical Specification	
Rated service voltage	up to 1000 V
Rated current	up to 6300 A
Rated impulse voltage	8 KV
Form of separation	2 / 3 / 4
Degree of protection	up to IP 65
Other	Internal Arc & Seismic tested

ABB's electrical distribution solution ArTu K is smart, user friendly, has a compact footprint, total protection , designed considering selectivity with maximum ergonomics and simple to operate with highest safety. ABB Devices can be connected to supervise, monitor and control them centrally and automatically via communication network.

6 Common Differences Between Reflective And Conventional Mass Insulation

Reduction of heat transfer from outside to inside of a building lowers the cost of (electricity) cooling during summer days...

In summer, radiation from the sun strikes the outer surfaces of walls and ceilings and is absorbed causing the surface to heat up. This heat flows from the outer wall to the inner wall through conduction, which is then radiated again, through the air spaces in the building, to other surfaces within the building. Radiation between surfaces is through invisible, infra-red heat rays.

Reduction of heat transfer from outside to inside of a building lowers the cost of cooling during summer days because of lower consumption of electricity. A reflective insulation system helps the process. It is typically formed by layers of aluminium or a low emittance material and enclosed air spaces, which in turn provide highly reflective or low emittance cavities (Air bubble film) adjacent to a heated region.

The performance of the system is determined by the emittance of the material(s), the lower the better, and the size of the enclosed air spaces. The smaller the air space, the less heat will get transferred by convection. Therefore, to lessen heat flow by convection, a reflective insulation, with its multiple layers of aluminium and enclosed air space (INSUreflector), is positioned in a building cavity (stud wall, furred-out masonry wall, floor joist, ceiling joist, etc.) to divide the larger cavity (3/4" furring, 2" x 4", 2" x 6", etc.) into smaller air spaces. These smaller trapped air spaces reduce convective heat flow.

Reflective insulation differs from conventional mass insulation in several ways:

1. Reflective insulation has very low emittance values 'E-values' (typically 0.03 compared to 0.90 for most insulation), thus it significantly reduces heat transfer by radiation.
2. A reflective insulation does not have significant mass to absorb and retain heat.
3. Reflective insulation has lower moisture transfer and absorption rates, in most cases.
4. Reflective insulation traps air with layers of aluminium & air bubble film plastic as opposed to mass insulation that uses fibres of glass, particles of foam, or ground up paper.
5. Reflective insulation does not irritate the skin, eyes, or throat and contain no substances, which will out-gas.
6. The change in thermal performance due to compaction or moisture absorption, a common concern with mass insulation, is not an issue with reflective insulation.

FLIR offers an Imaging Multimeter with IGM

FLIR DM284 Imaging Multimeter with IGM is a professional, all-in-one True RMS digital multimeter with built-in 160x 120 FLIR thermal imager that can show you exactly where an electrical problem is to speed up troubleshooting. The DM284 visually guides you to the precise location of an electrical problem and helping you to pinpoint hot spots faster and more efficiently.

IGM enables you to scan panels, connectors, and wires without requiring any direct contact — so you can do your job from a safe distance. Once you find an issue with IGM, the DM284 can verify and confirm findings with advanced contact measurement features to help solve the most complex electrical issues. As per the company, the product is ideal for field electronics, commercial electric, light industrial, field service and HVAC work.

Key features

• Pinpoint problems quickly and safely with IGM; • 18 Functions DMM including True RMS, VFD mode, LoZ, NCV, and more; • Includes high-quality test probes and a Type K thermocouple input; • Simple user interface and various thermal color palettes to choose from: Iron, Rainbow & Greyscale; • Drop-tested and IP rated for splash and water resistance with 10-year warranty

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

Fluke Infrared Cameras deliver 640 x 480 image quality

Fluke Corp. introduces the Fluke Ti480 and TiX580 Infrared Cameras with 640 x 480 resolution and MultiSharp Focus, delivering exceptional image quality to industrial, process, utilities maintenance and building inspection professionals who need high measurement accuracy to quickly detect problems.

With the Ti480 Infrared Camera, Fluke offers a rugged, pistol-grip form factor. The camera provides fast, one-handed operation to perform multiple inspections quickly and accurately. Now there is an 'everyday' camera, with four times the resolution power of many commonly used 320 x 240 pixel cameras, for quick point-and-shoot troubleshooting.

The new TiX580 Infrared Camera features a 240-degree rotating screen that allows thermographers to easily navigate over, under, and around objects to preview and capture images with ease. The 5.7-inch screen provides 150 percent more viewing area than a standard 3.5-inch screen, enabling thermographers to quickly identify issues in the field and easily edit images directly on the camera, reducing production time back at the office.

For further information: Email:- info.india@fluke.com

IGUS offers device to supply energy to robots

The motion plastics specialist igus has expanded its range of multi-axis energy chains and introduces a new size for the lightweight triflex TRLF. With 125 millimetres diameter, this is the largest in the range and can safely guide even more cables and hoses. The e-chain for torsional movements is impressive with very fast assembly and disassembly, which significantly reduces shut-downs. For this reason, it is extremely popular with robot manufacturers and users.

Industrial robots have become indispensable in production today, as they save a lot of labour and time. In order to achieve this in the equipment on the robot itself, the motion plastics specialist igus has developed the multi-axis triflex TRLF energy chains, which are now available in a new size. The 'L' in the product name stands for 'light' because material is saved through the open design of the individual links, but at the same time the cables and hoses are still guided safely. The 'F' stands for 'flip open' and describes the mechanism very well: "Each single chain link has three pivotable cross bars that can be opened up at any time by hand or wiith a screwdriver," explains Harald Nehring, authorised agent for e-chainsystems at igus. "This allows the filling with big cable diameters or hose packages." With the new size TRLF.125 with a nominal diameter of 125 millimetres, even large and/or stiff hoses or a large number of individual cables can be inserted quickly and easily.

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

Process Technique presents BELUK APFC-Regulators

In networks with unpredictable asymmetric loads, the BELUK BLR CM range of power factor regulator (APFCR), can measure the current and reactive power need of each phase individually. In addition, the controller recognizes if a 1- or 3- phase capacitors being used. In conjunction with the intelligent control algorithm, the result is a 100% optimised compensation of reactive power even under unpredictable asymmetric load networks. The BLR CM range of controllers have the patented algorithm.

Both capacitive steps and inductive steps can be used simultaneously for PF compensation. Therefore, the BLR CM can react to and control both inductive as well as capacitive loads. Furthermore, equipped with a real-time algorithm and transistor outputs, the BLRCM-t is good for triggering thyristor switches (in dynamic compensations). Deviations are determined immediately (about 1ms) after measurement of one period. Thus, a reaction time of about 20ms can be achieved.

For further information:
Email:- resource@processtechnique.com

Testo offers automatic Multimeter testo 760

After intensive research and development work, Testo AG has now reached its target to provide an all round solution to the HVAC/R sector by introducing first of its own set of electrical measuring instruments, backed by latest German technology.

The testo 760 digital multimeter family comprises three models for all important electrical measuring tasks. Function keys replace the traditional dial on all three instruments, which means easier operation and greater reliability. Incorrect settings are now impossible, because the measurement parameters are detected automatically via the assignment of the measuring sockets and also shown by the illumination of the appropriate function keys.

The testo 760-1 model is the standard version for almost all daily measuring tasks. The testo 760-2 is differentiated by a larger current measurement range, the true root mean square measurement - TRMS - and a low-pass filter – for VFD output voltage measurements accurately. The testo 760-3 is the model with the highest specification and, in addition to the features of the other two models; it has a voltage range of up to 1,000 V, along with higher measuring ranges for frequency and capacitance. In addition, µA current measuring range is also available.

For further information: Email:- info@testoindia.com

Beckhoff presents Servo Terminals with integrated STO safety function

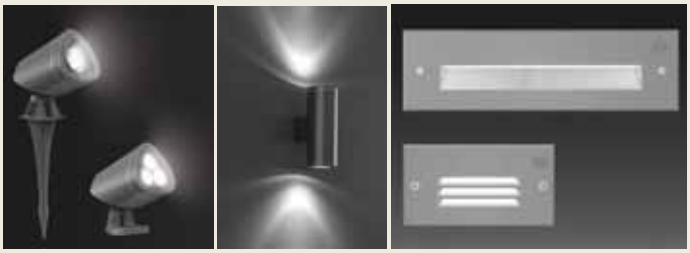
The servo terminals in the Beckhoff EtherCAT Terminal system integrate a complete servo drive to facilitate highly dynamic positioning tasks in a standard I/O terminal housing. With the new EL72x1-9014 version, STO (Safe Torque Off) safety functionality is now available in an extremely compact terminal design for DIN rail installation. The new servo terminals enable space-saving drive solutions with safety-related functions that can be directly integrated within the EtherCAT Terminal system.

The EL72x1-9014 servo terminals streamline the implementation of STO (Safe Torque Off) safety functions, corresponding to safety level Cat 3/PL d, according to EN ISO 13849-1:2015. In conjunction with One Cable Technology (OCT), safety integration in an I/O terminal form factor results in a heightened ability to implement space-saving and cost-effective solutions with safety-related drive functionality.

In addition, a 2-channel shut-off with corresponding contactors in the motor cable provides a considerable reduction in cabling, space requirements and cost; a single cable connects the safety output (e.g. EL2904) and the STO input of the servo terminal. In addition, the OCT solution minimises cable costs and space needed for the motor connection.

For further information: Email:- info@beckhoff.com

K-LITE introduces LED Landscape – redefined



The Essence of lighting is one of the most important things in our lives. The K-Lite team is passionate about creating a distinctive atmosphere that improves the quality of life in the cities and towns by exploring the many potential facets of lighting that supports the wellbeing and safety of all.

Founded in 1977 in India, K-Lite has grown to be the leading manufacturer of outdoor luminaires and decorative poles. K-Lite's proven performance in the landscape segment is because of its ability to stylishly convey the identity of a space with a blend of efficiency and modularity to maximise the visual comfort that is best suited to each specific space.

Their landscape range includes

Linear Wall Washer, Up-Down Lighters, LED Strips/Neon flex, Promenade Lighting, Bollards, Under Water Lighting, Post top luminaires, Bulk Heads, Path finders, Polar lighting and newly added series of Facade Lighting.

For further information: Email:- info@klite.in

ABB offers Residual Current Circuit Breaker

ABB has introduced Residual Current Circuit breakers (RCCBs), which are the safe devices to detect and trip against electrical leakage currents, thus ensuring protection against electric shock caused by indirect contacts. These devices must be used in series with an MCB or fuse, which protects them from the potentially damaging thermal and dynamic stresses of any over currents. They also act as the main disconnecting switches upstream of any derived MCBs (e.g. domestic consumer unit).

Main benefits

- Safety performances ensured worldwide by international marks approval
- High quality execution and attention to details
- Complete range of products and related accessories

Main features

- AC, A, B, AP-R types available to ensure protection against all kinds of earth fault currents
- Rated Currents from 16A up to 125A
- Rated IΔn Sensitivity 10, 30mA, 100mA, 300mA, 500mA and 1A

For further information:
www.abb.com

Hager India's introduces insysta range of wiring

The Hager group has a legacy of 60 years in the field of providing products & solutions to distribute, control & manage electrical supplies in residential & commercial buildings.

Hager India now presents you with insysta™ range of wiring accessories "**Fashioned in France, Engineered in Germany, Made in India**"

insysta™ combines the engineering of Hager with aesthetics that every home owner, interior designer & architect would be proud to recommend & possess. The real material range is "art" of a kind and would adorn the walls of any home or building. This real material frames are designed by Europe's finest designer Erwin van Handenhoven. The front plates show off the finesse & charm of French Fashion, to adorn your walls. These are available in oak wood, glass, stainless steel & slate finish options.

The comprehensive range offers "AX" rated switches to switch inductive loads without derating. insysta™ switches can be front loaded & removed, thus giving easy & fast access when installed.

Terminal screws are captive and proper laser marking is been done to ensure right selection of the load for lifelong. The complete range includes basic necessities like USB chargers, data sockets, telephone sockets, along with motion sensors, and hospitality solution.

Complete range is made up of UV stabilized, fire retardant poly carbonate material which ensures aesthetics of all accessories for lifelong. Cover plate compensation with grid plates is a perfect unification of style & functionality.

For further information: www.hager.co.in

Blue Sea Systems introduces SI-ACR Automatic Charging Relay

SI-ACR automatically combines batteries during charging, isolates batteries when discharging and when starting engines. The Dual Circuit Plus Battery Switch simplifies the switching of two batteries to OFF or ON while still providing battery isolation between the engine and auxiliary battery. The Combine function can be used to parallel the batteries in the event of a low engine battery.

Features

- Protects sensitive electronics by temporary isolation of house loads from engine circuit during engine cranking
- Designed for 12 or 24 volt systems
- 12/24 volt auto ranging voltage input
- Hermetically sealed contacts/vapourproof
- Ignition protected – safe for installation aboard gasoline powered boats
- Supports high-output alternators up to 120 Amperes
- Dual sensing

Optional features

- Start Isolation allows temporary isolation of House loads from Engine circuit during engine cranking to protect sensitive electronics from sags and spikes
- Remote LED remotely indicates ACR states - requires optional LED

For further information: www.bluesea.com

Yokogawa Meters & Instruments releases DC Calibrators

Yokogawa Meters & Instruments Corporation has developed the 2560A Precision DC Calibrator. The 2560A is a high precision instrument capable of outputting a wide range of DC voltage and current for calibration of analog meters, thermometers, and temperature controllers that use a thermocouple or Resistance Temperature Detector (RTD).

The 2560A Precision DC Calibrator is an accurate and low-cost calibrator that can output DC voltage over 1200 Volts and DC current over 36 Amps alone. In addition to being able to calibrate analog meters, the 2560A can calibrate thermometers and temperature controllers that utilise a thermocouple or RTD.

By specialising for DC voltage/current generation, and refining the built-in functions, 2560A kept its price low and achieved the following high performances. It can be used for applications that require high accuracy and stability.

For further information: www.yokogawa.com

Powering The Poor

Under DDUGJY, out of 597, 464 census villages, 590,774 villages (98.8%) have been electrified...

Under Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY), Government of India is providing free electricity connections to Below Poverty Line (BPL) households. Out of total 4.27 crore connections sanctioned, free electricity connections to 2.5 crore BPL households have been provided as on 31.10.2016 under the scheme.

State-wise Coverage and Achievement of BPL Households under DDUGJY [Including Rural Electrification (RE) Component]

Sl. No.	Name of the State	Coverage	Achievement (As on 31.10.2016)
1	Andhra Pradesh	2457287	2414555
2	Arunachal Pradesh	74679	51621
3	Assam	1794604	1210224
4	Bihar	10660852	3767019
5	Chhattisgarh	1448997	1143343
6	Gujarat	848005	842945
7	Haryana	257902	198580
8	Himachal Pradesh	19578	16290
9	Jammu & Kashmir	142885	69148
10	Jharkhand	2367897	1275170
11	Karnataka	1036966	950098
12	Kerala	192919	150305
13	Madhya Pradesh	3209701	1668407
14	Maharashtra	1621836	1221350
15	Manipur	137525	70307
16	Meghalaya	121758	104383
17	Mizoram	30643	29710
18	Nagaland	98616	54559
19	Odisha	4499998	2776723
20	Punjab	92988	92988
21	Rajasthan	1791657	1166426
22	Sikkim	13601	13601
23	Tamil Nadu	526468	502094
24	Telangana	1125306	708865
25	Tripura	208732	137962
26	Uttar Pradesh	5212392	1910948
27	Uttarakhand	238404	237921
28	West Bengal	2480034	2204398
	Grand Total	**42712446**	**24989940**

Source: Press Information Bureau (India)

In order to provide access to electricity to all rural households and also ensure quality and reliability of power supply in rural areas, Government of India has launched 'Deen Dayal Upadhyaya Gram Jyoti Yojana' (DDUGJY) with an outlay of Rs.43033 crore and Budgetary support of Rs.33453 crore consisting of separation of agriculture and non-agriculture feeders, strengthening and augmentation of sub-transmission and distribution network, metering at all level and rural electrification.

In addition to this, rural electrification component projects with total outlay of Rs.32860 crore including budgetary support from Government of India of Rs.29574 crore have been subsumed in DDUGJY. Under the scheme, adequate infrastructure would be created in all the villages to provide access to electricity to all households. Release of service connections to households is the responsibility of concerned State DISCOM / Power Department. Projects under the scheme are to be completed in 24 months from the date of award.

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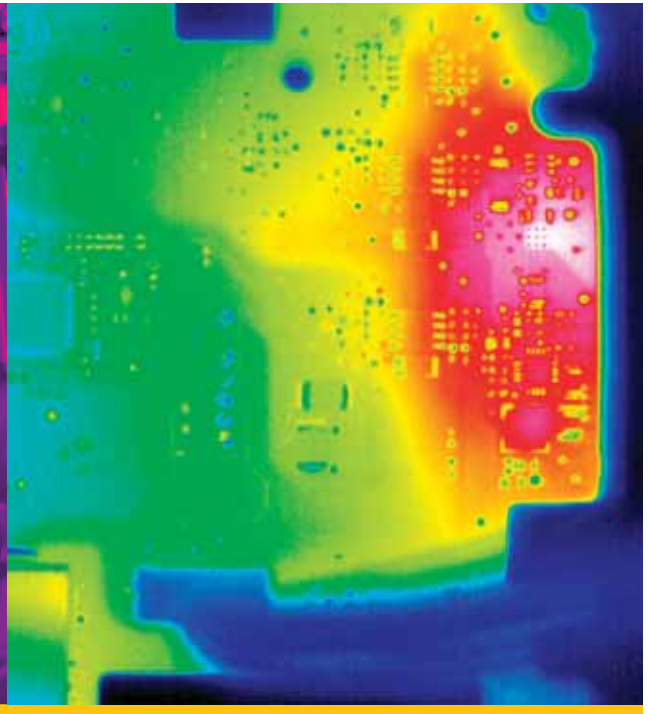

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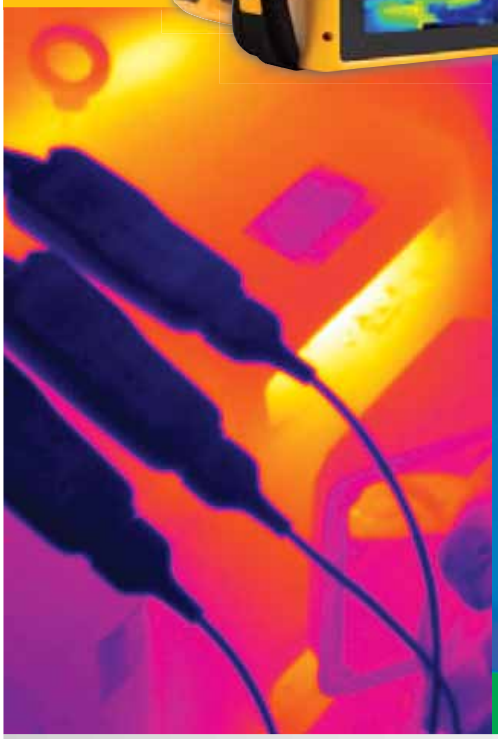

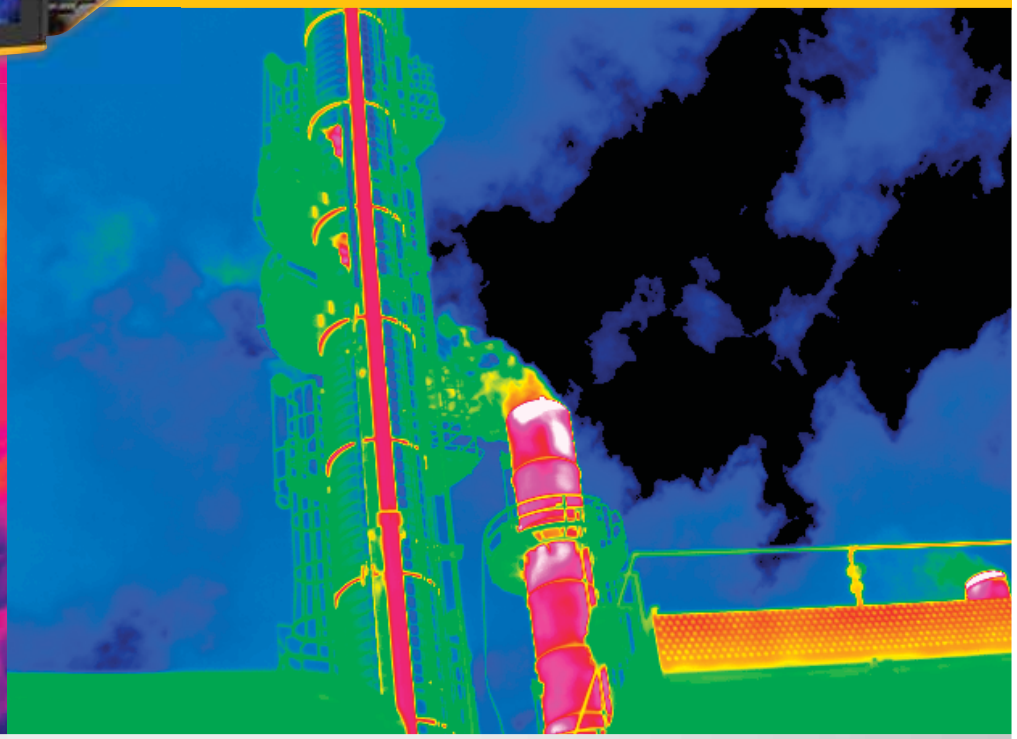

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