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Publisher's Letter

Mahadevan Iyer

"Adding 22,000 circuit kms of transmission line within just 20 months of its tenure is a record for the present government..."

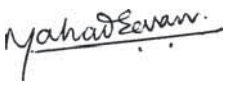
According to the 2015 edition of BP's Energy Outlook, India's energy production is to rise by 117% to 2035, while consumption is to grow by 128%. The country's energy mix evolves very slowly over the next 22 years with fossil fuels accounting for 87% of demand in 2035, compared with a global average of 81% (down from 92% today). Oil remains the dominant fuel (36%) followed by gas (30%) and coal (21%). CO_2 emissions from energy consumption increase by 115%.

To address the ongoing challenge, the present government has added 30,000 Megawatt more capacity of thermal power in the last 20 months of its regime. According to union power minister, Piyush Goyal, Power being the most important ingredient of infrastructure for nation's development, the government is laying utmost emphasis on this sector.

Realising that mere addition of power plants is not a panacea for all challenges in the sector, the ministry of power has also put emphasis on enhancing the working capacity of the power plants. The result is, as per the minister, achievement of 60% working capacity of power plants.

Adding 22,000 circuit kms of transmission line within just 20 months of its tenure is a record for the present government. During last 18 months, 71% of additional transmission capacity has been created – and by 2019 it will reach 200%. As of 2015, total thermal installed capacity stood at 189.3 GW, while hydro and renewable energy installed capacity totalled 41.6 GW and 35.8 GW respectively. At 5.8 GW, nuclear energy capacity had increased considerably which otherwise remained the same from 2010 to 14. I think it's a good pace, at the outset, but of course, we have to accelerate further.

Do send in your comments at miyer@charypublications.in



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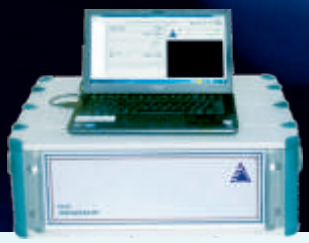

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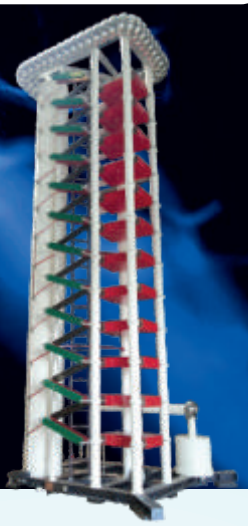

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P K Chatterjee (PK)

Tariff Policy Amendments

With a view to making UDAY (Ujwal DISCOM Assurance Yojana) successful, the union cabinet has approved the proposal of the Ministry of Power for amendments in the Power Tariff Policy. Literally, this is a historic event considering the comprehensive benefits of the consumers, producers and all other stake holders. The focus centres around 4 Es: Electricity for all; Efficiency to ensure affordable tariffs; Environment for a sustainable future; Ease of doing business to attract investments and ensure financial viability.

As per the amendments: 24X7 supply will be ensured to all consumers and state governments, and regulators will devise a power supply trajectory to achieve this. Also, power to be provided to remote unconnected villages through micro grids with provision for purchase of power into the grid as and when the grid reaches there. The amendments also include a provision for affordable power for people near coal mines by enabling procurement of power from coal washery reject based plants.

What will be the benefits for the consumers? First of all the move is targeted to reduce the cost of power production through efficiency. Secondly, to arrest further spread of carbon footprints, the drive towards harnessing renewable powers will witness a major boost. Yet another significant area that is expected to get a good impetus is conversion of waste to energy. More clearly, usage of sewage water for power generation will ensure availability of more clean water for drinking and irrigation.

Looking at the amendments from the business angle, we can expect that the move will ensure availability of power at reasonable and competitive rates. Overall financial viability of the sector is also expected to increase as new investments will flow in the sector with facilitated ease of doing business.

“Overall financial viability of the sector is expected to increase as new investments will flow in the sector with facilitated ease of doing business...”

However, all the above are depending on how the amendments are implemented! 'Hope our efficient power minister should stringently focus on that!

Please e-mail me your views at pkchatterjee@charypublications.in

P. K. Chatterjee

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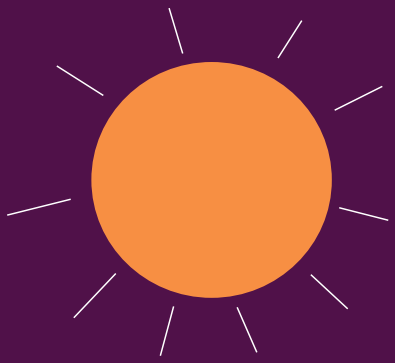

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RENEWABLE ENERGY

MNRE displays its first ever tableau on Republic Day

Ministry of New & Renewable Energy (MNRE) has showcased its various activities and initiatives for the first time in Republic Day Parade. The Theme of display was 'Mega Watt To Giga Watt – Making The Sun Brighter, Even At Night.' The tableau highlighted its ambitious project of renewable energy capacity target of 175 GW to be achieved by the year 2022. All systems on the tableau were being run by the energy produced through the solar panels and energy stored in a device called Eco grid.

The new and renewable energy sources have been accepted universally as the foremost choice for being clean, non-polluting and inexhaustible sources of energy. Being environment-friendly, they preserve nature, promote greenery, health, happiness and prosperity for the mankind. India has announced a very ambitious renewable energy capacity target of 175 GW by 2022. We already have an impressing cumulative existing installed capacity of approximately 38 GW of solar, wind, small hydro and bio-energy.

India has already achieved impressing cumulative existing installed capacity of approximately 38 GW of solar, wind, small hydro and bio-energy. The vision 2022 of achieving the installed capacity of 175 GW, aims to transform India through rapid strides in the renewable energy sector, job creation and skill development. To meet these targets, the Ministry of New and Renewable Energy is spearheading research and technology development in new areas such as ocean, tidal energy, hydrogen etc. It has also been spearheading research and technology development in new areas such as ocean, tidal energy, hydrogen etc. which would also contribute greatly in the future.

SAFETY

Tata Power treads ahead on digital

Tata Power has introduced its digital interface by launching 'Tata Power Suraksha,' a safety mobile app for its employees. At Tata Power, safety is a core value and in pursuit of this belief and commitment, the company has digitised its safety initiatives for its employees. Designed to foster high-level engagement and provide a user-friendly experience, the app aims at reporting and tracking any unsafe practice / scenarios. 'Tata Power Suraksha' provides an easy tool to the user for reporting unsafe scenarios. The application dashboard exhibits the four key verticals i.e., Post Issues, My Issues, Reports, Help & Feedback. The app allows users to register any issue or incident that they come across in real-time by uploading images, describing the same in the free text box while enabling them to directly submit the issue to the concerned authorities.

The most significant feature of the app is that it allows users to define the risk of the issue/incident, and the GPS tracker automatically provides the geographical location in latitude and longitude details. Tata Power Suraksha app is available for a free download from the Google Play Store available on Android handheld devices offering employees a fast and convenient way to report a safety concern.

Speaking on the launch, Ashok Sethi, COO & ED, Tata Power said, "In this digital age we are increasingly using smartphones & handheld devices to simplify our lives, and the all-new Tata Power Suraksha app is an innovative way to enhance employee participation towards strengthening the values of Safety. At Tata Power, safety is a value – and the Suraksha App is one more step that supports our thrive for improving safety. We wish to remain a relevant part in India's growth story, and reach new heights through constant innovation and excellent services."

SOLAR ENERGY

Modi, Hollande lay foundation stone of ISA headquarters

Prime Minister Narendra Modi and French President Francois Hollande have jointly laid foundation stone of International Solar Alliance (ISA) Headquarters and inaugurated the interim Secretariat of ISA at National Institute of Solar Energy (NISE) in Gurgaon on 25th January 2016.

According to Upendra Tripathy, Secretary, Ministry of New and Renewable Energy, ISA will be a major international body headquartered in India. It will be a new beginning for accelerating development and deployment of solar energy for achieving universal energy access and energy security of the present and future generations. Tripathy has further said that India offered to host ISA at the premises of NISE – and has offered 5 acres of land. Three floors of the Surya Bhawan of NISE has been offered for starting the interim secretariat. India's effort is to build an iconic structure for ISA Secretariat. In addition, India has offered a contribution of Rs 100 crore (around US $15 million) for creating ISA corpus fund. Also, the Government of India has offered training support for ISA member countries at the National Institute of Solar Energy – and also support to ISA member countries for demonstration projects for solar home lighting, solar pumps for farmers and for other solar applications.

ISA has been envisioned as a specialised platform, and will contribute towards the common goal of increasing utilisation and promotion of solar energy and solar applications in its member countries. The Paris declaration on International Solar Alliance states that the countries share the collective ambition to undertake innovative and concerted efforts for reducing the cost of finance and cost of technology for immediate deployment of competitive solar generation, financial instruments to mobilise more than 1000 Billion US Dollars of investments needed by 2030.

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APPROVAL

Cabinet Committee gives nod to invest Rs 30,000 crore

The Cabinet Committee on Economic Affairs, chaired by the Prime Minister Narendra Modi, has given its approval for setting up over 5,000 MW of Grid-Connected Solar PV Power Projects on build, own and operate basis. The work will be implemented by Solar Power Developers (SPDs) with Viability Gap Funding (VGF) under Batch-IV of Phase-II of the Jawaharlal Nehru National Solar Mission (JNNSM). The total investment expected under this scheme is about Rs 30,000 crore.

This would help in creating additional 5000 MW capacity of Grid-connected solar PV power generation projects in four trenches of each 1,250 MW capacity during four financial years viz. 2015-16, 2016-17, 2017-18 and 2018-19. This would also help in employment generation of about 30,000 people in rural and urban areas with reduction of about 8.525 Million T of CO_2 emissions into environment every year.

The tenders will be State-specific based on the demand from particular State. States/Union Territories/Discoms/State Utilities are the beneficiaries. This will also facilitate to create employment and infrastructure in the States. Installation of 5000 MW Solar PV plants will generate about 8,300 Million units per year, which caters power to almost 2.5 Million households.

The phasing of investment is estimated as under:

Year	Total (Rs crore)	Handling & Monitoring charges for SECI @ 1% (Rs crore)	Total fund requirement (Rs crore)
2015-16	500.00	5.00	505.00
2016-17	1125.00	11.25	1136.25
2017-18	1125.00	11.25	1136.25
2018-19	1125.00	11.25	1136.25
2019-20	1125.00	11.25	1136.25
Total	**5000.00**	**50.00**	**5050.00**

SUCCESS

HARTING Japan: A 30-year success story in the land of the rising sun

It is precisely 30 years since the HARTING Technology Group founded a subsidiary in the Japanese capital of Tokyo. The Japanese subsidiary HARTING K. K. has since proven a resou nding success, as Philip Harting, Chairman of the Board and President/Partner, underlined at the celebrations. "Founding a subsidiary here in Japan in 1985 was the right decision. Japan was the leading economic superpower at that time. Even back then it was clear that the Asian region offered enormous growth potential for HARTING," remarked Philip Harting at an event in Tokyo.

Kenji Nogata, Managing Director of HARTING K. K., sees continuing strong growth opportunities for the coming years. "We are well represented in the mechanical engineering, robotics and railway technology markets. We aim to further expand our market share in these sectors," said Nogata.

HARTING is represented nationwide in the land of the rising sun via a sales network. In addition to the subsidiary in Yokohama, the Technology Group also has offices in Chubu (Central Japan), Kansai (Western Japan) and Kyushu (Southern Japan).

The HARTING Technology Group is a worldwide renowned provider of industrial connection technology for the three lifelines of power, signal and data with 13 production locations and subsidiaries in 43 countries. The company also manufactures checkout systems, electro-mobility components as well as hardware and software for customers and applications in automation technology, robotics and transportation engineering. In 2014/15, some 4,200 employees generated revenues of €567 million.

Looking back with pride on 30 years of HARTING Japan: Chairman of the Board Philip Harting (R) and Managing Director Kenji Nogata...

AMENDMENT

Cabinet approves amendments in Power Tariff Policy

The Union Cabinet, chaired by the Prime Minister Narendra Modi has approved the proposal of the Ministry of Power for amendments in the Tariff Policy. For the first time a holistic view of the power sector has been taken and comprehensive amendments have been made in the Tariff Policy 2006.

The amendments are also aimed at achieving the objectives of Ujwal DISCOM Assurance Yojana (UDAY) with the focus on 4 Es: Electricity for all, Efficiency to ensure affordable tariffs, Environment for a sustainable future, Ease of doing business to attract investments and ensure financial viability.

Some of the significant highlights of the amendment include: 24X7 supply will be ensured to all consumers and State Governments and regulators will devise a power supply trajectory to achieve this; Power to be provided to remote unconnected villages through micro grids with provision for purchase of power into the grid as and when the grid reaches there; Affordable power for people near coal mines by enabling procurement of power from coal washery reject based plants; Reduce power cost to consumers through expansion of existing power plants; Benefit from sale of un-requisitioned power to be shared allowing for reduction in overall power cost; Transmission projects to be developed through competitive bidding process to ensure faster completion at lower cost; Faster installation of Smart meters to enable "Time of Day" metering, reduce theft and allow net-metering; and Lower power cost by creating transmission capacity for accessing power from across India.

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BUSINESS

Siemens Ltd. wins order worth Rs. 155 crore

Siemens Ltd (together with Siemens Malaysia), has won a crucial order worth approximately Rs. 155 crore from Malaysia-based PSI International, one of the largest petrochemical companies of the world and a subsidiary of Petronas. The scope of work for the project involves supply of 420kV Gas Insulated Switchgear for PSI International's new petrochemical (RAPID) Greenfield project.

Siemens in India is a leading powerhouse in electronics and electrical engineering with a business volume aggregating about Rs. 12,000 crore. Siemens Ltd., in which Siemens AG (Germany) holds 75% of the capital, is the flagship listed company of the Siemens group in India. It is the only Siemens company in the world other than parent Siemens AG and Siemens Inc. in America that is listed on the stock exchanges. Siemens in India focuses on sustainable growth, innovation and environmental solutions.

APPROVAL

Soil Machine Dynamics receives DNV-GL approval

A well established and world renowned customer of Carroll & Meynell, SMD (Soil Machine Dynamics), has just received approval from DNV-GL for a portable control cabin from which submersible ROVs are piloted.

The 20 foot container cabin, which is transferable between on-shore installations, off-shore rigs or platforms and ships has now been fully approved to the DNV standard for certification 2.7-2 (2013) for Off-Shore Service Modules.

As part of this approval the cabin includes a Carroll & Meynell 295 kVA step up transformer with a maximum 3.55kV output voltage to power the main drive motors of the ROV.

The new transformer has been approved as part of an integrated system within the cabin, which includes both input and output overload protection devices.

MV INVERTER

Mitsubishi Electric launches medium voltage inverter drives

Mitsubishi Electric has launched a range of innovative medium voltage inverter drives at SPS IPC Drives 2015 (Nuremberg 24-26 November 2015), which are designed for both the current and future energy needs of industry. The drives are compact and modular, allowing for flexible installation in confined areas – and deliver industry-leading energy efficiency with advanced IGBTs (Insulated-Gate Bipolar transistors). With regenerative braking available as standard, they offer high levels of customer value in many applications.

Faced with the challenges of ensuring long-term reliability while improving energy efficiency, medium voltage inverters have previously been fixed with a rigid cabinet layout. The flexible construction of the MVe2 now offers simple solutions for customer applications, ensuring high levels of energy efficiency in operation, and also being easy to install, commission and maintain.

In particular, the 10/11kV drives have a direct 10/11kV motor feed, immediately removing the need for the transformer found in competitor products. They are a common development by Toshiba and Mitsubishi Electric Corporation (TMEIC), based on decades of experience in the production of medium voltage inverters.

The MVe2 has a very small footprint, probably the smallest on the market for its class. This is very significant because suitable installation space is often very limited in the industries where the range is to be deployed. Aware of this, the design team applied some original thought processes and developed a separately locatable front end transformer section. This uses just a few cables to connect the inverter, enabling it to be positioned in a more convenient location.

The designers also ensured that, unlike many other medium voltage inverters, the MVe2 has a lower head room requirement, allowing it to fit comfortably into a standard shipping container. This ensures safe and economical transportation to site, compared to taller inverters that must be individually sealed against the weather for transportation with special arrangements being made by the freight company to allow for the extra height during the journey.

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RURAL PROJECTS

OMC Power, Sun Edison join hands

SunEdison, Inc., a well known solar technology manufacturer and provider of solar energy services, and Omnigrid Micropower Company Pvt. Ltd. (OMC Power), the first power company to transform the provision of electricity in rural India into a commercially viable, sustainable and scalable business, have signed a framework agreement to develop 5,000 rural projects, representing 250 megawatts (MW) of electricity, throughout India over the next three to five years.

Approximately 400 million people in India have no access to electricity, and even for those who do, the only options are often unreliable and expensive fossil fuel-based solutions.

Building upon the 36 kW micro power plants OMC Power has already put in place across India as part of a sustainable and reliable rural electrification plan, this partnership will quickly bring electricity to 10 million additional people.

"There are approximately 1.5 billion people that do not have access to electricity and another 1.5 billion people that don't have reliable, 24/7 electricity. What is most exciting about this partnership is that SunEdison is embarking on its purpose of transforming lives in a very big way," said Ahmad Chatila, President and Chief Executive Officer of SunEdison.

"Solar electricity costs have come down dramatically and continue to come down, thus making it a better choice than conventional fossil sources. We don't have to make a false choice between cost and clean power any more. While a 1 gigawatt (GW) coal power plant can take 3 to 4 years to be developed and constructed, and a nuclear power plant of similar capacity can take 5 to 10 years, a solar photovoltaic power plant can be developed and built in less than a year and can compete on costs," he added. BI

EQUIPMENT

GE to deliver steam tubines to Taihang power plant

GE has announced two deals that will help meet the growing high-efficiency power needs in northern and central China under contracts with Huaneng Power International (HPI) and China Power International Development Limited (CPI International) for two steam turbine generator units respectively at Taihang Power Plant and Dabieshan Power Plant phase II project.

GE will deliver two ultra-supercritical steam turbines coupled with two turbo generators to Taihang Power Plant that will each produce 660 megawatts (MW) of power. Located in North China's Shanxi Province, the 1,320 MW of new electricity will meet the energy needs of Beijing, Tianjin and Hebei areas and boost economic development in the region. The units are scheduled for delivery by the end of 2017.

GE has a long-term cooperative relationship with HPI that dates back more than a decade and includes supplying steam turbines and generators for Pingliang II Power and tower boilers for Luoyuan Power Plant.

GE also will deliver two 660-MW ultra-supercritical steam turbines generators units to Dabieshan Power Plant phase II project. As one of the backbone power providers in China's Hubei Province, the project will help satisfy the ever increasing local power needs and further enhance the reliability of local power grid. The units are scheduled for delivery by mid-2017.

In 2008, GE successfully provided equipment to the first phase of Dabieshan power plant with excellent performance. CPI International and GE have previously partnered on many important energy projects in China. BI

SCORE

Schneider tops in 'Global 100 Most Sustainable Corporations' list

Schneider Electric has been recognised as one of the 2016 Global 100 Most Sustainable Corporations in the World, coming 12th overall and 1st in its GICS Industry. It's the fourth year running the Group ranks among the top 15 corporations in the sustainability index by Corporate Knights, the magazine for clean capitalism, released every year at the World Economic Forum in Davos.

Companies who make the Global 100 ranking are the top overall sustainability performers in their respective industrial sectors, selected from a starting universe of 4,353 listed companies with a market capitalisation greater than $2 billion (USD) on October 1, 2015. Schneider Electric ranks first its sector and is among the 11 French companies listed. The Global 100 is determined using 12 quantitative sustainability indicators, as the amount of revenue companies generate per unit of energy consumed for example.

Jean-Pascal Tricoire, Chairman & CEO, Schneider Electric commented, "With overall score up to 70.5% in 2016 from 68.4% in 2015, we have achieved our best Global 100 score ever, ranking 1st in our sector and demonstrating our commitment to put sustainable development at the heart of our strategy."

"Even so, we've dropped three places in the global ranking, which means that the overall standards have risen. That's great news for everyone and invitation to increase our efforts," he added. BI

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VSD SYSTEM

ABB wins order for variable speed drive system

ABB has won an order from Tianjin Cement Industry Design & Research Institute Co. Ltd, a subsidiary of SINOMA Group, for a highly energy efficient variable speed drive solution for a dual pinion ball mill at the PT Semen Bosowa Maros cement plant in Indonesia. The equipment will be delivered in March 2016 and commissioned in the third quarter of 2016. The order was booked in the third quarter of 2015.

ABB was selected for that project because the end customer had been satisfied with earlier deliveries for the first cement grinding line at the plant, including a gearless mill drive (GMD) and a vertical mill with ABB slip ring motors.

"ABB's solution was favoured for several reasons, not least because of the high-level of efficiency offered by the permanent magnet motors used and the absence of a gearbox in the system, which maximises availability and reliability" said Rachid Hamdani, Project Director of PT Semen Bosowa Maros.

This will be the first drive system for a grinding application with permanent magnet motors in this power and torque range. The solution has the highest efficiency among all variable speed drive systems and will raise productivity at the plant, while minimising electricity consumption.

LED BULBS

Led bulbs prices come down further

Government of India, through its flagship initiative Domestic Efficient Lighting Programme (DELP), has achieved a further 10% reduction in prices of 9W LED bulbs in another round of LED procurement for Madhya Pradesh. The procurement price has come down to Rs. 64.41 (exclusive of taxes) from existing Rs. 73, while the efficiency of 9W bulbs has increased by 20%.

Energy Efficiency Services Limited (EESL), a Public Energy Services Company under the administration of Ministry of Power, Government of India (GoI), has through a combination of aggregation and transparent procurement achieved a rapid decline in LED prices making it affordable to the common man.

In the recent round of procurement of 9W LED bulbs for the state of Madhya Pradesh the price has come down to Rs. 64.41, which is exclusive of taxes. This is a 10% reduction from the June, 2015 price of Rs. 73 and about 80% reduction from February, 2014 price of Rs. 310.

The Government has ensured transparency and encouraged competition by using e-procurement of goods and services. This has resulted in significant reduction in transaction cost and time and enhanced process efficiency. This, in turn, has led to a much larger participation of bidders thereby increasing competition and reducing the cost of LED bulbs.

As of Date, the Savings Achieved through DELP Scheme

Estimated daily energy savings	1.80 crore kWh
Estimated reduction of peak Demand	1,612 MW
Estimated daily cost reduction of bills of consumers	Rs. 7.09 crores
Estimated daily greenhouse gas emission reductions	14,750 tonnes of CO2

The DELP scheme is being monitored in a transparent manner through a publicly available portal (www.delp.in). As of now, EESL has distributed 5.1 crore LED bulbs and the programme has led to significant savings to the country and consumers – who are using these bulbs.

POWER DISTRIBUTION

Larson Electronics releases a new portable power distribution system

The MGL-100C-480-15K-120-208Y-12X20 temporary power distribution system from Larson Electronics provides a safe and reliable way for operators in industrial settings to tap into and utilise power sources independently of the work area.

The transformer is designed to operate with 480 volts, three phase – which is then stepped down to single phase 120 volts AC and three phase 208Y volts AC.

One hundred feet of Type W line-in power cord is included to connect the substation to a primary 480 volt three phase power supply. The secondary current is wired to a 120/208Y, three phase 100 amp load center with main breaker for circuit protection.

The 120 volt line-out protection is provided by twelve 20 amp, 125 volt, 1 pole breakers. Connection to 120 volt is provided by twelve 5-20 120 volt, GFCI waterproof duplex receptacles with weatherproof covers.

The transformer and distribution assembly is mounted to a standard steel dolly cart style frame resulting in an extremely stable, durable, and mobile power distribution platform.

Two rubber tires and a cart style mounting platform provide easier substation mobility, and a center point lift eye allows for easy lifting with cable or chain hooks. This power distribution system is NEMA 3R rated and ideal for many indoor and outdoor applications.

Check out the Compact City
at Hall: 3A, Stall: HA7

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MACHINE VISION

Ambienta to grow its European machine vision platform

Ambienta, the largest European private equity fund specialised in environmental investments, has purchased Mikrotron, a Germany-based company supplying high-speed machine vision cameras. Mikrotron, together with Tattile, which Ambienta purchased in 2012, will constitute the core of LakeSight Technologies, the consolidation project backed by Ambienta aimed at building a European leader in the machine vision sector.

Machine vision systems, typically used in quality inspection and automation solutions, for industrial processes, are crucial in reducing unnecessary processing, thus improving energy and materials efficiency.

Machine vision is a €2 billion fast-growing market characterised by high fragmentation, where 90% of suppliers have a turnover below €10 million. All these small companies, despite their strong innovation capabilities, have similar size-related issues such as narrow product offerings, small and local sales teams, limited access to management resources, lack of strategic focus and investment constraints. LakeSight Technologies aims at overcoming these issues by establishing a European platform comprising smaller synergic players that can share sales channels, management resources and investment programmes. Ambienta's end goal is to create a unique player with sales in the €40-50 million range and global sales reach. BI

ENERGY MANAGEMENT

Schneider Electric's energy management tool finds great success

Schneider Electric's 'Energy University,' an online, non-proprietary education tool for energy management and automation, has grown to more than 500,000 registered participants worldwide. Available in 13 languages to professionals in 185 countries, the program has provided free energy efficiency education courses to professionals since 2009. With over 200 free courses to choose from, Energy University offers a wide array of course topics including: energy efficiency, building controls & automation, lighting, HVAC, data centers, industrial systems, electric systems, healthcare and more.

"The continued momentum of Energy University (http://www.schneideruniversities.com/energy-university) comes just weeks after world leaders convened at COP21 to discuss a universal climate agreement," said Chris Leong, Chief Marketing Officer, Schneider Electric. "Energy education is a critical link to enabling organizations and communities around the globe to build a more sustainable and efficient future, ultimately leading to a healthier planet. At Schneider Electric, we seek to guide our customers and Energy University participants to become true catalysts of change in their industries and communities by applying what they have learned to make the world more sustainable," he continued.

In addition to improving efficiency in education, the program also provides resources to underserved communities where that information is needed most.

All Energy University courses are free and discuss real-world solutions – and provide practical information on how to make the best use of energy efficiency measures, allowing companies and communities to take advantage of education tools they may not have access to otherwise. In some underserved communities, the access to Energy University is even helping in opening doors for employment, paving the way for the first step out of poverty. BI

TRANSFORMER

Solomon Corp, Maddox Ind Transformer expand their services

Solomon Corporation and Maddox Industrial Transformer have expanded their substation rebuild and repair services in Solomon Corporation's Georgetown, TX, facility. Expanded services are a joint effort between the companies, and will offer commercial, industrial and utility customers located on the Gulf Coast and in the southwest region the speed, quality and convenience they desire.

Solomon is in its tenth year of operating the Georgetown facility in alliance with the Texas Electric Cooperatives (TEC). The facility will continue to serve the transformer repair and disposal needs of TEC member coops and other utility customers. The expansion will allow the facility to remanufacture and repair small power transformers up to up to 10 MVA at 69 kV. The facility is staffed with experienced technicians and supported by Solomon's significant engineering, design and manufacturing capabilities. With significant work already in progress, the expansion will focus on building inventory to serve industrial and utility customers in the region.

Development of the Georgetown facility builds on the existing partnership between Solomon Corporation and Maddox Industrial Transformer announced in October 2015. The partnership is a benefit to the customer base of (both) the companies, improving fulfillment, purchasing, and inventory management.

"Together with Maddox, we are extending our capability to build larger transformers and to respond to short lead-time and emergency situations. We'll have significant inventory of ready-to-ship items and our shop floor will be set up to turn critical items quickly. This market demands speed and we are positioning to meet the demand," said Tom Hemmer, Solomon CEO. BI

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S Yang to become CAO of the World Bank Group

Shaolin Yang

He joins the group at a critical juncture as the organisation works to end extreme poverty and boost shared prosperity...

According to a recent announcement by World Bank Group President Jim Yong Kim, Shaolin Yang will take over the position of Chief Administrative Officer (CAO) in the group, with effect from Feb 29, 2016. Yang joins the group at a critical juncture as the organisation works to end extreme poverty and boost shared prosperity. Chief Administrative Officer (CAO) and Managing Director is a new position in the Bank Group, created to bring together the functions of organisational strategy, budget and planning, and information and technology, among other responsibilities.

Yang, a Chinese national, is currently the Director General of the Department of International Economic and Financial Cooperation at the Ministry of Finance of China, in charge of economic and financial cooperation between China and international financial institutions as well as foreign governments. In his position, he played a critical role in the creation of the Asia Infrastructure Investment Bank.

Yang started his career following the World Bank in 1992 as program officer in the World Bank division in the Ministry of Finance. He served as the Executive Director for China at the World Bank Group from September 2009 to November 2013. “We’re very pleased to welcome Shaolin back to the Bank Group in this critical new role for the institution,” said Kim.

T Eliasson becomes Executive VP and CFO of Sandvik

Tomas Eliasson

He is currently CFO for the global household appliance maker Electrolux, a position he has held since 2012...

Tomas Eliasson has been appointed Executive Vice President and CFO of Sandvik and Member of the Group Executive Management, effective no later than July 2016. He will succeed Mats Backman, who will join Autoliv.

Eliasson is currently CFO for the global household appliance maker Electrolux, a position he has held since 2012. Previously, he was CFO for ASSA ABLOY during 2006-2012 and Seco Tools between 2002-2006. His professional career started at ABB in 1987. He holds a bachelor of science in business administration and economics from Uppsala University, Sweden.

"Eliasson has extensive experience from relevant industries and companies. He will be a strong contributor to Sandvik in the finance areas, and he will also take a leading role in driving the further progress of the Sandvik Group in general," says Björn Rosengren, President and CEO of Sandvik.

"I would like to thank Mats Backman for his valuable contributions as CFO. I wish him all the best in his future career," says Björn Rosengren.

GM India appoints Kaher Kazem as President and MD

Kaher Kazem

He began his career at GM Holden in Australia as a Senior Engineer. In 2009, he became VP of Quality and Manufacturing for GM Thailand...

Kaher Kazem has been appointed as President and Managing Director of GM India, effective from January 01, 2016. He has succeeded Arvind Saxena, who had decided to retire from GM, after leading GM India since early 2014.

Kazem began his career with GM in 1995 at GM Holden in Australia as a Senior Engineer. He later held several leadership positions in GM Holden Manufacturing Operations.

In 2009, he became Vice President of Manufacturing and Quality for GM Thailand/ ASEAN. He was appointed President and Managing Director of GM Uzbekistan in 2012. Prior to taking on his new position, Kazem served as Chief Operating Officer (COO) of GM India – overseeing the industrial side of GM’s business in India – from August 2015.

Kazem has a bachelor’s degree in electrical engineering from the University of Adelaide and a master’s degree in business administration from La Trobe University.

“I want to thank Arvind, who has helped lay the foundation for the future success of GM India. We look forward to a smooth transition to ensure the continued execution of our business transformation,” said GM Executive Vice President and GM International President Stefan Jacoby.


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An Innovative Solution For POWER SHORTAGE IN INDIA

As a country, we can boast of our six major strengths as well as we do have our own weaknesses...

Water, power and health are the three most important items necessary for any country. Apart from water, power is utmost important for every person. India is now facing acute shortage of power by all, more specifically by our industry sector. Due to this problem, our economy is not growing as per our expectation. Earlier, for a similar situation related to food, we could overcome the problem through Green Revolution. Later, we could overcome the malnutrition for our younger children and babies through White Revolution. Now, we are facing power shortage problem and the time has come to bring out Energy Revolution. The economic growth of the country crucially depends upon the generation of power and also on the per capita consumption. As compared to many countries, India per capita consumption is far below. In such a situation, we need to make an advance plan for the future. In the present study, an innovative solution is suggested for our power problem.

GERMI is pushing many innovative ideas and has taken up renewable energy projects in many ways. Here, the total power problem requirement for the next decade has been looked to in a holistic manner and suggested innovative and permanent solution. Hopefully, the suggested solution will make India more independent in power sector. If implemented, it helps our country to grow economically, generate more employment to the large technical human resource available in our country, helps environment and reduces the carbon dioxide and other toxic gases to the atmosphere.

It is known to all that India is now facing shortage of power. Most of our industries and establishments in many states are facing major problems due to lack of power. There exists a large gap between power demand and production. We are not progressing well on par with other developed countries due to this problem. (Ref. 1, 2) Our economic growth is crucially depending on our power sector. Although, many plans are proposed earlier by the Planning Commission of Govt. of India, it was not effective. We are all facing acute shortage of power now. As the population is increasing more people started using the latest technologies with many comforts. The demand for power is increasing year after year. For example, citizen's life style is also changing fast. Persons travelling by bi-cycles earlier, want to travel by motor cycles. Persons travelling by motor cycles want to travel by cars. Persons using fans earlier, want air-conditioning equipment. People use to wash their clothes earlier manually want to use washing machines etc. All such things need more power. People's way of living is changing fast due to new electrical gadgets introduced with technological advancement for comfortable living. People living in under developed countries want to live like developing countries. People from developing countries want to have same comforts as that of the citizens living in developed countries. Of course, it is the right of every citizen in this planet to live the way they want to live. This driving force is one of the major factors for the present day energy demand in the whole world.

In the above scenario, it is the duty of the government to provide power to all our citizens for comfortable living. In any nation, provision of water and power to their citizens are two major items. These two items are utmost important. They are considered to be on top of the agenda and considered as priority items apart from housing, health and other aspects. Every nation needs to find its own resources first and plan in such a way that those reach to its citizens with ease. Once their own resources are not enough for them, then they need to plan to get those from other countries as imported item etc. In the above scenario, let us examine and plan our power sector in India in an innovative way.

Power sector – the present scenario

If one examines our country's power production scenario, we have generated 255 GW of power during the year 2014. This generation of power can be divided into two different fuel types, namely, the renewable fuels and non renewable fuels. Figure -1 provide these details (Ref. wikipedia website). Accordingly, 72% of power is being generated using non-renewable sources such as coal, diesel, nuclear etc., and 28% of power is being generated using renewable sources – such as hydro, small hydro, wind, solar, biomass etc. The total power production from non-renewable sources is close to 184 GW and from renewable sources, it is 71 GW (numbers rounded off for clarity).

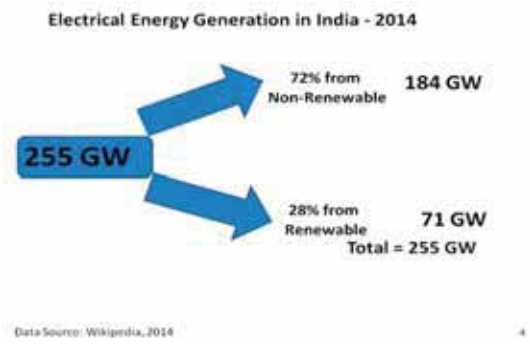

Fig. 1

Fig.1 shows electrical power production in India from all types of fuel sources. Although this number is very high as compared to several other countries, since our population has crossed more than a billion, our per capita consumption is very low. It is much lower than all developed countries like US, UK, Japan, Germany etc., and it is less than developing countries like China, Brazil etc. For comfortable living, we need to grow in power sector in an aggressive manner and work towards this direction from now. Let us say, we want to grow in all the sectors on annual rate of 7 or 8% or 9% for the next 10 years or so, then our power sector also needs to grow at the same rate. Following this logic, by the year 2024, we are expected to generate 603 GW of electricity. Unless we plan now and work aggressively, this number cannot be reached. Figure 2 provides these details.

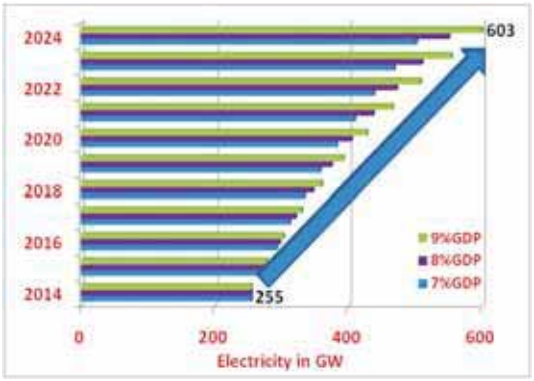

Fig. 2

Power sector and its future demand

Fig.2 Power generation and the expected demand for power in different years from the year 2014 until 2024 with expected annual growth rate of 7, 8 and 9%

As one can see, the target is huge (603 GW). This means we need to increase our power production 2.4 times more within 10 years. Reaching this target needs meticulous planning with careful funding. However, one can find a simple solution to reach this target. Now let us examine, the present day power generation using different fuels. As of now, we are generating 5 GW from nuclear, 25 GW from oil and gas, 154 GW from coal, 21 GW from wind, nearly 2 GW from solar, 41 GW from hydropower, 7 GW from biomass totalling to 255 GW. If we multiply all these power generation units from different fuels with 2.4, then we have 12 GW from nuclear, 60 GW from oil and gas, 370 GW from coal, 50 GW from wind, nearly 5 GW from solar, 98 GW from hydropower, 17 GW from biomass totalling to 612 GW, which is close to our target of 603 GW. This is a simple solution for our future

target. But we need to decide whether such a simple solution is useful and beneficial to our country or not. If one critically analyses this, major portion of the fuels needs to come from other country's. We use to think that we have plenty of coal for 100s of years for our use.

But this was found to be untrue. As we all know, presently we are importing even coal for our power plants. Additionally, this type of solution makes our country always depend on other countries and need to spend our foreign currency. This in turn makes our rupee value at a low level compared to other currencies. Thus, this is not a better solution for our country.

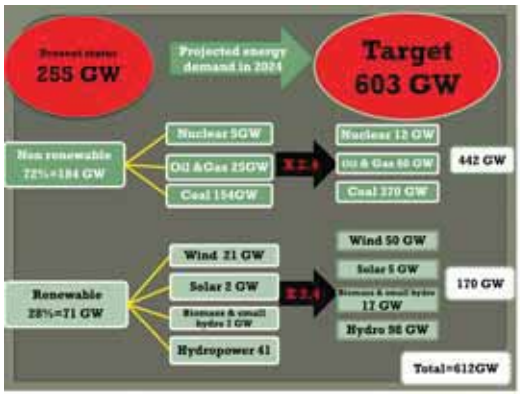

Fig. 3

Fig. 3 represents different types of renewable and non-renewable fuels being used for power generation in India during 2014 – and the targeted energy demand for the year 2024 to be reached with a simple multiplication factor of 2.4 with the existing fuel source.

Power sector – smart plan

In such a scenario, let us find a smart plan. To do this, let us examine the strengths of our country. Fig.4 shows the details. One can see that we have 6 major strengths as our resources. Ours is a tropical country, and thus we have 300 sunny days nearly at all the locations, regions of our country. We have regular seasons like summer, winter and rainy seasons. These seasons with undulating topography of the landmark – and many other factors provide more heat at one location, less heat at another location. Such a variation drives the air from one area to the other, which in turn provides large wind blow at many locations.

We have many rivers flowing in our country like Ganga, Sindhu, Narmada, Tapti, Mahanadi, Godavari, Krishna, Kaveri etc. There is a unique character of these rivers. For example, major rivers in northern India, the Ganga and its tributaries, are flowing from near west towards the east. At central Indian region, we have two major rivers-the river Narmada & Tapi, flowing from the East towards the West. As we go further down, in south Indian peninsular region, all the remaining rivers – Mahanadi, Godavari, Krishna, Kaveri etc., are flowing again from the West towards the East. This is a unique feature of a natural water resource in India. No other country in the world has such a phenomena. Linking of these rivers could have addressed our country's water shortage problem – and our farmers' challenge for ever. But we are yet to take up this major task in a concerted way.

Fig. 4 Shows six major strengths of our country. Another unique feature of our country is the distribution of hot water as natural springs

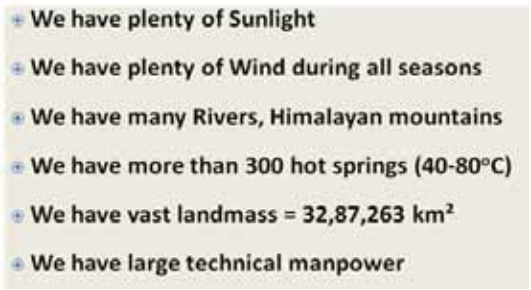

Fig. 4

with temperature of the water varying from 40-80 ^{0}C. There are nearly 300 such locations in India distributed in different parts, for example, all along the Himalayan region, all along the central Indian region following the mega lineament, namely, the Narmada-Sone lineament zone, the Mahanadi, Krishna-Godavari, Cambay rift valleys, along the Konkan coast etc. The surface temperature of 40-80 ^{0}C of hot water at these locations increases to as much as 100-200 ^{0}C at varying depths of 500-2000m.

With new technology, one can generate power from as low as 51^{0}C. India is yet to enter the geothermal power scenario. Although, MNRE with the help of the national institutes like Geological Survey of India (GSI) and National Geophysical Research Institute (CSIR-NGRI) have investigated many geothermal locations, exploitation of this resource is yet to be initiated.

Additionally, another advantage of our country is that we have large land mass totalling to about 33 lakh sq.km. Other small countries are generating large power from solar energy alone. For example, a small country like Germany which has a land mass of 1/9th of our country is generating about 33 GW from solar energy, whereas we are yet to reach 2 GW from solar as on 2014.

Our vast land mass has large uncultivated land and plenty of buildings that contains large roof area are yet to be utilised to fullest use, for example to install the solar panels. Other important strength of our country is technical manpower. We have the world's largest human resource with technical skills in the form of engineers, doctors, scientists etc.

We need to use them for our country's growth in a planned manner. We need to provide them suitable jobs. We need to make them entrepreneurs. We need to give them comforts on par with other developed countries. If we make a strategic plan to utilise this human resource, we may become a major technical human resource hub to the whole world.

While, we can boast of our six major strengths, we do have our own weaknesses. For example, we do not have enough hydrocarbons to meet our demand. We do not have enough nuclear fuel. Even our large resource, namely, the coal fuel is not enough to meet our power demand.

We have more than 1 billion people with us. We need to take care of their welfare. Most of them are uneducated. Most of them are unskilled labourers. Most of them are not well cultured and civilized. Thus, within our country we have two types of societies. On one side, we have civilized, cultured, educated, wealthy citizens. They are on par with any developed country citizens but they are in minority in number. On the other side we have uncivilized, uneducated, uncultured, poor citizens and they are in majority in number. As a country, we need to take care of all our citizens equally. This is our social responsibility.

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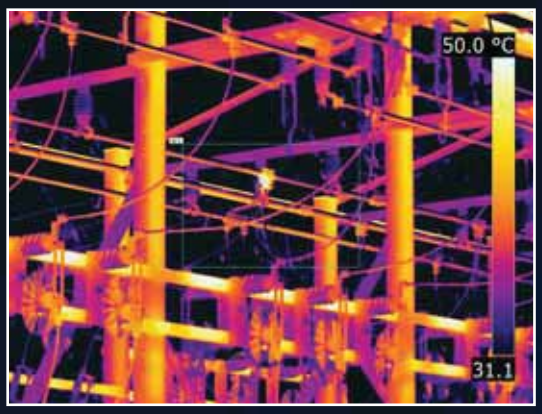

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A critical substation failure may cascade into a series of problems. The result can be a massive failure of banking facilities, security systems, manufacturing plants, food refrigeration, communication networks, and traffic control systems. An electric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

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Another issue which has surfaced recently is the global warming. Due to excess release of CO_2 into the atmosphere by many countries, especially the developed countries for the last several decades, it is now noticed that temperature of the earth is rapidly increasing beyond the expectation. This may lead to catastrophe for all the countries. For example, sea level rise of 1 to 5m may be a disastrous to low altitude countries like Bangladesh. The country may loose its land resource and

Fig. 5

may turn into a calamity for all its citizens. This is one of the problems. There may be many other problems related to atmosphere, seasons, environment, health etc. for many countries.

Fig.5 shows different types of fuels being used for power generation during the year 2014. The non-renewable energy fuels is multiplied with a number close to 1 and renewable energy sources are multiplied with different numbers depends on the growth and resources available in our country.

Keeping our country's strengths, weaknesses and also realising the importance of the global issues like climate change problem, a smart solution is suggested here. In this suggested solution, the non-renewable energy fuels presently being used for power generation need to be continued almost at the same level. This means, we continue to generate power using coal with 154 GW, nuclear with 5 GW, Oil and Gas with 25 GW. However, we need to aggressively plan to generate more power from our own renewable sources. Accordingly, we need to plan the wind power from 21 to 210 GW, (a 10 fold increase), from 2 to 100 GW of solar power (50 times increase), from 7 to 21 GW of biomass (a 3-fold increase), from 41 GW of hydro power to 82 GW (a 2-fold increase) and about 5 GW of power from geothermal (from the present zero level). All these resources together will give us 612 GW crossing our target number of 603 GW.

The above solution is reached based on our past experience on the available renewable sources and also based on our Hindu ancient books (Puranas). In our ancient books, it is said if one depends and believes on Panchamahabhut, the entire world energy needs can be met. These are the five fundamental elements, namely the 'Agni', energy from fire, the 'Vayu', energy from wind, 'Jal', energy from water, 'Pritvhi', energy from the earth and the 'Akash', energy from the sky. In fact, we have been using these elements for the generation of power. For example,' Agni' being used by burning the coal and biomass etc., 'Vayu' being used to generate power using wind mills, 'Jal' being used to generate hydro power, 'Pritvhi' being used to generate geothermal power by many countries and finally the 'Akash', being used to generate power from the sunlight coming from the sky. However, the quantity of power being generated from these resources is far below as compared to other resources. The time has come to depend and concentrate more on the renewable source as compared to non-renewable resource.

For more than a century our technology has developed more towards non-renewable resource, namely the Coal, Oil, Gas and Nuclear. Technology to generate power using renewable source has started late and more seriously only for the last few decades or so. Thus, the technology is still growing with more and more innovations. From the cost economics point of view, the energy generation from renewable sources is higher as compared to non-renewable sources. As the technology grow more, and matures, the cost of generation is likely to come down. Thus, more focus need to be paid on research and development for power generation using renewable sources. All new innovations need to be encouraged and experimented with pilot scale models. As more and more locations and countries start using renewable sources, all the equipment costs and the prices of accessories will automatically come down. One day the cost may be on par with non-renewable energy fuels, and the citizens will have a choice to choose the way they want use power.

Summary

It is observed that 72% of power comes from non renewable sources and 28% from renewable sources. Assuming that we aggressively increase our economy with 9% annual growth, the expected power generation is 603 GW by the year 2024. In such a situation, we have two options to reach this goal. One option is to multiply the power presently being generated with 2.4 to reach the target. However, in the present study this type of solution is not recommended, this solution will make India depend on other countries. Accordingly, an innovative solution based on the following is suggested. The non renewable sources of power (presently at 184 GW) will be maintained more or less at the same level. However, the present generation of 71 GW of electricity from renewable sources need to be enhanced to reach 418 GW of electricity. Thus, the present generation of 21 GW of wind needs to be increased to 210, generation of about 2 GW electricity from solar needs to be enhanced to 100 GW, generation of 7 GW of power from biomass and small hydro needs to be increased to 21 GW, generation of 41 GW electricity from hydro power need to be increased to 82 GW of electricity. Finally, the near zero power generation from geothermal resources need to be increased to 5 GW electricity. This solution will make India less dependent on other countries. Even in our old ancient books (PURANAS), it is clearly stated that Mahapanchabhutam are the solution to our energy needs. They are-Jal (hydro power), Vayu (wind power), Agni (biomass), Prithvi (coal thermal power) and Akash (solar power). However, instead of depending on all these sources, we concentrated only on the fuels available inside the earth (Prithvi). This is the main problem of our earlier power planning. Thus, the suggested solution will make our country strong economically.

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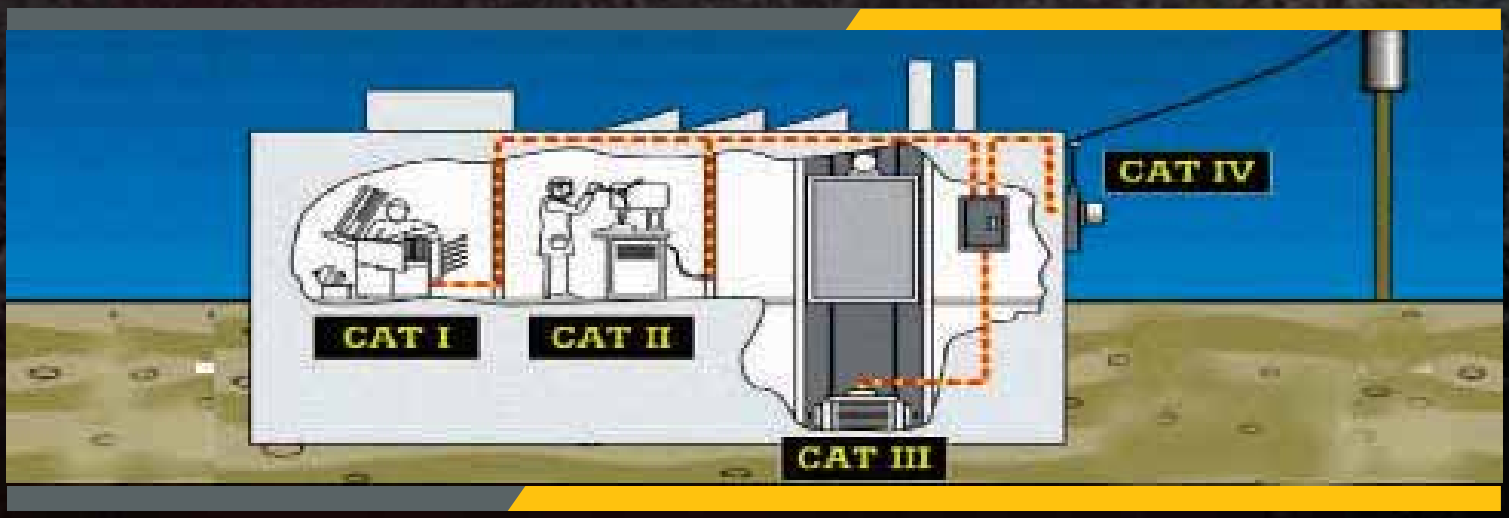

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The solar plant will be an important component in Jordan's strategic diversification of its generation portfolio…

STATCOM in a grid will increase power transfer capability by enhancing voltage stability and maintaining a smooth voltage profile under different network conditions…

The 52.5 Megawatt (MW) Shams Ma'an project will be one of the largest photovoltaic facilities in the Middle East when it is completed in 2016…

A report in Wikipedia states that Jordan is among the highest in the world in dependency on foreign energy sources, with 96% of the country's energy needs coming from imported oil and natural gas from neighbouring Arab countries. This complete reliance on foreign oil imports consumes a significant amount of Jordan's GDP. ABB will supply a substation for the Shams Ma'an photovoltaic project, the largest of its kind in Jordan and a significant project in the Middle East. It will help the country reach renewable targets of 10% of its energy mix by 2020.

It will use over 680,000 solar panels spread over two million cubic meters, and is set to produce 160 gigawatt-hours/year, equivalent to one percent of Jordan's power production: The 52.5-Megawatt (MW) Shams Ma'an project will be one of the largest photovoltaic facilities in the Middle East when it is completed in 2016. Located in the southern region of the country, the new plant will reduce Jordan's reliance on imported oil and gas, and is one of the first renewable energy projects and the largest of its kind in Jordan.

As such, the plant will be an important component in the country's strategic diversification of its generation portfolio, which is intended to boost energy security. Jordan's annual daily average solar irradiance is among the world's highest, and the country's National Energy Strategy includes ambitious targets to increase the contribution of renewable energy sources such as solar to the national energy supply. The share of renewable energy in the total energy mix is anticipated to reach 10% by 2020.

First Solar, Engineering, Procurement & Construction (EPC) contractor for the plant, has commissioned ABB to build a substation that will integrate the solar energy into the grid. As part of the project scope, ABB will engineer, manufacture and supply the 33-kilovolt (kV) interconnection facility with the grid in a Prefabricated Electrical Center (PEC).

This will include the 33kV gas-insulated switchgear, substation automation, control and protection systems, 33kV capacitor banks and ancillary equipment to ensure proper interfacing with the remote-end utility substation, which was also supplied by ABB last year.

In addition, ABB will supply a two-megavolt-ampere reactive (MVAR) static compensator (STATCOM) including coupling transformer. Installing a STATCOM in a grid will increase power transfer capability by enhancing voltage stability and maintaining a smooth voltage profile under different network conditions. The STATCOM also enables improvements in power quality. This will be the first ABB STATCOM to be installed in Jordan.

This is not the only solar power plant in the Middle East in which ABB is contributing its technology to support integration of renewables, in line with the company's Next Level strategy.

ABB previously won substation orders to integrate 200 MW from the Mohammed bin Rashid Al Maktoum solar park phase II into the grid in Dubai, United Arab Emirates.

This solar park is expected to produce 3,000 MW of clean energy when completed in 2030 – making it one of the biggest renewable energy projects in the Middle East and North Africa.

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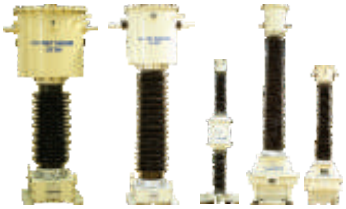

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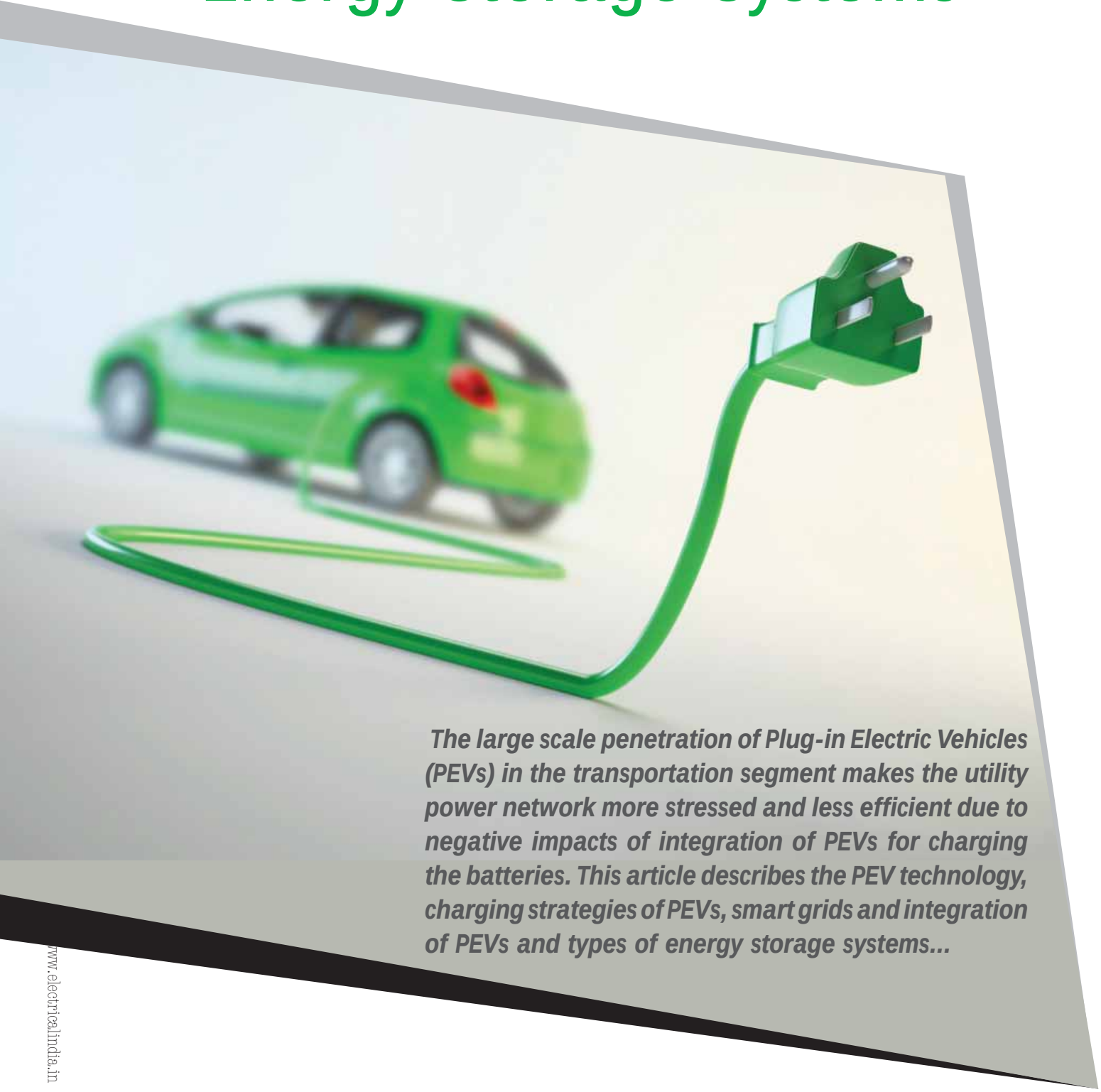
PEVs, Smart Grids And Energy Storage Systems



The large scale penetration of Plug-in Electric Vehicles (PEVs) in the transportation segment makes the utility power network more stressed and less efficient due to negative impacts of integration of PEVs for charging the batteries. This article describes the PEV technology, charging strategies of PEVs, smart grids and integration of PEVs and types of energy storage systems...

The Plug-in Electric Vehicle technology is fast emerging for modernizing transport segment and offset climatic challenges due to fossil fuel depletion. The technology causes negative impacts to power utility systems that are used to charge the batteries in PEVs. Research advances are progressing towards resolving the technical and economical issues to bring down ownership costs of PEVs. The large scale penetration of PEVs in the transportation segment makes the utility power network more stressed and less efficient due to negative impacts of integration of PEVs for charging the batteries. Integration of PEVs with the power network at high penetration level demands a new technology, that is, a smart grid to integrate renewable energy sources and to operate the grid more efficiently, which includes time flexible demand side management. The smart grid technology with the two way communication of digital information and power flow monitoring is emerging to operate the grid smarter with intermittent renewable sources and reduced generation of fossil-fuel fired traditional power generators. The power from renewable sources is from the intermittent solar and wind farms that are seasonal and uncertain. A new technology on Electrical Energy Storage Systems, with storage capacity in megawatt scale, is emerging to store off-peak period energy, and supply to the grid on-peak period appropriately to balance the load side management. All the three technologies are emerging fast, and are complimentary to each other. A comprehensive overview of the three technologies is presented in this article.

The Plug-in Electric Vehicles (PEVs)

The Plug-in Electric Vehicles (PEVs) are the Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs). PEVs will dominate the transportation in the personal mobility mode and in the automobile market by 2030. The focus on promoting use of electric vehicles in road transportation is very essential to meet the climate change targets and manage the ever hiking prices. However, there are lots of uncertainties in the market about the acceptability of PEVs by customers due to the capital and operation costs and inadequate infrastructure for charging systems. Manufacturers are also not sure of the market, even though predictions are strong and attractive. Major manufacturers, however, are already ready with their plans to introduce electric vehicles in the mass market. The use of PEVs has both technological and market issues and impacts. Series of research works have been reported to address the issues related to PEV technologies and its impacts on political, economic, environmental, infrastructural and market potential aspects.

The new vehicle technology in transportation segment is the Plug-in–Electric Vehicles. PEVs need battery charging infrastructure to operate charging stations by utility network systems. PEV charging stations are located at business centres, retail stores, colleges, workplaces, parks and libraries. Charging station technologies are advancing rapidly with faster charging capabilities, increased communications, improved controls and lower capital costs. Electric vehicles support fuel independence, cleaner air, and economic growth. The technologies, economics, and support for clean energy have created a new market opportunity. The adoption and roll out of PEVs can accelerate with continued collaboration around EVSE (Electric Vehicle Support Equipment) infrastructure, utilities, vendors and their collective customers, and play a key role in the world economy and environment.

The environmental benefits of plug-in electric vehicles increase with use of 'green' sources such as solar, wind or small-scale hydroelectricity. PEVs typically emit less greenhouse gas emissions than conventional vehicles. The technology is, therefore, promoted with incentives from Governments.

PEVs Technologies

A Plug-in Electric Vehicle (PEV) uses electric energy from a battery power source. The storage batteries, which supply power to the vehicle, need to plug-in to recharge. There are several types of plug-in electric vehicles, each with different features. The types of electric drive vehicles, other than PEVs, are: Photovoltaic Electric Vehicles (PVEVs) and Fuel Cell Electric Vehicles (FCVs).

-A **Battery Electric Vehicle** (BEV) is fully electric and powered by the on-board battery. The vehicle is capable to go up to 100 miles on full charge. The batteries are then plugged- in to a power source to recharge.

-An **Extended Range Electric Vehicle** (EREV) is similar to BEVs, but it may have an on-board gasoline fuelled generator to provide additional energy, when the batteries are low. These may have up to about 50 miles range on the initial battery energy.

- A **Plug-in Hybrid Electric Vehicle** (PHEV) has both an electric motor and a typical gasoline or diesel engine to power the car. A plug-in-hybrid electric vehicle is designed with types of configurations such as series-hybrid, parallel-hybrid, or combined series-parallel hybrid:

- Series-Hybrid: Only the electric motor provides power to drive the wheels. Sources of electrical energy are either the battery pack (or ultra-capacitors) or a generator powered by a thermal engine. Such vehicles are Extended-Range Electric Vehicles.
- Parallel-Hybrid: Both the electric motor and fossil powered engine provide power in parallel to the same transmission.
- Power split or series/parallel hybrid: This allows running the vehicle in an optimal way by using the electric motors only, or both the IC Engine and the electric motors together, depending on the driving conditions.

The PEVs system has the following components of the drive train.

- Electric Motors: This device converts the electrical energy from the battery to mechanical energy, thus propelling the vehicle by AC or DC motor.
- Electric Generators: The generator converts mechanical energy to electrical energy. In some vehicles the two functions are combined into a single device by motor-generator.
- Inverters Battery packs invariably supply DC current: The AC motor in a PEV is coupled with the battery pack using an inverter. The inverter converts the DC from the battery to AC and powers the AC motor.
- Chargers: It converts the AC electrical output from the generator into DC and charges the battery pack. A charge controller optimises the charging process that prolongs the life of the battery. The Electric Vehicle Support equipment (EVSE) includes 120 V/ 240 V AC plug-in, Control device, Charging cable cord, Connector and Coupler.
- Large Battery Packs Battery packs store the energy to power a PEV. The variants of electric vehicles use different types of battery packs: lead acid, NiMH, Li-ion.

Challenges and Opportunities

The use of PEVs has technical and commercial challenges as well as business opportunities.The technical impacts are: Technology is not fully developed. The technology is evolving with time to bring down purchase cost comparable to a conventional vehicle. The issues and challenges are:

- The development of battery technology and raw materials to keep the cost affordable with Vehicle size and to meet the expected range of travel.
- Public awareness on its availability, cheap in cost, less in operational cost and better economic and environmental impacts at large.
- Use of PEVs as source of power by utility to manage peak load-shaving in power grids.
- Development of grid infrastructure to integrate PEVs with Smart Grids.
- Development and investment of Charging Infrastructure by Utilities.
- Managing the load balancing, peak hour Shaving, Off-peak charging tariff structure and economic and cost effective user billing infrastructure by utilities.
- Development and investment on manufacturing, Tariff regulations, and incentives to promote PEVs.
- Development and management of Information Communication Technology (ICT) infrastructure in the Smart Grids.
- A drive to focus on PEVs penetration in the transport sector, establishment of Smart Grids, and integration of PEVs and renewable energy sources.
- Development and management of Energy Storage Systems to maintain an efficient operation of the power network .

The use of PEVs has technical impacts in distribution power network. The impacts vary with the vehicle penetration levels, charging pattern, fleet charging profile, distribution network power losses, integration of PEVs at the transformer levels, vehicle driving pattern, and Demand Response (DR) strategy to reduce peak loads, driving distance, battery sizes, and tariffs. Widespread use of PEVs with new vehicle technology has a positive impact on environment and economy. It helps in clean transportation, energy independence and reduces emission of gases, such as carbon dioxide, nitrogen oxides and sulphur oxides.

Other impacts on power grid due to increased penetration of PEVs are: Increase in additional power load for charging PEVs in uncontrolled scenario. However, off-peak charging of PEVs improves the load curve for electric utilities. Therefore, the use of high penetration PEVs should be properly optimized under different charging scenarios and technologies.

The charging scenarios are either controlled or uncontrolled. Certain strategies are required to manage charging behaviour to limit the daily charging peak. The charge management methods are: tariff rates such as Real Time Pricing (RTP) under Time of Use (TOU) tariff and Controlled charging from Smart Grid under Critical Peak Pricing (CPP) tariff.

The battery capacity determines the charging time, and is inversely proportional to the State Of Charge (SOC) of the battery. The electric load curve in power system network depends on the percentage of PEVs penetration and the charging strategies.

The charging station has single phase AC/DC conversion devices. DC distribution with super- capacitor energy storage device supplies power to the battery, when the power demand for the charger exceeds the average demand of the grid. A 230 kVA Transformer is required for every 50 parking spaces, and accordingly, infrastructure for charging station and system integration of BEVs to the grid operation is needed.

Demand Response (DR) is another dynamic benefit to the grid by interrupting the PEVs demand on peak hours. The Plug-in bidirectional Vehicle-To-Grid system (V2G) batteries in smart grid charging become distributed storage systems for the electrical grid. The energy supplied to the grid is priced to pay back the cost of Vehicle to Grid (V2G) batteries in PEVs. The distributed storage would make the grid more stable, secure and resilient by frequency regulation and spinning reserve as backup capacity within the distribution system. V2G system allows greater penetration of wind and solar resources into the grid.

A large scale penetration of PEVs will introduce several technical challenges and will impact different aspects of the power system grid:

- Impose uncertainty in load in the distribution system, need reliable communication network, impose cyber security issues and quality and stability of the overall distribution system.
- Other challenges are focus on charging and control strategies for coordination and integration of PEVs with grid, grid interface technologies, energy management issues, demand response services, power losses, voltage and frequency regulation issues.
- The average operating temperature of transformers will increase under the additional load of charging PEVs. This could shorten their life, thus adding costs to the electricity grid.
- There will be potential power supply shortage, if the aggregated battery charging profile includes the on-peak period.
- The batteries should be storing electricity from the lowest carbon emitting sources, namely nuclear energy and renewable energy. But, the challenge is then to make the demand and supply load curves coincide. The battery load curve depends on the time for recharging and charging power.
- The new PEVs fleet impacts the electricity transport and generation capacity. The electricity grid operators require innovative management methods to tackle the issues.

The utility operators of the electricity grid deploy new techniques to monitor, and remotely control the electricity demand. Beyond such a mono-directional power flow management from the electricity grid to the vehicle battery, more integration methods are being explored. These innovations are also being considered in the framework of research and development efforts towards a smart and reliable grid, as needed by the growing role of distributed energy resources, including intermittent renewable energy resources.

The utility needs to meet additional expenditure for up-gradation of the electrical system to meet the additional load due to sudden charging by PEVs cluster at a time. As a mitigation strategy, most utilities are developing PEV charging permit requirements.

An accurate and up-to-date data about line and transformer capacity will be the key for development. Advanced Distribution Management Systems (DMS) with intelligent line and transformer sensors and smarter meters help operators in real-time to effectively manage the network. Advanced Metering Infrastructure (AMI) and Integrated System Model (ISM) are used to manage the changing distribution environment. Charging station should

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have communication facilities that transfer information on PEVs and battery storage status to the utility DMS. Utility needs investment on this real-time monitoring process.

A smart charger ensures that the plug-in batteries are charged only when the electricity is at its cheapest, saving money. Moreover, utilities could temporarily turn off chargers in thousands of homes or businesses to keep the grid safe during peak hour demand.

High penetration of PEVs in electric grid has specific impacts on distribution network systems. They are:

- Phase imbalance: Lower percentage of PEVs using single phase charging results in larger variation in current imbalance, but the lower total load reduces the voltage imbalance. However, when higher numbers of PEVs are charging, then the diversity increases and so lowers the current imbalance and keeps the voltage imbalance within limits.
- Power Quality issues: The non-linear elements such as inverters and battery chargers in PEVs increase voltage distortion and current harmonics significantly. Harmonic currents cause excessive neutral current and transformer hotspots. New designs of chargers are in the market to control harmonics with low TDH of 30% against the present 60-70 % TDH.
- Transformer degradation and failures: The load pattern on deployment of PEVs will change and the power system may not be capable of handling the new load pattern with the additional load demand. A study reports that harmonic distortion, load distortion, increased temperature and higher penetration rate of PEVs in a transformer and charging characteristics degrade the transformer life span by 40 % per year and increase failure rate.
- Circuit Breakers and Fuse Blow-outs: The harmonic distortion affects the interruption capability of circuit breaker. High harmonic current on fuse behavior has thermal effects and dissimilar current.

The use of PEVs creates opportunities to automotive industries, electricity utilities, vehicle charging companies, battery manufacturers and all levels of Government organisations and most importantly consumers. Governments are driven to adopt PEVs in the transport sector to increase the fuel economy standards, meeting the local air quality standards, energy security and compulsion to reach the target of climate change.

The market challenges are high initial cost of PEVs due to high battery costs, limited drive range, high charging time and limited charging infrastructures. Other challenges are: lack of consumer education and acceptance, smart grid integration, lack of familiarity to PEVs.

Market penetration of PEVs would largely depend on public policies from regulatory bodies. The regulatory bodies for policies and regulation of electric vehicles are:

- World Electric Vehicle Association (WEVA)
- Electric Drive Transportation Association (EDTA)
- Electric Vehicle Association of Asia Pacific (EVAAP)
- European Association for Battery, Hybrid and Fuel Cell Vehicles (AVERE)

1.3 Electric Vehicle Market Forecasts

The major PEVs markets are in North America, Western Europe, and Asia Pacific with compound annual growth rate of 23.7 percent through 2023, according to Navigant Research Report. Various published research reports predict PEVs annual growth projections of 16 to 20%. Governments worldwide are keen to increase penetrations of PEVs due to the environmental, economic, and energy security benefits. As such, government incentives to spur growth in PEV development have been fundamental to growing Plug-In Electric Vehicle (PEV) penetration within the vehicle market.

Promotional Programs on PEVs

The Governments in Canada, China, Europe, India, Japan and United States have special promotional programmes to promote adoption of PEVs. The programs provide incentives by way of rebate for new PEVs and preferences to use Government charging stations, parking spots and priority lane for driving and provides subsidies for sale, and annual tax exemption.

Europe provides, for new PEVs, tax exemption and penalty charges on carbon-dioxide related taxes. Some states provide income tax rebate and tax deduction on investment on external recharging station infrastructure, exemption from road taxes, tax breaks, annual bonuses, exemption from first registration taxes, free parking in public parking spaces, exemption from annual circulation taxes, exemption from all non-recurring vehicle fees, waiver of import tax and 100% discount on London congestion charges. Greener Vehicle Discount (GVD) and Ultra Low Emission Discount (ULED) schemes are also operative.

Indian Government provides 20% subsidy of ex-factory price of PEVs and exemptions on road taxes, VAT and registration charges. There would be customs/excise duty reduction. The government has set up a National Mission for Hybrid and Electric Vehicles to encourage manufacture and sale of electric vehicles.

Japanese Government provides subsidies up to 50% on clean energy vehicles and provides tax deduction and exemptions on environment friendly vehicles that meet the environmental performance criterion. The PEVs are exempted from both the acquisition tax and the tonnage tax, and 50% reduction of the annual automobile tax.

US Government grants tax credits on new purchase and on the cost of installing home-based charging station. Other facilities are free charging of electric vehicles in public charging stations and work place charging stations, preferred parking spots in public parking spaces and reduced interest rates on vehicle loans for employees.

Smart Grids

India is the third largest country in the world in Electrical Transmission and Distribution. Therefore, it needs an efficient and strong system for distribution, where the smart grid concept could help. Smart Grid is an integration of Electrical and Digital technologies, and, Information and Communication. Smart grid delivers and monitors electrical power to the consumers using two way digital technology. Figure 1 shows the smart grid concept of integrating fuel based and renewable energy sources and information and communication infrastructure.

The smart grid with integrated PEVs is a modernized electric grid that uses communication network to collect information about the power network and monitors the grid for efficient operation. The components of power network grid are power supply, batteries and battery chargers with optimized

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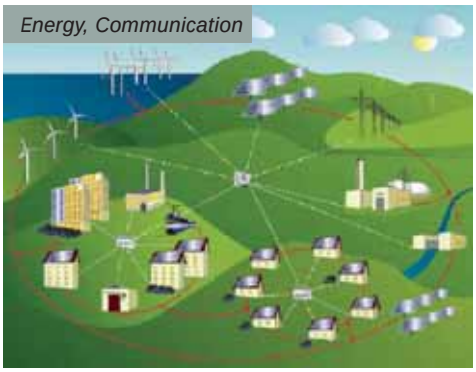

Fig.1 The smart grid concept...

charging system and converters. The smart grid has communication network to communicate to various electric devices in the power network through wired and wireless networks. The communication network comprises five levels viz.

- Wide Area Network (WAN) to connect substation and control centers in the distribution system,
- Neighborhood Area Network (NAN) through wireless networks, power line communication networks or Ethernet to connect smart meters and data collectors in the distribution system,
- Field Area Network (FAN) for monitoring and information exchanging between PEVs and control centers,
- Home Area Network (HAN) to control and monitor PEVs, Smart Meters and Energy Management System, and
- Control Area Network (CAN) to connect charge controller and charging station.

Secure and bidirectional control and communication mechanisms for accommodating PEVs is needed for reliable billing, demand response arrangements for V2G integration, reliable and stable load balance and cyber security in case of security breaches to meet the integrity and availability of PEV integrated system in the communication network. The cyber attack on integrated PEV System has severe negative effects on electric power and transportation infrastructure simultaneously. The cyber security challenges are categorized as follows:

- Payment security with authentication and data encryption technologies to protect secured payment transactions from frauds,
- Smart metering with real-time data acquisition of accurate energy consumption for pricing,
- Cyber physical critical infrastructure to protect devices and PEVs in the network against malicious cyber-attacks or firmware infections,
- Cyber attacks in data transmission in the wireless network,
- Cyber attack on client privacy of PEVs on information such as location, identity, distance travelled and energy exchange patterns.

There are two methods to detect data intrusion, namely, Anomaly Detection methods and Misuse Detection methods to identify malicious data

Smart Grid Technology

The smart grid technologies are grouped into five key areas:

- Integrated communications will allow for real-time control, information and data exchange to optimize system reliability, asset utilization, and security. Areas for improvement include: substation automation, demand response, distribution automation, supervisory control and data acquisition (SCADA), energy management systems, wireless mesh networks and other technologies such as power-line carrier communications and fiber-optics.
- Sensing and measurement will evaluate congestion and grid stability, monitor equipment health, energy theft prevention, and support control strategies. Technologies include: smart meter, wide-area monitoring systems, electromagnetic signature measurement/analysis, time-of-use and real-time pricing tools, advanced switches and cables, backscatter radio technology, and digital protective relays.
- Advanced Metering Infrastructures (AMI) use digital meters that record usage in real time. The communications infrastructure such as wires, fiber, Wi-Fi, cellular, or power-line carrier are used to get the data backup to the utility.
- Phasor Measurement Units (PMUs) is high speed sensors that are distributed throughout a transmission network to monitor the electric system.
- Other Advanced Components are innovations in superconductivity, fault tolerance, storage, power electronics, and diagnostics components that are changing the abilities and characteristics of grids.

The smart grid must be self-healing, allow active participation of consumers in operation, ensure higher quality power, accommodate all generators and storage options, enable more efficient operation, enable new electricity markets and enable higher penetration of intermittent renewable power generation sources. IEEE is developing guidelines and standards on how the grid should operate using the latest in power engineering, communications and information technology. A secure and reliable real-time two way high speed communications infrastructure is an essential part of the smart grid reality. Research advances on smart grid technology include communication architecture network technologies and integration technology of PEVs and renewable energy sources with energy storage system coordination.

The most serious concern for utilities is controlling the (EVSE) Electric Vehicle Supply Equipment, which add load to the grid. A high percentage of consumers will instinctively charge their EVs at home, which has a serious impact on peak grid demand. The home charging stations typically draw electricity load of 6.6 kW (240V and 30 amps) in addition to the house load of 7 kW. Even low levels of EV adoption in a particular neighborhood can strain existing power infrastructure.

The Electric Power Research Institute (EPRI) report suggests that if two customers on the same transformer plugged in 6.6 kW charging stations during a peak time, their additional charging load may exceed the emergency rating of roughly 40 percent of the distribution transformers.

The Smart Grid is the key to smart EV charging. The Smart Grid provides the visibility and control needed to mitigate the load impacts and protect components of the distribution network from being overloaded by EVs, thus ensuring electricity generating capacity is used most efficiently. With a Smart Grid, utilities can manage when and how EV charging occurs while still adhering to customer preferences.

Smart Grid integration of EVs enables utilities to provide consumers to know the cost of 'fueling,' positive impact on the environment and ability to set charging preferences. A Smart Grid also allows utilities to collect

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EV-specific meter data, offers specific rates for EV charging, engages consumers with information on energy transmission, and collects data for greenhouse gas abatement credits.

Utilities can remotely monitor charging stations and allow for the comprehensive management of EV charging. Utilities can also troubleshoot charging issues without unnecessary on-site service calls and manage when connected EVs are charged.

Communication Demands Of Smart Grid

Integrated communication involves data acquision, protection and control. Therefore, the communication infrastructure is the most important priority in building a smart grid.

With the Smart Grid, utility offices will be able to support, integrate and optimise EV charge management as part of an integrated Demand Side Management (DSM) operation. This approach requires systems that manage EV charging and optimize with other Demand Response (DR) programs.

The Smart Grid also allows utilities to seamlessly integrate an EVSE meter with the Advanced Metering Infrastructure (AMI) system. This allows a utility to break out EV charging from the primary meter and bill for EV charging at a separate rate. AMI integration can also make it easy for utilities to track and report EV charging usage for greenhouse gas credits and use data to predict local reliability issues.

A novel load management solution is necessary for coordinating the charging of multiple Plug-in Electric Vehicles (PEVs) in a smart grid system. Utilities are becoming concerned about the potential stresses, performance degradations and overloads that may occur in distribution systems with multiple domestic PEV charging activities. Uncontrolled and random PEV charging can cause increased power losses, overloads and voltage fluctuations, which are all detrimental to the reliability and security of newly developing smart grids. Therefore, a real-time smart load management (RT-SLM) control strategies are being developed for the coordination of PEV charging based on real-time and minimization of total cost of generating the energy plus the associated grid energy losses. This approach enables PEVs to begin charging as soon as possible considering priority-charging time zones, while complying with network operation criteria such as losses, generation limits, and voltage profile.

Successful integration of plug-in electric vehicles into the power system is a major challenge for the future smart grid, such as charging and control strategies of PEVs, Vehicle-to-Grid (V2G) technology, and several application domains, such as wind energy integration, frequency regulation, design of parking areas and participation in electricity markets.

DC Fast Charging Equipment

DC fast charging equipment can reduce the time in less than an hour to a full charge on a standard BEV. A new connector, that combines Alternating Current (AC) and DC fast charging in one unit, is now available. The Society of Automotive Engineers (SAE) standards have defined PEV charging levels. AC level 1 and 2 charging stations convert the AC to DC power through the PEVs on-board chargers. DC Level 1 and 2 charging stations provide electricity from AC to DC through an of-board charger. DC power is directly delivered to the vehicle. AC Level 1 charging uses 120 V single phase outlet with current ratings 15A and 20A, and is suitable for home charging. AC Level 2 charging is used for both private and public charging facilities. It provides a range of 15-20 miles per hour of charging time. DC Level charging is for commercial and public applications. DC Level charging offers a range of 40 miles to a PEV per hour of charging time.

There are two alternative charging methods: inductive charging or wireless charging and battery swapping. Wireless charging is convenient and can address many issues related to costs, driving range and battery capacity and life.

The Wireless Power Transfer (WPT) charger transfers power wirelessly to the vehicle charging circuit that feeds the Energy Storage System in the vehicle. However, the WPT technology and standards are still under research and development for large scale deployment. Battery Swapping is a method by which the dead battery is replaced with fresh battery at Battery Swapping Stations. However, battery Swapping Stations have technical challenges such as upfront investment in battery packs, difficult to standardise, huge investment in Swapping Station infrastructure and manpower, and big concern on safety and reliability of service.

Charging Strategies

The number of PEVs in the near future will increase and stress the already overloaded power grid, creating new challenges for the distribution network. To mitigate this issue, several researchers have proposed the idea of charging PEVs using renewables coupled with smart charging strategies. There are researches on control algorithms, smart charging techniques and different power electronic topologies for photovoltaic charging facilities (PCFs).

A group of Plug-in Electric Vehicles (PEVs) is controlled by an 'aggregator.' The aggregator is responsible for making the charging schedule for each PEV and also participates in power system regulation or electricity market bidding. However, practically, to coordinate the charging of large scale PEVs in power system, the diversities in charging infrastructure, PEV types and local operational constraints in the power system needs to be well considered.

Therefore, hierarchical control of PEVs is regarded as an effective way to achieve charging cost minimization and system operational security. Hierarchical control frameworks for PEV charging includes coordinated charging strategy for charging station, coordinated charging strategy for battery swapping station, hierarchical coordinated charging strategy for multiple charging stations and a three level coordinated charging framework for large scale of PEVs. The hierarchical charging control framework and optimization methods reduce peak demand and charging costs.

The uncertainties on place and time of charging by Plug-in Electric Vehicles (PEVs) use stochastic based approaches to identify the load scenarios and the impacts of a new type of load of the PEVs battery charging.

It incorporates several PEV models with different charging strategies, such as non-controlled charging, multiple tariff policies and controlled charging. It uses a stochastic model to simulate PEVs movement in a geographic region and a Monte Carlo method to create different scenarios of PEVs charging. It calculates the maximum number of PEVs that can be safely integrated in a given network and the changes in the load diagrams by PEVs, voltage profiles, lines loading and energy losses.

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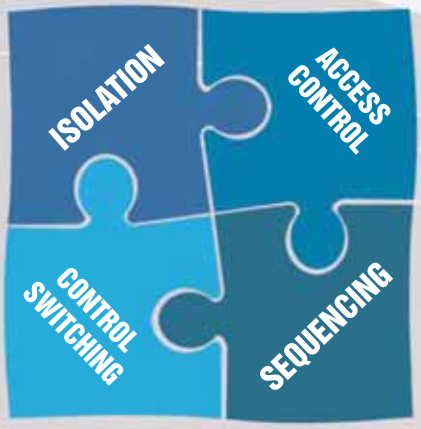

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A Model Predictive Control (MPC) framework could control in real-time the charging processes of a set of plug-in electric vehicles (PEVs) located in a load area (LA). The Electric Vehicle Supply Equipment (EVSE) is used to recharge the batteries, and a share of generation from Renewable Energy Sources (RES). The framework works regardless of the EVSE technology and power level, either direct current, alternating current, single phase or three phases.

Integration Of PEVs In Smart Grid

The integration of Electric Vehicles in electric power systems poses challenges on technical, economic, policy and regulatory issues that should be managed with new architectures, concepts, algorithms, and procedures. PEVs offer an uncommon opportunity to address energy security, air quality, climate change and economic growth. However, market growth is uncertain due to policy, economics and technical challenges and easy adoption of PEVs nationwide.

Next-generation transmission and distribution infrastructure will handle bidirectional energy flows, allowing for Distributed Generation (DG), such as from photovoltaic panels, fuel cells, charging to/from the batteries of electric cars, wind turbines, pumped hydroelectric power, and other sources. Classic grids were designed for one-way flow of electricity, but if a local sub-network generates more power than it is consuming, the reverse flow can raise safety and reliability issues. A smart grid with integrated PEVs improves voltage level and operates the grid in stand-alone mode also.

Communications and metering technologies inform smart devices, during the high cost peak usage periods, to reduce demand. The utility companies have the ability to reduce consumption by communicating to devices directly and prevent system overloads. Consumers and businesses will consume less during high demand periods, if consumers are aware of the high price premium at peak periods.

Demand Response (DR) support allows generators and loads to interact in real time, coordinating demand to flatten spikes, thus eliminate the cost of adding reserve generators, extend the life of equipment, and allow the low priority devices to use energy, only when it is the cheapest.

Use of robust 2-way communications, advanced sensors, and distributed computing technology will improve the efficiency, reliability and safety of power delivery. It also opens up the potential for entirely new services such as fire monitoring and alarms that can shut off power and make phone calls to emergency services. The benefits associated with the smart grid include:

- More efficient transmission of electricity,
- Quicker restoration of electricity after power disturbances,
- Reduced operations and management costs for utilities, and ultimately lower power costs for consumers,
- Reduced peak demand, which help lower electricity rates,
- Increased integration of large-scale renewable energy systems,
- Better integration of customer-owner power generation systems, including renewable energy systems,
- Improved security.

Electrical Energy Storage (EES) Systems

The developments made in storage technologies and solutions have shown that electricity can be stored now in megawatt scale. These electricity energy storage (EES) applications are increasingly becoming viable around the world in the context of smart grid environment.

The Electrical Energy Storage (EES) is a key technology with unique capability to meet the hourly variation of power demand and electricity pricing in smart grid systems. Smart grids encourage more renewable energy sources in the grid system to reduce CO_2 reduction.

EES reduces the cost of electricity use by charging storage batteries during off-peak hours and supplying energy to the grid during peak hours. EES improves reliability of supply by supporting users during power failures due to disaster periods. It maintains and improves power quality, frequency and voltage stability when connected in the power network.

Renewable energy sources have excessive power fluctuations and undependable supply. EES solves these problems with the use of large amount of renewable energy sources, when connected on grid. During off-grid period, plug-in electric vehicles with batteries are the most promising technology to replace the fossil fuels from electricity mostly from renewable energy sources.

Smart grid technologies keep the grid more flexible and interactive with consumers with information on low pricing of electricity and availability of opportunity to sell power to the grid between power production and consumption. EES is one of the key elements in developing a smart grid.

The power demand must be met by equal amount of power generation at the same time. Load demand varies with time and is unpredictable. Power generation cannot follow the demand exactly. There will be always imbalance between supply and demand and that will negatively impact the stability and power quality of frequency and voltage. The power system is a grid network of connecting the generators and consumers that are widely disbursed. The location of generators and the concentration of consumers cause congestion in power transmission. These characteristics of power supply system create different technical issues.

During peak periods generation is costlier than the cost of generation during off-peak periods. Accordingly, the power network becomes stressed and causes problems that need extra cost to maintain stability of the system to meet the demands. In such situations, the grid charges energy storage systems during off-peak hours and the ESS feed back to grid during peak periods, and thus keep the system less stressed and reduce the cost of electricity generation. Cost-free surplus power from renewable energy sources viz. Photovoltaic solar cells and Wind power generation can be used to charge energy storage systems intermittently as and when these sources are available. Power supply should be available continuously and flexible with time to consumers. The generators, therefore, produce power sufficiently to meet the demand and power to control the stable frequency accurately to maintain power output variations second by second.

Renewable energy sources do not have such facilities to control frequency regulations. The Energy Storage Systems (ESS) such as pumped hydro with large amount of power generation capacity and stationary batteries with quick response capability can support renewable energy output and support critical loads during power failures or low voltage situations to consumers. ESS is a suitable solution to supply power to congested transmission line and remote areas as standalone system.

The emerging trends for ESS technology is to use more renewable energy sources and to make the future smart grids more efficient. The use

of ESS is thus summed up: Time shifting of load balancing, power quality by frequency control, mitigating the congestion in the power flow in the transmission line, supplying power to isolated grids, providing emergency power supply to protection and control equipments, and time shifting of power from renewable sources to recharge batteries, when power demand is low in the grid.

Types Of EES

Energy storage technologies encompass a large set of diverse technologies. They are broadly classified into mechanical, electrochemical, chemical, electrical and thermal energy storage systems. Mechanical systems include Pumped Hydro System-PHP, Compressed air-CAES and Flywheel- FES energy systems. The Electrochemical systems are secondary batteries, Flow batteries and chemical Hydrogen systems. The Electrical systems are: Double Layer Capacitors-DLC, Superconducting magnetic coil-SMES, thermal systems and sensible heat storage systems.

Batteries

Storage Technologies: Storage technology is lagging behind other critical PEV technologies. The United States Advanced Battery Consortium (USABC) has focused on research in advanced battery technology for BEVs and hybrids. The Matrix battery concept can help optimize BEV performance to match vehicle dynamics.

Hydrogen gas is increasingly recognized as an important fuel and energy storage sector of the future. The overall demand for hydrogen as a fuel is projected to grow. However, use of hydrogen has grown for the power-to-gas market combined with its use in the fuel cell sector.

Lithium Batteries Research is going on advanced battery technologies with a magnesium-sulphur combination over lithium, which ranks high in longer storage hours, weight, reliability and life. Lithium's energy density is a hindrance for successful applications both in automobiles and electronics devices. The new magnesium-sulphur batteries are likely to be in production by 2020. Battery performance: The key performance parameters of batteries are: Energy, Power, Lifetime, Safety and cost. Batteries make up roughly one-third of the cost of today's electric vehicles. Lithium- ion batteries are the most commonly used batteries for vehicle applications.

Nickel Metal Hydride (NiMH): NiMH batteries have reached their maximum potential. Car makers are moving to lithium-ion batteries, especially due to higher energy density and low self-discharge rate. It meets the energy storage requirements for PEVs.

Battery disposal: The poisonous battery metals, especially lead and cadmium would likely leak into the environment, and that affect human health and eco-system. However, there is the need for an efficient recycling system for used batteries.

Battery costs: Lithium-ion battery costs are lower than NiMH batteries but the range of 600- 700 $/kWh is seen more realistic. The high production volumes of Lithium-ion battery could significantly decline the cost.

Lithium supply security: Lithium, heavy metals and other rare elements such as neodymium, boron and cobalt are used for the batteries and power train of PEVs. The demand for these materials is expected to grow significantly for use in plug-in electric vehicles. Some of the largest world reserves of lithium and other rare metals are found in China and South America.

Hazard to pedestrians: The visually impaired people consider the noise of combustion engines a helpful aid to cross streets. Electric Vehicles operate at below 30 km/h speed, that cannot be audible by all road users and is a hazard to users. Japan, U.S. and the European Union have legislations to regulate the minimum level of sound for plug-in electric vehicles to help visually impaired people.

Wireless Power Transfer Technology (WPT) has been developed to address battery limitations. WPT is the transmission of electrical power from the power source to the electrical load without physical connectors. WPT charging technology requires lesser energy storage device, if the vehicle is powered wirelessly, while driving. Dynamic WPT enabled infrastructure would allow power delivery, while PEVs in motion. EVs equipped with such technology would not require large amount of energy storage.

Conclusion

The Plug-in Electric Vehicles (PEVs) is a new vehicle technology that has evolved with time. There are various issues related to technical, political, economical and environmental aspects to improve the penetration level of adopting use of Plug-in Electric Vehicles. A scalable and viable business model for public charging infrastructure has yet to fully emerge. The technical issues are in respects of charging stations, infrastructure installations, development of cost-effective quality batteries and its characteristics for use in PEVs. There is need to building the infrastructure for PEVs, policies on pricing, regulations to vehicle integration, building smart electric grid, manufacturing safe components such as batteries and electrical components, building battery charging installations, operational infrastructure including manpower development, funding for infrastructure building and policies on regulation of services of the new technology.

The new technology of modernising the grid is the smart grid that is emerging to integrate the power network with a smart digital technology of communication network. The smart power grids are more efficient with the use of Information Communication Technology and integration of variable renewable energy sources, PEVs and electrical energy storage technologies. There are opportunities and challenges to these technologies related to manufacturers, electric utilities, vehicle charging companies, battery manufacturers and all levels of governments, and the power and vehicle users.

K Ramalingam
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GE's H-class technology has been embraced by customers in Korea, Japan, the United Kingdom, Brazil, the United States, France, Russia, Germany, Turkey, Egypt, Pakistan and Argentina...

The fully assembled 9HA gas turbine being transferred for packing and shipping...

According to Wikipedia, electricity in Pakistan is generated, transmitted, distributed, and retail supplied by two vertically integrated public sector utilities: Water and Power Development Authority (WAPDA) for all of Pakistan (except Karachi), and the Karachi Electric (K-Electric) for the city of Karachi and its surrounding areas. There are around 20 independent power producers that contribute significantly in electricity generation in Pakistan states.

For years, crippling electricity shortages have plagued Pakistan, creating challenges for residents and businesses alike, and fixing the problem has become a priority for the Federal Government of Pakistan. To address this, GE will provide two high-efficiency 9HA gas turbines, one steam turbine and two Heat Recovery Steam Generators (HRSG) to SEPCOIII Electric Power Construction Corporation, a wholly owned subsidiary of Power China, for the new 1.2 Gigawatt (GW) Haveli Bahadur Shah power plant.

The steam turbine and HRSGs have been engineered by Alstom, and with GE's recent acquisition of Alstom's power and grid businesses, they have been incorporated into GE's portfolio. Power China will handle engineering, procurement and construction of the plant.

This project, the third one GE has announced in Pakistan since October, marks the 5th and 6th HA turbines for Pakistan among a total of 33 worldwide orders for GE's HA, the world's largest, most efficient gas turbine. Together, Haveli, Balloki and Bhikki combined-cycle power plants will be able to provide the equivalent power needed to supply nearly 20 million Pakistani homes, which can fulfill more than 65% of the power shortage in Pakistan.

"We are taking action to provide sustainable, reliable energy that allows residents to live comfortable lives and local companies to consistently conduct business. The Haveli facility will help put power on the grid efficiently, using the most advanced technology available," said Rashid Mahmood Langrial, CEO of National Power Park Management Company Limited (NPPMCL), the holding company of Haveli Bahadur Shah power plant. Contextually, NPPMCL is a wholly owned Special Purpose Vehicle (SPV) of the federal government to implement Balloki and Haveli Bahadur Shah RLNG power plants to meet the energy demand in Pakistan.

"GE's HA gas turbine and steam tail technologies going into the Haveli plant are both complementary and a standout in the industry. At Haveli, Balloki and Bhikki plants, GE's high efficiency technologies will help bring reliable power to the grid, so we can help Pakistan overcome shortages and meet its expanding energy needs," said Joe Mastrangelo, President and CEO, Gas Power Systems at GE Power.

Among key agreements in the country, GE has signed a memorandum of understanding with the Federal Government of Pakistan to develop Pakistan's energy resources to meet the projected demand of 54,000 megawatts by the year 2020.

Including the Haveli Bahadur Shah plant, 33 HA units have been ordered among 82 that have been technically selected by customers around the world. GE's H-class technology has been embraced by customers in Korea, Japan, the United Kingdom, Brazil, the United States, France, Russia, Germany, Turkey, Egypt, Pakistan and Argentina.

These gas turbines provide a combination of the most output, highest efficiency and best operational flexibility and lead the industry in total life cycle value. The 9HA offers a net combined-cycle efficiency of more than 62% and leads the industry with cleaner, reliable and cost-effective conversion of fuel to electricity.

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"We would urge our potential customers to work closely with us to support and develop their knowledge..."

*Born out of the research division of **GEC Alsthom**, **M&I Materials Limited** combines the proven pedigree of long-standing products with the R&D expertise to bring new solutions to market. The company is dedicated to manufacturing specialist materials for industry and science, and is the driving force behind a portfolio of its successful brands – including **APIEZON**, **METROSIL**, **MIDEL** and **WOLFMET**. In an exclusive interview with **Electrical India**, **Barry Menzies**, **Commercial Director-MIDEL transformers fluids**, is giving an account of their company's business to **P K Chatterjee**. Excerpts...*

Q What's your observation on the growth trend of the Indian transformer fluids' market?

A We see the growth of the Indian market as being a key strategic area for the transformer fluids sector. There is a growing focus on fire safety and environmental issues for power transformers, and a clear need for ester-based fluids that deliver a high fire point and environmental protection in terms of non-toxicity.

Q What kind of potential are you finding here as far as M&I Materials' business line is concerned?

A The response from the Indian marketplace has been very positive. We are currently in very promising negotiations with a mix of end users, power companies and key influencers working towards broadening our footprint in the sub-continent.

Q What are the specific areas or segments of power sector where your products are the best fit?

A MIDEL was initially recognised as a viable alternative to mineral oil in niche applications where fire safety or environmental impact was of primary importance.

Since then, we've built on this success to respond to end users' changing needs, so now we are providing solutions from small distribution units, indoor and underground sites, through wind, traction and transmission applications to the latest 400 kV-range transformers. Installations include high altitude sites to deep sea and extremes of both cold and heat.

Q How does METROSIL protect equipment and electrical insulation from the effects of over voltages?

A Metrosil non-linear resistors are high performance surge protection devices that provide excellent service in a wide range of applications around the globe.

Manufactured from a semi-conducting material, with the distinctive property that its electrical resistance depends on the applied voltage enabling it to act as an 'electrical safety valve' to protect equipment and insulation from the effects of over voltages. Millions of Metrosil varistors have been sold throughout the world with current ratings varying from microamps to kiloamps and capable of absorbing energies from 10 to 50,000 joules per disc.

Q Where lies the superiority of MIDEL over other transformer fluids?

A Risk mitigation is a core element of MIDEL's value; for example, an end user wanting to install a GSU transformer filled with mineral oil and equipped with fire suppression system in an area close to a power plant. In this scenario, a much lower risk factor was assessed (by an external risk assessor) for using an underground GSU transformer filled with MIDEL without any fire suppression system. The MIDEL transformer could then be placed close to the generator, with the additional benefit of significantly reducing losses in bus bars between the generator and the transformer. Over the years, MIDEL has delivered risk reduction where transformers are installed in high-density residential areas, inside or close to buildings, hospitals, schools, protected environments and other sensitive locations. This advantage is recognised by many insurance companies who regularly advise their clients to replace mineral oil with MIDEL.

Q How are you planning to expand your reach in the Indian market?

A The MIDEL commercial team in India is very experienced and dynamic. Headed by Nitin Satija, our team is very active in the transformer sector, and will build the profile of MIDEL transformer fluids by acting as a source of accurate technical support and advise for OEMs and power utilities.

Q Have you taken any step to educate your potential customers in India?

A The MIDEL technical team makes frequent presentations at industry conferences and events. We are often asked to present these technical papers because we are recognised as being straightforward, highly accurate and objective.

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

A We are seeing growth in the uptake of MIDEL synthetic and natural ester fluids in the marketplace. We would urge our potential customers to work closely with us to support and develop their knowledge in specifying a cost effective, robust and proven alternative to traditional cast resin and mineral oil transformers.

Energy Conservation In COAL BASED DRI PLANT

Energy is lost in terms of waste heat , discharge of char material (waste) etc in the process. By integration of heat utilization and using radiator, the loss of energy may be reduced...

The process of Coal based DRI plant is thoroughly studied and a few initiatives were taken to reduce energy consumption of the plant. Innovative development and drives have been taken in this area – and that have enriched the desired results. By adopting the ways and means – energy conservation and carbon emission, both were improved substantially. Further scope of development has also been identified in this article.

Opportunities for energy conservation in coal based DRI plant

- Provision of covered coal storage to minimize moisture content and improve Injectability.
- Procurement of reliable, good quality coal.
- Modification of the coal injection system.
- Improvement of the draft for transmission efficiency.
- Provision of variable speed drives for the kiln discharge fan.
- Modification of blowers for kiln off gas to optimize efficiency.
- Reduction of radiation loss from KILN shell.
- Preheating of feed by extracting heat from waste flue – emission through chimney.
- Different improvement in electrical installations.

Modifying coal handling, procurement, and injection has the potential of reducing the thermal load From 25 GJ/metric ton of DRI to between 15 and 19 GJ/metric ton of DRI.

The coal consumption ranges from 950 to 1,000 kg/metric ton DRI as charged. This is equivalent to an energy consumption of 21 to 23 GJ/metric ton DRI, using 23 GJ/metric ton of Indian sub-bituminous coal.

Coal consumption at ISCOR is reported to be 800 to 900 kg/metric ton of DRI using 28 GJ/metric ton for South African sub-bituminous coal, equivalent to an energy consumption of 22 to 25 GJ/metric ton DRI.

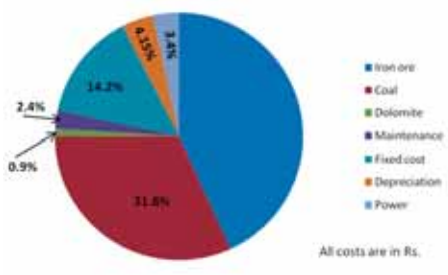
The installation of a coal washing system, which will reduce the ash content of the coal feed and reduce coal consumption as well. Electrical consumption has been minimized in the plant process through the use of high-voltage motors, proper sizing of motors and compressors, and close monitoring of consumption to ensure identification of efficiency problems.

Energy conservation measures for sponge iron plants using process integration principles

During the operation a tremendous amount of heat is generated in coal based sponge iron plant and significant part of this heat associated with the waste gas, remains unutilized. While utilizing this heat in the process the energy demand of the process may be reduced, which decrease the coal consumption as coal is the only source of energy in this plant. Further, it is seen that existing plants consume 5.57 times more energy than theoretical value. The best design includes preheating of air as well as feed materials to rotary kiln and cooling of kiln outlet using waste gas. It consumes 12.5% less coal in comparison to existing system. This design also satisfies the practical condition of the process.

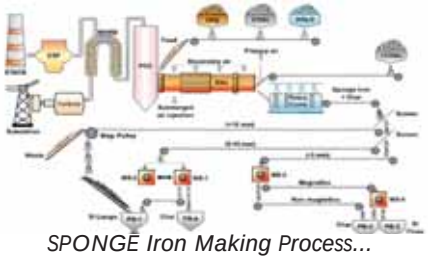
Cost details for one tone production of sponge iron

The cost of sponge iron production varies with different inputs such as iron ore., coal, dolomite, fuel, maintenance, depreciation, power etc., the cost of these input, taken directly from the plant, for one tone production of sponge iron are drawn in the fig. below. It is clear from this fig. that 31.8% cost is due to the coal, which is a considerable amount.



In fact , the energy demand of the process can be reduced by proper integration of heat within the process, which results less energy to be supplied by coal. Consequently, coal consumption is decreased.

In sponge iron making process, coal is the prime source of energy utilised. About 98% of energy input in the process is coal and 2% electrical energy is consumed in the process.



SPONGE Iron Making Process...

Sponge iron is produced by direct reduction of iron ore carried out in rotary kiln, which involves following chemical reactions:

½ Fe_20_3+3/2C0= Fe+3/2$C0_2$ .....(i)-12,866 KJ/kmol

1/3 Fe_30_4+4/3C0= Fe+4/3$C0_2$ .....(ii)-3,904KJ/kmol

Fe0+C0 = Fe+$C0_2$ .....(iii) -16,108Kj/kmol

Fe0+C = Fe+C0 .....(iv) +156,482Kj/kmol

Equation (IV) indicates the heat required for desired rate of reduction of iron oxide to iron. Thus, generated by equation IV is utilized for further reduction for iron ore.

So, energy conservation in the process primarily depends on coal. Energy is lost in terms of waste heat , discharge of char material (waste) etc in the process. By integration of heat utilization and using radiator, the loss of energy may be reduced, as suggested by Mr. Prasad [Refer: A. K. Prasad, R. K. Prasad, S. Khanna, Design modifications for energy conservation of Sponge Iron Plants, J. Thermal Sci. Eng. Appl. 3 (2011)].

Waste heat is utilised for generation of electricity through waste heat recovery boiler. In this process, chimney discharge of waste heat is about 170 degree centigrade. This heat may be further extracted up to 140 degree centrigrade, and can be used for preheating of coal feed to kiln. This process can reduce moisture content in coal, hence reduce coal consumption. Additional benefit in the process is smooth operation of rotary kiln, without jamming. As a result trouble free operation of sponge iron and power plant operation can be achieved.

Coal catalyst / additives has also been tried in some plant to reduce coal consumption in sponge iron making. And about 2.5 % reduction in coal consumption is expected / estimated for this initiative.

Reduction of radiation loss

Reduction of radiation loss from the shell of kiln is investigated and analysed by this author for a period of three years. Heat shield paint (coating) was developed in collaboration with M/S Novata Industries & applied on kiln shell, suitable for application on the shell body. By the application of the coating, the radiation loss was reduced and 2.7% coal saving was observed.

The surface temperature of the kiln shell varies from 300 degree to 400 degree centigrade. It is understood that about 15 to 20% of heat is lost through the shell body by radiation and convection process. For reduction of losses as well as reduction of coal consumption – an attempt was taken and accordingly a special coating was developed (Temshield) in collaboration with M/S Novata Industries, Mumbai and applied a thin coating (300 micron) on 500 TPD and 375 TPD kiln shell. Different trials, modification and studies were done and finally a savings of 2.7% of coal consumption was achieved.

Small white patch: 1st trial of the coating...

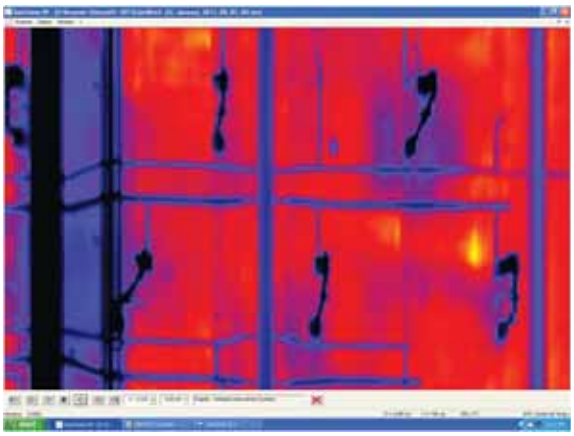
Energy conservation initiative was taken in electrical installation as well.

Energy Efficient Technologies in Electrical Systems has a major role in the industry. Various methods and instrumentations have been developed for the purpose. They are:

- Maximum demand controllers.
- Automatic power factor controllers.
- Energy efficient motors
- Soft starters with energy saver.
- Variable speed drives.
- Energy efficient transformers.
- Electronic ballast.
- Energy efficient lighting controls.
- Auto Star delta starter.

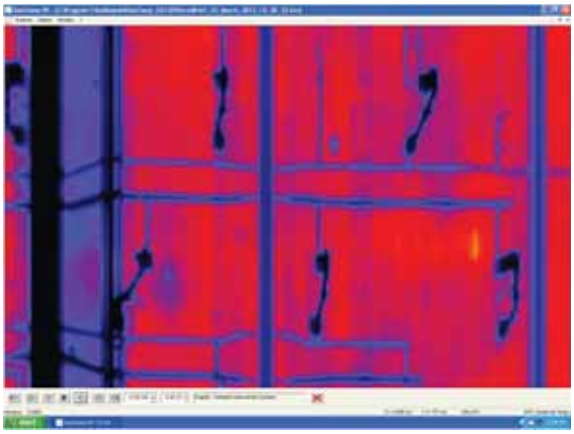
Induction motor is used most widely in the world. The reasons are:

- Low cost
- Simple and rugged construction
- Absence of commutator
- Good operating characteristic
- Good power factor



The dotted section: The kiln shell temperature recorded before application of the paint in the highlighted zone...

Coated Kiln Shell



The dotted section:On application of the paint, the surface temperature was observed to have reduced by 40°C as seen on the online thermography screen...

- High efficiency
- Good speed regulation

It is a great challenge now-a-days to operate the induction motor efficiently and economically. The following points are considered for these.

There are several methods of starting of squirrel cage induction motor which depends upon the following factors:

- The size and design of motor
- The kind of application
- The location of the motor in the distribution system
- The capacity of the power system

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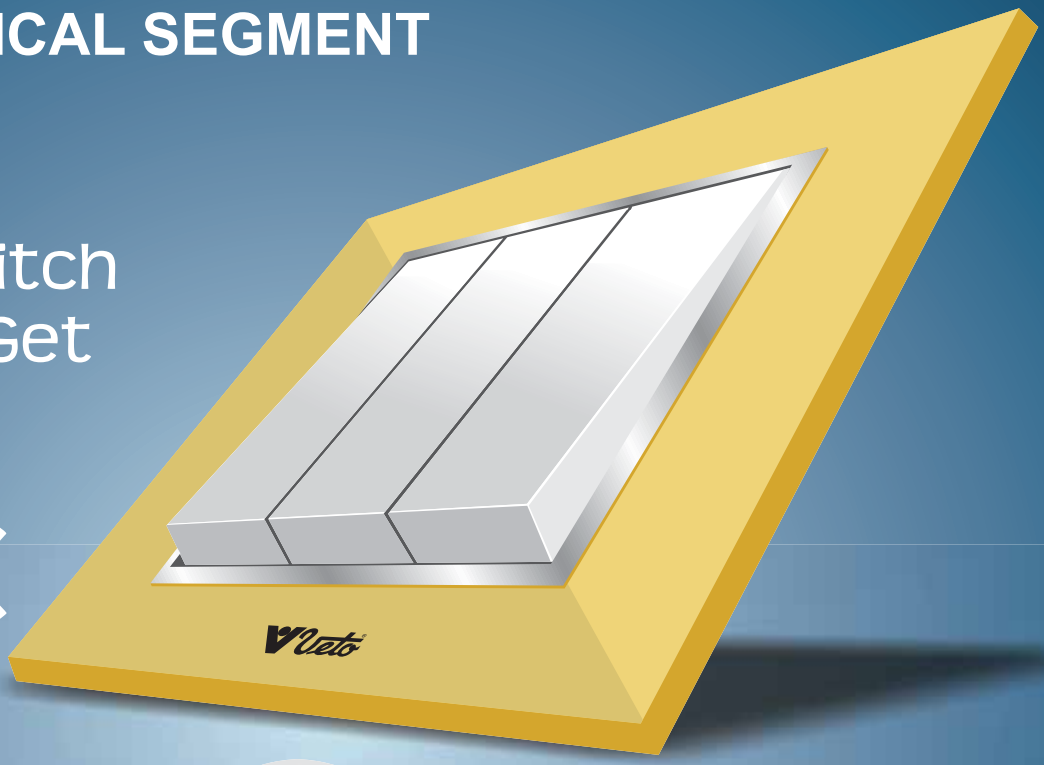

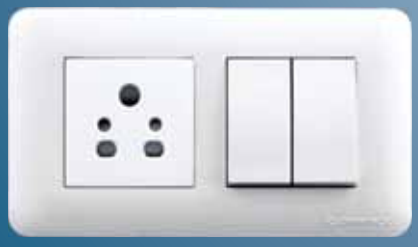

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In the industry 90% load is consumed by motor. Out of which 95% are induction motor.

Energy efficient motors

Energy-efficient motors are now available in India, which operate with efficiencies that are typically 3 to 4 percentage points higher than standard motors. Energy-efficient motors are designed to operate without loss in efficiency, at loads between 75 to 100 % of rated capacity. This may result in major benefits in varying load applications. The power factor is about the same as that of standard motors or may be higher than that. Furthermore, energy efficient motors have lower operating temperatures and noise levels, greater ability to accelerate at higher-inertia loads, and are less affected by supply voltage fluctuations.

Soft starter

Soft starter provides a reliable and economical solution of motor operation by delivering a controlled release of power to the motor, thereby providing smooth, steeples acceleration and deceleration. Motor life is extended because damage to windings and bearings is reduced.

Advantages of soft start

- Less mechanical stress
- Improved power factor
- Lower maximum demand
- Less mechanical maintenance

Variable speed drives

Variable Frequency Drive (VFD) is a power electronics device, which generates variable voltage and frequency output from a fixed (constant) input of voltage and frequency. While the maximum variable output voltage is equal to the input voltage in magnitude, maximum output frequency can be as high as 8 to 10 times of input frequency. Thus, if a VFD is fed from a supply voltage of 415V, 50Hz, then maximum output voltage from the VFD shall be 415V, but maximum output frequency can be 400Hz. VFD is one of the options when we look for the operation of process equipment with variable speed. This can be achieved by varying the speed of the connected motor.

There are numerous applications, which involve blower, fan extruder, lift, spinning machine and paper machine where variable speed is needed and scope of energy consumption is available (throttled operation).

VFD is used for smooth starting and stopping for energy conservation of the system by controlling speed. It can be represented as follows:

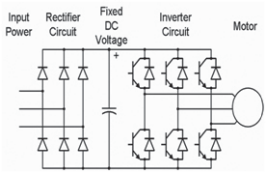
Flow α speed

Head α (speed) ^{2}

Power α (speed) ^{3}

Motor running with under load condition and scope of energy reduction.

The induction motor with a percentage loading below 50% would operate at lower efficiency in delta mode. This efficiency at low loading can be improved by converting delta connection into star connection. The reported savings due to this conversion varies from around 3% to 10% because the rated output of motor drops to 1/2 of delta configuration without affecting performance and the percent loading increases as compared to delta mode. This option does not require any capital investment and is one of the least cost options available for the energy conservation in induction motors.



Induction Motor...

Loading of motors have been studied and observed under-loading of motors in some equipment

The observed features are:

- Less efficiency
- Low power factor
- High voltage related iron losses
- Capacity optimization by voltage reduction.

Under-loaded motors

- Converted Delta connection to star (method of voltage reduction)
- Implemented Auto star-delta-star converters
- Benefits obtained are:
  - Reduction in voltage related Iron losses
  - Reduction in copper losses which means less energy conversion
  - Operates with improved Power Factor
  - Improved motor efficiency

Calculation of motor loading

Motor loading = input power drawn by the motor (kW) at existing load

$=\sqrt{3} \times KV \times I \cos\phi$

Where KV=Rated Kilo Voltage

I =Rated Current

$\cos\phi$= Power Factor

Under-load results in lower efficiency and power factor, and requires higher initial cost of the motor and related control equipment. Under loading is common for several reasons. Original equipment manufacturers tend to use a large safety factor in motors they select. Under loading of motor may also occur from under utilization of equipment.

For motors, which consistently operate at a load below that of 50% of rated capacity, an inexpensive and effective measure might be to operate in star mode. A change from the standard delta operation to star operation involves re-configuring the wiring of the three phases of power input at the terminal box.

Operating in star mode leads to a voltage reduction by a factor of √3. motor is electrically downsized by star mode operation, but performance characteristics as a function of load remain unchanged. Thus, full load operation in star mode gives higher efficiency and power factor than partial load operation in the delta mode. However, motor operation in the star mode is possible only for applications where the torque to speed requirement is lower at reduced load.

As speed of the motor reduces in star mode this option may be avoided in case the motor is connected to a production facility whose output is related to the motor speed. (By Bureau of Energy Efficiency)

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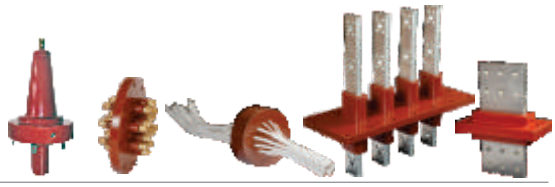

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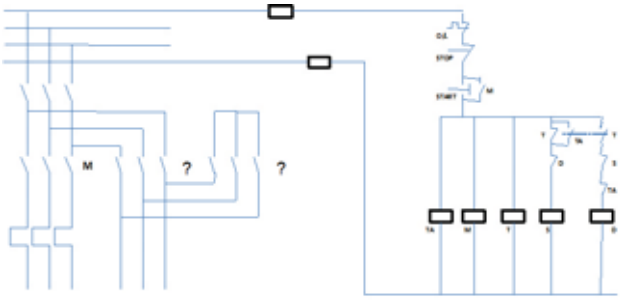
A study of squirrel cage induction motor's efficiency and energy saving

Among the several methods available for reduction of energy consumption of induction motor, we have chosen the improvement of motor efficiency and loading factor by star-delta-star connection as the

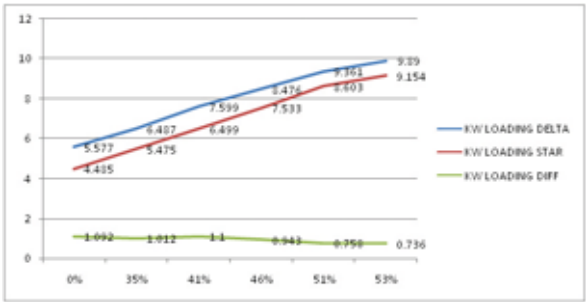


Star- delta- star starter...

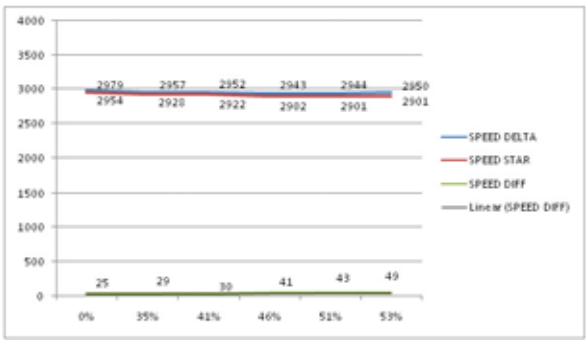
method doesn't require any investment. It require minimum down time for implementation.

Besides the technical information collected from different sources, we have investigated and tested an 18.5 kW secondary blower at different loads, both with delta and star connection at our test bench of W/S. We started the blower from a star/delta starter and made it star again, after the blower reached a stable condition. Thus, we improved the system and eliminated the problem of low torque at star connection during starting.

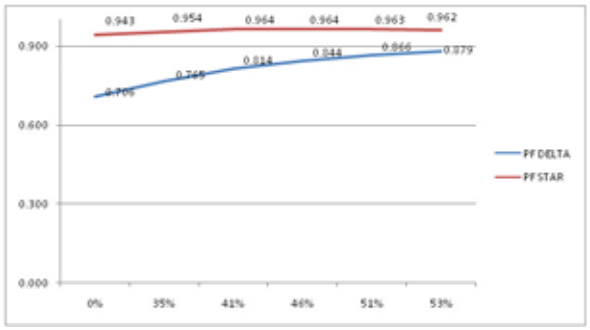
In our investigation, we found the best result at about 45% of loading. RPM in star mode is reduced by (30 rpm) 1% and energy output is reduced by 1%. But total energy saving is around 14%. Net saving is around 10%.



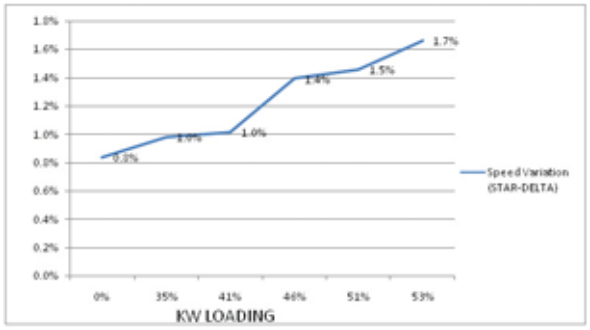
TREND OF KW LOADING (DELTA-STAR)
(X axis % loading vs Y axis kW)...



TREND OF SPEED VARIATION (DELTA-Star motor)
(X axis % loading vs Y axis RPM)...



TREND OF VARIATION IN POWER FACTOR (DELTA-STAR))
(X axis % loading vs Y axis PF)...



TREND OF % VARIATION IN SPEED (DELTA-STAR))
(X axis % loading vs Y axis % variation in speed)...

The graphical representations are shown above for convenience.

We are operating a number of motors in star connection and getting the benefit of energy conservation.

By adopting the above initiative energy consumption of per ton sponge iron making was reduced remarkably. Electrical energy consumption was reduced from 100 kWh/ MT to about 94.4 kWh / MT.

Energy conservation and efficient operation of plant and machinery are the essential requirement in our daily life. It reduces our energy cost and carbon-di-oxide emission as well.

Innovation in this field adds value and improves our life cycle parameters.

Further R&D in this field is required, particularly use of CBM (Coal Bed Methane) for sponge iron making process with a mix with coal etc. to reduce carbon-di-oxide emission.

The author of this article has taken initiative and practised the above processes in sponge iron industry to reduce energy consumption to a great extent.

Robbin Pramanick
Chief Project Officer
WESCO Limited

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A Custom-Built SOLUTION

A robot, called Penny at Sandvik's facility in Gimo, performs a critical step in the insert manufacturing process, placing up to 1,600 precision-ground inserts per hour onto racks for the PVD coating furnace, then sending the completed inserts off for marking and packaging...

Sandvik is a global engineering group with more than 47,000 employees with a strong commitment to enhancing customer productivity, profitability and safety. Their operations are based on unique expertise in materials technology, extensive knowledge about industrial processes and close customer cooperation. This combination, coupled with continuous investments in Research and Development (R&D), has enabled them achieve renowned positions worldwide. 'Penny the Robot' is one of their many excellences…

Predictable productivity is what Penny brings to Sandvik's insert manufacturing process. Penny works hard. She works all day, and never tire from the tedium of her job of moving carbide inserts from one side of a metal cage to the other.

Some might call her a robot, but Penny is far more than that. She's a custom-built material-handling solution, designed and built by the Sandvik Production Equipment team in Gimo, Sweden, under the direction of Project Manager Johan Eriksson.

In the words of Eriksson, "She can 'see in 3D' what she is doing and is smart enough to self-calibrate her movements." He continues, "Penny is the first of her kind. Once the final specifications were agreed to, she required more than a year to be built.

She has just recently been delivered to Sandvik's facility in Gimo, which is the largest carbide insert factory in the world where she is undergoing final acceptance testing."

Penny performs a critical step in the insert manufacturing process, placing up to 1,600 precision-ground inserts per hour onto racks for the PVD coating furnace, then sending the completed inserts off for marking and packaging.

Because Penny has an advanced vision system, she can 'see in 3D' what she is doing – and is smart enough to self-calibrate her movements. She is fast and accurate, but she also has a delicate grip – picking up one millimeter-wide inserts is no problem for her, and there is never a risk of damaged or misplaced inserts.

Because of her predictable productivity, Sandvik can continue to offer high-quality products at a competitive price. "What we do here at Sandvik is a fine art. There's nothing else on the market quite like Penny," says an understandably proud Eriksson.

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IMPROVEMENTS IN Micro-Grid Fault Detection

Micro-grids include low voltage distribution systems with distributed energy resources and controllable loads that can operate in medium voltage grid connected mode or in islanded mode. It provides environmental and economic benefits for end-user, customers, utilities and society. However, their implementation creates great technical challenges, such as the protection. Micro-grid system has bidirectional power flows, which make traditional fault insufficient. An algorithm combining of cumulative sum and power flow method is found to be simple and faster for detecting micro-grid faults in both modes of operation...

A protection system defends the power system from the harmful effects of a sustained fault. Power system protection has main aim to provide maximum sensibility to faults and unnatural conditions and to restrict false alerts during normal state of operations. The protective relays are more of a preventive device which comes in to picture only after a fault has occurred which tries to help in reducing the duration of fault and limiting the damage, outage time and related problems. In general, the first step in the power system relaying algorithms is to detect the faults and the next step is to isolate defected part from the healthy system.

Amicro-gridsystem is a flexible bi-directional powerflow distribution network that is able to suit combination of loads, Distributed Generation Units (DGUs), storage systems like batteries and power conditioning units. This structural characteristic of micro-grid system allows it to function as a single controllable system within its service domain, which generates and distributes electric power to its loads. The bi-directional power flow characteristics of micro-grid systems can be beneficial in providing benefits to utility grid operators and investors, Distributed Generation Units (DGU) owners and customers. Such advantages may include exchanging active and reactive powers, reducing transmission system overloading and improving power transmission and distribution. However, along with these benefits, micro-grids have also aroused an important challenge of protection the provision of rightly coordinated and authentic protection system.

Micro-grid and need of protection

Micro-grids have granted a viable option to achieve increase in power demands by certain load centres through connecting more installed distributed generating units to distribution feeders, rather than expanding present distribution networks. The most positive characteristics of micro-grids are the comparatively short length between the generation and loads and low generation and distribution voltage level.

A micro-grid is compiled of interconnected distributed energy resources (renewable and non-renewable), which are able to provide sufficient and continuous energy to the most part of the micro-grid inner load requirements. A micro-grid must be able to operate both in grid connection mode and in autonomous mode from the utility grid seamlessly with little or no disturbances to the loads within the micro-grid during a disruption. It is a network of small-scale power supply, which is contrived to provide power to a small residential area or small community. The key concept that discerns this approach from a traditional power service is that micro-grids have small power generators and are spread and settled in close proximity to the energy users. This very crucial form of de-centralized electricity supply ensures large environment profits. A typical micro-grid configuration is shown in Fig.1.

Protection issues in micro-grids

Connecting distributed generators to main grid like micro-grid, which can work in stand-alone mode also, changed system properties significantly. Voltage and Current profiles and dynamic demeanor of the whole power system are changed. As a result, the classical protection techniques which are sufficient to detect faults in radial system become inadequate and insufficient. The problems concerns are as follows:

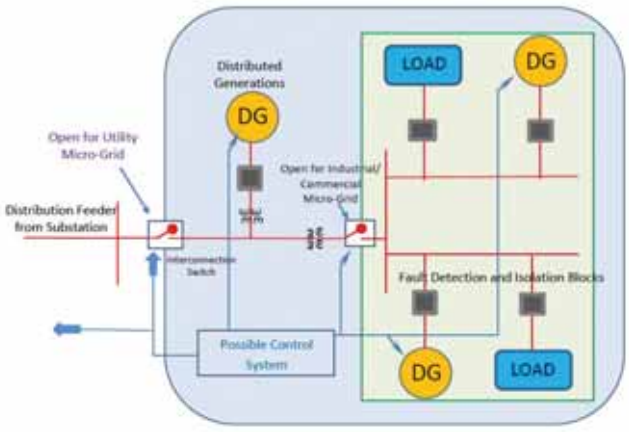

Fig.1: Typical micro-grid configuration...

Loss of Selectivity

System protection is more selective when the protective device nearest to the transmission fault is activated as fast as possible to disconnect or isolate the fault from the system. In Micro-grid, the power flow is bidirectional, so traditional over-current protective system becomes inadequate. A possible scenario is the disconnection of a healthy feeder by its own protective relay – because it contributes to the short circuit current flowing through a fault in a neighbouring feeder.

Blinding of Protection

The presence of generator reduces the fault current or over-current detected at the beginning of a feeder or the fault current supplied by other local circuit current, the voltage drop over the feeder section between the generators. Because of the generator's contribution to the short – and the fault increases, this results in a lower fault current from the grid. If this reduction is sufficiently large, current detected at various points are too low to trigger fast disconnection. This can result in prolonged over-current or earth faults.

Protective Disconnection of Generators

Distributed Generators in micro-grids have to be saved against all types of short-circuits, over- and under- current and voltages, unnatural frequencies, harmonic distortions, etc. Depending on the position of the fault in a micro-grid, the protection system of generators should employ different time delay, which assures the selectivity of the system.

Islanding Mode of Micro-grid Operation

Micro-grid islanding operation through intentional islanding has to be studied as an alternative option, which drastically increases the reliability of system because generators in micro-grid are capable to supply loads in it even if grid is disconnected.

Single-Phase Connection in Micro-grid

Some of the distributed generation units outputs single-phase power in micro-grid system e.g. batteries, small photovoltaic systems or stirling engines. This affects the three-phase current, leading more current in the neutral conductor and stray currents in the earth.

The power output of distributed generators in micro-grids is frequently irregular. Due to this, the behaviour of the system during faults alters constantly. In addition, governable islands of different shape, size and

capacity can be formed as a result of faults inside a micro grid. Therefore to deal with bi-directional power flows and low short-circuit current levels in micro grids dominated by micro-generators, a newfault detection method comprising of Cumulative Sum and power flow method is proposed.

Cumulative sum algorithm

The traditional fault detection algorithms mainly use the differential principle for detecting faults – and because of this they are sensitive to noises or spikes or variation of parameters in the signal. To overcome these drawbacks, Cumulative Sum Algorithm (CUSUM), an integral approach is used where adaptive sorts of filters are utilized which offer valuable advantages over traditional detectors. CUSUM method works in time domain and uses sample elements of voltage and current waveform to detect faults. As power signals alternate, the two-sided CUSUM algorithm is appropriately designed for the purpose of fault detection in power system by using the current samples (S_k) of any phase and prepares two complementary signals such as

$$S_k(1) = S_k \text{ and } S_k(2) = -S_k \quad (1)$$

Using the above mentioned two signals, the two-sided CUSUM test is expressed as:

$$g_k(1) = \max(g_{k-1}(1) + S_k(1) - v,\ 0) \quad (2)$$

$$g_k(2) = \max(g_{k-1}(2) + S_k(2) - v,\ 0) \quad (3)$$

Where g_k ( ) and v are represented by test statistics and drift parameter respectively. A fault is registered if

$$g_k(1) > \text{hor } g_k(2) > h \quad (4)$$

Where h is an arbitrary constant and which should be ideally zero during normal state of operation.

The max-operation in above mentioned relations provides a positive or zero value for the g_k ( ). In the above relation, v provides the low-pass filtering effect which determines the performance of the algorithm. In general, the value of v is little more than amplitude of current signals. With an increased level in the current signal due to transient disturbances, if any $S_k > v$, the corresponding g_k starts growing and if it provides an index higher than the threshold h, a fault is registered. As observed from Fig.2 (a), the g_k value increases by a factor of the difference between S_k and v. The two-sided approach fits here as a power system signal alternates and is advantageous from the detection-speed point of view. To understand the principle of above approach, a current signal of 50 Hz frequency and 1kHz sampling rate is used and the behaviour of cumulative sum algorithms is checked under case studies as given in table 1.

The working of the CUSUM algorithm corresponding to the 3 cases is given in Fig 2. From the simulation it is clear that the output is zero during normal sinusoidal wave of the input signal. As the algorithm works on the

Table 1. Testing of CUSUM Algorithm

Case	Signal	Parameters
1	Amplitude Deviation	Amplitude_1: 1 A Amplitude_2: 2 A (after 100ms)
2	Frequency Variation	Frequency_1 : 50Hz
3	Noise	Distortion : 10% (after 100ms)

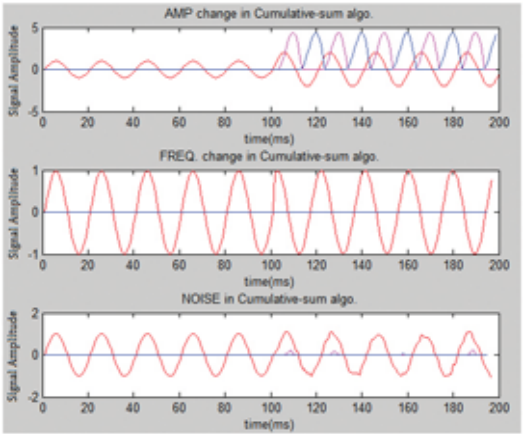

Fig. 2: Cumulative Sum method output during a)amplitude change, b)frequency variation &c) noise (red curve = input signal, blue and pink = g_k's, test statistics)...

sampled value at an instant it is immune to frequency variation and by selecting higher threshold value algorithm output is unaffected by noise.

Algorithm implementation

The previous section has shown that the CUSUM algorithm can facilitate detecting transient disturbances into faults and non-faults. It is found that the power output of distributed generators like synchronous generators, induction generators and inverter interfaced protection units is unpredictable due to which whenever there is a fault, power output of these DG sources changes. The ability of the DG units to detect external faults depends strongly on the technology of the generator and the type of fault. In case of Synchronous generator, the initial fault contribution can reach more than six times the generator full-load current and can decay over several seconds below generator full-load current as the generator field collapses. In case of asynchronous generator, the fault is of the order of synchronous generator but for only two to three cycles time period. And in case of inverters based-DG, most of them cannot supply current under external fault conditions; usually no more than 1.2 to 1.5 times of their rated load current. Fault detection schemes using over-current principles, which are universally applied in radial system, are not usually effective in all these power sources.

As traditional over-current fault detection is complex and inefficient for low fault current levels, proposed algorithm is fashioned to detect low level transient current disturbances immediately and isolate the defected region using circuit breaker. CUSUM method is capable to detect lower level faults provided h is set to lower value. A trip signal is initiated if a transient disturbance level is above the acceptable range. Also, it is faster in terms of speed these properties can be used to find faults in presence of asynchronous generators. The concept of Load flow is incorporated along with CUSUM method for accurately locate fault in looped system. The flow chart of the proposed Fault Detection Algorithms is shown in Fig.3.

The steps for detecting faults using proposed algorithm are:

Step 1: Initialize ϑ, g_k-1 for Cumulative sum algorithm

Step 2: Data Acquisition of every bus in Micro- grid system

Step 3: Applying CUSUM algorithm for detecting faults in all 3 input

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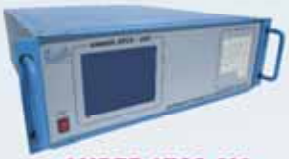

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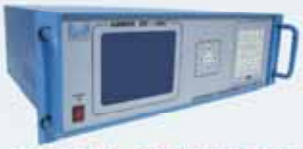

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current phases.

Step 4: Evaluate the condition g_k>h if it is True, check whether it is a load bus else continue step 2.

Step 5: Check whether the faulted bus is load bus or not. (This is done by introducing delay in all generator bus fault detection blocks to improve selectivity).

Step 6: Tripped that specific load bus which has fault detection signal near it.

Step 7: Monitor the power flows and direction between all generator buses, P_{ij}.

Step 8: Tripped the generator bus which has high amount of power flows in to it.

If P_{ij}> 0, Trip gen i (High fault current at gen i)

Else Trip gen j

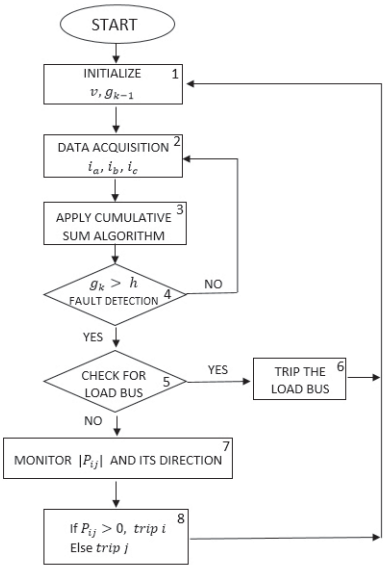


Fig.3: Flow Chart of the proposed Fault Detection Algorithm...

Due to bidirectional flow property of micro-grid, the proposed algorithm first detects the fault in micro-grid system later power flow method is utilised to exactly locate the fault. Delay is introduced in the algorithm at generator buses to improve selectivity of the system.

To check the functionality of algorithm it is implemented on a laboratory micro-grid model, which composed of the following components

- A 208 V, 60 Hz supply (the utility grid);
- A 2.5 kVA, 4-pole, 208 V synchronous generator (HU);
- A 1.8 kVA, 4-pole, 208 V synchronous generator (HU);
- Two 1.8 kW Y-connected resistive loads;

The fault detection blocks were used at all 4 buses to detect transient disturbances in the system. The current through each bus were collected using current sensors.The operating voltage of the laboratory micro-grid was set for one level, which is 208, in order to match the grid voltage. The single line diagram of above 4-bus micro-grid system is shown in Fig 4.

The step by step procedure of the algorithm was realized using Simulink SimPowerSystems tool box. Each fault detection block includes

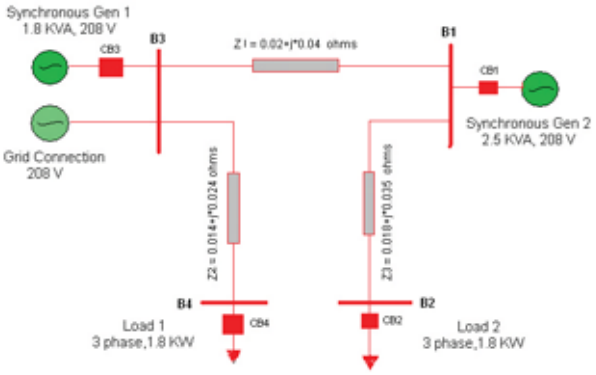
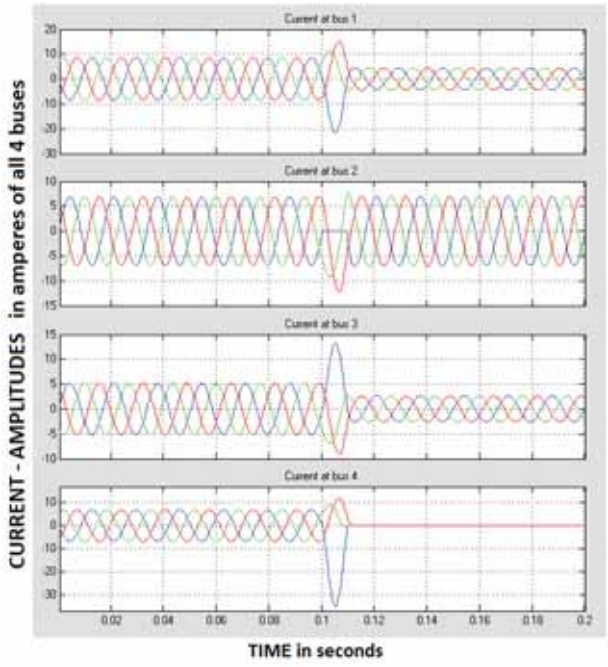


Fig.4: 4-bus test micro-grid system...

current sensor, which reads samples at a sampling rate of 1 KHz from the current flowing through that bus. The output signals of current sensor were fed to algorithm which detects the presence of transient disturbances in the system. If due to presence of transients, the current amplitude goes above predefined threshold value, fault is registered. The φ value used in the above test micro-grid system is 10 (110% of highest current value of the system under normal state). So, if current amplitude goes higher than 11 (ideally h = 0, but to avoid noise from the system the value of h is considered as 1) fault is detected. The working of the algorithm is limited to system under study. In order to demonstrate the performance of the proposed algorithm, simulated transient disturbances were investigated in the following section.

Simulation results

Case 1: Single phase fault at bus 4 in islanded mode



(a) Three Phase Current Signals...

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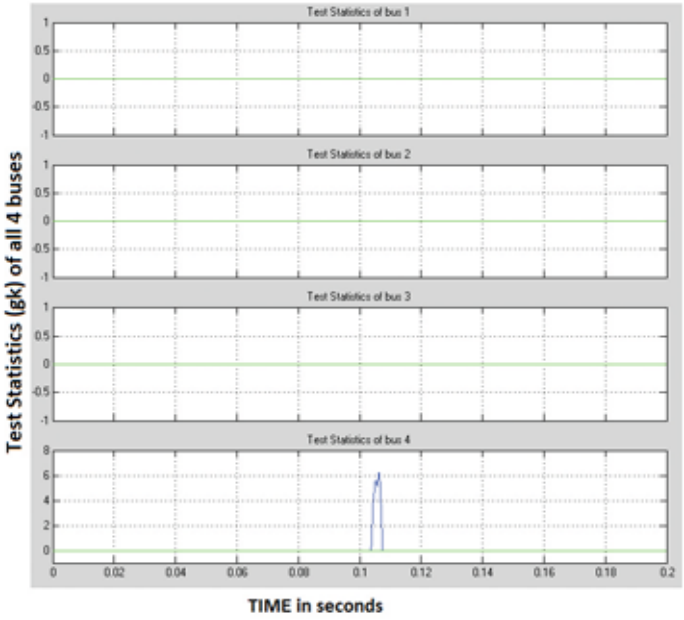


(b) Test Statistics

Fig.5: Performance for Single Phase fault at bus 4 in islanded mode...

A single phase-to-ground fault was created through activating a 1Ø controlled switch to connect phase A to ground point near bus 4 in islanded mode of operation of a test micro-grid system. Due to fault, higher level transient current triggers at all generator buses and a 4th bus which is a load bus as per Fig.5. Now by introducing delay in each protective device near all generator buses, block near load bus will detect the transient current quickly so that the defected region was tripped immediately to avoid further damage to the system. Delay introduction helps to improve the selectivity of the protective system. The simulation test result shows encouraging performance in terms of accuracy, sensitivity, reliability and simple implementation of real time relaying.

Case 2: 3-phase fault at bus 2 in grid connection mode

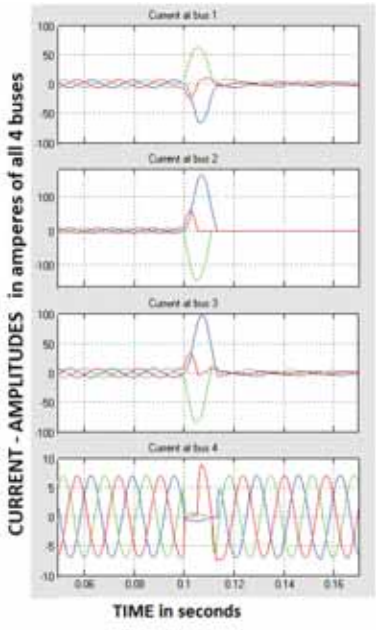
The 3φ-to-ground fault at terminals of the load at Bus 2 was performed for purposes of investigating the responses of the proposed algorithm to a high level fault current in the grid connected mode. The loads at buses 2 and 4 were being supplied by the generators at bus1 and 3 when a 3Ø–to-ground fault was connected to the ground at Bus 2. The detected 3Ø current signals for each protective device near all buses are shown in Fig. 6.

The simulation indicates that the digital relay at bus 2 only changed the status of its trip signal (from 1 to 0 in less than 3ms after the starting of the fault) in response to the 3Ø-to-Gnd fault at bus 2. Due to incorporation of delay in all protective device near generator buses selectivity of the system improves.

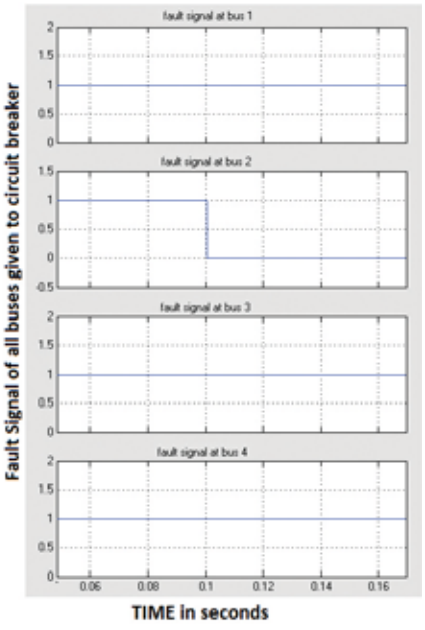
Case 3: 2-Phase fault at bus 1 in islanded mode

The line-to-line fault on the terminals of the generator Bus1 was performed in order to investigate the responses of proposed algorithm to an asymmetrical fault within the domain of the micro-grid in islanded mode of operation. As the generator buses 1 and 3 units were supplying the load buses, phase A was suddenly connected to phase B on the terminals of the generator at bus 1.

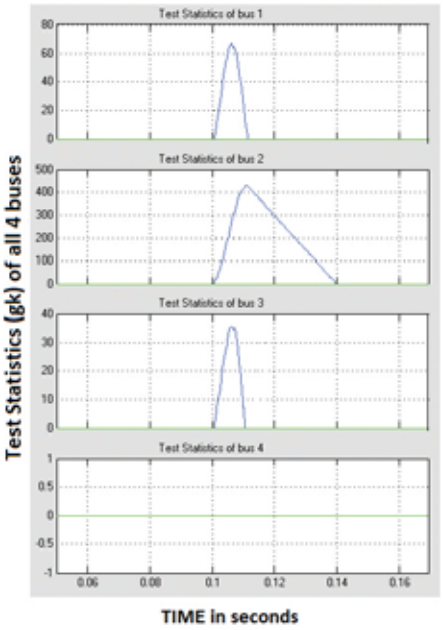
The simulation results from Fig. 7 shows that the line-to-line fault at the terminal of synchronous generator triggered high level transient



(a) Three Phase Current Signals



(b) Fault Detected



(c) Test Statistics

Fig.6: Performance for 3Ø fault near bus 2 in grid connected mode

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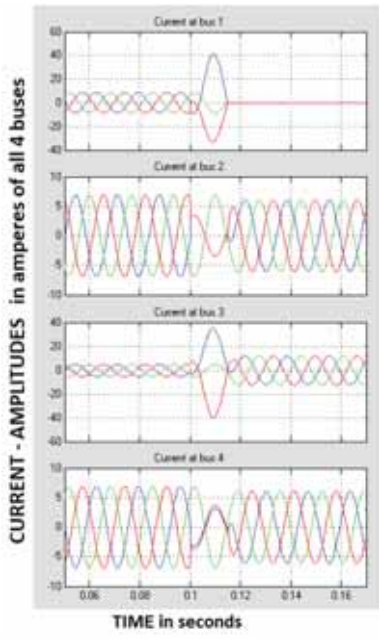
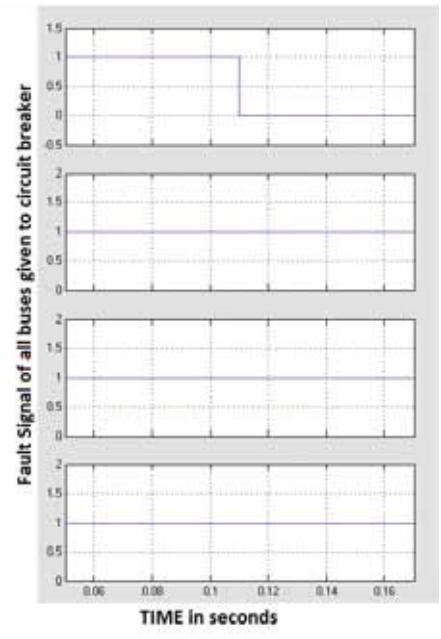
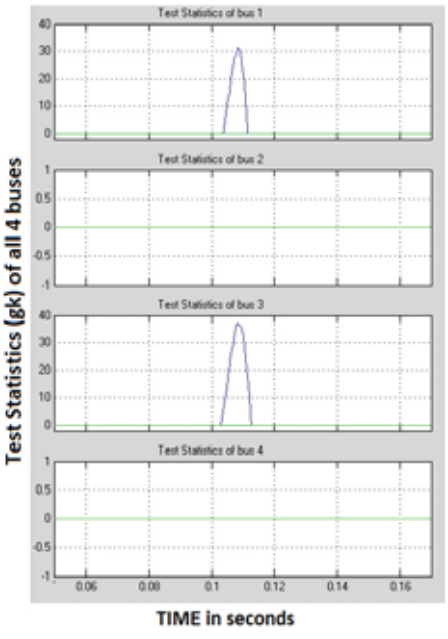


(a) Three Phase Current Signals...



(b) Fault Detected...



(c) Test Statistics...

Fig.7: Performance for 2-Øfault near bus 1in islanded mode...

disturbances in 3Ø current at all generator buses. By using the power flow method the exact location of fault is detected as due to fault the power flow was high near defected region. Due to incorporation of delay for improving selectivity of the system, the output trip signal given to circuit breaker near generator bus 1 shows some time lag.

It is found that a fault at any bus cause transient disturbances in overall system. The faults at load bus can be easily detected by using CUSUM algorithm by incorporating some delay at generator bus to improve selectivity and accuracy of the system.

Whereas in case for fault at generator bus the concept of Power Flows is used along with CUSUM method (which detect higher level transient at all gen. buses) to detect exact location of fault. By monitoring theta (θ) values i.e. power flows through all generator buses, we can find the actual location of faults in loop system.

The test result of the fault relaying for micro-grid demonstrated significant abilities to accurately detect, classify, coordinate and responds to different types of transient disturbances.

Furthermore performance result showed high degree of insensitivity to parameters of protected components, harmonics contents and/or micro-grid mode of operation.

In all tested faults, the algorithm was able to detect, locate and clear faults under milli-seconds through disconnecting only the faulty region while maintaining an operating status for the micro-grid.

Conclusion

A simple and fast proposed algorithm consisting of power flow assisted cumulative sum method pose an improvement for detecting faults in MG. A CUSUM based fault detection method alone is insufficient for detecting faults in looped system like micro-grid – so Load Flow theory is incorporated along with it to find the exact location of the fault.

The algorithm is both robust and efficient in fault detection. The simplicity, reliability, accuracy and fast response to transient disturbances of the proposed relaying method comprising of CUSUM and Load flow validate its application for protection of micro-grid and their host utility grid.

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Indian Institute of Technology Madras,
Chennai, India

Interview

K Linga Reddy
Chairman

"Distribution sector is the primary target where competition is more and volumes are large..."

***PETE Hammond Power Solutions Pvt Ltd** was started by **K Linga Reddy (Chairman)** with more than four decades of experience in Transformer Industry covering all aspects of Designing, Development, Manufacturing, Testing, Commissioning and Servicing and **Managing Director K Ravi Krishna Reddy** with more than two decades of experience in the same Industry.*

***Hammond Power Solutions Inc. (HPS)**, Canada is a 99 Years old company started by **Bill Hammond**, which rose from a small business enterprise to an MNC with multiple manufacturing facilities spread throughout the world.*

PETE and Hammond joined hands in 2012. A Canadian stalwart in dry type transformer manufacturing had come forward after critical study of PETE's capabilities. So, PETE and their partner's excellence in Dry Type Transformer range is quite well known today. A synergy of experience and technology in the International Transformer arena is now in business to fulfill all the requirements of global customers.

*In an exclusive interview with **Electrical India**, **Chairman Reddy** is describing his company's capability and business potential to **P K Chatterjee**. Excerpts...*

How is the Indian Transformer Industry growing?

India Power and Distribution Transformers Market to witness robust growth due to growing demand for electricity and government initiatives for power additions. The market for power & distribution transformers in India is projected to grow at a CAGR of 10.5% during 2015-2020.

Growth of the country's power Transmission and Distribution (T&D) sector remained sluggish during 10th and 11th five year plans due to inadequate investments allocated by the Indian Government. However, under the 12th five year plan, the Indian Government is focused towards expansion of the country's T&D network with significantly higher investments than previous five year plans.

Upcoming government projects like Green Energy Corridor for power generation from renewable sources would further add to the overall power and distribution transformer installations in the country.

Other initiatives like Restructured Accelerated Power Development and Reforms Programme are aimed at providing basic power infrastructure to rural inhabitants and households in the country, thereby boosting the demand for power and distribution transformers in India.

'India Power and Distribution Transformers Market Forecast and Opportunities 2020' has analyzed the potential of power & distribution transformers market in India and provides statistics and information on market size, industry behaviour and trends.

What types of innovations are being sought here?

We have developed 'Pad-Mounted Transformers' to cater for the needs of urban underground Power Distribution Systems.

Pad Mounted Transformer...

Also, we have successfully come out with 'Multi-Pulse Transformers' to meet the required phase angle between secondary windings in VFD system inputs.

Pad Mounted Transformer...

Also, we are pursuing manufacture of 'Reactors' for VFD drives systems to curb the harmonics that emanate from the VFDs. Right now we are supplying those to the US Market.

Reactor...

How are the government's new policies helping you to generate more business?

Government is contemplating to improve the Urban and Rural infrastructure. Hence, they need wide variety of power transformers to meet the changes required. Further, smart cities and digitized villages need perfect power quality, which needs efficient power transmission and distribution. Hence, I see much more demand for transformers because transformer is the basic component in Power Transmission.

Please tell me about the recently developed products in PETE.

As I have already explained to you, we are working more on products like Pad-mounted, Multipulse, Reactors and PV Solar Sub-Stations. Also, as our JV partners are experts in Cast Insulation Transformers, we are using their expertise to meet the demands of the Indian Customers. Their Cast Insulation Dry Type Transformers are very important in high density population areas like big malls, theatres, multi-storey sky scrapers. The frequent mishaps in these areas demand stringent electricity laws for the use of fire resistant dry type transformers. We have also developed Compact Sub-Stations (CSSs).

Compact Substations...

Nowadays Solar Power is in focus. Previously we have done great business in Wind Energy related transformers. Now, Solar Power handling

PV Solar Systems...

needs PV compact transformer sub-stations. We are successful in developing both Modular and Container type – and we have successfully commissioned these units to cater to the PV Solar Power Systems.

As the new demands come up from society, we must be able to meet them. Otherwise, we are out of business. We have to adopt the new changes using the existing capabilities. This is the trick of the Trade.

Please tell me in brief about your manufacturing facility and capability.

Our Production facility has changed during the last five years. A sea of change! Now we have 132 kV grade power transformer manufacturing and testing facility added to the existing 33 kV grade. But this facility is separate in a different location.

We have another facility for dry type Cast Resin and Cast Coil transformers.

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Fabrication unit exists separately and exclusively. Recently, PETE Group of companies started manufacturing Epoxy Bushings and Spouts.

How do you take care of quality and consistency in your products?

Quality is in-built in the system. Production facility and quality checks are not separate. Now, we have come to a stage wherein quality building is part of the manufacture. As you know, we have been adjudged as No. 1 Quality Leader in our range of MSME transformer units and we received a National Award from Rastrapathi in the year 2010. Now we have to keep it up, you know!

Which segments are you primarily targeting as far as new transformers are concerned?

Power Sector is the main arena that we focus on. Distribution Sector is the primary target where competition is more and volumes are large. Special Purpose Transformers are icing on the cake.

How is the demand scenario in the reconditioning and repairing market?

We are not focusing on repair jobs, but we don't say 'no' to the needy customers. Hangings are more in repairing but volumes are not there compared to production or manufacture.

Is the new trend of captive power generation opening up a lucrative market for you?

Yes, of course! Captive Power Generation and Evacuation of power in Power Generation. This segment is growing fast. We have to pick up the demand. We have a substantial market in these areas.

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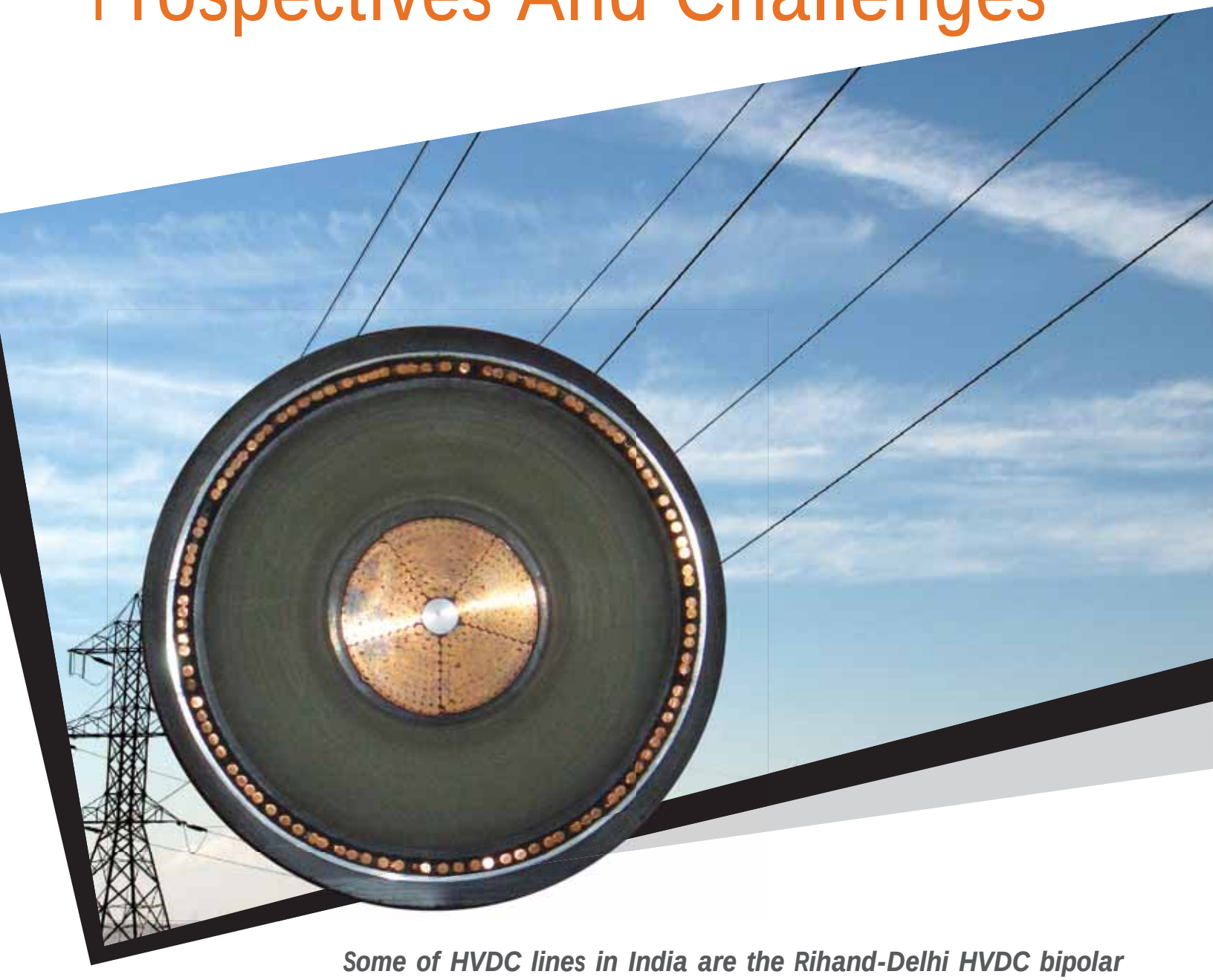
HVDC EXTRUDED CABLES
Prospectives And Challenges



Some of HVDC lines in India are the Rihand-Delhi HVDC bipolar 500 kV DC transmission link, having rated capacity of 1500 MW is of length 814 km; Chandrapur-Padghe bipolar line of transmission is of length 753 kms with capacity 1500 MW at 500 kV; Talcher-Kolar 500 kV DC transmission line of length 1836 kms has capacity of 2000 MW and many more lines are in progress...

The global interest on HVDC power systems has seen a significant growth in the last few years – and has assumed greater importance. HVDC power transmission systems have gone through remarkable developments because of the increasing need for the transmission of bulk power at higher voltages and over longer distances with reduced power loss, least amount of right of way, and better stability and control in the transmission system. HVDC is a proven technology for transmission projects that interconnect asynchronous networks. Today, HVDC land transmission technologies are used to carry electricity over long distances by a) HVDC overhead lines to carry high power (>1,000 MW) over distances above 200 km and b) HVDC underground cables to carry medium and high power (100 MW – 1,000 MW) over distances above 50 km. Few typical lines are: The Itaipu HVDC transmission overhead line in Brazil consisting of two bipolar DC transmission lines of length 785+ 805 km and operating at +/- 600 kV DC is by far the most impressive HVDC transmission.The 350 kV monopolar HVDC link connecting the geothermal plant on the island of Leyte and southern part of main island of Luzon feeding AC grid in the Manila region is of length 430 km. Xiangjiaba-Shanghai +/- 800 V DC, 6400 MW, 1953km commissioned in 2010 is the world's largest UHV DC transmission system. Some of HVDC lines in India are the Rihand-Delhi HVDC bipolar 500 kV DC transmission link, having rated capacity of 1500 MW is of length 814 km, Chandrapur-Padghe bipolar line of transmission is of length 753 kms with capacity 1500 MW at 500 kV, Talcher-Kolar 500 kV DC transmission line of length 1836 kms has capacity of 2000 MW and many more lines are in progress.

Converter stations are required to connect to the AC system which entail significant investment costs. The new generation of converters (VSC–Voltage Source Converters) use IGBT (Insulated Gate Bipolar Transistors) which allow the power to be transmitted as it is in both directions without requiring polarity reversal. This has allowed re-introducing the use of extruded cables in DC power transmission. The cost factor for the HVDC cable is only to 2 – 3 compared to HVDC overhead line of the same capacity. So far, HVDC cables have mainly been used in submarine applications, either connecting offshore wind farms to land or transmitting electricity over long distance through the sea where overhead lines cannot be used. Now, HVDC cables are also being used for land transmission projects. HVDC undergrounding can safely transport high power loads over long distances with minimal losses. In addition to transport efficiency, only a limited number of cables and joints are required, hence allowing narrow trenches. Globally, long distance HVDC underground transmission cable system projects have been realized, some are in progress and many others may be planned for the near future.

Prospects of HVDC technology

Some of the advantages of HVDC Systems are:

- Can carry more power for a given size of conductor
- Both overhead lines and underground cables can transmit power without any distance limitation.
- Better stability and very fast control of power in the transmission system
- Direction of power flow can be changed very quickly (bi-directionality).
- The need for ROW (Right Of Way) is much smaller for HVDC than for HVAC, for the same transmitted power.
- The environmental impact is reduced with HVDC.
- VSC technology allows controlling active and reactive power independently without any need for extra compensating equipment.
- VSC technology gives a good opportunity to alternative energy sources to be economically and technically efficient.
- HVDC transmissions have a high availability and reliability rate.

HVDC extruded cable technology

High Voltage Direct Current (HV DC) cable technology has features which make it specially attractive for certain transmission systems like long distance, bulk-power and long submarine cable crossings. In case of long distance transmission with HV AC Cables, the capacitive currents which are proportional to the length of the cable, the cable capacitance and the frequency of supply, amount to 10 – 25 A/Km and become large in comparison to the currents that have to be transmitted. For long lengths above 60-80 Kms the capacitive currents become equal to the active current that the cable has to transmit and hence the losses are very much higher and further the current rating of the cable is reduced drastically. With DC Transmission, the frequency of supply is zero and only the conductor resistance plays a major role.

However, the electric field distribution at DC Voltage differs greatly from that for AC Voltages, whereas in AC cables the field distribution within the cable insulation is distributed capacitively in accordance with the permittivity of the cable insulation. The field distribution at DC is determined by the conductivity of the insulation, which is not constant and depends strongly upon the temperature and the electric field. Surface charges and space charges also play an important role. Consequently the fields in DC Cables are space, temperature and time dependent. This makes the determination of the field at DC voltage more complex than in an equivalent case with AC voltage.

History of HVDC cable development

The world's first operation of HVDC power transmission began in the year 1954 connecting the mainland of Sweden and Island 'Gotland'. During the period Mass Impregnated (MI) cables (insulating paper impregnated with high viscosity insulating oil) were used for medium voltages while Oil Filled (OF) cables (using insulation paper which was impregnated with low viscosity insulating oil and kept in pressurized condition) were used for higher voltage and larger capacity applications. Since then, MI and OF cables have been the mainstream of DC power transmission cables. Examples of a mass impregnated, paper insulated cable and an oil filled, paper insulated cable are shown in Fig 1 and 2 respectively.

In the year 1999 XLPE extruded cable designed to operate at 80 kV was used in Gotland. Here, a Voltage Source Converter (VSC) was used as an ACDC converter. Polymer insulated cables which are lighter, easier to handle and also offer easier jointing than Paper Insulated Cables can therefore now be used with advantage. With XLPE insulated cables, a higher conductor temperature can be used, and this allows a smaller size of cable to be used with a more compact construction. Additives

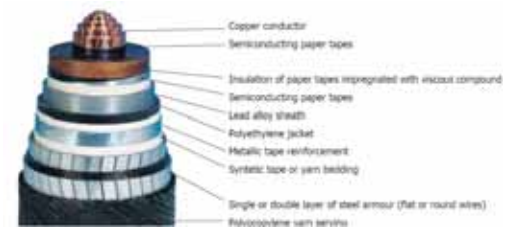


Fig 1. MassImpregnated, Paper insulated Cable...

Fig 2. Oil Filled Paper insulated Cable...

traditionally used for HV AC Cables such as anti-oxidants, cross linking agents, lubricating additives, those used for increasing cross linking density and scorch resistant additives can be selectively used in various combinations to produce XLPE Insulation for HV DC Cables. Currently HVDC extruded cables based on XLPE insulation are designed to operate at 320 kV and around 1000 MW. The construction of a typical HVDC, XLPE extruded cables is shown in Fig.3. An aluminium or copper conductor is covered with a thin semicondcting layer to have a smooth interface to the following insulation layer. A second semiconducting layer covers the insulation. Depending on the application and design other layers are added to the cable. For exmple in case of damage to the cable, swelling tape absorbs water and expand, blocking the water from moving axially along the cable. The screen wires are grounded. Aluminium laminate provides a diffusion barier against foreign substances, especially humidty. And finally the covering sheath jackets all the layers. An extruded lead sheath as water barrier and armoring wires provide the mechanical protection to the cable. Some of the leading HVDC cable manufacturers are ABB, Sweden; Prysmian Cables, Nexans, France, Germany, Norway; J-Power, Japan; LS Cable, Korea; Europa cables, Brussels; Brugg Cables, Switzerland and many other manufactures.

Development of high voltage DC-XLPE cable system

The history of cable development is as follows

- 1984~1989 : Fundamental research on DC insulation material
- 2007~2010 : Establishment of manufacturing technology of practical DC-XLPE cable

Figure 3. Typical HVDC Extruded cables (courtesy Prysmian, ABB)...

- 2005~2006 : Verification on long-length extruding of DC-XLPE....
- 1988~1995 : Development of DC 250kV cable and factory joint
- 1993~2001 : Development of DC 500kV cable and factory joint

Materials for HVDC extruded cable insulation

At the beginning of the era of extruded HVDC insulation, materials like LDPE, XLPE – which are used for HVAC applications were tried with different thermo-chemical treatments such as cross-linking and or mixed with proper additives. Even currently the materials used for HVDC cables are based on PE are used. Further, development of extruded DC cables has gained attention since 1990s with the use of modified semi conductive and insulating materials for minimizing the space charges under HVDC field. Peroxide cross-linkable polymer systems based on high pressure polyethylene resins or low-density polyethylene compounds with nano-fillers are being explored.

The insulation of HVDC cables should have the following properties:

- Stable Insulation resistivity: i.e., Insensitive to variations of temperature, electric stress, polarity reversals, and constant value during the time of electrification.
- Low thermal resistivity.
- Low space charge retention properties.
- High DC breakdown strength, particularly superimposed impulse conditions and insensitive to temperature and polarity reversals.

Characteristics of polyethylene & XLPE

Polyethylene is the simplest hydrocarbon in polymer and a typical example of synthetic polymer. It is obtained from the polymerization of ethylene. Polyethylene is classified as linear, branched and cross linked polymers. The linear Polyethylene is constituted as long chains, tied up through weak interactions (van der walls bonds) and feature the highest crystallinity degree.

The branched Polyethylene's are new chains that develop from the intermediate points of the native chain and weak van der walls interactions are established since the chains are less packed; the degree of crystallinity is now lower than the linear polymers. Cross linked Polyethylene are three dimensional structures with primary bonds in all directions. Such materials are hard, mechanically resistant, non-fusible and insoluble in all the reagents and are called thermosets.

Cross linking, which also called vulcanization, is usually realized chemically through peroxides. Such peroxides are activated at elevated temperatures, giving rise to reactions among residual functional groups of different molecules, with the formation of more complex molecules and the definite hardening of the product.

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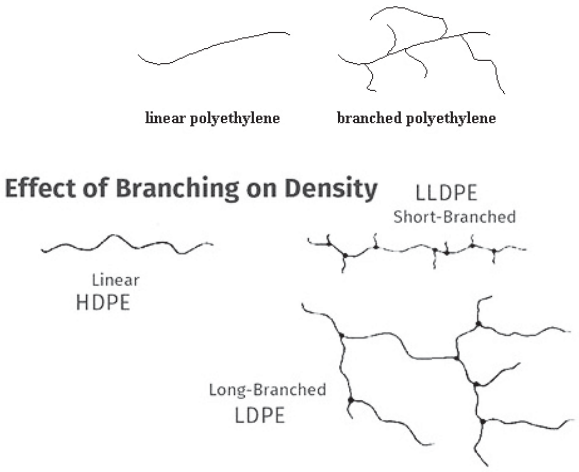

Figure 4 Linear, branched polyethylene...

On the contrary, linear and branched Polyethylene can be formed at high temperatures in order to exploit their higher plasticity at such temperatures, without involving further modifications of their molecular structure. The high temperature weakens the van Der Walls bonds, so that the material resembles a paste and can be shaped. Therefore, linear and branched Polyethyleneare denoted as thermoplastic resins and contrary to the thermosetting resins.

Polyethylene vary in molecular weight and degree of branching, with the highest branching occurring in LDPE. Other PE families are unbranched or high density PE (HDPE) and short branched linear low density PE (LLDPE). The polyethylene commonly used of HV insulation process is XLPE, which is LDPE cross linked with an organic peroxide, typically dicumyl peroxide. In the production of XLPE, methane, acetophenone, and cumyl alcohol are among the by-products of the decomposition of dicumyl peroxide.

HVDC extruded cables: challenges

The design of insulation for HVDC extruded cables is one of the most challenging issues, mainly due to the dependence of its dielectric properties on temperature, electric field distortion due to accumulation of space charge in the insulation. Space charge occurs whenever the rate of charge accumulation is different from the rate of charge removal, and may arise due electrons and ions. Space charge occurs due to injected charge carriers at the electrodes, whether mobile or trapped charge (already present in the bulk of the cable insulation) due to three processes in a dielectric under an electric field, namely: a) variation in conductivity, b) ionization of species within the dielectric and c) charge injection from the electrodes driven by a DC field not less than approximately 10 kV/mm and polarization in structures such as water trees. Of these phenomena, the first two contribute most to the space charge accumulation.

Space charges are also formed due to the presence of ionic dissociable additives, impurities, dislocations and chemical or physical defects. Thus, it has become a major challenge to the researchers all over the world to develop a space charge free insulating material with good dielectric properties.

Issues with space charges

It is well established that the electric field distribution over the extruded cable insulation is strongly affected by space charge, which can control the cable system behavior, in particular, its long-term reliability and life expectancy. When a DC voltage is applied across a cable dielectric, space charge accumulates in it at a rate which primarily depends on the voltage level and the properties of the cable insulation and of the conductors. If the space charge density becomes sufficiently high, the local field strength may exceed the breakdown strength of the extruded insulation, leading to insulation failure. This includes distortion of electrical stress distribution due to space charge formation and accumulation, electrical treeing initiation, breakdown as well as insulation aging. Research on the behaviour of space charges in extruded solid cable materials has gained a lot of interest during the last three decades. New materials and application environments set the challenges for improved reliability of extruded insulation and better understanding of the properties of insulation is very essential to achieve this goal.

Mechanisms of formation of space charges

The formation of space charges in extruded cables is associated with the injection of charges from the electrodes involved in the transfer of electrons (and holes) through the electrode-polymer interface. This process is highly dependent on the conditions of the interface, including the electrode material, the surface defects the impurities and the oxidation level. The formation of space charges in extruded cables is associated with ionization of some chemical species. These species can be introduced during manufacturing of the material, such as antioxidants, or cross-linking by products, or other impurities.

For space charge accumulation to take place, the injected charges and / or the charges already present in the polymer must be trapped in the material; thus the phenomenon depends on the availability and nature of traps. The residence time of a charge carrier in a trap depends on the trap depth, the energy required to extract the carrier, the temperature, and the applied electric field. Polymers exhibit both 'shallow traps' and 'deep traps.' In polyethylene a depth of traps ranging between 0.1 and 1.4 eV has been found. The characteristics of the material have an influence on the trapping process, e.g., the degree of crystallinity, oxidation, impurities, lattice structure defects (both chemical and physical) and by products from the cross linking reactions.

Commercially available PE contains polar impurities such as phananthrene, benzoic acid and benzophenone, which may be oriented by the external field to give anet dipolar polarization. The presence of space charge at the trapping sites such as crystalline-amorphous interfaces, may produce regions of high electrical stress, leading to breakdown of the PE insulation used in HV applications.

Methods for space charge measurement

Space charge measurement methods have been developed and extensively used for laboratory investigation on samples like plates and small length cables, which help to increase the understanding of the intrinsic behaviour of the dielectrics. However, they do not permit to completely take into consideration synergetic effects such as electric

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Figure 7: A view of high voltage indoor lab 2400 kV, 240 kJ...

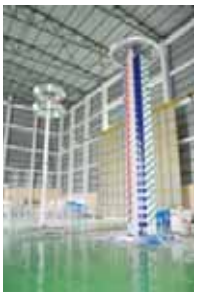

Figure 8: A view of impulse generator...

fields, byproducts, temperature gradients and semiconductor/ dielectric interfaces on the space charge evolution within the insulation of the cable systems. Further, using thermal step method an industrial facility to take into consideration the synergetic effects on the space charge distribution in the cable insulation is reported.

The space charge measurements are classified into two categories, namely thermal methods and pressure methods.

Thermal methods: Thermal pulse method, Laser Intensity Modulation Method {LIMM} and Thermal Step Method (TSM),

Pressure pulse methods: Some of the pressure methods are a) Pressure Wave Propagation method (PWP), b) Laser Induced Pressure Pulse method (LIPP) and c) Pulse Electro Acoustic method (PEA).

Qualification tests on HVDC cables

The extruded HVDC cable system is qualified according to international standards and recommendations. The latest document governing the qualification of extruded HVDC cables is the CIGRE Technical Brochure (TB) No. 496, which was issued in April 2012. Mechanical testing and other tests not specific to HVDC cables are based on IEC standards – whereas the electrical testing is in TB 496.

Central Power Research Institute (CPRI) is a government of India organization which was set up in 1960 and is the the power house of the Indian electrical industry. It has has full-fledged facilities in the areas of testing andevaluation of power cables upto 400 kV (AC) covering different type of cable insulation. Recently, the laboratory has been augmented with facilities like 600 kV, 4200 kVA ac test system, 600 kV voltage dividers, 2400 kV, 240 kJ Impulse generator, partial discharge detector, dissipation factor bridges, 600 kV standard capacitors etc to conduct long term ageing test 'Pre-qualification test' on EHV cables. Some of the available test facilities for EHV cables at CPRI, Bangalore are shown in figure 5, 7 , and 8. Further it is proposed to set up additional test facilities

Figure 8. Outdoor 600 kV, 4200 KVA transformer for conducting pre-qualification test...

like Polarity reversal test and superimposition tests which are required for qualification of HVDC extruded cables.

Conclusions:

In conclusion, there is a great potential for development of extruded HVDC cables globally. The design of insulation for HVDC extruded cables is one of the most challenging issues, mainly due to the dependence of its dielectric properties on temperature, electric field distortion due to accumulation of space charge in the insulation. Even if the main insulation is XLPE, it is necessary to keep in mind that history of insulation from melting to extrusion and amount of peroxide and anti-oxidant could modify microstructure and so properties of the polymer.

Due to complexity of the phenomena involved (injection trapping / extraction etc) it is not easy to predict the distribution of space charge in the cable and these aspects are great challenges for the cable manufacturers. The Indian cable industry should come forward and network with research organizations in developing indigenous technology to design, develop and manufacture HVDC cables. The space charge issues should be addressed by looking for alternate nono materials and fillers.

The test facilities available at CPRI would be of immense use to Indian cable manufactures and utilitiesfor development of HVDC cables. Active participation of the Indian manufacturers will be highly beneficial to the Indian Power Sector.

B Nageshwar Rao
Joint Director
Central Power Research Institute (CPRI)
Bengaluru, Karnataka, India

Technicians working at wind energy projects at a training session at the new Siemens Wind Service Training Center in Orlando, US...

Financer Visits Training Facility

In addition to the renewable energy projects in Peru, EXIM Bank financing has helped Siemens' customers finance the purchase of power generation equipment and components, water treatment solutions, and health care systems...

EXIM Bank is an independent federal agency that supports and maintains U.S. jobs by filling gaps in private export financing at no cost to American taxpayers. The Bank provides a variety of financing mechanisms, including working capital guarantees and export credit insurance, to promote the sale of U.S. goods and services abroad. Nearly ninety percent of its transactions directly serve American small businesses.

Siemens recently welcomed Export-Import Bank of the United States (EXIM Bank) Chairman Fred Hochberg to the company's Wind Service Training Center (WSTC) in Orlando, which serves as a hub for Siemens' energy businesses. During a tour of the WSTC, Chairman Hochberg and Siemens Power Generation Services CEO Randy Zwirn highlighted EXIM's importance to supporting jobs and boosting renewable energy exports.

In 2015, Siemens was honoured as EXIM Bank's 'Deal of the Year' and 'Renewable Exporter of the Year' for two wind projects the bank helped finance in Peru. EXIM Bank authorised a pair of direct loans totaling nearly $65 million for the Tres Hermanas and Marcona wind farms (with an estimated aggregate of 129 megawatts) in the Ica region of southern Peru, the bank's first renewable energy transactions in that country. The wind blades and geared nacelles for these projects were produced at Siemens wind energy factories in Iowa and Kansas. With a long-term service and maintenance agreement included, Siemens' wind service technicians maintain the turbines train at Siemens' WSTC in Orlando.

"As a major exporter in the United States, we're pleased to welcome Chairman Hochberg to Siemens. EXIM Bank has played an essential role in providing competitive financing for several major equipment purchases from Siemens' U.S. factories, helping to support jobs and boost exports. With a long-term commitment to growing our export business, particularly in the area of renewable energy, we are pleased that EXIM Bank will continue to be a resource for our customers," said Zwirn, who previously served as a member of EXIM Bank's advisory board.

"EXIM's work with Siemens over the years reflects our continued commitment to increasing U.S. renewable energy exports while supporting good-paying jobs through the small business supply chain here at home. Siemens continues to build a strong manufacturing presence in the U.S., which is the key in helping strengthen American competitiveness and exports," said Hochberg, Chairman and President of EXIM Bank.

In addition to the renewable energy projects in Peru, EXIM Bank financing has helped Siemens' customers finance the purchase of power generation equipment and components, water treatment solutions, and health care systems.

Orlando is the global hub for Siemens Power Generation Services division, as well as the Americas hub for Siemens Wind Power and Renewables division and the Power and Gas division. Siemens state-of-the-art Wind Service Training Center is one of four such facilities for Siemens globally, with instructors providing highly advanced technical and safety training for installation and service technicians working at wind energy projects located throughout the Americas region. EI

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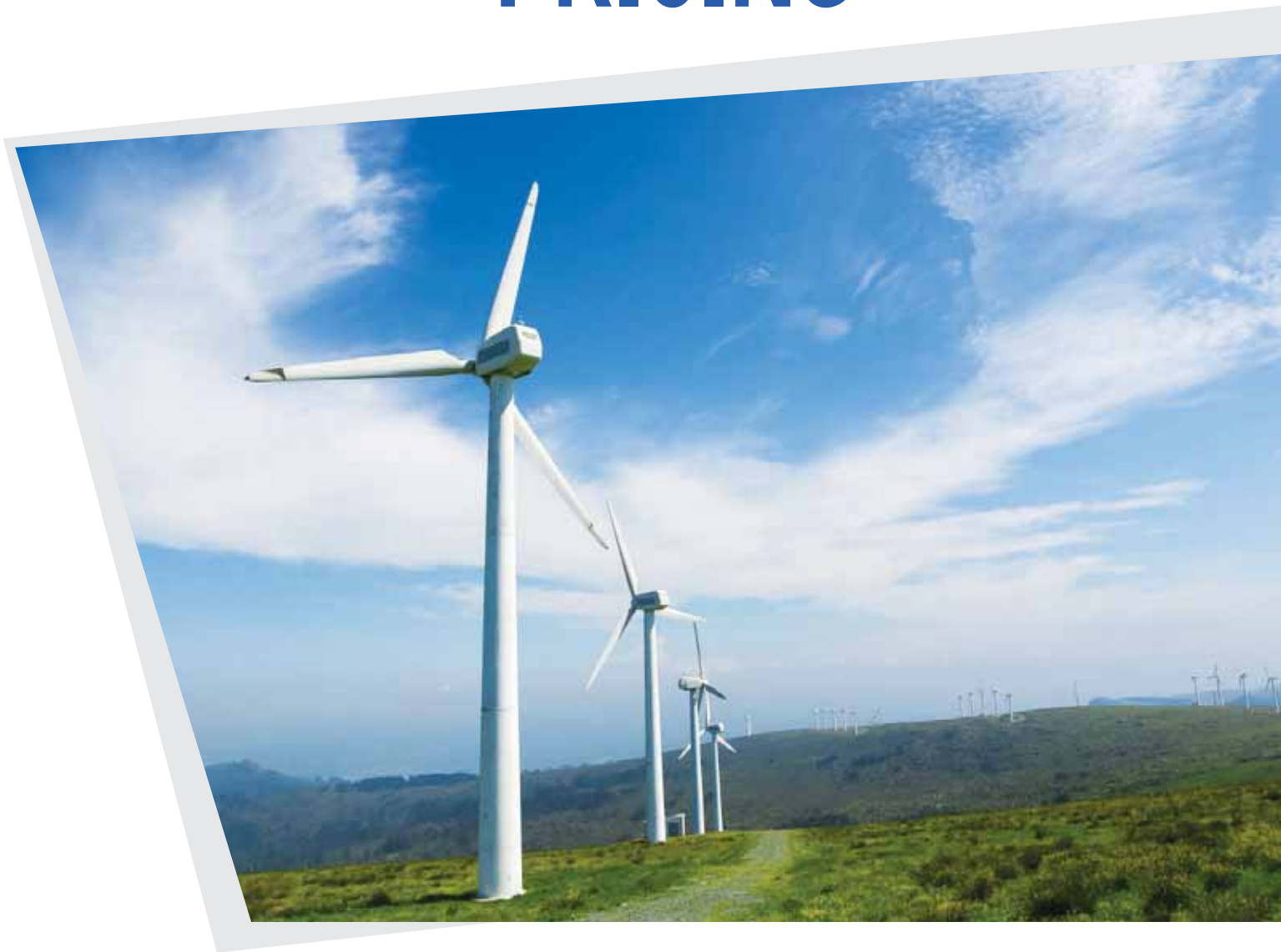


In India, long term power accesses have continuously dominated the electricity power market and still the issue like bringing long term and short term players together in meeting the load in real time are to be addressed...

In the present deregulated electricity market, the power system engineers have started emphasising the terminology called 'Negative pricing.' This has gained its significance when the renewable penetration increases more than the demand especially in the lean hours.

The installed capacity of our power stations in India is 282.023 GW (as on November 2015, by www.cea.nic.in) while the base load energy deficit and the peaking shortage is 2.1% and 2.6% respectively for the fiscal year 2015-16. So within few years, India can anticipate negative pricing by the power producers, which needs to be solved in terms of reforms and policies. Business Line has also stated (dated 20th July 2015) that "there is a huge surplus capacity sufficient to meet demand for the next three-four years, during which period some private producers will go bankrupt, which will push up the stress levels of banks."

Significance of electricity market

Compared to other market commodity, electricity cannot be stored; it should be available as and when required by the customers. At the same time, both generation and demand changes time to time. In this market, the electricity is sold in the form of energy and power. Energy is sold for a period of 15 min, 30 min, 60 min blocks etc., while power is sold to take care of ancillary services. In India, long term power accesses have continuously dominated the electricity power market and still the issue like bringing long term and short term players together in meeting the load in real time are to be addressed.

What is negative pricing? How this is possible?

Negative pricing phenomenon happens during when the power generation companies meet the demand which is less and operate with stringent constraints. For example, in the wind surplus region, the wind power producers are ready to pay the grid operators to sell their power during surplus supply which is termed as 'negative price.' This is because they receive tax credit/subsidy on the other way. Every country in the world has different energy policies and incentive schemes to meet their renewable targets. Renewable action Plan (REP) with feed-in tariffs, Production Tax Credit (PTC) are some of them. This harmful effect most of the time even overlooked in the western countries.

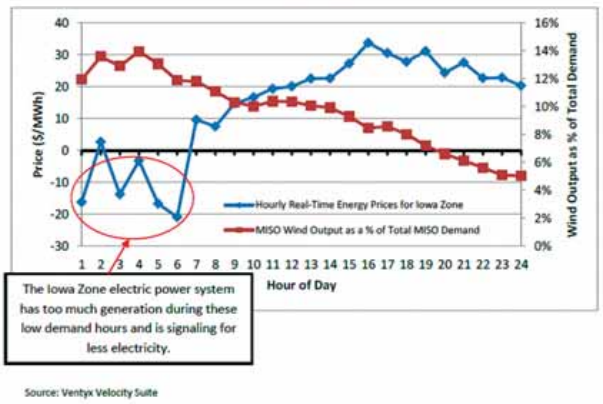
Existence of negative pricing in U.S.

In 2014, United States met 89% of their energy requirement from their own production while the remaining energy was met by importing petroleum. Around 11% of energy comes from renewable sources (source: US energy information Administration).

IOWA, which is enriched with wind power (under Midwest Independent System Operator) suffered approximately for six hours with negative pricing during morning hours. This is shown in figure 1. Electric Reliability Council of Texas (ERCOT), PJM ISO and California ISO too suffered from negative energy prices in the past few years. National Renewable Energy Laboratory has shown how negative locational price is created due to the rapid increase in wind power than the growth in transmission sector.

In mid-2015, the spot clearing price at Texas went negative and sustained for many hours. The price went from $ 17.40/MWh for a given block to zero in the next block. It immediately reached the negative region with the negative price of $ 8.52 /MW hand lasted for four hours. It was said that negative pricing can occur wherever supply demand mismatch exists.

Figure 2: Real-Time Hourly Electric Energy Prices and Wind Output in the Iowa Zone of MISO on June 14 2012



Courtesy: Frank Huntowski, Aaron Patterson and Michael Schnitzer, The North Bridge Group...

Clean Technica, a news and analysis site has stated that on 2nd July 2015, in Australia, Queensland which is enriched with solar power pulled down the pricing to negative when the demand was low. This has changed the dynamics of the Australian electricity market on that day.

In the European Uniion, out of 28 countries, Germany leads in net electric power generation with its share of 19.2% followed by France and U.K with 17.7% and 11% respectively (courtesy: www. ec.europa.eu). The European market has a share of 24% of renewable sources (as per the report published by European Commission, "EU Energy markets 2014"). Still it was predicted that the negative pricing in European market will increase from 64 hours in the year 2013 to 1000 hours or above by 2022. Baringa, a consulting firm in United Kingdom reported that the negative pricing can increase still further when low carbon generators offer prices lower than the negative pricing. These generators can adopt this strategy to avoid loss due to shut-down or start-up costs. By adding more energy storage technologies, the negative pricing can be dropped drastically.

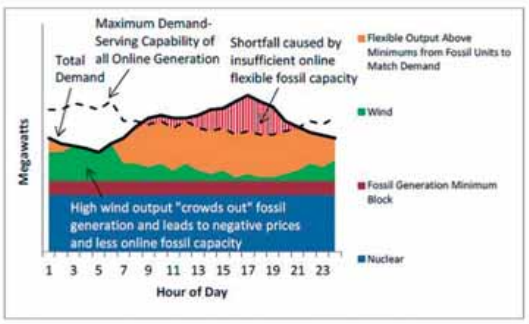
Belgium, Germany, France and Spain too face negative electricity prices. In 2012, 10 hours of negative pricing were recorded in France with 44 hours of nil energy pricing in Spain and 56 hours of negative pricing in Germany.

In India, no work has been carried out or initiated till now. One reason could be that the impact of negative pricing may take few more years to be felt on the system. And this is due to the existence of wide gap between the demand and generation. But during off peak hours when renewables take their upper hand then negative pricing cannot be avoided. In a subsidy based renewable market, that too with varied operational and economic constraints, it is sure that the clearing price gets distorted and create an unreliable electricity market.

Impact of negative pricing

This negative pricing directly affects the dynamics of the market. It

can be temporary or remains over a time period. It disturbs the market clearing prices for other participants where it creates huge loss and burdens them financially. More clearly, the revenue received by the



Courtesy: Frank Huntowski, Aaron Patterson and Michael Schnitzer, TheNorthBridge group...

generation companies intended to meet the base load gets reduced as they do not receive any subsidies too.

Negative pricing changes the pattern of unit commitment. It plays a significant role in the market where storage of energy is not possible. Researchers are also working in finding the relation on how the negative pricing can support the usage of inefficient storage devices.

Figure 2 shows how wind generation in the early hours reduces indirectly the availability of conventional power plant. This still creates/ increases the gap between the generation and demand especially in the peak hours. Consumers will be burdened by bearing the extra transmission cost when the power flows from wind rich areas to the load centres during negative pricing. It is a challenge to make the end consumers benefitted from the impact of negative pricing. Proper study has to be made as it creates a vulnerable situation to the transmission system. From the power producers' point of view, it gives an incentive for them through which they can come out with various means of meeting the demand under different conditions.

Impact of negative pricing in other market

In Canada during 2014, propane manufacturing companies were trading at negative price which went for few hours while in U.K., since 2006, the association of natural gas price and negative pricing has been identified. In India, there exists a strong debate on negative pricing of coal and its impact on power tariff, which will create instability in the market. This is because the price of the coal is cheaper when purchased from auctioned blocks. In mid-2015, Ford has seen the negative pricing in the Chinese automotive market which was temporary. EI

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Monitoring
Subsea Cable Health

Established in 2003, the European Marine Energy Centre (EMEC) Ltd. is the first and only centre of its kind in the world to provide developers of both wave and tidal energy converters – technologies that generate electricity by harnessing the power of waves and tidal streams – with purpose-built, accredited open-sea testing facilities.

Recently, Fraunhofer UK, a part of Europe's largest application-oriented research organisation, has joined forces with Synaptec and EMEC to develop an innovative solution to address cable and electrical infrastructure integrity within the marine renewable energy industry.

Funded by the UK Government's business innovation experts InnovateUK, the ORCHIDS project (Offshore Renewable energy Cable Health monitoring using Integrated Distributed Sensor systems) has brought a unique grouping of expertise together to tackle one of the key challenges in offshore renewable energy.

Subsea cable health is a particular challenge for marine energy and offshore renewables due to the hostile environment in which they are placed. The ORCHIDS project is to address this challenge...

"Subsea cable health is a particular challenge for marine energy and offshore renewables due to the hostile environment in which they are placed and have to operate. Failure of cables can also lead to costly losses of revenue and hefty repair bills," remarks David Hytch, Offshore Renewables Specialist at Innovate UK.

"As business focused innovation experts, Innovate UK recognised the potential benefits of the ORCHIDS project to reduce the cost of offshore renewable energy and improve the use of these technologies for sustainable, secure and competitive power generation in the future. Thinking about the future and supporting projects involving businesses with high growth potential is exactly what Innovate UK is for and we are pleased to be able to provide funding for ORCHIDS and help connect the collaborators through the Energy Catalyst programme," he continues.

The project is looking to enhance subsea cable monitoring capabilities by combining emerging optical sensing techniques to enable a smart cable management system that can be utilised during manufacture, transport, installation, through to end of life.

The feasibility study will include a market assessment looking at the commercial case for the technology alongside a technical review of different distributed fibre sensing techniques that can operate alongside Synaptec's unique offering.

Henry Bookey, Senior Researcher at Fraunhofer UK says, "This project is the first step towards a combined smart cable system and will allow us to map out the technical and commercial challenges along the way to the first commercial deployment of this unique system. The use of optical fibres found within modern power cables as a cable condition monitor combined with innovative current and voltage sensors is an attractive prospect for offshore infrastructure monitoring."

Matthew Finn, Senior Business Development Manager at EMEC says, "Our core business is providing developers of wave and tidal energy devices with grid-connected test berths in the harsh conditions experienced around Orkney. However, our infrastructure also opens up opportunities for a range of broader R&D activities and this project was an ideal way to explore how we could use EMEC's subsea cables to develop new monitoring technologies."

Philip Orr, Managing Director at Synaptec Ltd adds, "We are delighted at this opportunity to work with Fraunhofer UK and EMEC to demonstrate the potential to combine our unique electrical sensing technologies with cutting-edge acoustic sensing techniques. We firmly believe that making full use of optical fibres that are now intrinsic to power transmission lines and cables will lead to improved instrumentation coverage in a cost-effective way, and to enabling a smarter, more adaptive electricity network."

Armoured sub sea cables at EMEC...

Interview

"Toshiba has a significant presence in India in the T&D Sector..."

Toshiba Transmission & Distribution Systems group is a world leader in the supply of integrated solutions for energy **Transmission & Distribution**. In an exclusive interview with **Electrical India**, **Dr. Katsutoshi Toda**, **Chairman & MD** of **Toshiba Transmission & Distribution Systems (India) Pvt. Ltd.** is focusing on his company's contribution to the **Indian Power Sector. Excerpts...**

What kind of potential are you finding in the Indian power sector nowadays?

India's changing economy is the major driver for its energy requirement and development. The average growth rate is expected to grow @ 7.5% annually for next few years. This is resulting in transformation in the Indian Power Sector. However, the Indian Power Sector is currently facing challenging issues like fuel availability & pricing, environmental clearances, grid stability, high AT&C losses in the transmission and distribution sector, financial health of the SEBs – which is getting addressed by the Central Leadership in terms of e-auctioning of coal blocks, single window clearances, SEBs' restructuring through schemes like UDAY etc. – may unblock the policy logjam for the sector.

In India, to bridge the gap between the Generation Capacity and Transmission Network an estimated investment of $ 75 bn is expected in next few years. In addition to this, a large opportunity is expected in the agriculture feeder separation, Green Energy Corridor and SMART GRID Technology.

Does Toshiba offer complete customized solutions to the T&D sector?

Toshiba has a significant presence in India in the T&D Sector from MV to UHV segment both in terms of products and solutions. Toshiba has one of its largest Vertically Integrated 'State of Art' Manufacturing facilities in India to offer Energy Efficient Amorphous Transformers for the distribution sector, which contributes in bringing down the losses.

Besides this, it has already made significant investment in the infrastructure facilities of Power Transformer to cater to the UHVAC Segment in terms of product technology and services.

Toshiba is already positioned in the MV Switchgears and with Solid Insulated Switchgears & Gas Insulated Switchgears in place it covers the complete value chain of the T&D Sector. Toshiba's strength is in its offering to the customized requirements for Transformers and Switchgears to its clients.

What kind of new technologies are you introducing in the Indian power sector?

With a Significant Investment in the Infrastructure and Manufacturing facilities in India, Toshiba is bringing in new technologies like 'Solid Insulated Switchgears', 'Gas Insulated Switchgears' and UHVAC Transformers by transferring its Process and Design Technology from Japan to its Indian manufacturing base.

'Solid Insulated Switchgear' is a compact, safe and reliable switchgear, which is completely environmentally friendly – gas and maintenance free and addresses the issues of land and environment.

Solid Insulated Switchgear

Gas Insulated Switchgears

We shall be offering 'Gas Insulated Switchgears' both for the indoor and outdoor applications.

Please tell me something about your energy solution services.

Toshiba is contributing to the creation of infrastructure that enriches the quality of life for people throughout the world. In order to ensure stable supply of electricity, we offer hydro, solar, geothermal and wind power generation facilities in the renewables space, as well as thermal, hydroelectric and nuclear power generation systems. We are also a leading supplier of power transmission and distribution systems that deliver electricity to homes, commercial facilities and other users; rechargeable batteries for the efficient storage of energy; an independent energy supply system utilizing renewable energy and hydrogen; smart grids, next-generation energy distribution systems combining power infrastructure with communications infrastructure; and smart metering infrastructure and services which enable to cater next generation energy solution services.

What are you doing to increase the life of transformers that are used in open environment?

The life of transformer is mainly dependent on its operation and maintenance other than the use of high quality materials and the design aspects. Toshiba uses latest analytical tools for designing transformers considering the short circuit conditions in the grid, and the transformers are designed using very high quality materials in the insulation system – which is the heart of the transformer. The dynamic stability of the transformer is taken care of during the design and manufacturing. Besides these, few of the important diagnostic and monitoring equipments like On-line Moisture monitoring, Gas analyers, are supplied along with the transformer which keep a track on the healthiness and the performance of the transformers. We also ensure with the users on the proper installation and the periodic maintenance as per the O&M manual of Toshiba – as well as offering seminars to the users.

What are your contributions to airfield lighting?

Toshiba Lighting has been an industry leader in development of all kinds of airport lighting and control systems, from apron floodlights to runway illumination. Toshiba provides airfield lighting, control & monitoring systems and stop bar lighting systems as a kind of Advanced Surface Movement Guidance & Control System (A-SMGCS) for domestic and international airports. Providing high quality and reliable airfield lighting systems for more than 40 years, as a leading manufacturer in Japan and has over a 90% market share of inset-type airfield lights and over a 70% market share of airfield lighting control and monitoring systems including Narita, Haneda and Kansai International Airport.

Our systems make a vital contribution to aviation safety, both in Japan and throughout the world, and are manufactured to meet the stringent requirements of the ICAO (International Civil Aviation Organization). This is a seperate business segment of Toshiba.

How competitive are your solutions in general?

As explained to you ,Toshiba has a Vertically Integrated manufacturing facility at Hyderabad, which helps in maintaining Quality, On-Time Delivery and Cost effectiveness. Most of the components like Tanks, Radiators, Winding, Copper Coils, Insulation and Oil are made in house under Stringent Quality norms in the Distribution & Power Transformers – and the same model is followed in our upcoming products in Switchgears for MV and HV. This is our strength due to which Toshiba has such a wide spread of customer base in India and Globally.

What are your new plans in 2016?

Toshiba will position TTDI, the new company as a Global Manufacturing base for its T&D business in India and the global market. We aim to be a major player in the T&D segment with new technological products and services being rolled out from TTDI India base – and shall be occupying a significant share in the T&D space with our Quality and Global Competitiveness, which we are building up in our 'Value - Chain.' In the current year, we have plans to roll out few of our new products for which the infrastructure facilities are in place and would like to contribute to the power sector by addressing the concerns of land issues by supply of GIS, SIS and by offering the energy efficient transformers to the Distribution Companies to bring down the losses in this sector. Currently TTDI has a significant presence in the export market – we would like to leverage the same and will make our footprints in few new geographies thereby contributing to the foreign exchange earnings for the country.

What is your message to the Indian power sector?

Indian Power Sector is witnessing massive transformation due to the recent initiative and policy measures implemented by the GOI, and hence we see that this will give a boost to this sector in terms of growth and sizeable investment. The power sector globally for the next few years will be very demanding because of the rising energy demand in developed and developing markets. The T&D sector globally is expected to attract investment of $1trn over next 5-7 years. This will certainly drive the demand of Electrical Industry and open up New Technological products like SVC/STATCOM and solutions in the T&D space.

With the 'Make in India' thrust by the GOI, the manufacturing sector will see huge opportunities in new technology development, building up manufacturing base to cater to the global markets and claim Global leadership. This needs manufacturing sector to develop high quality process and norms, which shall meet the Global Standard to make the Grid Reliable, Safe and Affordable.

However, skill development, increase in the R&D investment and discipline in the project execution and monitoring are the key for the success of this segment. Participation by private players will be very significant in the growth plan of T&D segment, especially in Tariff-Based Competitive Bidding (TBCB), SMART GRID Technology projects, and Renewable Sectors.

Grid Isolated PV Assisted Wind Generation System

The principal advantage of the induction generator is its brushless and robust construction, low cost and that it does not need a separate DC excitation or does not require grid synchronization (in case of grid connected generation)...

Continual research to develop a clean source of energy is of primary importance nowadays as fossil fuel reserves are constantly decreasing. There are detrimental effects on environment due to their prolonged usage. Solar, wind, hydel, biomass, geothermal, tidal and nuclear energy are chiefly regarded as the possible replacements of fossil fuels. Wind energy among them is abundant, free of cost and without any environmental concerns. However, wind energy is intermittent in nature and also uncontrollable. Hence, a backup power source along with wind energy conversion system would be helpful and make the generation system more reliable. Difference in temperature at various regions gives rise to flow of wind. The kinetic energy of moving wind is converted into electricity in wind turbine coupled to generator shaft.

The mechanical power from wind is converted to either Direct Current (DC) or Alternating Current (AC) using DC generators or AC generators respectively. The DC generator has commutator and brush assembly which are prone to mechanical failures. Also, an inherent converter is required to produce the more convenient to use AC for both industrial and household usage. The AC synchronous alternator can generate at any speed corresponding to rotor speed. While this is an advantage especially at low wind speed conditions, a converter is required for fixed frequency operation. Induction Generators (IG) are mostly used in generation of electrical power from wind. Also, induction generators can be used in small hydro schemes with great effect. These generators are used for low and medium power generations. The principal advantage of the induction generator is its brushless and robust construction, low cost and that it does not need a separate DC excitation

or does not require grid synchronization (in case of grid connected generation). Induction generators can be assumed as the best alternative for power generation from a wind energy conversion system especially for grid-isolated domestic applications.

For grid-isolated induction generators, the voltage build-up takes place when capacitors of suitable value are connected in across the stator windings. The capacitors provide the magnetizing current necessary for maintaining the magnetic field. These IG's do not depend on the power system for excitation and are hence called self-excited induction generators (SEIG).

- Three-phase Self-Excited Induction Generator (SEIG) can be built using a three-phase induction machine with per-phase connected terminal capacitors across the stator terminals. Three-phase loads can be connected across the stator terminals, once the generator starts to generate.
- Inverter assisted three-phase induction generator where the excitation requirement of a three-phase induction generator with change in load may be supplied from a static excitation converter like a three-phase inverter. The inverter DC bus may be alternatively connected to a photovoltaic (PV) panel as shown in Fig.1. The PV panels help in supplying real power when the generated power through IG alone is

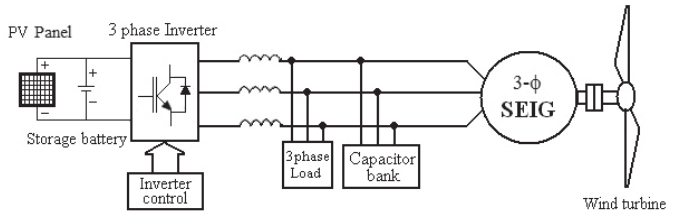

Fig.1. Three-phase self-excited induction generator with inverter...

insufficient to meet the load. The PV panel can also act as a source of reactive power during varying loads and wind speeds.

- Sometimes, a switched capacitor may be connected across stator terminals for supplying the extra reactive power requirement with change in loads or wind speeds for SEIGs. This practice is avoided nowadays because this causes switching transients.
- The three-phase SEIGs are favourable units for supplying small industrial loads. Although a lot of research has been done on large scale wind energy generation, only a handful of research has been done for small scale electricity generation from wind.
- Single-phase self-excited induction generators for supplying single-phase domestic and industrial loads are also being researched. For these induction machines, two windings are commonly available in the machine stator - the main and the auxiliary windings. One winding can be used to supply the excitation requirement of the machine while the other may be used to deliver power to the load. Single-phase SEIG suffers from the problem of voltage regulation and also poses problems in determination of excitation requirements.
- Inverter assisted single-phase induction generator scheme aims to increase the operating range of the generator and is shown in Fig.2. However, the issue of load voltage collapse may arise in inverter assisted IGs if load current increase, as a single battery may drain out with increase in load necessitating requirement of a backup source.

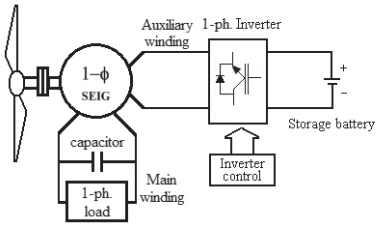

Fig.2. Single-phase inverter assisted induction generator...

- Three-phase induction machine is a cheaper alternative to a single-phase induction machine for similar power ratings in the upper ranges of power above 0.75 kW. Also, a three-phase induction machine will generally have smaller stator frame size than single-phase induction machine, which will enable the machine to be installed in smaller space. A suitable alternative of a single-phase IGs for micro power generation is a three-phase induction machine working as a single-phase IG supplying single phase loads.

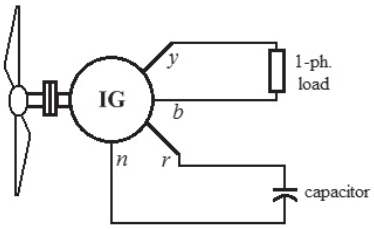

Fig.3. Three-phase induction machine operated as single-phase induction generator...

- Three-phase induction generator supplying single-phase loads can be thought as an alternative way of generating single-phase power. Such a scheme is shown in Fig.3.

The major drawback of a three-phase induction machine operating as a single-phase IG is its asymmetrical excitation or unbalanced loading arrangement. This creates unbalanced current flow in the stator and hence de-rating the generator is employed in all such schemes to limit the stator unbalanced currents.

- Three-phase induction machine with PV assisted inverter excitation is beneficial scheme than conventional generator of similar ratings for single-phase, grid secluded applications. With proper control, such a

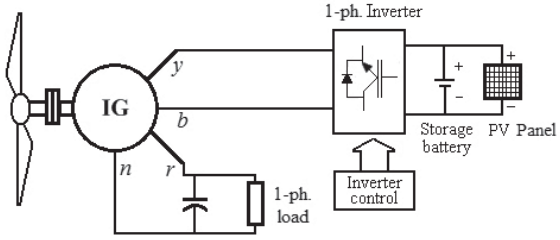

Fig.4. Three-phase induction machine operated as inverter assisted single-phase IG...

scheme of generation can be made balanced. Such a scheme effectively uses an inverter at the stator terminals. This scheme is shown in Fig.4.

A PV assisted wind standalone system is beneficial – as it increases reliability of supply. However, the economic consideration for such a

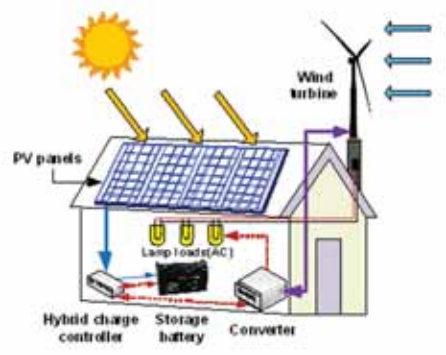

Fig.5. A PV assisted wind system domestic standalone setup...

scheme (Fig.5) has to be beneficial to the end user too.

An economical analysis is carried out for a single-phase generation using a wind turbine harnessing 1kW of power. Some decisive factors are taken into consideration for overall economic analysis. These factors include initial capital required to develop a wind-solar system, cost of energy and operating cost. A simulation study is conducted for the same using a conventional wind turbine system with rectifier-inverter (converter) and a wind turbine with PV panel and storage battery for the proposed system. The simulation is done based on projection time duration of 25 years with a domestic load of 5kWh/day and 600 Watts-peak load. The simulated system is shown in Fig.6, with the seasonal domestic load profile in Fig.7. Typical power curves obtained from an induction generator based wind turbine connected to the system is shown in Fig.8. The principal requirement for the proposed system includes the wind turbine–generator set priced at Rs. 1,00,000/unit for a 1kW machine. The operation and maintenance cost is taken as 2% of the initial capital

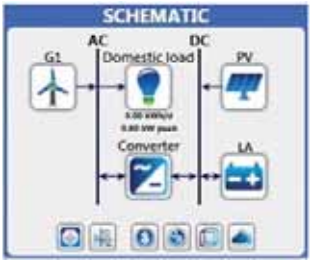

Fig.6. Schematic diagram of the simulated system...

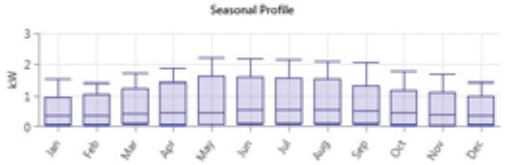

Fig.7. Typical seasonal load profile considered...

cost of the turbine. Cost of the converter system is taken at Rs. 7,000/unit for a 800VA system considered. For the proposed system, it is evident that the initial capital requirement is increased due to the use of PV panels priced at Rs. 25,000 for a 430W panel including charge controller.

12V 150Ah, lead-acid deep cycle battery is chosen which is priced at Rs. 15,000/unit which increases the initial cost of the system. The cost of energy comprises the costs for 430W PV panel, two battery units and 1kW wind turbine with inverter system for supplying the domestic load. Periodical cleaning of PV panel surface and watering of batteries are to

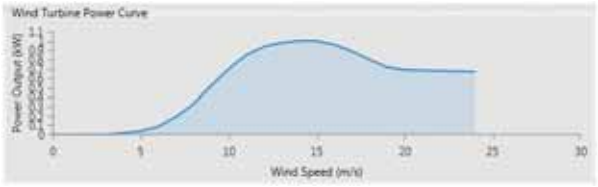

Fig.8. Power curves obtained from an induction generator based wind turbine...

Table: Economic analysis of a wind-PV system for grid isolated application...

Decisive factors	System Cost
Initial capital required (Rs.)	1,62,000.00
Cost of energy (Rs./kWh)	7.50
Operating cost (Rs./year)	1,500.00

be considered. The payback period of the simulated system is 25 years, by the time when purchased initial cost of the scheme will diminish and hence the system can be regarded as a cost effective for long run.

The batteries can be used to:

- Provide electricity during periods when the radiation obtained from the sun is low and during the night hours.
- Also, the batteries supply the necessary reactive power with aid from the PV panels during varying loads or during low wind speed operation.
- The system reliability is increased with PV panels and battery during fluctuating loads or low wind speeds whereas conventional IG systems are highly dependent on terminal capacitors only.
- However, there are some challenges associated with installing such a system.
- The engineering challenges presented by the structures, controls, electrical conversion and associated electronics are formidable.
- There is a need for satisfactory research cooperation between the private and public sectors to actively develop and use small scale wind generation technology indigenously.

Integrating a PV system although will increase the initial cost but will be a reliable technology for a domestic grid isolated system as shown.

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Bright Future *For* Energy Storage

While batteries are currently too expensive for large-scale use, improving technology is cutting costs, which means storage systems could replace some plants and avoid the need for new ones, as well as reduce demand for oil...

A narrow focus on cost alone may be leading to misconceptions about the real value of energy storage according to a new report by the World Energy Council 'E-storage – shifting from cost to value'. The report, which focuses on solar and wind applications, says that the focus only on investment costs is leading to the perception that energy storage is more expensive than it actually is because it ignores the system value of stored energy.

The report is calling for the true value of energy storage to be recognised by taking into account both its cost and revenue benefits. It looks at a number of storage costings across the technology spectrum to conclude that the widely used levelised cost of energy methodology is hindering the progress of energy storage. The analysis identifies 'double trouble' problems with the methodology, namely arbitrariness, which does not allow for differences in application cases, and incompleteness as only limited account of revenue is taken.

Christoph Frei, Secretary General of the World Energy Council, said, "Energy storage is a critical catalyst of the energy transition whose benefits are still undervalued. The costs have already come down, but will have to fall further for a much broader roll-out and use in household and e-mobility. The investment community has good reason to be excited about the innovation and business models that will emerge from new opportunities.

The report also estimates that with the many new technologies in the pipeline, storage costs of energy will fall by as much as 70% over the next 15 years. Solar storage will become more competitive as new battery technology drives prices down, and wind storage more attractive as technical advances in areas such as composite materials enables the power generated by wind turbines to increase. While batteries are currently too expensive for large-scale use, improving technology is cutting costs, which means storage systems could replace some plants and avoid the need for new ones, as well as reduce demand for oil.

In order to create the right policy environment that will unlock the potential of energy storage, and capitalise on its true cost and value benefits, the report makes five recommendations to policymakers:

- Go beyond just costs – cheapest is not always best
- Examine storage through holistic case studies – generic cost estimates are not sufficient
- Work with operators and regulators to accelerate the development of flexible markets – often the full value of flexibility is not sufficiently recognised and monetised
- Establish supporting policies and an enabling regulatory framework to facilitate further commercial deployment of storage technologies
- Consider storage as a key component for grid expansion or extension.

However, the report warns that the value of stored energy needs to be assessed on a case by case basis because revenue streams will vary over time, and between countries as they are dependent on the market, policy regime and variability of competing resources.

Frei further added, "To take full advantage of the growing wind and solar electricity shares, policymakers must review electricity market design so to incentivise the build-up of storage capacity and ensure reliable and affordable electricity supply."

The World Energy Council report 'E-storage – shifting from cost to value' is the work of 23 leading industry and academic experts from across the world, who are in the World Energy Council Storage Knowledge Network. The lead author is DNV GL with PwC making a significant contribution towards the cost analysis.

The Storage Knowledge Network is one of 15 Knowledge Networks in the World Energy Council who will all be preparing reports for the World Energy Resources flagship study, which will be presented at the 23rd World Energy Congress in Istanbul, Turkey in October 2016.

ELECTRICAL REVOLUTION Triggered

The authors propose a smart apparent energy metering solution that offers ROI in less than a year. They also highlight the benefits of using the unit (kVAh) of the correct apparent energy parameter...

To achieve a smart electrical grid, both HT and LT sectors need to be fitted with smart meters. Since LT represents the bottom of a pyramid with a wide base (large number of small consumers), such an implementation poses a big challenge, particularly due to the higher cost of smart technologies. On the other hand, the high amount of Aggregate Technical and Commercial (ATC) losses in the LT power sector offers an elegant scope for exploitation of the smart technologies in the LT.

High technical losses are primarily due to overloaded systems with high currents flowing to feed poor power factor loads. In this article, we highlight the importance of defining Power Factor (PF) and apparent energy correctly for effective reduction in the technical losses. Next, we demonstrate the use of smart LT apparent energy (kVAh) meters supported by a fair apparent energy based tariff.

This elegant single parameter based tariff incorporates an embedded power factor based discount mechanism to offer a Win-Win solution, where consumers can avail discounts in their electricity bills while the utilities minimise their line losses through reduction in harmonic and reactive currents. Its successful pilot implementation at Anand, Gujarat is covered in this article.

Introduction

The century old electrical network share is under challenge. While the energy generation landscape is changing with a drive for small and non-carbon based generation technologies, the demand side, too, is witnessing a change due to a push for a greatly improved efficiency, with the networks enabling the consumers to interact with them. These 'smart' networks are becoming more and more consumer centric with fundamental changes in the design and control of networks. And when billions of dollars are being spent on building the elements of our 'smart' electric power grids, framing and adhering to standards and protocols to achieve inter-operability of the smart grid devices and systems, gain significance.

India has been facing numerous problems due to insufficient generation and transmission capacities and overloaded distribution systems. One of the topmost issues is that of high Aggregate Technical and Commercial (ATC) losses and the resulting high tariffs. To counter this problem, the Ministry of Power (MOP), Govt. of India, in 2001, had initiated large scale deployment of static (electronic) meters under its 'Accelerated Power Development Program'. Even as the execution of the 100% metering program is in progress, these meters are facing a threat of obsolescence. Unless, the MOP and its technical wing – Central Electricity Authority formulates a framework in India for its own smart grid, a lot of investment that it is envisaging for strengthening the power sector would face a threat of becoming prematurely obsolete.

Implementation of the Smart grid in the LT sector is challenging due to its large number of small consumers. The additional cost of smart Advanced Metering Infrastructure (AMI) is a big burden for the Indian electric utilities.

In the developed countries, smart metering aims to shave off the peaks and flatten the load curve through Demand Side Management (DSM) techniques. But, in a developing country like India, the only manner in which AMI can be effectively adopted is by justifying the Return on additional Investment (ROI). Only if the smart project is made to addressthe ATC loss problem (in addition to DSM), can the cost of the smart technologies be offset against the savings in losses, making the project viable. We propose the use of smart LT apparent energy meters for effective reduction in ATC losses. In this article, we focus on the reduction of technical component of the ATC losses through the implementation of a fair apparent energy based tariff.

Smart solution for technical losses

While the utilities have been able to handle the poor Power Factor (PF) problem in the HT sector by incorporating suitable penalty mechanism in the tariff, the problem has been essentially unaddressed in the LT sector. As a consequence, the line loss in the LT feeders is observed to be considerably higher than that in the HT feeders. Due to the exponential relationship between the line current and losses, it is wise to take appropriate measures to reduce the current flowing in the overloaded LT lines.

War of currents – II

We have indicated how at the Centre for Apparent Energy Research, CAER, we are fighting the War of Currents – II (WC-II), more than a century after the WC- I was fought between Edison, a brute-force experimenter who promoted DC, and Tesla, a mathematician who advocated AC distribution. The AC generation at Niagara Falls in 1893, jointly by Tesla and Westinghouse, marked the defeat of DC. The key to the success of the AC system, then, was the ease with which AC voltage levels could be changed with simple and efficient transformers having no moving parts.

Today, while we are fighting the WC-II, the load scenario has changed considerably. In the LV distribution system, most of the home or office appliances incorporate electronic devices that operate on DC.

Hence, the need for AC to DC converters – internal (desktops, LCD monitors, LED Lamps) or external (mobile phones, cameras) that not only make the appliances complex and expensive but also inefficient (these black boxes are observed to invariably operate at poor PF and inject high levels of harmonic currents). By resorting to DC power distribution such as the '380 V DC wiring for Building wide Power Distribution', a single more efficient AC to DC converter at the building entry point can result in atleast 15% savings in energy.

However, DC distribution is a major change – and for a developing country like India it is advisable not to opt for this change keeping in view the high level of investments already put in for AC distribution. But, unless the utilities adopt stronger measures to become more efficient, we predict that the change-over to DC distribution is inevitable.

We, at CAER, support Tesla's AC system and believe that Apparent Energy tariffs can help the utilities resist the pressure to change over to a DC system.

The WC-II that we have initiated through the launch of Apparent Energy Tariffs and Metering in opposition to the well established Active Energy Tariffs is significant. While 'simplicity' was the theme Tesla chose to win WC-I, we have chosen 'power quality' to be the theme for winning the WC–II, and our focus is on harmonic currents and reactive currents.

Street lighting pilot

Empowered with recommendations from the Ministry of Power, and two separate directives from the Gujarat Electricity Regulatory Commission (GERC), CAER has been successful in demonstrating technical loss reduction to the tune of an amazing 92.7% in a pilot street lighting project involving three such feeders of Anand Municipality. The total power consumption per lamp (street lamp + line loss) was lowered down from the initial values of 58W and 108VA to the final values of 27W and 27.7VA respectively. This corresponds to current reduction of 73% and line loss reduction by 92.7% (seeTABLE I).

In other words, on project completion, the current and line loss levels were down to 27% and an amazingly low - 7.3%, respectively, from their original levels. A saving of 8 Watts (in line loss) amounts to a saving of Rs 11 per street lamp per month. If we consider a typical street light feeder with 80 lamps, this represents a savings of Rs 880 per month. Considering the cost of a smart energy meter to be Rs 1,600, the return on investment is less than two months.

More importantly, this pilot has given a basis for CAER's estimate of national level savings potential of Rs 15 million per hour. Through the implementation of an apparent energy tariff with 25% discount, CAER was able to demonstrate its effectiveness in reducing, both the harmonic current and reactive current levels. TABLE II. shows the street lighting (SL) tariff rates as offered by the GERC.

Table 1 Savings in Line Losses...

Action	Apparent Power Consumption	Apparent Power/ Current Savings	Line Loss	Line Loss Saving	Line Loss Savings / month[a]
	(VA)	(%)	(W)	(%)	(`)
Initial Condition	99		9		
Improvement of PF from 0.5 to 1.0	49	50	2.25	75	8.91
Reduction in active energy consumption from 49 W to 27W	27	23	0.66	17.7	2.10
Total		**73**		**92.7**	**11.01**

[a]. *Assuming tariff rate of Rs 4/kWh*

Correct definition of apparent energy

There is a lot of clutter associated with the measurement of 'apparent energy' that means different things to different people. For some, it simply replaces measurement of active energy and power factor, while for others, it may be a replacement for active and reactive energy measurements.

Even the official documents published by the Ministry of Power, Govt. of India, and the Regulators had erroneous or misleading interpretations of the terms 'Power Factor' and 'apparent power'. To get rid of the misconceptions, we have shown in, why apparent energy is a scalar and

Table 2 Street Lighting (SL) Tariff offered by GERC...

Tariff as per ERC directive	Active Energy Tariff	Apparent Energy Tariff	
	(Rs/kWh)	(Rs/kVAh)	Scope and Status
GERC Tariff Directive, in 2010 [3]	3.35	2.50	Pilot; Optional
GERC Tariff Directive, in 2011 [6]	3.60	2.70	All the four Gujarat State Utilities; Optional
GERC Tariff Directive (2015)	4.05	3.05	All four utilities; Optional

cannot be computed as a vector sum.

To eliminate scope for wrong usage, we have focused on the correct definitions of Apparent Power and Energy and justify why they cannot be defined in any other way. We chose to refer to the definitions of the IEEE Standard 1459 – 2010 released by the IEEE Power and Energy Society (PES) as a basis, and have thereby verified that our implementation of apparent power S, in Volt-Ampere (VA), as the product of RMS voltage, V, and RMS current, I, in our energy meters is correct. That is,

$$S = VI \qquad (1)$$

For a constant line power loss, and a constant load rms voltage V, the apparent power is the maximum active power that can be transmitted through the line. In other words, minimizing S means maximising the amount of useful energy transmitted while keeping the thermal stress of the line constant. It is surprising therefore, that such a key parameter remained dormant and unexploited for over a hundred years!

What is even more astonishing is that the parameter, which the electric utilities are currently measuring as apparent power is actually nothing more than the 'Fundamental Apparent Power', S_1, and considerably different from the original correct definition of apparent power, S. Probably the reason for the confusion is because both, S and S_1, share the same units – namely Volt-Amperes (VA). However, the basic difference crops up from the fact that, consistent with the IEEE 1459-2010 definitions, the fundamental apparent power, S_1, is measured using fundamental active and reactive components, according to

$$S_1 = \sqrt{P_1^2 + Q_1^2} \qquad (2)$$

It is interesting to note is that, though the old Ferraris meters have been replaced by sophisticated static ones, all the current meters still measure S1, wherein the harmonic currents go undetected.

Correct definition of power factor

The confusion in the definition of apparent energy does not end there. It has also been responsible for the confusion in the definition of another important parameter, namely power factor. Let us begin with the correct definition. The power factor PF is the ratio of active power over apparent power. It is dimensionless. $PF = \frac{P}{S}$

PF can be interpreted as the ratio between the energy actually

transmitted to the load over the maximum energy that could have been transmitted keeping the line losses the same. It is clear, therefore, that maximum utilization of the line occurs when P = S, and hence PF can also be considered to be a utilization factor indicator.

On the other hand, the fundamental power factor, denoted as PF_1, also dimensionless, is the ratio between fundamental active power P_1 and fundamental apparent power S_1.

$$PF_1 = \frac{P_1}{S_1}$$

Since S_1 can differ considerably from S in the presence of harmonics, it is clear that PF_1 can differ considerably from PF. Hence, it is clear that the measurements of kVAh and PF as taken by the electric utilities are incorrect in the scenario of non-sinusoidal currents.

Solving the neighbour's problem

To curb harmonics, we have shown the need for utilities to choose PF over PF_1 and measurement of S instead of S_1 or P. In spite of this deterrent, if harmonics continue to get injected, then there is still a major hurdle that needs to be overcome.

Assume that your neighbour is injecting large amounts of harmonics into the electrical grid. There is no doubt that he will be paying a much higher bill when billed on the basis of S instead of P. But what happens to the harmonic currents so injected. Ideally we expect that the utility would have active devices installed on the lines that quench these harmonics. This would prevent the harmonic currents from flowing through the grid, sneaking through and damaging sensitive electrical appliances at your home. In reality, utilities are observed not to take this responsibility.

In such a situation, the harmonic currents would enter your home and get registered by your S meter. Would this problem negate the use of S meters? No. The purpose of using S meters to encourage consumers to use resistive loads is still being met. In our case, if we use Smart Switched Mode Power Supplies (SSMPS), we can continue to operate at unity power factor by lowering down the S consumption to match the P consumption, thereby restoring your own bills back to normal levels.

In other words, the SSMPS has the capability of offering a resistive load to the distorted voltage waveform offered by the utility and distortedon account of such neighbours.

Moreover, we also expect the above example to be a rare occurrence. When an electrical revolution gets triggered with S as an enabler, the market forces would stabilize to a scenario where loads injecting high harmonic currents get systematically eliminated from the system.

The Smart Plug-meters...
(courtesy NXP Semiconductors)

Smart apparent energy meters

By taking commonly used electrical appliances, we have shown inTABLE III, that S is generally significantly greater than S_1. To be successful in effectively demonstrating the role of apparent energy tariffs in curbing loads that inject harmonics in addition to reactive loads, it is therefore essential that the energy meters record and display S instead of S_1. Keeping this in mind, CAER developed low cost meters that record true apparent power, S, (and not S_1) way back in the year 1996. However, it was not before fourteen years had passed that CAER could succeed in putting in place a pilot project with meters that record S instead of S_1.

In 2011, CAER redesigned the apparent energy meters and based on them a new energy metering chip – the EM773 from NXP Semiconductors that has an inbuilt metrology engine to compute S, as per the new IEEE 1459. Further, to offer a smart solution, the EM773 chip was connected to a two way RF transceiver – OL2381 (also from NXP), that gave it a wireless M-Bus communication capability.

Figure 2 shows the user interface offered by such a smart apparent energy meter. The differences between S and S1 or PF and PF1 for a typical household appliance can be observed from the readings displayed.

Looking at the project's success, GERC has changed the status of Street Lighting (SL) tariff from Pilot / experimental in 2010, to one that can be applied to any SL feeder under any of the four electric utilities throughout Gujarat state in 2011. Thus, CAER has succeeded in achieving billing on true kVAh, or S, on a non-experimental basis for the first time worldwide!

At the time of publication of this article, we

Table 3 Consumption of Common Electrical Appliances...

Description	Active Power	Apparent Power	Fundamental Apparent Power	Power Factor	Funda-mental Power Factor	THD Current
	P					
(Watts)	S					
(VA)	S_1 (VA)	PF	PF_1	THD_I		
(%)						
Compact Fluorescent Lamp (CFL)	35.24	61.09	36.57	0.58	0.96	133
Laptop Adaptor	22.61	46.91	22.99	0.48	0.98	178
LCD Monitor	15.48	32.42	17.01	0.48	0.91	162

Figure 2. The User Interface of the Smart Plugmeters...
(courtesy NXP Semiconductors)

have noticed a number of street light feeders in Anand and Vadodara districts that are billed on the basis of true kVAh (S). Big industrial estates, municipalities and even small village panchayats have opted to get billed on the basis of Safter replacing their old inefficient street lamps with smart dimmable LED lamps that operate at unity PF.

Conclusions

We have proposed a smart apparent energy metering solution that has ROI in less than a year. The benefits of using the unit (kVAh) of the correct apparent energy parameter, S, as a tariff unit include better power quality for a range of needs, while optimizing asset utilization and operating efficiency. EI

Dr Vithal Narasinha Kamat

Dr Kamat worked in the Centre for Development of Telematics (CDOT), Centre for Apparent Energy Research and, Centre for Embedded Software Engineering Solutions...XPSemiconductors

Narasinha Govind Kamat

He successfully revived Baroda Electric Meters Ltd., but later had to sacrifice it for the cause of kVAh metering...

Using Global Experience

Mitsubishi Electric is developing new technologies and solutions to make power generation, distribution and consumption far more efficient and environmentally friendly...

Energy From Waste (EFW) plants around the world rely on automated systems from Mitsubishi Electric to optimise performance and ensure the maximum levels of efficiency while also achieving rigorous environmental standards for emissions...
[Source: Mitsubishi Electric Europe B.V.]

Within the power industry, Mitsubishi Electric is moving on a growing market for small and distributed power plants, which are linked to the renewable power sector. Their full-life-cycle services and high quality technology qualify Mitsubishi Electric as the efficient partner for any power-generation project. Energy From Waste (EFW) plants around the world rely on automated systems from Mitsubishi Electric to optimise performance and ensure maximum levels of efficiency while also achieving rigorous environmental standards for emissions.

Interest in EFW has never been higher. In many countries a significant percentage of the demand for electricity could be met from EFW generation plants. This would massively reduce the need for waste disposal in landfill sites and would also make a major contribution to recycling targets.

Mitsubishi Electric has a long history of supplying turnkey Electrical, Instrumentation and Control (EI&C) projects to power generation plant operators across all continents of the world. This includes cutting edge technology, design, installation, commissioning and maintenance.

As well as in traditional power plants, Mitsubishi Electric has supported Energy from Waste (EFW), biomass and other new and emerging solutions. Within its experience, there are biogas-based generation at waste water facilities, electricity generation from steam turbines and district heating.

At the SPS IPC Drives 2015 Fair, Mitsubishi was showcasing several innovative solutions for the EFW industry, including the PMSX micro, a control system developed specifically for smaller plants, and the Virtual Power Plant that uses cutting edge control technologies to create a stable energy network by automatically managing multiple renewable power plants to work together and meet real-time energy needs.

PMSX micro is designed specifically for smaller scale applications. It runs on a single industrial computer and delivers proven control technology in an inexpensive and easily engineered package. Its integrated alarm and event system allows rapid responses to unexpected events and also records events and messages securely in sequence, allowing process flows to be traced in the event of problems or changes to the plant. Built-in maintenance functions and a range of analysis options help operators interpret process data and improve plant performance.

The Virtual Power Plant has been developed to meet the emerging need to integrate numbers of small green or renewable generation sites, such as solar, wind, wave, energy from waste, biogas, etc. While such sites can make a valuable contribution to the overall energy requirement, some tend to be non-constant in their operation. The Virtual Power Plant can monitor real time demand for power and co-ordinate the output of the generating sites to which it is networked to meet the demand at any point in time.

The powerful and flexible Mitsubishi Adroit Process Suite (MAPS), also being demonstrated at the show, was a life-cycle software tool that maximises values along the whole value chain. It is a single integration package that takes users through all the stages of a power plant project from the initial process, engineering and control system design stages, through the installation, commissioning and acceptance testing stages, to operations and regular maintenance and then later upgrades and redevelopment projects.

Mitsubishi Electric has recognised that energy costs will continue to rise over the coming decades and that climate-related taxes will grow ever more burdensome as governments across the world strive to incentivise industry to reduce emissions. This has brought the issues of energy management and emissions reduction to the fore, not only in the generation industries, but across all sectors.

While this is currently affecting energy intensive industries the most, it is inevitable that all businesses will have to periodically reassess their energy usage and energy management strategies. Therefore Mitsubishi Electric is developing new technologies and solutions to make power generation, distribution and consumption far more efficient and environmentally friendly.

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"Consumers should not go by special offers..."

Kusam-Meco introduced and pioneered the use of Digital Multimeters and Clamp Meters in the Indian industry. The company continues to introduce new products with unique features and protection – to meet current market demand and safety to cater to the customers' diverse applications. In an exclusive interview with Electrical India, Chandmal Goliya, Managing Director, Kusam Meco Import - Export P Ltd., is talking to P K Chatterjee about the evolution of the T&M instruments market in India and his company's product portfolio. Excerpts...

What kind of transformation has happened in the Indian Test & Measuring (T&M) instruments segment (say) since 1980?

Test & Measuring instruments, for nearly three quarters of the 20th century were mainly Analog Electrical Instruments. The instruments operated on the mechanical effects of electrical signals, which were indicated by the means of the displacement of a needle on a calibrated dial (scale). The analog mechanism involved many mechanical components and the instruments required more knowledge of mechanical engineering. The contribution of electrical engineering knowledge was comparatively less. Most of the instruments were made by hand, which increased the cost as labour cost increased. Moreover there was lot of dependence on the skill of the person making the instrument as well as the precision of the components.

As Electronic technology improved, leading to the invention of transistors & integrated circuits, from diodes & triodes more compact instruments with more function could be designed using those ICs.

Kusam-Meco introduced Hand Held Digital Multimeters & Clamp Meters way back in 1986 in India. Initially, we introduced 3 ½ digit Multimeters & 3 ½ digit Clamp Meters. It was a difficult job, but our perseverance paid off. Following the successful introduction of these products, many more Digital instruments were introduced by us. Today we have over200 instruments in our range – out of which almost 50 instruments have 'UL' certifications with highest safety levels.

How is the demand from the customers changing in this segment?

The demand for Test & Measuring Instruments by customers is changing from low cost instruments to high safety instruments. Hand Held Instruments are used by holding the device in the palm and taking the measurement of various electrical parameters such as Current, Voltage, Resistance.

Due to faults in the supply system or in the connection of the instruments, there is a possibility of the user suffering injuries. Hence, the demand from the customer is changing from cheap instruments to safer instruments. Also, due to new developments of electronics products like Computer, UPS etc., which generate lots of harmonics, the demand for the instruments is to include measurement of such parameters.

What kind of innovations have you done in your products as far as customers' advantages are concerned?

As I said earlier, customers now look for higher safety protection level in Test & Measuring Instruments. Kusam-Meco has about 50 instruments, which conforms to CAT III 1000 volt & CAT IV 600 volt safety levels. These products have been widely accepted by the users.

In addition, we have also added many functions such as VFD AC Voltage & VFD-Hz, Insulation Resistance Test with PI & DAR function, loop current measurement, Auto check DC/AC Voltage, dB function, CREST capture, Current Clamp adaptors, Logic Level frequency etc., within the same instrument – thereby making it easy for the user to make many measurements in one instruments. In other instruments also, there are many unique features added. Our company was also the first to introduce 500,000 counts hand held Digital Multimeters.

What kind of attention do you pay to maintain quality standard and consistency of your products?

The instruments marketed by us are designed to meet CE, IEC & UL standards. Once the pilot production is ready the instruments undergo all the tests specified in the above standards at an independent laboratory – to prove the compliance of the various requirements of each of the standards.

Only after the instruments pass the tests, mass production is commenced, and released in the market. Periodically also, representative instruments undergo all the tests at independent laboratory for compliance. Thus, the customer is assured of the highest quality.

Who are your major customers in India as well as abroad?

Our customers include: GAIL, NALCO, DRDO, TATA, Mahindra, Bharat Petroleum, ONGC, KIOCL Limited, BSNL, Hindustan Aeronautics, Steel Authority of India Limited, Sterlite, WIPRO, Reliance Energy, Reliance Infrastructure, Reliance Communications, TATA Steel, Indian Oil, CEL, Aditya Birla Group, NPCIL, APGENCO, AREVA, Jindal Power, Jubilant Life Sciences, ACC Limited, POWERGRID, AMBUJA CEMENT, National Thermal Power Corporation Ltd., Gujarat Heavy Chemicals Limited, ABB, Welspun, Lanco, ITI Limited, Aarti Industries, OCL India etc.

What kind of after-sales service do you offer to your customers?

Our company has ISO 9001: 2008 for providing 'Marketing & After Sales Service' for our products. We have trained our service engineers to calibrate equipments, to service, check and re-calibrate the instruments, which are received for servicing. The calibration validity of our standards are reaffirmed every year at NABL accredited Laboratories.

What are your new plans in 2016?

We will be displaying many new products at Elecrama. You will find in our stall: Gas Detectors, Multifuntion Power and Harmonics Analysers, Thermal Imaging Cameras, Process Calibrators, Insulation Multimeters, Infrared Thermometers, Digital Clampmetes, Digital Multimeters, Sound Level Meters, Digital Anemometers and Humidity and Temperature Meters.

What would you like to suggest to the T&M instrument buyers?

We would like to ask the Test & Measuring Instruments buyers not to be carried away by foreign names or cheap prices. They should check the quality and price of the products and the after sales-service provided by the company. Consumers should not go by special offers (low prices etc.) given by many companies to cover the poor quality or poor service of their products. EI

A Dedicated Service Provider To The Indian Power Industry

S. P. Industries is working towards the innovation and introduction of new products to fulfill the market needs...

SP Industries (Formerly M/s Shri Parameshwari Enterprises) was established in the year of 1994. It is an ISO 9001:2008 Certified Company. The company is one of the leading manufacturers & marketers of 'AMBER' Test and Measuring Instruments for the power industries.

They are constantly involved in the development activities in consultation with their technical advisor, and their success can be attributed to experience, as well as to their high standards of Quality and Innovation. Reliability and trust-worthiness form the hall mark of quality of the products being manufactured by S. P. Industries.

Their calibration standards are certified by NABL accredited standard calibration laboratories like ERDA, CPRI, ETDC etc. Calibration certificates for their products can be issued from S. P. INDUSTRIES.

Their service engineers provide installation and operation training for their products. Training includes proper operation of test sets, routine maintenance procedures etc.

They provide service and support at clients place. Also, they have an in-house service and support facility to assist customers in making cost effective and correct use of a product.

The support includes assistance in planning, installation, training, troubleshooting, maintenance and upgradation of a product. They have a unique unit for sales and service as well. Their major support goes to the Manufacturers of Transformers, Motors, Generators, Switch gear equipments, HT/LT Coils, Transformer oils and organizations handling Power Generation, Transmission and Distribution.

SP Industries also caters to the Service Providers, who erect and commission the substations, National level standard Calibration and Research Laboratories.

They are working towards the innovation and introduction of new products to fulfill the market needs.

Last, but not the least is their valuable clients include ERDA, CPRI, ERTL, MPSEDC, SHANTHALA, BSPHCL, KPTCL, WBSETCL, TNEB, KSEB etc. And major corporations include L&T, Godrej, Toshiba, BMC, Kappa, CGL and GE.

Middle East Feeder, Distribution Pillar Market To Grow

Growing needs for effective low-voltage electrical distribution across medical centres, hospitals, educational institutions, retail parks, shopping centres, and office buildings are expected to boost adoption...

The Middle East feeder and distribution pillar market is anticipated to reach USD 217.4 million by 2022, according to a new study by Grand View Research, Inc. The regional industry is characterized by vast investment in the power sector due to rising electricity demand across the residential and commercial areas.

The industry is expected to witness rise in demand in commercial and light industrial applications over the forecast period. Increasing need for efficient low voltage outdoor electricity distribution along with emerging real estate sector and industrial growth in the region is anticipated to drive demand over the next seven years.

Industry players use premium quality raw material for manufacturing to ensure features such as low maintenance cost, resistivity to adverse conditions, and high endurance.

They also offer customized solutions based on the contract or tender to cater to specific needs of the customer.

Technological advancement such as smart-grid compatibility may add new dimension to product features, which is anticipated to spur industry growth over the next seven years.

Strong Research and Development (R&D) activity is expected to be a crucial success factor for feeder and distribution pillar market players.

Growing needs for effective low-voltage electrical distribution across medical centres, hospitals, education institutions, retail parks, shopping centers, and office buildings are expected to boost adoption over the next seven years.

But, fluctuation in raw material and crude oil prices may adversely affect growth, as the Middle East economy is highly dependent on oil prices.

THE ADVANCED TEST EQUIPMENT FOR THE POWER INDUSTRY

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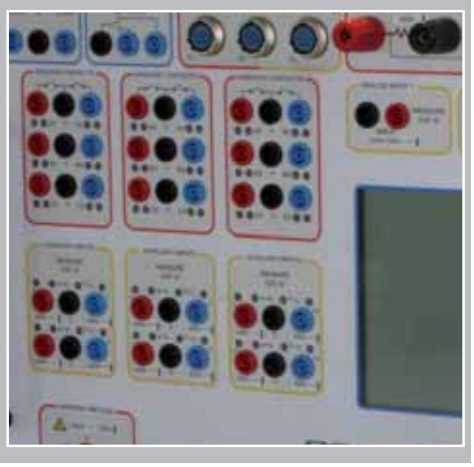

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DEIF Offers

A Complete Power Management System

AGC-4's power management package enables you to configure your own system from one genset to multiple mains, multiple gensets – up to 992 gensets in the same application...

In recent times, new technology and increased environmental awareness, combined with the liberalisation of the power sector, have led to a boom in decentralised power production. An increased demand for high quality emergency power plants is another trend, as critical applications like Data Centres, Hospitals, etc. demand close to 100% secure, reliable electric supply. The control of decentralised power production and emergency plants orders for highly advanced and specialised technology.

DEIF's robust and reliable Automatic Genset Controller, AGC-4 features proven technology that is flexible and suitable for a wide variety of complex applications that has a mix of Solar, Gas, Hydro and Steam power plants,both for power generation and emergency power supply.

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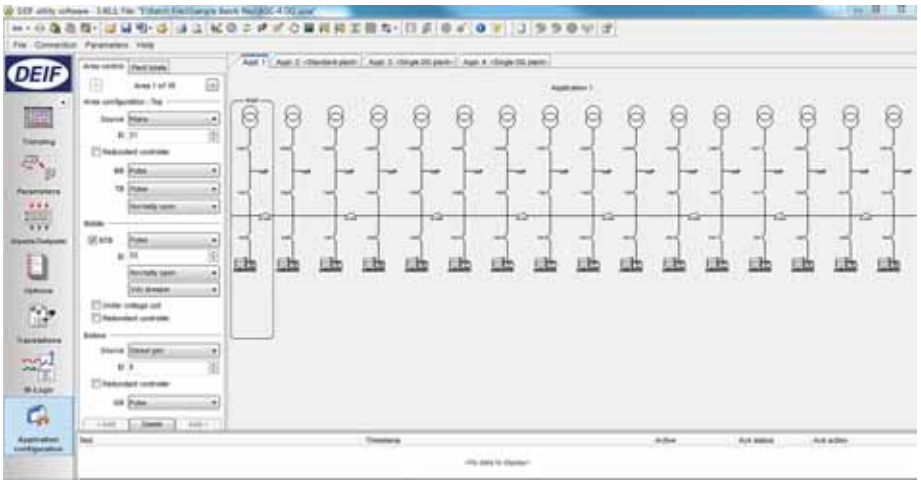
AGC-4's power management package enables you to configure your own system from one genset to multiple mains, multiple genset up to 992 gensets in the same application. The complete power management system can easily be monitored from the PC utility software through a graphical supervision page. Running status, hours in operation, breaker status, condition of mains and busbars and fuel consumption are just some of the values that are presented.

Multi-master system and internal redundant communication between the controllers make it safe for operation with master backup. Every DG can be the commanding unit. Basic functions under power management include load-dependent start/stop operation, priority selection of genset, priority selection of mains (ID to Run), load management, multi-start DG control, ground relay, heavy consumer control, non-essential load trip, and quick setup.

Extendable multiple displays

Up to 3 displays can be connected over the CANbus to one controller to replicate the parameter values. These display units can be placed 30 metre away from the controller unit, example one display unit can be mounted on the controller unit near the genset in the machine room, one in the switchboard room and the third in plant control room, all connected over the CAN line.

Each AOP has 16 tricolor configurable LEDs and 8 configurable push-buttons. All LEDs can be configured for both alarm and function indication via the PC software. AOPs make it possible to optimise the panel perfectly for the exact application for lamp indications relevant to the operator, reducing panel size,save wiring, and ease troubleshooting.



The number of components on your switchboard/panel can be reduced as AGC-4 has all protections functions and measurements can be viewed on the display, with synchronisation and load sharing includedenabling easy overview and operator-friendliness; while saving additional cost of meters.

Modular controller

AGC-4 controller isa modular controller wherein, it is possible to reconfigure the options to suit the last minute changes in the application giving you the much needed flexibility in hardware and software. While in service, it is also possible to replace only a faulty card by sending it to our repair centre without scraping the entire product. This proves to be economical as the service & replacement of card cost can range up to 30% of the unit cost, depending on the fault.

Scalable system

Aiding your future growth and expansion plans, DEIF's controller system is fully scalable, multi-master system of up to 992 genset with plant management option in one application, without making major modifications in the existing project. When building your applications, the AGC-4 allows you to change from island mode i.e., a single genset into a multi-purpose application.

Easy installation

The AGC-4 controller is base mounted which implies that all the cabling is done at the back, inside the panel which diminishes the load of cables on the

panel door. The display can be mounted on the switchboard/panel front or directly on the top of base unit thus saving space.

Serviceability

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

Fuel optimisation

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

Fast energy backup

AGC-4 controllers are capable of synchronous starting of multiple genset using Close Before Excitation and can deliver record start-up from an impressive less than ten seconds for multiple genset in parallel, redundant control systems, or even an entire redundant power plant. Switching over the load of whole plant quickly to backup genset is made efficient using digital voltage control.

With all its features and functionalities, AGC-4 proves to be the superlative of all controllers available in market today.

For more information, please feel free to write us at india@deif.com or contact DEIF India Pvt. Ltd. on (+91) 22 4245 2000.

ALL INDIA INSTALLED CAPACITY (IN MW) OF POWER STATIONS
(As on 31.12.2015) (UTILITIES)

Region	Ownership/ Sector	Modewise breakup							Grand Total
		Thermal				Nuclear	Hydro	RES * (MNRE)	
		Coal	Gas	Diesel	Total				
Northern Region	State	16538.00	2879.20	0.00	19417.20	0.00	7502.55	662.06	27581.81
	Private	13725.00	108.00	0.00	13833.00	0.00	2478.00	7187.08	23498.08
	Central	12000.50	2344.06	0.00	14344.56	1620.00	8266.22	0.00	24230.78
	Sub Total	42263.50	5331.26	0.00	47594.76	1620.00	18246.77	7849.14	75310.67
Western Region	State	21630.00	2993.82	0.00	24623.82	0.00	5480.50	311.19	30415.51
	Private	34271.00	4288.00	0.00	38559.00	0.00	447.00	13061.98	52067.98
	Central	12238.01	3533.59	0.00	15771.60	1840.00	1520.00	0.00	19131.60
	Sub Total	68139.01	10815.41	0.00	78954.42	1840.00	7447.50	13373.17	101615.09
Southern Region	State	14782.50	556.58	362.52	15701.60	0.00	11478.03	491.37	27671.00
	Private	6550.00	5557.50	554.96	12662.46	0.00	0.00	14968.59	27631.05
	Central	11890.00	359.58	0.00	12249.58	2320.00	0.00	0.00	14569.58
	Sub Total	33222.50	6473.66	917.48	40613.64	2320.00	11478.03	15459.96	69871.63
Eastern Region	State	7540.00	100.00	0.00	7640.00	0.00	3168.92	225.11	11034.03
	Private	8541.38	0.00	0.00	8541.38	0.00	195.00	234.43	8970.81
	Central	13001.49	90.00	0.00	13091.49	0.00	845.20	0.00	13936.69
	Sub Total	29082.87	190.00	0.00	29272.87	0.00	4209.12	459.54	33941.53
North Eastern Region	State	60.00	445.70	36.00	541.70	0.00	382.00	253.25	1176.95
	Private	0.00	24.50	0.00	24.50	0.00	0.00	9.37	33.87
	Central	250.00	1192.50	0.00	1442.50	0.00	860.00	0.00	2302.50
	Sub Total	310.00	1662.70	36.00	2008.70	0.00	1242.00	262.62	3513.32
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	60550.50	6975.30	438.57	67964.37	0.00	28012.00	1948.23	97924.60
	Private	63087.38	9978.00	554.96	73620.34	0.00	3120.00	35467.30	112207.64
	Central	49380.00	7519.73	0.00	56899.73	5780.00	11491.42	0.00	74171.15
	Total	173017.88	24473.03	993.53	198484.44	5780.00	42623.42	37415.53	284303.39

Figures at decimal may not tally due to rounding off

Abbreviation: SHP=Small Hydro Project (≤ 25 MW), BP=Biomass Power, U&I=Urban & Industrial W aste Power, RES=Renewable Energy Sources

Notes :

1. RES include SHP, BP, U&I, Solar and Wind Energy. Installed capacity in respect of RES (MNER) as on 30.09.2015 (As per latest information available with MNRE)
   *Break up of RES all India as on 30.09.2015 is given below (in MW):

Small Hydro Power	Wind Power	Bio-Power		Solar Power	Total Capacity
		BM Power/Cogen.	Waste to Energy		
4146.82	24376.26	4418.55	127.08	4346.82	37415.53

2. Installed capacity of Andhra Pradesh has been bifurcated in the ratio of 53.89 and 46.11 among Telangana and New Andhra Pradeh respectively. Except the installed capacity of Thamminapatnam (300 MW), Simhapuri (450 MW) and Tanir Bhavi (220 MW) are shown in the state of New Andhra pradesh.
3. *Koldam (1000 MW, four units) shares are provisional
4. Two units of Kondapall Stg-II of 371 MW each taken in private sector in A.P.
5. IPP Panipuram (2x660=1320 MW) , Tied capacity of 270 MW with Telangana and balance capacity of 1050 MW has been shown in Andhara pradesh
6. Baghlihar St-II,U-3 was commissioned in the month of October, 2015. At the time of preparation of report for October ,details of the project were not available . Hence, the project has been included this month onwards.

SOURCE: Central Electricity Authority, Government of India

INSTALLED CAPACITY (IN MW) OF POWER UTILITIES IN THE STATES/UTS LOCATED IN ISLANDS INCLUDING ALLOCATED SHARES IN JOINT & CENTRAL SECTOR UTILITIES (As on 31.12.2015)

State	Ownership/Sector	Modewise breakup							Grand Total
		Thermal				Nuclear	Hydro (Renewable)	RES (MNRE)	
		Coal	Gas	Diesel	Total				
Andaman & Nicobar	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	5.10	5.10
	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	10.35	50.40
lakshadweep	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	0.75	0.75
	Central	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sub-Total	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.75
Total (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
	Grand Total	**0.00**	**0.00**	**40.05**	**40.05**	**0.00**	**0.00**	**11.10**	**51.15**

SOURCE: Central Electricity Authority, Government of India

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Venue:
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Kusam-Meco offers Infrared Thermometer Model – IR-866

Model IR-866 is a new Handheld Infrared Thermometer introduced by 'KUSAM-MECO' an ISO 9001-2008 certified company. This model has MAX/ MIN/ AVG/ DIF functions, Adjustable high/ low alarm setting, Fast response time <250ms, Over range indication, Auto Power Off function and Diode Laser Output (Class 2).

It has high accuracy with measurement range -50ºC~2250ºC (-58ºF~4082ºF) and D:S ratio of 50:1. Its spectral response is 8~14µm and adjustable emissivity of 0.1~1.0. It has Auto Power off feature, which shuts the meter after 20 seconds of inactivity.

The operating temperature is 0ºC~50ºC (32ºF~122ºF) and storage temperature is -20ºC~60ºC (-4ºF~140ºF). Its dimension is 191.5 (L) × 126 (W) × 60 (H) mm and weight is 299g. Its relative humidity is 10~90% RH for operating temperature and <80% RH for storage temperature. This meter supplies User's manual, 9V Battery and Carrying case.

For further information: www. Kusamelectrical.com

Moore Industries introduces temperature transmitters

Whether you are adding a single safety loop, have a few points to isolate, or need to augment a larger Safety Instrumented System, Moore Industries FS Functional Safety Series of instruments are there to assist.

Their FS Series products are designed and built in compliance with IEC 61508, the leading worldwide functional Safety standard.

In addition to their FS Series of products FMEDA (Failure Modes Effects and Diagnostic Analysis) reports are available on many of their products that are used in safety applications.

For further information: www.miinet.com

Monitran launches a combined velocity, temperature sensor

Monitran, a developer and manufacture of sensors and condition monitoring systems, has launched the MTN/2285STC. It is a dual-output sensor ideal for monitoring vibration and temperature levels in the same location and for protecting motors, fans, pumps, compressors and other assemblies with rotating parts.

Both of the sensor's outputs are in the industry-standard range 4-20mA and are suitable for direct connection to a Programmable Logic Controller (PLC), Distributed Control System (DCS) or other industrial controller.

Andy Anthony, Managing Director of Monitran, comments, "Changes in vibration or temperature levels tend to provide the earliest indication that a piece of plant or equipment is in need of maintenance, and in some cases warrants shutting down to avoid damage. With our new dual-output sensor, engineers can connect directly to any equipment that accepts inputs in the 4-20mA range in order to monitor both parameters for maintenance, control or emergency-shutdown purposes."

For further information: www.monitran.com

Current Transformer (CT) testers

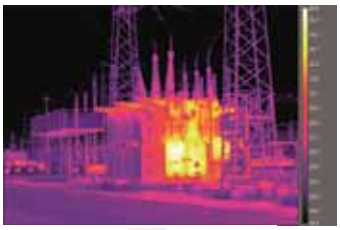
The CT-T1 is a microprocessor-based Current Transformer Tester that measures CT excitation current, turns ratio, and winding polarity tests, all without having to switch the leads during testing.

This CT Tester is precision-made, just like all of the Raytech products you already know. Built to stand up to the harsh environments of field testing, the CT-T1 comes with a 5 year warranty to guarantee years of accurate and reliable usage.

Raytech is a world leader in the design and manufacture of precision electronic measuring instruments and systems. The unique design approach of the engineering team at Raytech has resulted in the development of highly regarded measuring instruments, which have set new standards in the electrical testing industry. Our exceptional reputation for support and service is unmatched. Raytech products are designed for many years of trouble-free use, which is why we can offer a standard 2-year warranty – guaranteeing the highest quality instrumentation available.

For further information: www.ngepl.com

FLIR presents A310 PT



New Remote Monitoring System Features Thermal and Visible Cameras on a High-Performance Pan-Tilt.

The FLIR A310 PT pan-tilt unit enables you to distributesingle- or multi-camera solutions that cover vastareas. Utilizing standard Ethernet hardware andsoftware protocols, you can more efficiently control PileMonitoring, Warehouse Monitoring, Vessel Monitoring,Heat-Exchanger Monitoring and Sub-station Monitoring.

The FLIR A310 PT is an affordable solution for problemsdemanding built-in "smartness," such as image analysisand alarm functionality. Its precision pan-tilt mechanismgives operators accurate pointing control while providingfully programmable scan patterns, radar slew-to-cue, andslew-to-alarm functionality. Multi-sensor configurationsalso include a day/night 36× zoom color CCD camera onthe same pan-tilt package.

For further information: www.flir.com

Zero emission SF6 gas analyzer

TheZero Emission SF_6 Gas Analyzer is the latest in fully-automatic gas analyzers, and is designed for controlling and monitoring the quality of SF_6 in MV & HV gas insulated electrical equipment. Housed within a heavy duty IP66 Peli case; inclusive of wheels and handle, this portable field instrument weighs a total of 17kg (without accessories). A lithium battery provides up to eight hours of operation and a large gas storage bag allows up to five measurements to be taken before pump back is required.

Exceptional accuracy and stability are provided when measuring the purity of SF6 gas, through specially selected sensors. Other measurable gases can include H_2O, SO_2, HF, O_2 & CF_4.

A powerful 10 bar compressor, with a separate lithium battery power supply, then returns the gas to the electrical equipment at high pressure and 7'' inch (18cm) full color LCD display with touch screen operation and a built-in printer.

The analyses is pre-programmed with all current IEC and CIGRE test configurations. Measurement data is viewed in real time on the display and is saved to the analyses memory. Data is available for download via a USB memory stick in an MS Excel compatible format.

For further information, contact: info@atplonline.net

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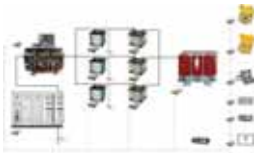

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