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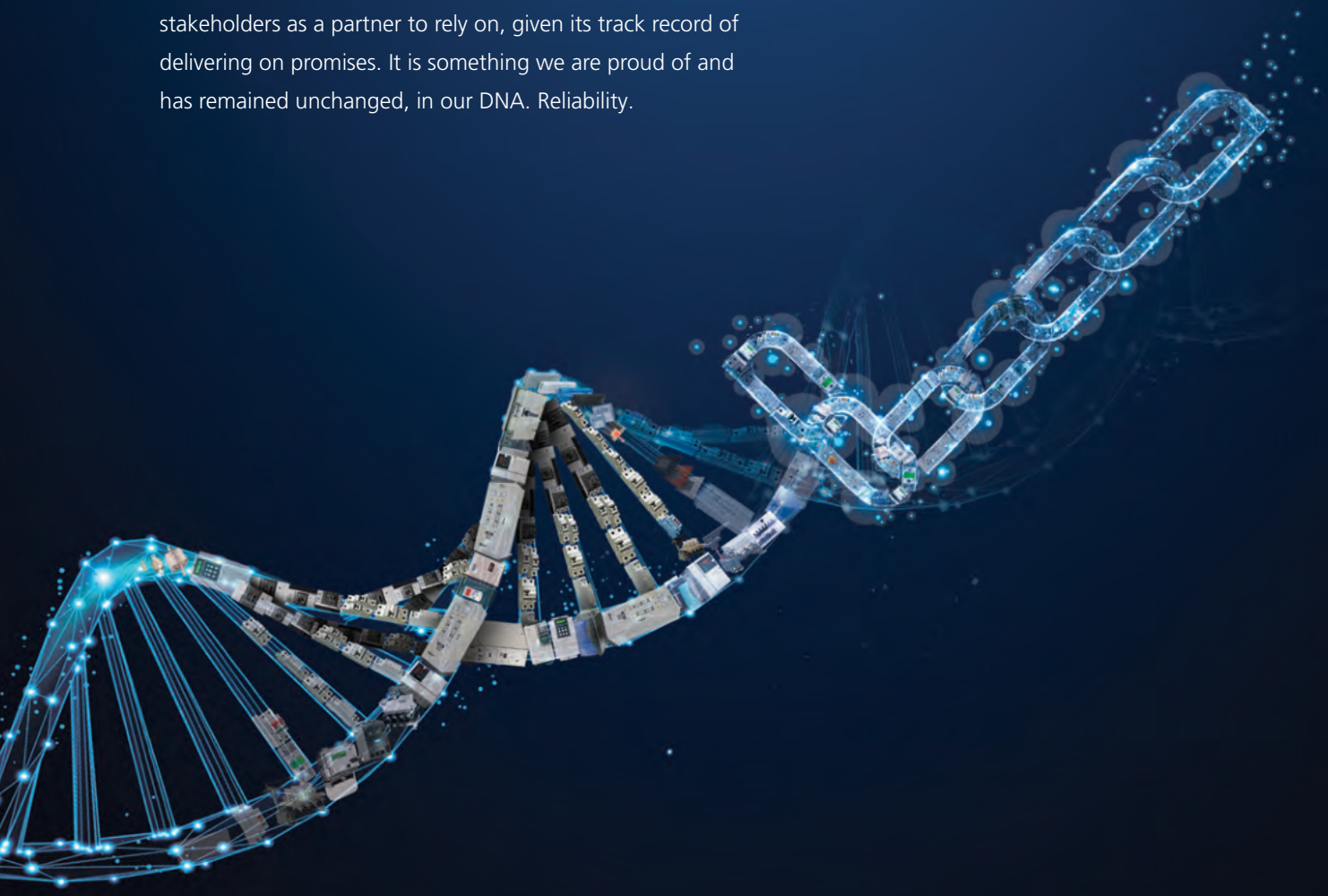

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From the Editor's and Publisher's Desk

Preparing for change...

We the team at the Electrical India Magazine are pleased to present you with the July 2020 issue. Amidst the chaos and the uncertainty prevailing in the present situation, we continue to discover our inner strength and the spirit we stand for. The focus for this month's issue is on smart grids, energy progress and management, transformers, energy storage, motors and cables. In this issue we also present you with an interesting read by BloombergNEF and Bloomberg Philanthropies which states the progress of clean energy. 'Increasing profitability, the way ahead,' would prove to be a very insightful read. An interview with Yash Dinesh Jain, Chief Marketing Officer, MicroSun Solar Tech, he gives us input on the company strategy adopted for the sake of product diversification. We have also featured interesting guest write-ups. One article is by Sopan Paithankar, Assistant Manager, Engie Solar India. The article focuses on energy management within the scope of energy generation and the consumption of electrical energy. We also continue from where we left the last time 'Part 2: A Review of Battery Charger Topologies and Infrastructure for Plug-In Electric and Hybrid Vehicles,' a very energetic article delivered by Dr L Ashok Kumar, Professor, Department of Electrical & Electronics Engineering, PSG College of Technology, Coimbatore.

Once again, I wish you a wonderful read. Do get in touch with me with your feedback.

Stay safe and stay connected!

Mahadevan

Publisher & Editor-In-Chief

Directors
Pravita Iyer
Mahadevan Iyer

Publisher & Editor-In-Chief
Mahadevan Iyer
miyer@charypublications.in

Commercial Director
Pravita Iyer
pravita@charypublications.in

Editor (Brand Positioning)
Ranjana Konatt
ranjana@charypublications.in

Editorial Assistant
Abegail D'mello
abegail@charypublications.in

Digital Marketing Executive
Smit Kubadia
smit@charypublications.in

Advertising Department
Head - Marketing
Yasmeen Kazi
yasmeen@electricalindia.in

Subscription & Marketing Department
Mariya Yenubari
sales@charypublications.in
sub@charypublications.in

Design
Sachin Parbalkar
Jebas Thangadurai

Accounts Department
Dattakumar Barge
accounts@charypublications.in

Chary Publications Pvt. Ltd.
906, The Corporate Park, Plot 14 & 15,
Sector 18, Vashi, Navi Mumbai 400703
Phone: 022 2777 7170 / 71
www.electricalindia.in

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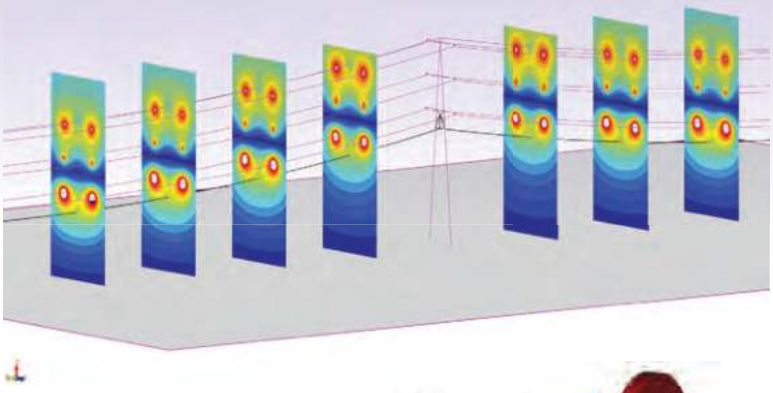

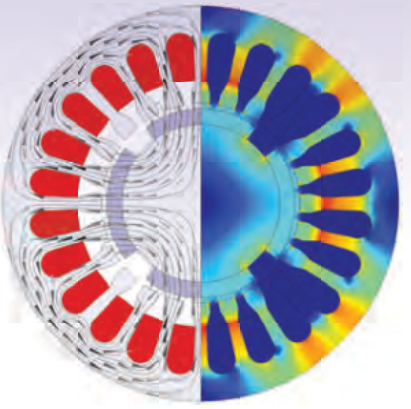

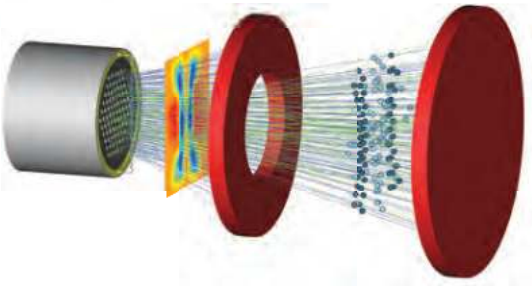

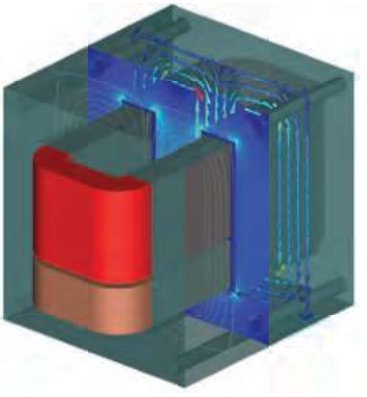

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Electrical India

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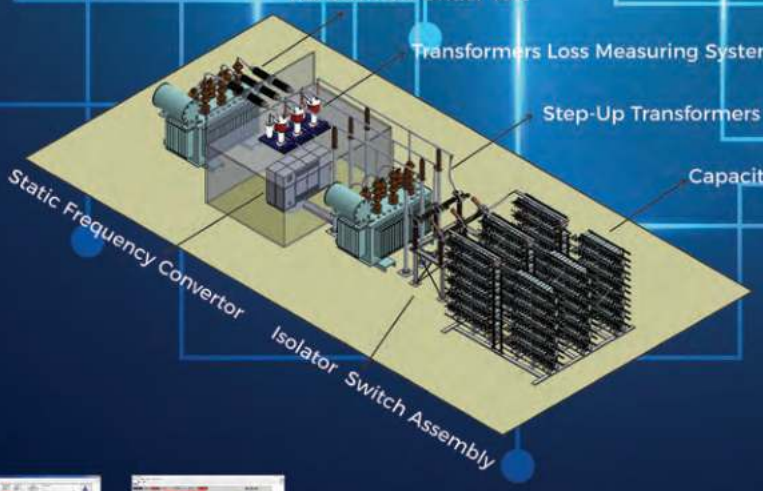
Assessing India's clean energy progress

The following text highlights a recent report by BloombergNEF and Bloomberg Philanthropies. Assessing India's clean energy progress and developing modes for clean economic growth

Integrated Transformer Testing Solutions



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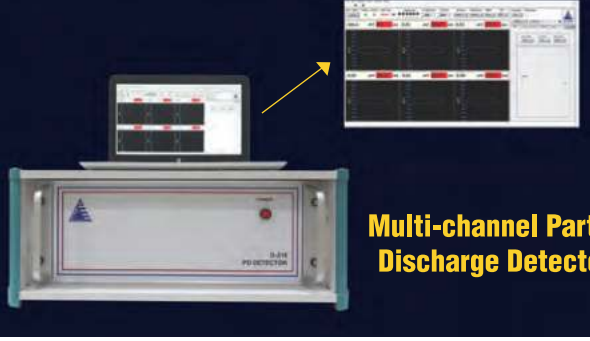

Multi-channel Partial Discharge Detector

APPLICATIONS

Routine and Type Test Equipment for the testing of:

- Power Transformers
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TATA POWER TO DEVELOP 120 MW SOLAR PROJECT IN GUJARAT

Tata Power, India's largest integrated power company, announced that Tata Power Renewable Energy Limited (TPREL), the Company's wholly owned subsidiary, has received a Letter of Award from Gujarat Urja Vikas Nigam Limited (GUVNL) on 12th June 2020 to develop a 120 MW solar project in Gujarat.

Photo by American Public Power Association on Unsplash

The energy will be supplied to GUVNL under a Power Purchase Agreement (PPA), valid for a period of 25 years from scheduled commercial operation date. The Company has won this capacity in a bid announced by GUVNL under Phase VIII dated February 2020. The project is required to be commissioned within 18 months from the date of execution of the PPA.

Speaking on this achievement, Mr. Praveer Sinha, CEO & MD, Tata Power, said, "We are proud to announce that we have been awarded 120 MW Solar Project in Gujarat, and are thankful to the Government of Gujarat and the officials at GUVNL for this opportunity. With this award the cumulative capacity of renewables will be 3,457 MW.

"We are pleased to announce our win and with we continue to demonstrate our strong commitment towards renewable energy as well as project development, engineering and execution capabilities. We hope to continue to build on our capabilities, deliver over expectations and create high benchmarks all around." said Mr. Ashish Khanna, President-Renewables, Tata Power.

The Plant is expected to generate about 300 MUs of energy per year and will annually offset approximately 300 Million Kg of CO2.

Tata Power's renewable capacity will increase to 3,457 MW, out of which 2,637 MW is operational and 820 MW is under implementation including 120MW won under this LOI.

STERLITE POWER ACQUIRES WRSS-XIX & NERSS-IX STRENGTHENING SCHEME FROM PFC

Sterlite Power, a leading global power transmission player, announced the acquisition of Vapi II North Lakhimpur Transmission Limited (VNLTL), a Special Purpose Vehicle (SPV) from PFC Consulting Limited. Through this SPV, the company will execute a large inter-state transmission system (ISTS) project - Western Region Strengthening Scheme-XIX (WRSS-XIX) and North Eastern Region Strengthening Scheme-IX (NERSS-IX), which it won through a tariff-based competitive bidding (TBCB) process, under the Build, Own, Operate and Maintain (BOOM) model for 35 years.

The Western Region Strengthening Scheme – XIX (WRSS-XIX) involves setting up of 318 ckm of lines and 1000 MVA transformation capacity across three distinct parts:

- Part A involves setting up 35 ckm lines in Gujarat to help distribute renewable energy being generated in the state to a wider set of consumers.
- Part B aims to establish a 1000 MVA substation in Vapi along with 51 ckm of lines to bring clean nuclear power from Kakrapar Atomic Power Plant in Gujarat for further distribution across the Union Territories of Daman, Diu and Dadra Nagar Haveli.
- Part C aims to set up 179 ckm of lines for critical system strengthening and decongesting the evacuation system in Navi Mumbai area. The link brings an ISTS feed of about 1000 MW into the Mumbai region to cater to its growing energy requirements which is expected to increase owing to Navi Mumbai Airport and Navi Mumbai SEZ, coming up in the region.

RENEWABLE ENERGY INDIA E-EXPO: A HIGH OCTANE EVENT

Renewable Energy India (REI) E-Expo, South Asia's first virtual renewable energy event by Informa Markets in India (formerly UBM India) concluded on a successful note 9th June 2020

Photo by Karsten Würth on Unsplash

The Renewable Energy India (REI) E-Expo, South Asia's first virtual renewable energy event by Informa Markets in India (formerly UBM India) concluded on a successful note 9th June 2020. The one-day virtual expo witnessed a footfall of 3860 attendees from71 countries. The global threat currently posed by COVID-19 and the subsequent stringent safety measures including travel restrictions, has impacted the exhibitions industry. This virtual expo by Renewable Energy India was crafted to consistently meet the needs of the renewable energy sector and enable professionals to sustain their critical business conversations and engagement and provide them with feasible solutions at a time when physical transactions are on a hold. Supported by Indian Biogas Association as Supporting Association and Cleantech Business Club as Visionary Partner, REI E-Expo also attracted support from Indo German Energy Forum - SO & Indo German Chamber of Commerce and brought together renowned brands, consultants, business experts and key Government officials pertaining to the sector under a common virtual platform. Speaking at the debut of REI's virtual expo, Yogesh Mudras, Managing Director, Informa Markets in India said: "The Covid-19 situation worldwide has made us rethink situations, adapt, innovate and move forward. While India continues with its Lockdown 5.0 version, it is witnessing the unlock 1.0. Currently, we are leveraging effective technologies available at our disposal as a global giant to ensure business stability and build expertise to mitigate the challenges brought about by COVID-19."

The inauguration witnessed a visionary address given by Charlie Gay, Founder of Greenstar Foundation; Former Director of the U.S. Department of Energy (DOE) Solar Energy Technologies Office; Visionary Advisor at CleanTech Business Club. Gay, also known as Dr Solar and a veteran with over 45 years' experience in renewable energy emphasized that "India has grown to support local manufacturing because the market is large enough to support it. The country has great opportunities in the clean-tech decade." Hans Josef Fell, President of the Energy Watch Group, delivered the Keynote Address.

Chaired by Shri Manu Srivastava, IAS, Ex-Principal Secretary, New & Renewable Energy Department, Madhya Pradesh and moderated by Justin Wu, Managing Director and Head of Asia-Pacific, BloombergNEF, the inaugural session was titled "Bringing future into focus: Fire chat with Global Leaders." The panellists of this session were leaders in the global renewable energy space such as Jinko Solar, AVAADA Group, Hero Future Energies, LONGi Solar, Premier Energies Limited, Vikram Solar, and Indo-German Energy Forum SO. The intriguing and engaging session emphasized on India's potential to be self-reliant and independent. The panel discussed about policy advocacy that needs to happen which helped give the RE sector the push it needed in the last many years. Most panelists acknowledged the fact that the RE industry in India had come a long way over the last five to seven years, though it is now suffering from a slowdown due to COVID-19 pandemic and lack of clarity about the govt's relief packages. The consensus call was that the government must treat the RE sector with care, address the uncertainties, and help must be provided when it's the most required.

GP GLOBAL LAUNCHES ITS FIRST SUSTAINABILITY PERFORMANCE REPORT, DRIVING SUSTAINABLE SOLUTIONS ACROSS ITS ENTIRE PORTFOLIO

GP Global announced the launch of its first Sustainability Report, demonstrating its commitment to delivering sustainable outcomes across its entire portfolio for the preservation of the planet and its inhabitants.

In support of the United Nations Global Sustainable Development Goals (SDGs) and the UAE 2030 Agenda for Sustainable Development, GP Global's Sustainability Report showcases an enterprise-wide review of the group's sustainability capabilities and objectives, which includes investing in non-conventional energy resources and expanding into Agri Trading markets, among others. With the mission to develop a sustainable product portfolio, GP Global will invest in non-conventional energy business markets including Biomass projects such as Briquetting Plants, Captive Power Plants and Steam Generation Plants.

Prerit Goel, Joint Managing Director at GP Global, said: "At GP Global, we believe that sustainable commodity solutions have the potential to deliver real progress and development when it comes to the health of our environment. Spearheading an important mission of developing an entirely sustainable product portfolio while contributing to providing solutions for global energy gaps, we at GP Global are actively exploring the Non-Conventional Energy space. "As a responsible organization, we have to think outside the box and ask ourselves how to achieve these sustainable fuel alternatives. While doing so, we aspire to create growth opportunities that benefit not only our business partners, clients and economies, but also our environment and society at large." Prerit continued.

CSR initiatives are also a key element of GP Global's Sustainability Report. Among several projects in the pipeline, GP Global have spent approximately USD 219,241 in creating indirect impact within society, with 65 percent of the value spent with the ASPAM Indian International School followed by JK Mangaliwala Charitable Trust. Other projects of note include construction of retirement homes, supply of equipment to these homes as well as orphanages, sports promotions and financial aid to poor students. EI

REMOTE RESTART TO WIND PROJECTS IMPACTED BY COVID

A recent industry study by RES (Renewable Energy Systems) finds Lidar to be fast at wind measurements than met masts presenting an opportunity to restart stalled wind projects safely and quickly

Embracing this opportunity, New Zealand engineering consultancy Energy3 has confirmed the immediate recovery of four wind development projects in New Zealand and Australia through almost instantaneous deployments of remote sensing Lidar device ZX 300, even with the presence of COVID-19 restrictions in each country.

Energy3 Services Ltd. has remained active in Lidar deployments and associated remote power supply provision throughout various levels of the 'lockdown'. The most recent deployments of ZX 300 have taken place in the North Island of New Zealand, and in NSW, Australia. Challenges were presented with the inability to travel regionally within both New Zealand and Australia however, with suitable planning, remote management and support, both Lidar deployments could be completed safely and on schedule.

"Lidars present the only solution for wind monitoring campaigns for deployment over this time – met mast work simply cannot not be undertaken in these situations. Lidars are quick to install without the need for intensive labour or heavy equipment components" commented Thomas Cameron, Founding Partner at Energy3. "Prompt turnaround and short lead-times from Lidar OEM 'ZX Lidars' means systems can be deployed within a matter of weeks from the time of order. EI

GUARANTEED 5 MILLION CYCLES AT A LOW PRICE WITH SLIM IGUS CONTROL CABLES

New chainflex M control cables have a 20 per cent thinner structure and save space in the energy chain

With its advanced chainflex M cable series, igus now proves that quality and low price are not mutually exclusive. After four years of research, the motion cable specialist presented the new control cables CF880/CF881 and CF890/CF891 at SPS. An up to 20 per cent thinner cable structure ensures lower bend radii. This allows the user to save installation space inside the energy chain and they are costs effective. The chainflex M series has a tested service life of five million cycles and comes with a 36-month guarantee.

A good e-chain cable at a small price! That was and still is the promise that drives the chainflex M series of cables, which igus introduced for the first time in 2013. Since then a lot has happened not only in mechanical engineering but also in cable development. Due to the increasing automation in the industry, faster and faster machines are called for. Accordingly, the development of lighter and smaller cables is required to reduce high accelerated masses. That is why igus is keen on further developing its cost-effective cable series without increasing costs. For more than 25 years, igus has been a specialist in the development of cables intended for use in the energy chain. The company tests its products under realistic conditions in the company's own 3,800 square metre test laboratory in Cologne - and these tests go on all the way until they fail completely. igus has been investing in the further development and long-term testing of its established chainflex M cable series for four years. The laboratory tests have shown that the cables can easily handle five million cycles. On all cables, including the optimised chainflex M series, igus issues a unique guarantee of 36 months worldwide based on its test data

ABB POWER GRIDS HYBRID HVDC BREAKER REACHES NEW LEVEL IN TESTING BY EU-FUNDED PROGRAM

Independent testing proves the maturity of the proprietary ABB Power Grids' technology, marking a major step towards power grids of the future

Full-scale, third party tests on ABB Power Grids' Hybrid high-voltage direct current (HVDC) breaker, carried out in the KEMA Laboratories (Netherlands) in front of attending European TSOs and grid developers, successfully proved the maturity of the technology. This development is significant in shaping the future of sustainable energy, increasing access to reliable and affordable energy for all.

The tests were performed as part of the 'Progress on Offshore Meshed HVDC Transmission Networks' (PROMOTioN) project, which was set up to unlock the full potential of Europe's offshore resources and tackle the technical, regulatory, financial and legal challenges to the implementation of these networks. The test program was developed under the PROMOTioN project and agreed with the other participating HVDC circuit breaker manufacturers.

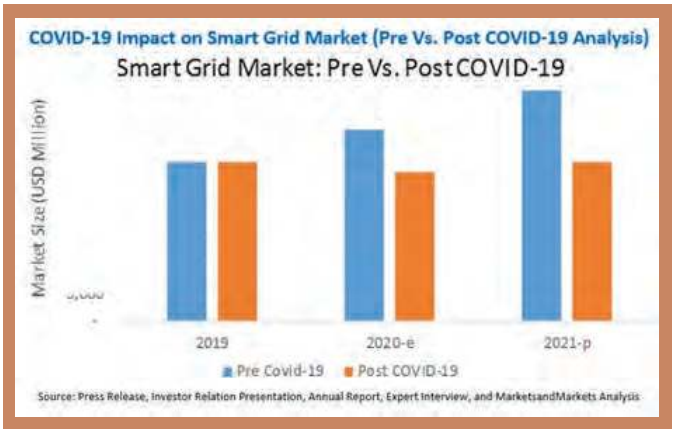
ABB Power Grids' Hybrid HVDC breaker removes a significant technical challenge in the development of HVDC grids, which has been a limitation for high voltage DC technology expansion. It permits the transmission system to maintain power flow if there is a fault on one of the lines; the breaker isolates the fault by breaking the direct current, even if extremely high-power levels are required. Earlier deployment of HVDC has led to an increasing number of point-to-point connections, and some multi-terminal systems, in different parts of the world.

Photo by Matthew Henry on Unsplash

Hardware segment market is expected to witness setback owing to the slowdown due to COVID-19, report suggests

MarketsandMarkets forecasts the smart grid market to grow from USD 23.8 billion in 2018 to USD 61.3 billion by 2023, at a Compound Annual Growth Rate (CAGR) of 20.9% during the forecast period. The major factors that are expected to be driving the smart grid market are modernization of aging grid infrastructure and increasing. Also, hardware is the core component of a smart grid infrastructure as it increases the flexibility of the electrical power grid. It includes various power products such as smart meters, controllers, routers, switches, wireless access points, bridges, gateways, hubs, repeaters, load tap changers, protective relays, and sensors. These hardware devices capture numerous data from both consumers and energy utilities to derive useful information and insights. The growth of the hardware segment until recently was driven by the transformation in the electric power sector, which focused on replacing aging assets with smart grid systems as this would enable power utilities to monitor and control the supply chain efficiently. However, the scenario is not the same after the outbreak of COVID-19. Manufacturers of smart grid hardware components are facing several issues related to order closures on time due to global lockdown. Also, there are delays in receiving raw materials from suppliers, primarily located in China and other Southeast Asian countries. These issues are taking a toll on manufacturers situated around the globe.

To name a few players in the smart grid market, we have GE (US), ABB (Switzerland), Siemens (Germany), Schneider Electric (France), Itron (US), Landis+Gyr (Switzerland), Aclara (US), Cisco (US), OSI (US), IBM (US), Wipro (India), Oracle (US), Honeywell (US), S&C Electric Company (US), Eaton (Ireland), Kamstrup (Denmark), and Trilliant Holdings (US), among others. GE is a globally diversified technology and financial services company. It operates through five business segments, namely, power, renewable energy, aviation, healthcare, and financial services segment, Capital. The company offers grid solutions equipment and services through its renewable energy business segment, which accounted for 17.6% of the total net sales in 2019. The company provides smart grid technologies and operations management systems for water, gas, electric utilities, and renewable energy. The company is the largest and most profitable smart grid infrastructure company in the world. GE offers all types of products and services for the energy, utility, and power industries. In the field of smart grids, GE provides solutions that are reliable and optimize the end-to-end grid operational efficiency.



Further, due to the impact of COVID-19, GE, for the first quarter of 2020, anticipates a negative impact on GE Industrial free cash flow of approximately USD 300–500 million, as well as a negative impact on operating profit of approximately USD 200–300 million.

Surge protection devices are also playing a vital role in keeping system and apparatus safe from surge and spike. At normal operating voltages, the SPDs are in a high-impedance state and do not affect the system. When a transient voltage occurs on the circuit, the SPD moves into a state of conduction (or low impedance) and diverts the surge current back to its source or ground.

Source: A report by MarketsandMarkets

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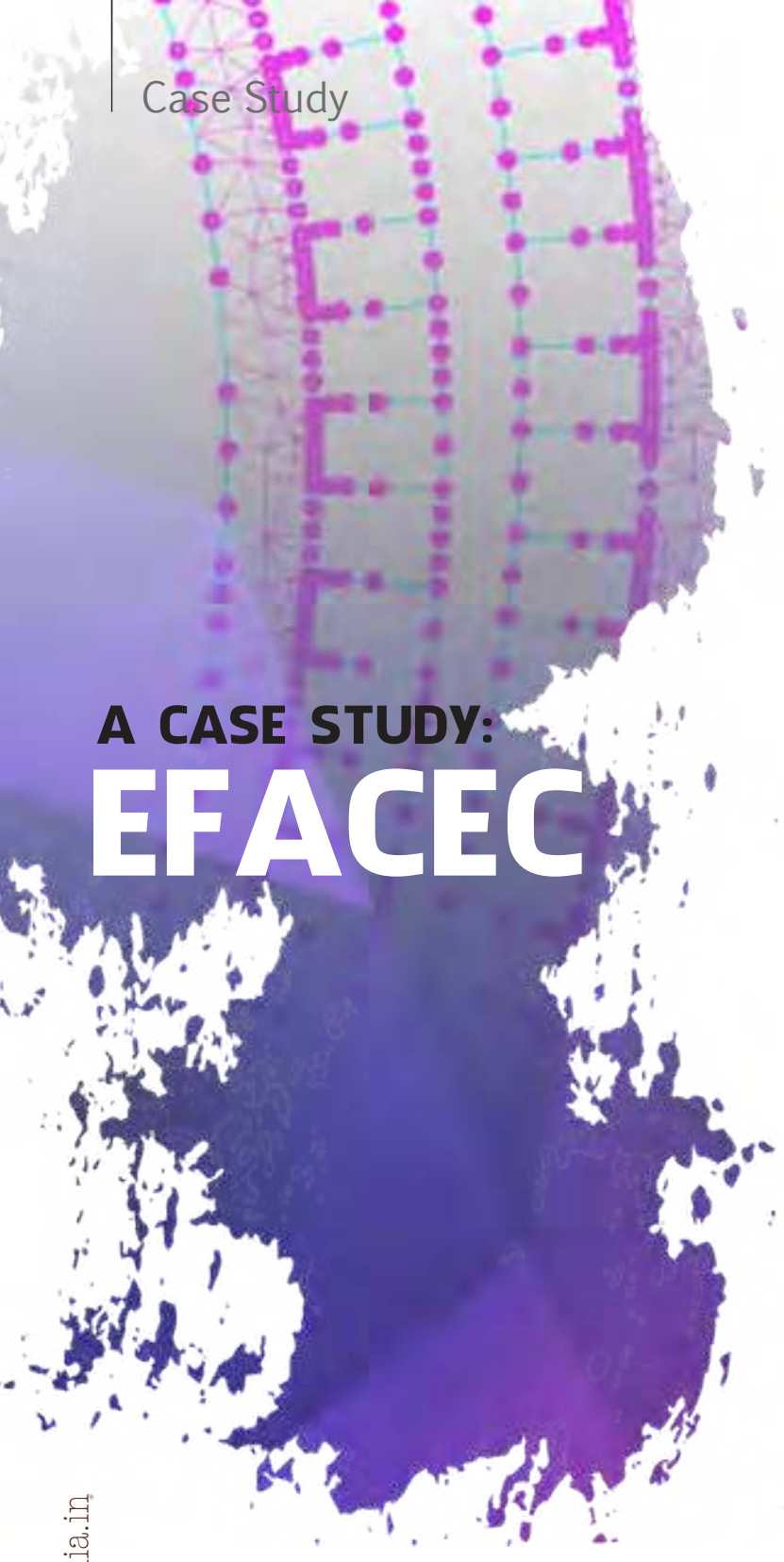


A CASE STUDY: EFACEC

Carlos Carvalho, Director of Technology at EFACEC, discusses the benefits of software modelling in the design and test of transformers

The EFACEC Group is leading the supply of integrated solutions and equipment in the market of power generation, transmission and distribution. The Group forms a complete value chain, from building turnkey projects to equipment manufacture, where integrated solutions are developed and designed in accordance with clients' needs. The Group offers a comprehensive range of activities such as: Power Generation, Transmission and Distribution, Automation and Telecontrol Systems, Electric Mobility Power Supply Systems as well as Maintenance and Technical Assistance Services.

The director of Technology, Carlos Carvalho, leads a 120 - -120 strong Engineering team in the EFACEC Power Transformers business unit: "Our division has the capability to design and manufacture Core and Shell type power transformers up to 1500 MVA, 525 kV, mobile substations up to 90 MVA, immersed and dry type distribution transformers. As such, a core element of EFACEC's business is the design and manufacture of power transformers. In the current market, transformers need to be ever more effective and competitively priced. To do this, we at EFACEC employ simulation software to build virtual prototypes of the system prior to manufacture, to avoid wasting time on costly mistakes."

He continues, "For the past 26 years EFACEC has been using simulation software from INTEGRATED Engineering Software to help iron out any design issues in the early stages, before they prolong the design lifecycle. The software we use at EFACEC are the ELECTRO, COULOMB, FARADAY and INDUCTO products. ELECTRO is a 2D/RS electric field solver designed specifically for applications such as transformers. ELECTRO can calculate electric field strength, transmission line parameters and capacitance. Our designers can automatically vary and experiment with geometry, materials and sources, therefore reducing the tedious, repetitive task of fine–tuning multiple design parameters. COULOMB is, by contrast, a 3D electric field solver used for calculations such as electric field strength, transmission line parameters and capacitance. Finally, FARADAY is a 3D eddy current field solver which can calculate force, torque, displacement current, flux linkage, induced voltage, power and impedance."

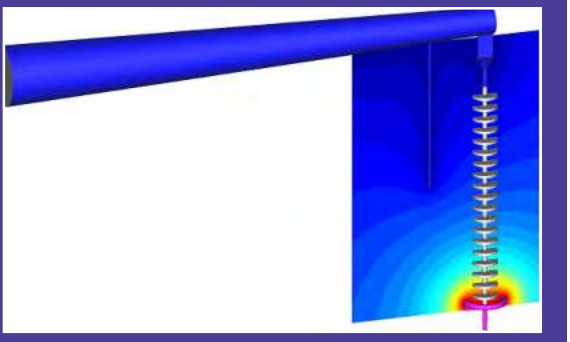
Despite using software simulation, a yet unsolved problem in the design of transformers came to light. The weak link theory was adapted to the design of the insulating structures inside oil immersed power transformers. The stratified insulation media is composed by pressboard barriers and oil channels. The dielectric permittivity of the pressboard is twice that of the oil and so the electric field accumulates in the oil channels. The oil dielectric strength is also much lower than that of the pressboard, so, in theory, if you can guarantee the dielectric strength of the weak oil, then the whole insulating structure will withstand the electric stress.

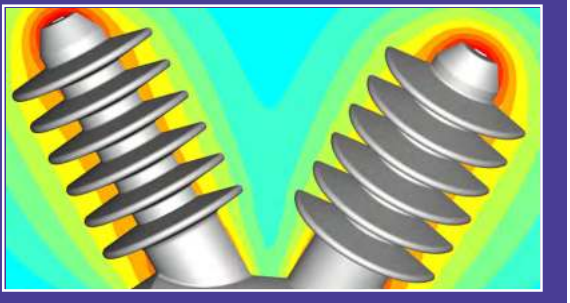
This empirical knowledge was developed initially by some power transformer manufacturers, and later, became public knowledge through technical papers published by Weidmann, a major supplier of pressboard to the power transformer industry. Weidmann carried out several research experiments toto settle the oil-curves, a group of decaying exponential E-field strength versus length curves that are accepted as almost the standard in the transformer industry.

Carlos continues, "We at EFACEC came across this theory and requested that INTEGRATED develop it into a software solution for inclusion in its programmes. INTEGRATED wrote a programme which was capable of this feature, effectively turning theory into reality." In less than a month, EFACEC had a custom-made solution to its problem, known as the partial discharge (PD) inception dialog feature.

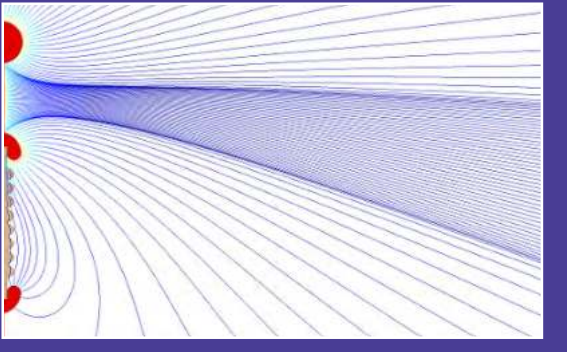
"The Partial Inception dialog feature helps us in our modelling and design phase by enabling us to simulate the dielectric tests and to evaluate the dielectric strength of the insulating structures between the windings, the leads, the bushing tails and the tank turrets etc. In the power transformer industry, we can say that each transformer produced is unique, therefore during the design phase, each transformer is like a prototype and so there are constantly new challenges to analyse", says Carlos.

There are many other applications for which the PD inception analysis may be useful, as it does not impose the base and the exponent of exponential oil curves. Therefore, users can replace these oil curves with their own air curves, silicon curves, tangential to porcelain curves or similar. Carlos concludes, "We at EFACEC strongly advocate the use of modeling software to test designs as it cuts costs and supplies real flexibility, particularly where a product range comprises of major elements, large transformers in this case, which are always slightly different from the last one manufactured. Even with our very specialised applications we have been able to achieve all the capabilities we require from software simulation."

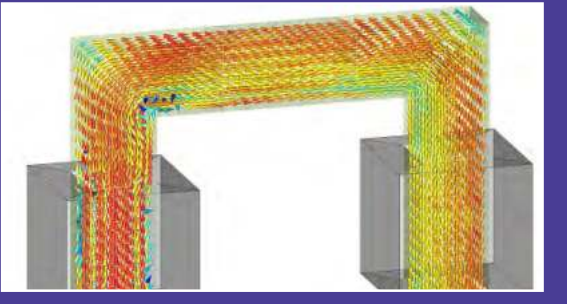




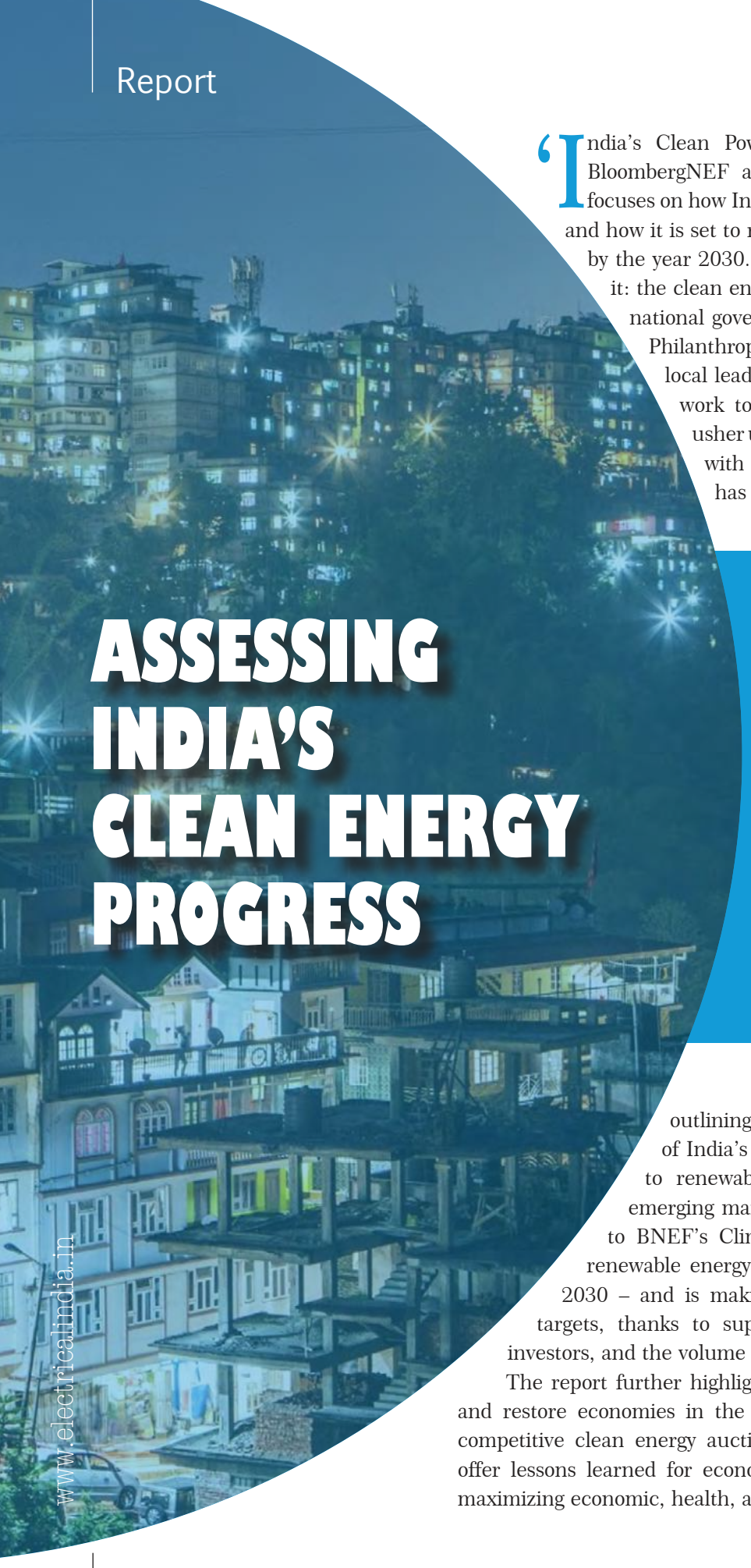
Thai-Model



Electro-Axi-symmetric-model



Transformer



ASSESSING INDIA'S CLEAN ENERGY PROGRESS

The following text highlights a recent report by BloombergNEF and Bloomberg Philanthropies. Assessing India's clean energy progress and developing modes for cleaner economic growth

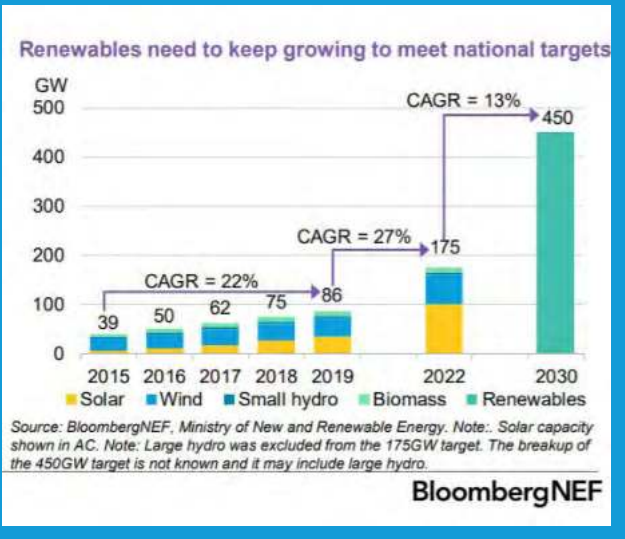
'India's Clean Power Revolution' is a report produced by BloombergNEF and Bloomberg Philanthropies. The report focuses on how India is moving towards a clean energy market, and how it is set to reach the renewable power target of 450GW by the year 2030. The report reads: 'There's no doubt about it: the clean energy revolution is here, and local, state, and national governments are at the forefront. At Bloomberg Philanthropies, we believe that these forward-thinking local leaders can share lessons and strategies as they work to create strong, sustainable economies and usher us into the clean energy future. In partnership with BloombergNEF, Bloomberg Philanthropies has released India's Clean Power Revolution, outlining the current successes and future potential of India's clean energy economy. India's commitment to renewable energy has made it the number one emerging market for clean energy investment, according to BNEF's Climatescope. The country has set ambitious renewable energy goals – 175 GW by 2022 and 450 GW by 2030 – and is making strong progress towards meeting those targets, thanks to supportive government policies, openness to investors, and the volume of renewables auctioned in recent years.'

The report further highlighted how as a nation that seeks to recover and restore economies in the wake of the COVID-19 pandemic, India's competitive clean energy auction market and clean energy progress can offer lessons learned for economies seeking to achieve a green recovery maximizing economic, health, and environmental benefits.

A Summary

Ambitious targets, comprehensive government policies and economics have placed India amongst the most vibrant clean energy markets in the world. As the energy transition accelerates, this decade brings new challenges and opportunities for all the actors in India's clean power revolution.

- Targets: In 2015, India announced a target of building 175GW of clean energy by 2022, a more-than-fourfold increase in installed capacity in just seven years. By 2030, Prime Minister Narendra Modi wants India to reach a new goal of 450GW of renewables.
- Integrating such volumes of variable generation will require a flexible power system. Apart from battery storage and peaker gas plants, lessons from around the world highlight the importance of demand-side measures, grid investments and market reforms for India.
- India is the world's largest and most competitive clean energy auction market, allowing it to procure some of the cheapest renewable power. New auction designs allow the replacement of fossil fuels through better integration.
- The 2030 target brings momentum to the goal of capturing more value from the transition domestically,



spelled out in the 'Make in India' strategy. The wind sector has already seen leading equipment manufacturers open factories to supply the national and international markets.

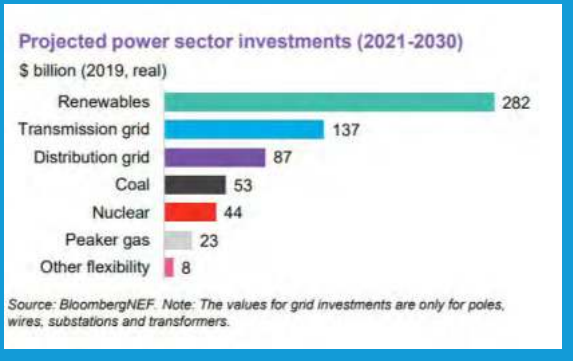
Executive summary (1/2) Renewables need to keep growing to meet national targets 53% Drop in annual weighted average auction tariffs for utility-scale solar, over five years 1 India ranked as the most attractive emerging market for clean energy investment in Climatescope 2019 80% Expected growth in India's power demand from now till 2030 39 50 62 75 86 175 450 0 100 200 300 400 500 2015 2016 2017 2018 2019 2022 2030 GW Solar Wind Small hydro Biomass Renewables

The transformation of India's power sector in this decade brings a $633 billion investment opportunity. Capital is needed to build more power plants, and also to replace and expand grid infrastructure. Public and private finance will need to mobilize to deliver these investments.

- Accelerating deployment calls for better coordination on land issues to ensure that grid availability matches the commissioning of new power projects. Simplifying land acquisition procedures and digitizing land records would remove a bottleneck affecting the sector today.
- The financial health and resiliency of power distribution companies will also need to be improved

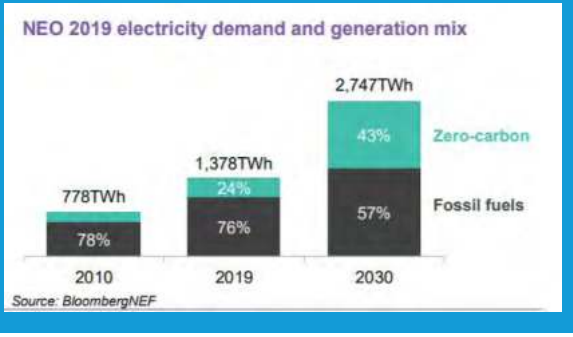
to give investors confidence that they will not face payment delays and retroactive contract negotiation. Procurement of clean energy by corporates looking to reduce their costs provides an opportunity to offer alternative bankable off-takers for clean energy project developers.

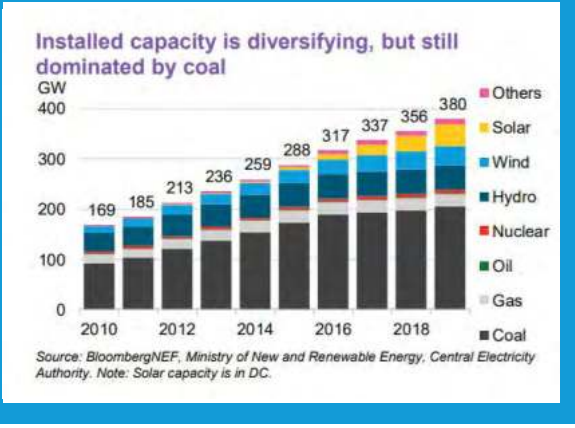
- The continuation of India's clean power revolution is critical to global climate efforts. Coal's role in the mix will continue to drop despite rising power demand. Retiring older coal plants will improve utilization rates for the coal fleet and significantly reduce CO2 emissions. New clean power generation will help India avoid more than 499 million tons of CO2 emissions a year by 2030 and bring peak emissions within reach in the next decade.
- In the last decade, India's net power generation capacity increased by 212GW – nearly the total grid size of France. Roughly 42% of this addition came from renewable energy sources including large hydro.
- India's wind and solar installed capacity quadrupled in a decade, to reach 82GW by 2019. The two main reasons for the sharp jump in capacity have been falling technology costs and proactive government policies to achieve the target of 175GW renewables by 2022.



Assessing Demand Growth – Installed capacity has more than doubled

Installed capacity is diversifying, but still dominated by coal

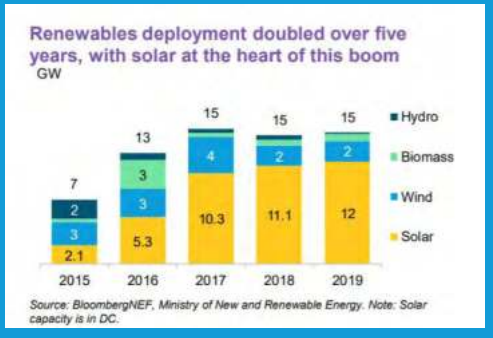




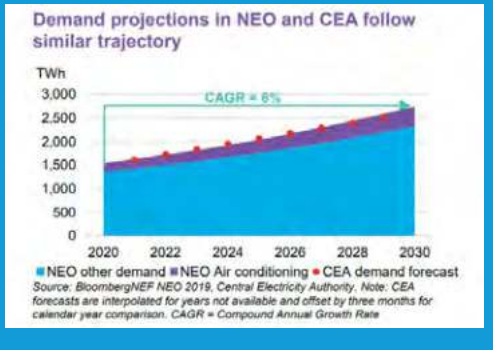
- Additions of renewables have risen from 2015 levels. From 2017, 15GW of renewables have been added each year. More than two-thirds of this came from PV, followed by wind. Installations of hydro power have remained low because of long construction timelines, environmental concerns and social pushback.
- At the end of 2019, the country had 143GW of clean generating capacity (including large hydro) – representing about 38% of all the power installed in the country.
- India's power demand in 2030 will be around 2,700TWh, up from 1,500TWh in 2020
- Increasing population and GDP per capita will continue to drive power demand growth in the next decade. Newly connected rural consumers will also expand their use of electrical appliances. Rising demand for air conditioning will push up its power usage by 25% by 2030.
- The share of demand from electric vehicles is less than 0.5% by 2030 despite early signs of growth by 2030.
- Despite the rise in power demand, per-capita electricity consumption in India will continue to remain below that of many developed and developing economies. Even by 2030, India's per-capita demand is lower than Brazil's today.

- This suggests that there is room for power demand to grow well beyond 2030, as India catches up with global trends in per-capita electricity requirements.
- Government's vision is more bullish than our least-cost system modeling results
- The report estimates that the size of the Indian grid will expand to 838GW by FY2029-2030, compared to NEO 2019's projection of a rise to 734GW by 2030.
- NEO 2019 predicts installed capacity of 204GW(AC) of solar, 109GW of wind (onshore and offshore) and 234GW of coal by 2030. By 2030, 62% of installed capacity would be non-fossil fuel based. This is significantly higher than the 40% India committed to under the Paris Agreement
- CEA projects 2,518TWh of gross electricity generation by FY2029-30, compared to a 9% higher figure of 2,747TWh for 2030 in NEO 2019. The plant capacity factors are higher in NEO 2019, leading to more generation from lower capacity compared to CEA projections.
- CEA expects India to source 54% of electricity from coal, 19% from solar and 12% from wind by 2029-

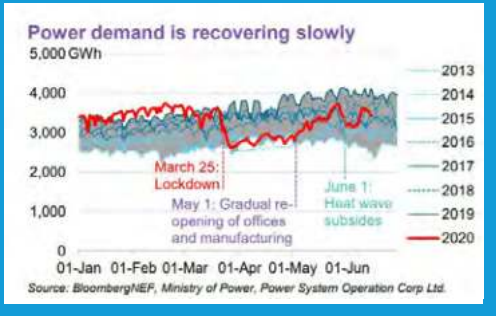
Renewables deployment doubled over five years, with solar at the heart of this boom

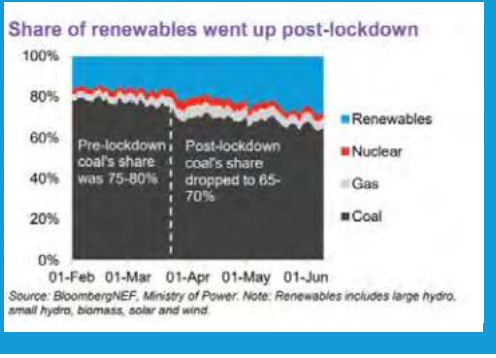


India's power demand is expected to grow by 80% in ten years



Covid-19: slowing power demand growth, but not the energy transition





2030. NEO 2019 projects that coal would supply 55%, and solar and wind just 15% and 11% respectively by 2030.

- Covid-19: slowing power demand growth, but not the energy transition
- India's power demand fell by 36% in the first week of the Covid-19 national lockdown as commercial and industrial users shut operations. Demand started to pick up after the economy began to gradually re-open.
- The share of renewables in the generation mix before India's virus lockdown was 14-18%. After March 25, the drop in power demand led to lower utilization of coal plants. Wind and solar generators were protected by their priority dispatch. This led to the share of renewables going up to nearly 30%. The pandemic has given grid operators and discoms the experience of operating the power system with higher shares of intermittent generation. This should help them plan the flexibility requirements and dispatch procedures for a 450GW renewables future.

Please Note: The above write-up is a report by BloombergNEF and Bloomberg Philanthropies

INCREASING PROFITABILITY THE WAY AHEAD

HIGHLIGHTS CMO, MICROSUN SOLAR TECH

Yash Dinesh Jain, Chief Marketing Officer, MicroSun Solar Tech gives expert insight into the company's portfolio and the way ahead within its sustainable energy portfolio

- By the Electrical India Editorial Team

Tell us about MicroSun Solar Tech. Summaries the solar energy sector from a holistic point of view, where is India headed in terms of sustainable energy?

MicroSun Solar is a Renewable Energy company, and it is one of the leading manufacturers of Solar Photovoltaic modules/panels, Solar Water Pumping Systems, Solar Lighting Systems and Solar Power Packs in India. It is a frontrunner in the area of renewable energy and provides end-to-end Solar PV solutions ranging from manufacturing Solar PV modules to Solar EPC projects. The company carries with it more than 12-years of technical experience of successful solar module manufacturing and project execution in India. The company has set up its state-of-the-art facility with a capacity of 150MW per annum of Solar PV modules manufacturing plant in Bangalore, India. By Integrating manufacturing, commercial expertise, research and development, across the entire Solar Value Chain, MicroSun Solar Tech Pvt Ltd provides industry-leading solar energy solutions that not only includes Module manufacturing, but also turnkey solutions throughout the entire life cycle of solar power plants and solar water pumping systems from project design, engineering, procurement, construction management and maintenance services. Our Consistent effort towards conservation, continual improvement and harnessing of renewable energy has made us deliver quality products to our esteemed clients. At present we are catering to Corporate Chains, Integrators, Private Sector, Indian Defense Force, Central Government Departments and State Government Departments.

Tell us in brief about your solar water pumping system. What are the advantages and application of it? Is it easy to install and what is the price range of these solar water pumps? What is the approach of the people in rural areas towards this kind of technology?

Solar Water Pumping System: With the cost of diesel and electricity rising constantly, solar-powered water pumps are the perfect alternative for rural regions as these have a low maintenance cost and ensure a long product life. The operation of solar-powered water pumps is economical owing to the lower operation and

Photo by American Public Power Association on Unsplash

maintenance costs. The pump uses the electricity generated by solar panels, which is fed to the solar pump controller (Variable Frequency Drive) which converts DC to AC and also adjusts the speed and output power as required by the pump.

Advantages: Simple and reliable, easy installation and unattended operation, one-time investment and negligible maintenance, no diesel, other fuel spills or costs, mobility option with few parts, no dependence on erratic grid power, better crop yield due to day time water availability, helps in multiple crop cultivation with round the year water pumping, can be connected to a drip and sprinkler irrigation system, environment-friendly choice

Applications: Irrigation purpose, drinking water, pond aeration & livestock watering, pond management, drip & sprinkler, water purification systems, filtration and poor circulation. There is a fantastic approach to this product category. Farmers are thinking for the long term and that is the way forward. It can be an additional source of income to farmers. In a view of this, PM-KUSUM scheme was launched by the Central Government in India. Farmers are required to pay 10% of total cost upfront and rest will be taken as Loan and Subsidies. Tenders have been floated in the recent past and many are in the execution stage. It looks more promising going forward.

Tell us about your company strategies undertaken to increase profitability and achieve higher sales volumes - also, elaborate on the concept 'Business-level product' diversification the new segment you are expanding into…

The company decided to look for Product diversification, it is was our strategy to increase profitability and achieve higher sales volume from new products which were included in our portfolio. Business-level product diversification – we are expanding into a new segment of the same industry that the company was already operating in. Our customer database increased into manifolds. The Key Products and Solutions, MicroSun Solar provides are:

- Solar Photovoltaic Modules.
- Solar Rooftop Systems. (On-Grid & Off-Grid)
- Solar Water Pumping Systems.
- Solar Street Lighting Systems.
- Solar Home/Office Lighting Systems.
- EPC for Grid-connected Projects. (KW & MW Scale Power Plants)
- Solar Inverters. (On-Grid & Off-Grid)
- Solar Energy Storage Systems

The Target is 175GW until 2022 by Government of India under the Ministry of New and Renewable Energy and Power, out of which only 34GW has been completed in India. The USP of our Product and Solution is that we do not compromise on our premium quality at any cost. The Solar Industry is more of trending towards the Price Driven market and we stand on the other side of the corner, sticking to our Quality because we see the future and not the present. Talking about the Solutions, we feel the better services and solutions that we have provided to our customers with near perfection has gained us a huge amount of positive response. The customer is completely satisfied with the content of the work we do. We want our customers happy all the time. Be it Post-sales services, or Installations, or EPC for grid-connected projects.

Photo by Riccardo Annandale on Unsplash

ENERGY MANAGEMENT

WITHIN THE SCOPE OF GENERATION AND THE CONSUMPTION OF ELECTRICAL ENERGY

The article highlights how energy management is an important aspect of generation and the consumption of electrical energy.

- The article is authored by Sandip Sopan Paithankar, Post-Graduation in Energy Management, Assistant Manager – Engie Solar India

Energy Management can be defined as the proactive, organized and systematic management of energy use in buildings or organizations that are used to satisfy both environmental and economic requirements. We can take the illustration of power curtailment in a solar energy project that leads to the loss of clean/ green energy generation for solar project developers. It can be tackled using the proactive major taken for other generations source which can support to sudden changes for load demand.

The power curtailment involves the management of oversupply of solar energy. In my opinion, if power curtailment takes place regularly then battery storage systems can be used to store curtailed power this use to smoothen the solar of next day generation hours. This way it will help to reduce the metering curtailment so that it shall be implemented to stabilise the grid. In this case, additional battery storage, the CAPEX of the solar project will increase respectively which is again the task for the solar project developer.

In this pandemic situation, the operational solar project is continuing to supply power to the grid as it is an essential service of the power sector industry. The operational solar project and solar parks are facing issues related to lack of resource availability for preventive maintenance of solar project equipment and support from original equipment manufacturer are not extensively as earlier. Due to this unapproachability of material which leads to keeping feed the solar power with the rest of operational capacity and with available resource only.

Also, the large-scale project which is under execution majorly affected in this unavoidable situation of the pandemic, the more details of final extensions of commissioning for ongoing execution solar project may confirm at the end of Q2, after the pandemic situation under control.

In the distribution system sector smart metering expected with include the prepaid metering scheme, again it may be impacted to the pandemic situation in the country.

The development on the off-grid system seems to be growing continuously from the last few years, due to the awareness of off system and technology are increasing day by day. the grid is posing an excessive number of complex tasks on the functioning of inverters in case distributed type systems. In advanced capabilities such as voltage and frequency sensors allow smart inverters to detect grid abnormalities, communication with the control panel of diesel generator and the power can be controlled

using the automatic function of the inverter. This type of smart inverters system can improve the productivity of small manufacturing industries, the import and export power can be controlled.

Inverters play a vital role in any solar energy system, inverter technology improving with adding a new feature to optimize the loss figure of inverter efficiency. The inverter manufacturer is flexible to provide the centralised and decentralised (string) inverters, so solar PV project developers and EPC player can achieve the best LCOE (lowest Levelized cost of energy). As the industry moving towards string inverters to reduce the DC cable losses which will be less in the assessment with a central inverter system. String inverter system reduces the footprint of the local transformer station of the solar project. The 3-phase string inverter will be more popular in future for the utility-scale system. Moreover, string inverters are equipped with more MPPT's, wide range of MPPT voltage, high efficiency, continuous grid monitoring, Insulation monitoring device, Ground fault detection, additional communication options etc.

The multiple MPPT features it can be installed in the plant which have high land undulated contour, MPPT will work more efficiently and it can give optimised output power compared with one MPPT inverter. The string inverter is easy to install on utility as well as rooftop scale projects. It can be installed on the wall, module mounting structure, separated free-standing supporting structure on ground-mounted type solar installations.

Every string monitoring is an important aspect that could be monitored continuously to understand the string power availability and power curve of a string inverter. Some inverter manufacturers offer hybrid inverter and smart inverters that can be used for small scale projects like commercial complex, institution and residential area. This smart having feature control and monitoring using mobile applications, auto priority settings for battery charging, battery discharging, managing consumption of instant solar power, managing grid power import and export.

At the end of Q2 and Q3 of 2020, might solar industry would suffer a lack of supply and delay in supply for solar inverter due to pandemic which is the most significant issues. The UPS systems are used for solar PV plants that provide emergency power to a load in case of grid failure, it provides emergency power to control circuitry of switchgear, emergency power to weather monitoring system, emergency power to plant lighting etc. The UPS designed for local transformer station ranges from 3kVA to 8 kVA and main transformer station/ main control room are ranging from 8 kVA to 15 kVA which depends on block sizing/ capacity of solar projects. For solar project, industrial-grade UPS have used this application, as load demands are different than commercial and residential loads. In the general engineering practice, 4 to 6 hr battery back is necessary for local transformer station and 6 to 10 hr are necessary in case of main transformer station/ main control room of the solar project. The ups system innovations developed the compact solutions offering for the solar industry, so it is easy to install integrated with switchgear compartment to the optimized cost of extra enclosure requirement for UPS system at transformer stations. In the case of main transformer station/ main control room is constructed in cement concrete, segregated room considering the ventilation requirements for UPS and Battery are provided.

One of the issue UPS systems face are caused due to a temperature rise which is mainly due to metallic enclosure are used for installation in solar PV project. The temperature rise issue can impact the UPS output power and life of the UPS system, proper ventilation is required to maintain the metallic enclosure airflow.

About the Author:

Sandip Paithankar is a solar PV design & engineering professional at Engie Solar, an in-bound design and engineering platform that helps companies in the development of solar projects. Previously, Sandip worked as a PV design engineer for a KACST KSA. He post-graduated with honours from MIT Pune with a degree in Energy Management and graduated with honours from Pune University with a degree in Electrical Engineering

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Part 2: A Review Of Battery Charger Topologies and Infrastructure

For Plug-In Electric and Hybrid Vehicles

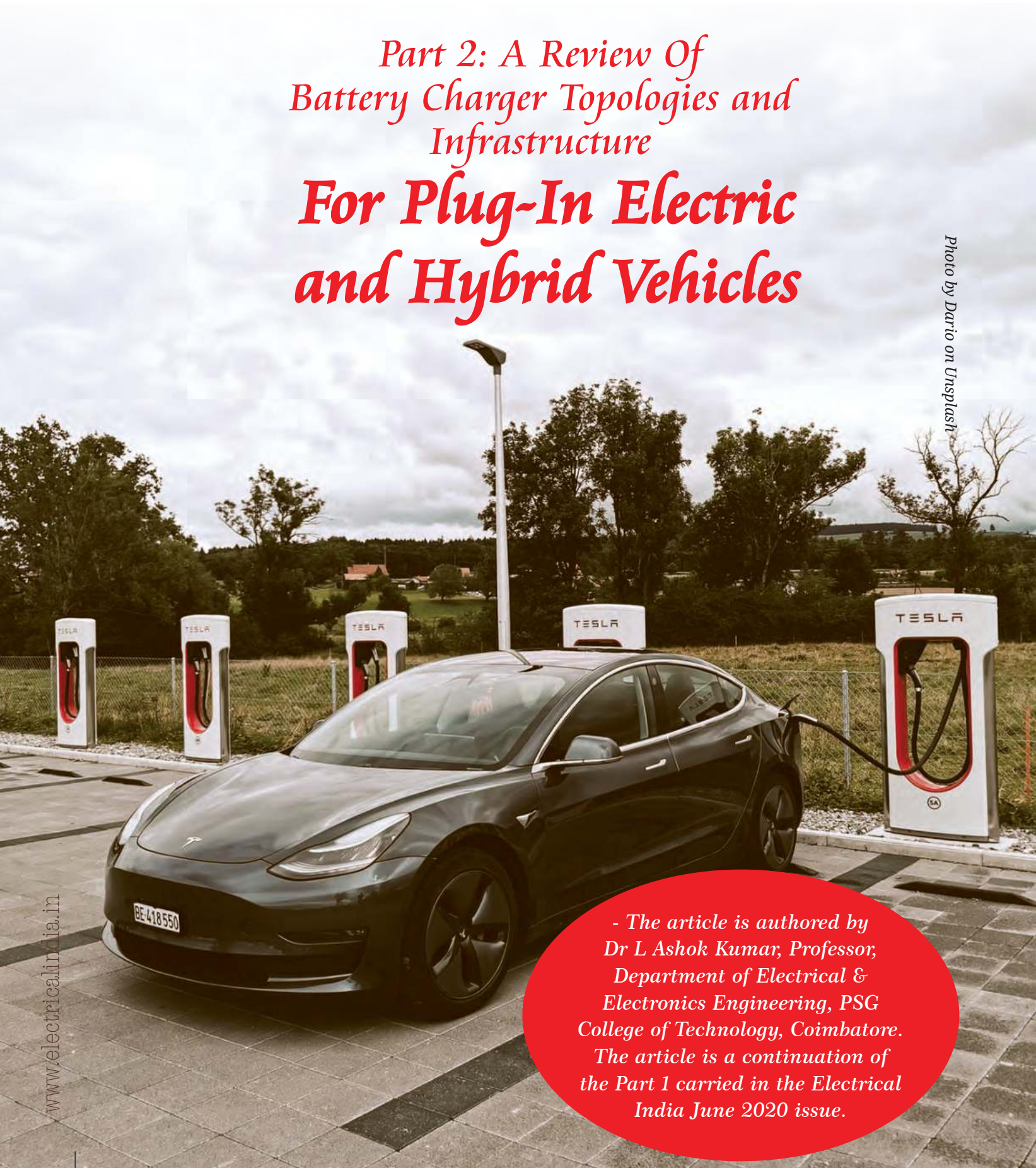


Photo by Dario on Unsplash

- The article is authored by Dr L Ashok Kumar, Professor, Department of Electrical & Electronics Engineering, PSG College of Technology, Coimbatore. The article is a continuation of the Part 1 carried in the Electrical India June 2020 issue.

Integrated Chargers

To minimize weight, volume, and cost integrating the charging function into the electric drive system has been proposed. The function can be integrated if charging and traction are not simultaneous. In an integrated charger, motor windings are used for filter inductors or an isolated transformer and the motor drive inverter serves as a bidirectional ac–dc converter. The most important advantage is that low-cost high- power (Levels 2 and 3) bidirectional fast charge can be supported with unity power factor. Control complexity and extra hardware are challenges to implementation in commercial products. A combined motor drive and battery recharge system based on an induction motor is currently used by the Ford Motor Company. A non-isolated integrated charger based on a split-winding ac motor will be used in the automotive industry. There are some applications for electric scooters and two-wheeled vehicles. A typical integrated charger system is shown in Fig. 10.

Classifications of Integrated Battery Chargers

Integrated charger topologies may be categorized based on motor count and inverter count. Each motor can be controlled by its dedicated inverter. It consists of two inverters to drive the main and auxiliary motors, and used them as an AC-DC converter for charging, while two three-phase motors were used as inductors for the converter with their neutral points connected to the grid.. The first machine plays a role in delivering regenerative energy to the battery by supplementing the driving force as a traction motor. The second machine starts up the engine or charges the battery. In the charging mode, both motors and inverters operate as an AC–DC boost converter. Disadvantages of this charger are the large number of extra components (twelve power switches, three contactors, and two motors) and control complexity. A two-motor/two-inverter integrated charger is discussed and it was shown in Fig. 11.one induction motor with a double set of stator windings comprising two motor halves.

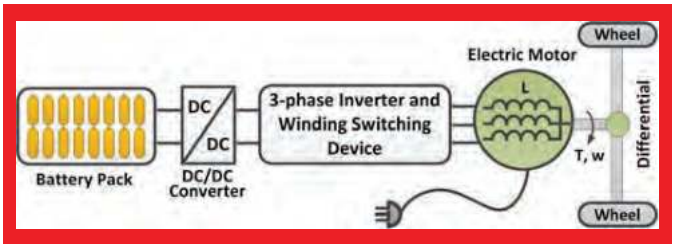


Fig. 10. Typical structure of integrated PEV charger.

One-Motor With One-Power Converter Topology: With one motor and one power converter, an integrated topology may be classified by motor type: Induction, permanent magnet (PM) and switched-reluctance motor (SRM) ,with isolated or non-isolated circuitry.

Non-isolated/Isolated Cases for Induction Motors:

Five non-isolated cases for induction motors have been reported. Non- isolated chargers tend to minimize size and weight. In the second, the three-phase motor and inverter together operate as an ac–dc boost converter, and the dc link voltage is stepped down to the nominal battery voltage through a bidirectional dc- dc converter. This one-motor inverter system is simpler to control than other topologies. It accesses the motor center tap to use the motor as a coupling inductor. An integral PFC charger is formed with four three-phase induction motors and their inverters. There is no extra hardware except a transfer switch. However, this integrated charger is only appropriate for vehicles with four-wheel drive. In the fourth topology, a three-level dc–dc boost converter is used as a front end for a two-wheeled vehicle. It is rearranged to act as a PWM-PFC charger in charging mode. A is a non-isolated single-phase integrated battery charger proposed and it has been installed on an electric scooter prototype and uses the propulsion inverter with an additional power rectifier and an LC filter. These are placed close to the motor. The on-board dc–dc converter consists of the three-phase motor windings and inverter switches, the induction machine is used as a line-frequency step-down isolation transformer in charge mode. A wound-rotor machine is used and the drive is modified to act as a three-phase PWM rectifier. Advantages include galvanic isolation, the possibility of bidirectional power flow, low harmonic

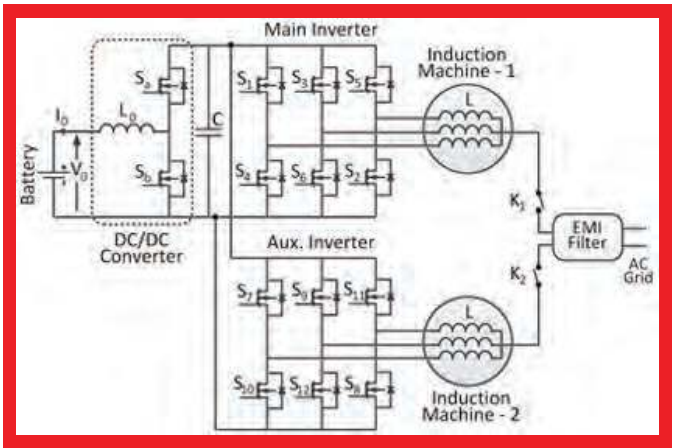


Fig. 11. Integrated charger with two motors and two inverters

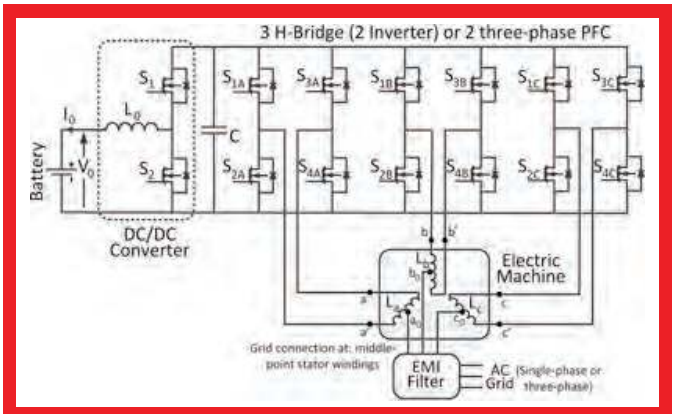


Fig. 12. PM nonisolated integrated charger topology connecting to the grid through midpoints of electric machine windings.

distortion, and unity factor. Disadvantages include high magnetization currents and the extra costs of the wound rotor and contactors.

Non-isolated/Isolated Cases for Permanent Magnet Motors:

PM non-isolated topology method connects the vehicle to the grid through the machine windings. The configuration of the integrated charger is shown in Fig. 12. Each phase is connected to two parallel PWM boost converters. The grid is connected to center taps in each phase, splitting the currents into equal and opposite portions. This cancels the MMF on the stator and ensures magnetic decoupling between the rotor and the stator. No rotation is possible. However, this topology is complex as it must control three independent currents. A second concept for fast on-board charging is used. It uses the PM motor as a filter. The same converter is used both for charging and traction. The structure of this converter is similar to a typical three-phase PFC. The topology is composed of two three-phase PWM boost converters and a buck–boost dc–dc converter. A third and similar topology is applied in to a scooter with an interior permanent magnet (IPM) motor traction drive as shown in Fig. 13. For charging, the ac motor drive is operated as a three-phase PFC coupled boost rectifier. No additional filtering is needed since the PWM ripple is minimized by means of phase interleaving. Using a general model of a three-phase ac motor, the feasibility of an integral charger with other ac motors is also studied Disadvantages include the need for extra hardware, which includes a single-phase rectifier bridge with a mechanical switch to access the center tap of the motor, a capacitor, and an EMI filter. A PM-assisted synchronous reluctance has four-pole machine with a three-phase winding in traction mode. Each phase winding is divided into two equivalent parts which are shifted symmetrically around the stator periphery in charging mode.

The traction inverter acts as a rectifier for charging. The device is equipped with two sets of three-phase windings, and the winding connections can be reconfigured from traction mode to charging mode with a relay. A contactor is used to connect the grid-side windings to the grid, as shown in Fig. 14. This charger serves as an isolated high-power bidirectional fast charger with unity power factor.

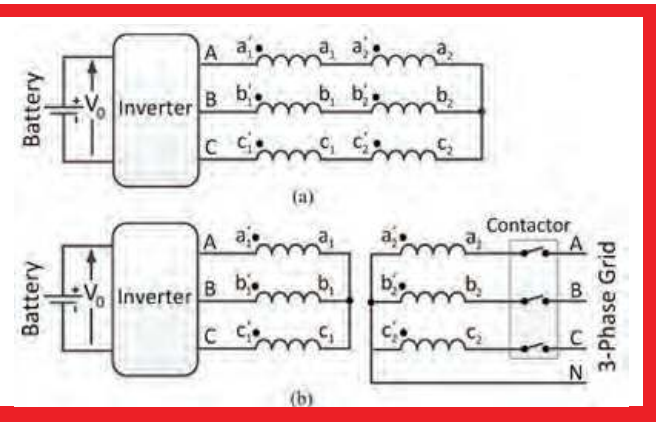


Fig. 14. Operation modes of an integrated charger presented in for internal PM machine: (a) traction and (b) charging.

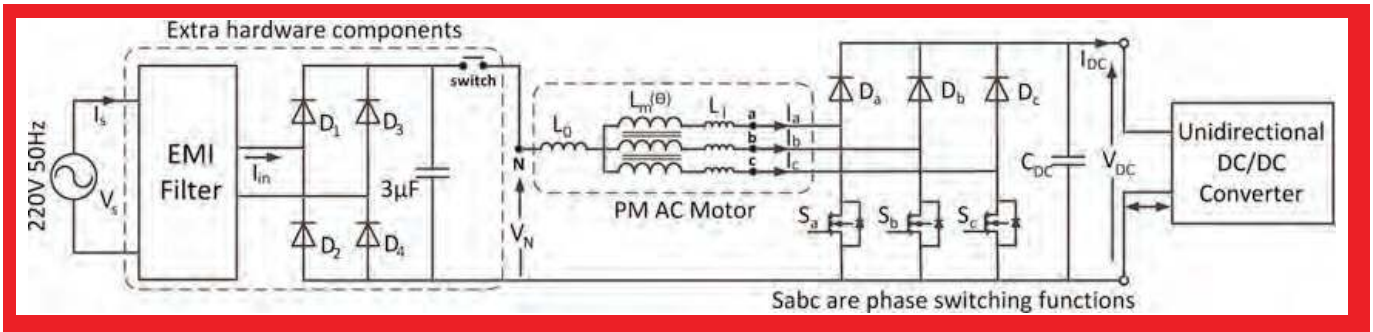


Fig. 13. Integrated battery charger as in the traction drive is transformed into a three-phase PFC boost battery charger for a scooter.

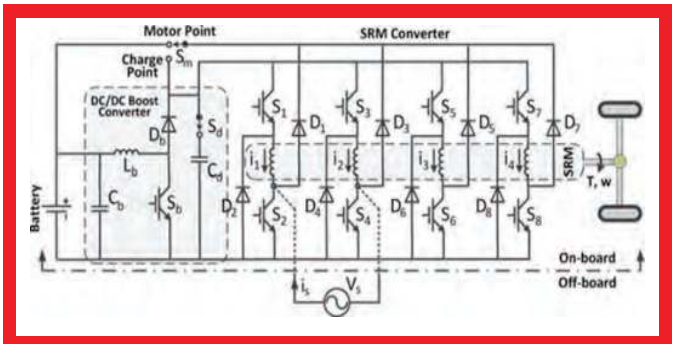


Fig. 15. Integrated battery charger configuration for SRM .

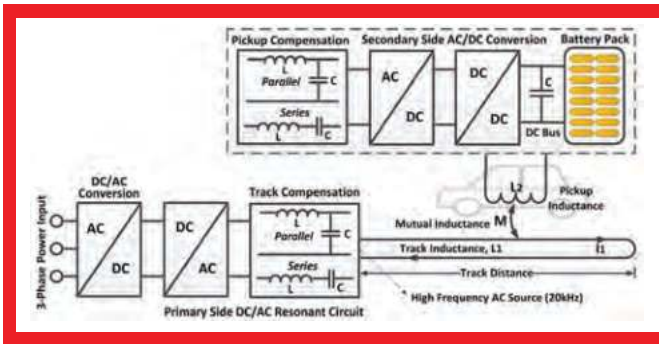


Fig. 15. Integrated battery charger configuration for SRM .

Non-isolated /Isolated Cases for Reluctance Motors:

Three reluctance machine topologies are implemented for an a compact battery- powered SRM drive for an EV with voltage boosting and on- board PFC charging capabilities, as shown in Fig. 15. Although the boost front-end dc–dc converter is external, the on-board charger is formed by the embedded components of the SRM windings and converter. During demagnetization of each leg, the stored winding energy is recovered to the battery. In charging mode, the power devices are used to form a buck–boost rectifier to charge from the utility with good power quality. SRM phase windings used as a transformer during charging in but without active PFC control. It used an extra winding on one phase of the stator to support transformer operation for a single-phase ac supply with an SRM. The rotor position will automatically align to maximum inductance over the first few cycles in charging mode. The extra winding can adjust the voltage level according to converter requirements.

CONTACTLESS INDUCTIVE CHARGING Conductive chargers use metal-to-metal contact as in most appliances and electronic devices. Inductive charging of EVs is based on magnetic contactless power transfer .

Conductive Charging

Conductive charging systems use direct contact and a cable between the EV connector and charge inlet. The cable can be fed from a standard electrical outlet (Level 1 or 2) or a charging station (Level 2 or 3). There are already several charging posts on the market. Available vehicles, including the Chevrolet Volt and Tesla Roadster, use Levels 1 and 2 chargers with basic infrastructure (convenience outlets). Conductive charging is also employed on the Nissan Leaf and Mitsubishi i-MiEV, which use either basic infrastructure or dedicated off-board chargers .The main drawback of this solution is that the driver needs to plug in the cable. This is a conventional issue.

Part 3 will be continued in the next issue of the Electrical India Magazine

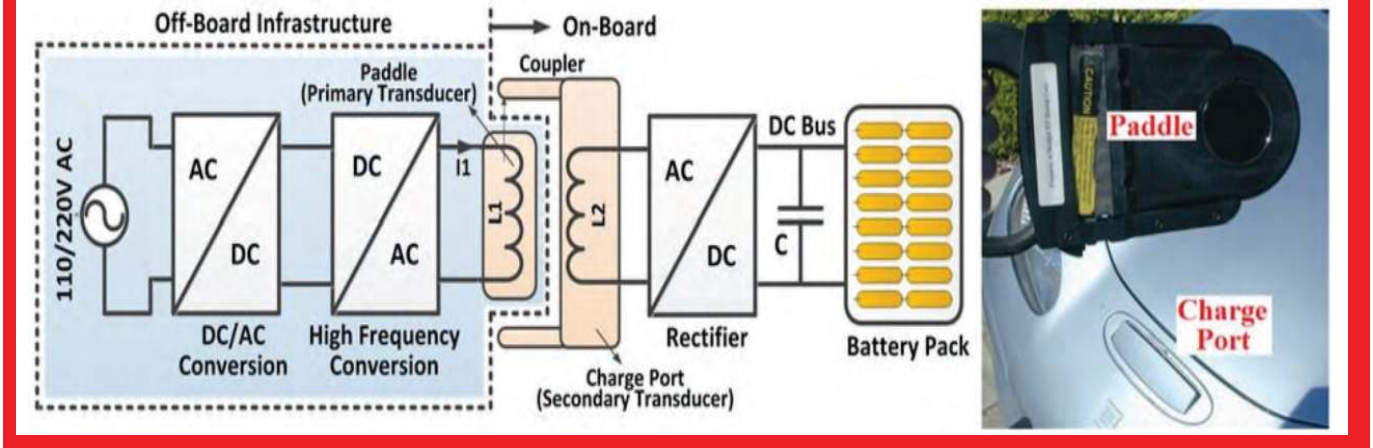


Fig.17. Inductively coupling road bed EV battery charging system.

THE RESURGENCE OF THE ELECTRICAL SECTOR?

Prabhajit Kumar Sarkar, Managing Director & CEO, Power Exchange India Limited (PXIL) speaks to Electrical India on the lockdown, the demand for electricity and the method and strategies adopted to ensure that operations continue unhindered.

- By the Electrical India Editorial Team

Talk about the demand for electricity within both the commercial and the industrial sector…

The electricity demand for commercial and industrial consumers has gone down considerably due to the lockdown and closure of all non-essential services with overall demand at national level falling by more than 30 per cent. The demand reduction has a huge impact on DISCOMs financials as commercial and industrial consumers are the backbone of their revenue sources. Further, it has a cascading effect on the supply side also. As is

being witnessed today, most of the generation in the country is operating at sub-optimal levels and payment default risks have elevated. Renewables are exposed to the curtailment risks and off-take from thermal generators has reduced significantly. As a result, the short-term market prices have also plummeted in March and April. The under-construction projects are also facing liquidity crunch and delay in the sourcing of materials and construction activities etc. All policy and regulatory decisions are focusing on easing the current situation. Given that the current situation is impacting the entire power sector value chain, the road to recovery might be a long one.

Will DISCOMs gear-up concerning purchases? Do we witness an increasing amount of purchases from the short-term power market? Kindly elaborate…

Typically, the onset of summers signals an increase in electricity demand up throughout the country as temperatures rise substantially in most parts of the country. During this period, the DISCOMs also gear up their purchases from the short-term power market to ensure smooth power supply in the wake of increased demand. However, this year, with the drop in commercial and industrial activities, the electricity demand is muted which has impacted the short-term trading volumes. Therefore, currently, the purchases witnessed in the short-term market are mainly transient, where DISCOMs are buying power to reduce their overall power purchase costs.

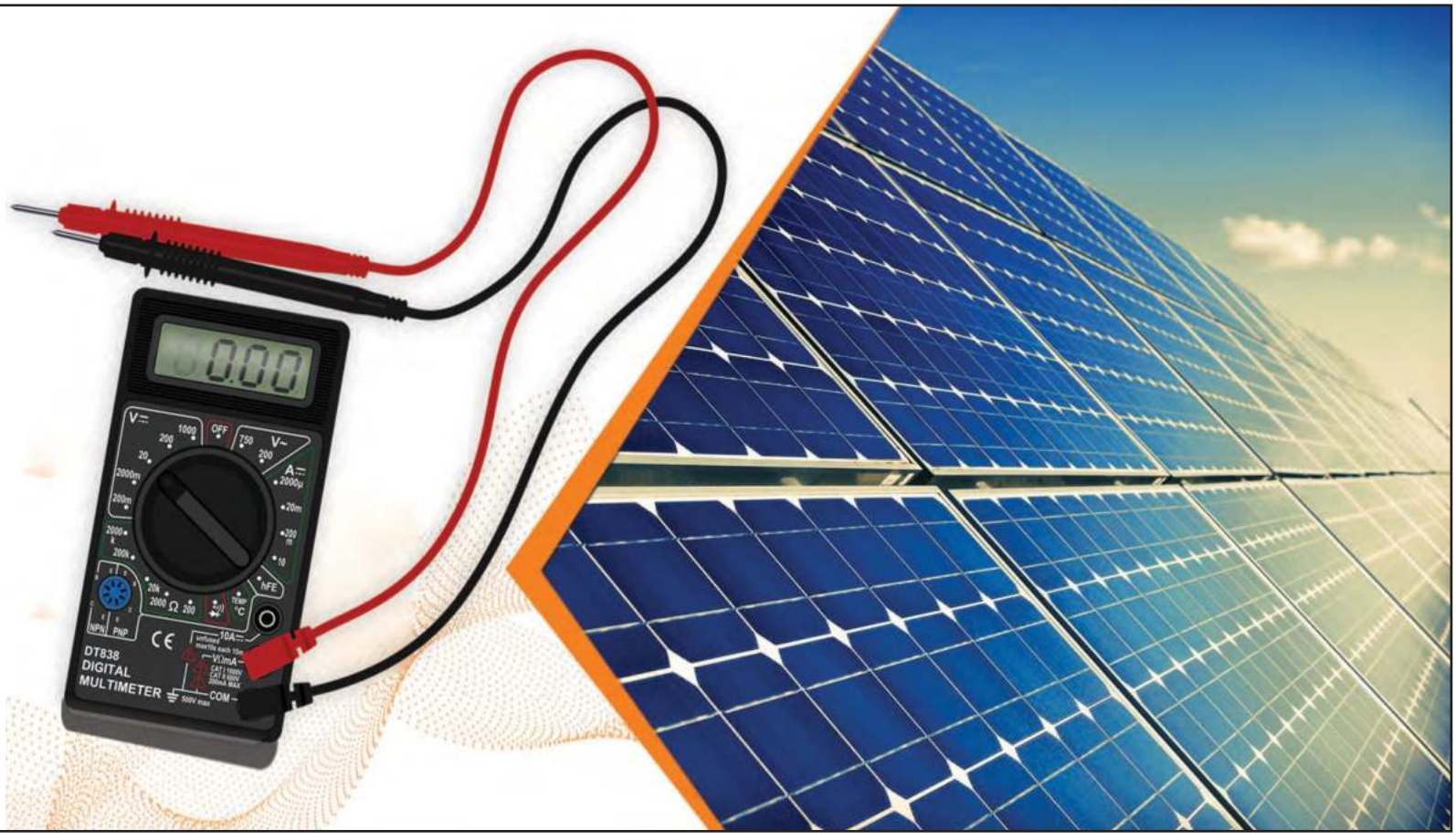
From our side, at PXIL, we ensure the availability of our transaction platform on a 24x7 basis and ensuring that customers can make most of the situation by transacting in all products seamlessly from any location.

What are the measures taken to make a comeback? How is the exchange committed to continuing its support to customers during the lockdown – what are the strategies in place?

PXIL has been providing uninterrupted services to all its customers during the lockdowns. The exchange is committed to continuing supporting its customers and has been assisting in alleviating the difficulties imposed due to the lockdown. We have implemented measures and processes to ensure business continuity and adequate service to our customers. We would focus on further strengthening of our core business operations and critical functions to ensure business sustainability so that all the needs of our customers are satisfied.

What are your strategies to make a comeback?

Over the last couple of years, PXIL has completely revamped its technology offering, which has allowed seamless operations to take place on a 24x7 basis even during this period of lockdown. On the business side, PXIL's primary focus has been on the term-ahead and REC markets. Now, we have enough liquidity to also scale up our operations in the day-ahead spot market. We expect a huge surge in the liquidity on the Power Exchanges on the back of new opportunities which are on the cards in the power sector. In short to medium term, we expect the introduction of many new products under categories such as Real-Time Markets, Ancillary Services and Longer Tenure Contracts which would help in deepening of power markets. As an exchange, we are continuously pushing the boundaries and prepared to take advantage of the opportunities that the power markets present to us.



A context of developing net metering regulations in India. The article is a continuation of Part 1 carried in the June issue of the Electrical India magazine.

NET-METERING:

Regulatory Avenues of the Solar Supply Chain and Business Models - Part 2

Third-party owned Rooftop PV net metering model

In this category of the net-metering model, the developers lease out solar PV systems to interested rooftop parties. This is a well-known model for residential owners in the United States, where turnkey installers lease rooftop systems to individual households who further, in turn, pay them a monthly lease rental. The owner of the house provides the rooftop and commissions with a turnkey installer to design and install the system. Alternatively, the installers can also offer an integrated service of leasing, commissioning and maintaining the systems to homeowners and guaranteeing standards of performance. The electricity generated from such a system is used to meet the rooftop owner's internal electricity needs while the excess generation is fed into the grid on a net metering basis. The following figure provides a broad level structure of a third party owned net metering model.

This model has the two main benefits, firstly, benefits to rooftop owner and secondly, benefits to developers. The household owner avoids large upfront investment for the solar equipment and on occasion avoids assuming technology or performance risk of solar systems.

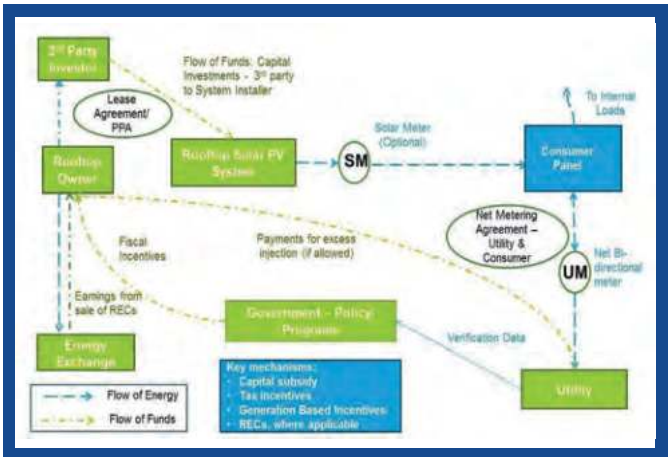


Figure 2: Business model II: Third party owned Rooftop PV net metering

Net-metering allows the rooftop owner to save on power consumed from the grid to the extent of solar generation. A part of savings in power consumption is shared with the developer by way of lease rental.

Whereas in terms of benefits to developer, the leasing company generates revenues by way of lease rental from the rooftop owner under a contract, as it continues to be the owner of the equipment, it also qualifies for claiming depreciation on the capital cost of the PV systems, with associated direct tax benefits. To make this model operational, electricity regulations need to be designed to remove specific barriers to the participation of developers and intermediaries, who play an important role in the propagation of such systems. Under prevailing regulations in the Indian context, a third-party-owned system, unless specifically addressed, may result in an open access transaction, with implications of wheeling charges and surcharge relating to cross-subsidy.

Challenges concerning regulation

Based on the above, it can be said that Energy Accounting and Commercial arrangements, Interconnection arrangements, Regulatory Instruments and Metering schemes are identified as determining parameters for coverage in the model regulations. A comparative review of the implementation of net-metered models in other countries like the United States, Japan and

Germany and the current level of regulations existing in various states in India indicate that there are certain critical issues about the energy accounting and commercial settlement process, requirements of the interconnection arrangements, the applicability of the current regulatory instruments like RECs on the net-metered projects and metering schemes options need to be addressed to implement net-metered based systems in India. These issues are now being addressed through the accompanying net metering regulations so that implementation can be streamlined across various states. Applicable metering code and standards also need to be defined for the net-metered connections.

Advantages of Net Metering

There are many advantages of net metering. It promotes clean energy production and reduced carbon footprint because it reduces dependence on conventional energy sources. It motivates consumers to adopt solar PVs and also promotes investment in this field.

- Low cost, easily administered method of encouraging customer investment in renewable energy technologies.
- It increases the value of electricity produced by renewable generation and allows customers to "bank" their energy and use it at when necessary, thus giving customers more flexibility.
- Net metering is a necessary policy to boost the growth of renewable energy.
- Giving customers control over their electricity bills – Net metering allows utility customers to generate their electricity cleanly and efficiently. During the day, most solar customers produce more electricity than they consume; net metering allows them to export that power to the grid and reduce their future electric bills.
- Net metering provides substantial economic benefits in terms of jobs, income and investment in the renewable energy sector.
- Protecting the Electric Grid – By encouraging generation near the point of consumption, net metering also reduces the strain on distribution systems and prevents losses in long-distance electricity transmission and distribution.

Net-Metering: Case of Maharashtra

Recently, the Maharashtra Electricity Regulatory Commission (MERC) has come up with new regulations for net metering in the state. The proposed regulations apply to net metering and net billing arrangements (gross metering), and grid-connected renewable energy generating systems (REGS) tied to the consumer's meter. According to the new regulations, the net-metering arrangement is permitted by the distribution licensee on a non-discriminatory, 'first come, first serve' basis to eligible consumers who have already installed or are likely to install a renewable energy generating system connected to the network of the DISCOM. There is a meter connection gap to a distribution transformer of the DISCOM that should not exceed 70% of its rated capacity.

MERC's regulations enforce the minimum size of the system as 1kW, should not exceed the sanctioned load (in kW) given to consumers, contracted demand, the cumulative capacity of the transformer and distribution licensee to be very active and participatory on making available net metering arrangements every quarter. However, these will not apply to those consumers with pending arrears with the distribution licensee and there are some relaxations on high tension (HT) consumers who can install and connect the renewable systems at their low tension (LT) bus bar systems. Consumers can install a renewable energy generating system with or without storage the inverter will have the appropriate arrangement to prevent the power from flowing into the grid in the absence of grid supply. As the most important compliance, the energy purchased by the DISCOM from these rooftop systems will qualify for its renewable purchase obligation (RPO).

Conclusion

It is seen that net-metering is a potential tool to drive power generation through renewable technologies, and it not only encourages the consumers to generate power for their own needs but also pays them for the excess power generated by their solar PV systems. The energy generated by Solar PV cells fulfills the immediate energy needs of the consumer's requirements and slashes his electricity bill. Any extra power generated is exported back to the electric grid. The net metering would credit the electricity thus exported to the grid. In summary, consumers are bill only for their net energy use.

Vivek Soni,
Chartered Engineer, PhD IIT Delhi Faculty, Bharatiya Vidya Bhavan's Institute of Management New Delhi

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Prevent Electric Shock and Electrical Fires

in Electrical Installation as per Indian standards

- The following article is authored by Gajaria Gokal, B.E. and M.E. (USA)

An Introduction:

- Step by step Guide to "Prevent Shock and Fire in Low Voltage Electrical installation" in residential building and industrial plants as per Indian Standards (IS), Electrical Wiring Code IS732:2019 and Earthing Code IS3043:2018.
- IS standards are as per International Electrical Commission (IEC), Europe. These are followed in the world.
- "Electrical shock, Loss of Life and Electrical Fire, Loss of Billions of Rupees and life."
- ELCB 30mA: MUST BE 30mA widely use protection against shock.
- In IEC standard, ELCB is named Residual Current Device (RCD). Cost Rs 1000
- Danger: This is brief guide for information. Please, take professional advice for any electrical work.
- Reference 11.2, Electrical Installation Guide as per IEC, 2018, by Schneider Co. Refer to chapters: F and Q

Body resistance and severity of shock:

- Body resistance: Dry skin is about 5 mega ohms. At 230 V. body 1000 ohms and wet boy 250 ohms.
- Severity of shock depends: Current flow from hand to hand through heart. Wet body.
- Current flow in mA and time. Current > 6mA, hand get paralysis and cannot let go hand held items.
- Maximum voltage person can tolerate in dry location 50V and wet location 25V

Electric Shock Protection:

- Main Causes: Water, outdoor, open Ground, rough area, touch Earthed metal, water pipes, e.g. Bathroom.

Inside a Flat:

Remedy:

- ELCB 30mA: Mandatory to install ELCB (Earth leakage Circuit Breaker). All lights and sockets circuits.
- ELCB and RCBO 30mA: Main purpose shock protection, additional protection against Fire due to earth fault.

High Electrical shock Risk locations: Bathroom and Outdoors:

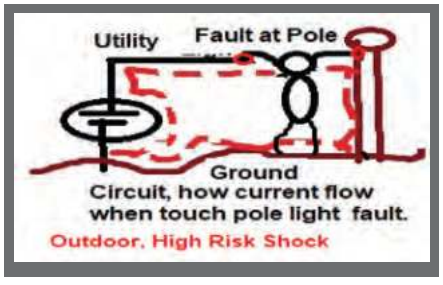
- Bathroom: Our bathrooms are small, about 10' by 6'.

Cause:

- Water, bare foot, touching earthed metal water pipes (now, plastic pipes). Water spray.

Remedy:

- Mandatory: All circuits and light must be protected by ELCB 30mA.
- NO sockets, light switch, water heater. Light, waterproof to IP44.
- Exhaust fan 23OV AC, waterproof to IP44 or prefer 12V AC, available in UK.
- For big size of bathroom with tube, refer to 11.2, chapter Q.



Outdoor:

Cause:

- Water, barefoot, open ground and may touch electrical metal pole lights.

Remedy:

- Mandatory: All circuits, lights and sockets, must be protected by ELCB 30mA.
- All electric items weatherproof to IP44.

RCBO: MCB+ELCB 30mA

- Miniature circuit breaker (MCB) for overcurrent, for shock RCD 30mA. (MCB+RCD 30mA). Combine in one device is called Residual Current Circuit Breaker Overcurrent (RCBO).
- In DB: Option to Install 2 numbers ELCB, each supply numbers of circuits or each circuit with RCBO.
- 2 numbers ELCB 30mA, disadvantage: If both trips then complete darkness. Person can fell down and hurt.

  If ELCB trips: To find the fault. Call electrician and time consuming to restore power supply.
- RCBO Advantage: If nuisance trip of one circuit or trip due to fault. No loss of complete power supply
- RCBO: Recommend for prestige buildings, high rise buildings, senior citizen homes, schools and etc.

In Europe: RCBO are now commonplace in commercial buildings and growing in popularity in residential.

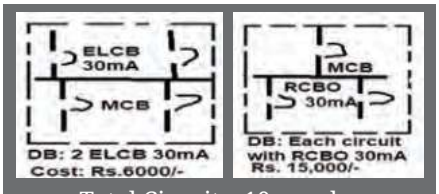
- My opinion to install DB with RCBO for each circuit: If RCBO trips in one circuit, no loss of complete power.

Protection by RCBO and AFDD in DB:

- (MCB+ELCB 30mA) = (RCBO)=Isolation, Overcurrent, Short Circuit, Shock and fire protection from earth fault.
- (MCB+ELCB 30mA+AFDD) = (RCBOA) = Isolation, Overcurrent, Short Circuit, Shock and Fire Protection from Earth fault and Fire due to Arc.

  C, Cost of DB with 2 ELCB 30mA or DB with each circuit with RCBO 30mA
- DB, ELCB 2 number 30mA 4 pole: Rs. 1500/- 2 numbers Rs. 3000/-. DB cost Rs. Rs. 6000/-
- DB, each circuit RCBO: Rs. 1200/- each. 2 Bedroom flat, 10 circuits, cost Rs. 12,000/-. DB cost Rs. 15,000/-

  Electric Fire Protection:



Total Circuits: 10 number


RCBO, 30mA, Rs 1200 AFDD

Main Causes:

- Arc, Cable arcing ground fault, overload. No correct cable derating factors for temperature and grouping

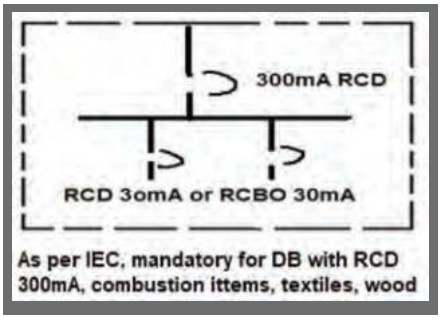
Combustion Materials storage electrical fire protection:

- Textiles, wood, papers showroom
- Remedy: Mandatory to install for fire protection by ELCB 300mA.

Fire due to arc from earth faults.

Cause:

- The majority of electrical fire are due to arc from leakage current in line-to-earth insulation failures
- Main and sub main circuits, high resistance ground fault: Leakage current produce arc.



Remedy:

- Recommend to protect by Ground Fault Protective Device (GFPD), setting at 5% to 10% of full load current.

  Fire Protection: Residual current monitoring (RCM) due to arc from earth fault:
- Commercial installations, high rise building and etc. If RCD trips during fault then loss of power.
- RCM is used as central control indication to know location of fault.
- As per risk factors, RCM make sense to install. Manufactures' advice.

Electrical Fire Presentation Guide: By Schneider Electric co, France.

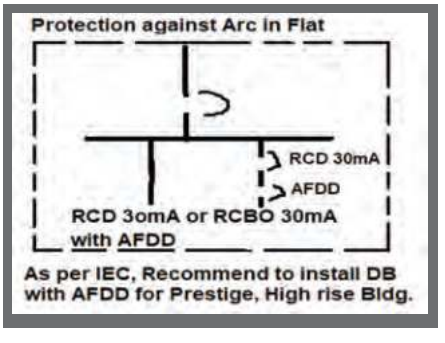
- Online download, free, PDF file: Guide, as per IEC, by Schneider Electrical Company, France. Path

6 Arc Fault Detection Device (AFDD): Protection against Fire from arc:

- Arc Fault Detection Device (AFDD): Prevent fire due to ARC. Not in Indian Standard.
- RCBO 110V: In USA, National Electrical Code (NEC): Mandatory since 2009 in residential flats. Cost Rs. 2000/-
- RCBO 23OV: IEC Recommends since 2012 for prestige Buildings, High Rise buildings and etc., cost Rs 8000/-
- IEC highly recommends for Combustion Materials Storage: textiles, woods, plywood and papers and etc.

Why AFDD to install in DB?

- Fire has the potential to put hundreds of occupants at risk within a matter of seconds. And when it comes to protecting life and property, there's no room for compromise.
- Beyond the risk to safety and life, fires can also have a major financial impact.
- With demand for electrical power on the rise, arc fault protection must shift from a "luxury" to a must.
- As per my opinion, at least, prefer to install for sockets circuit as per risk factors.



B, Video: From Eaton Company, on you tube. Path: https://youtu.be/UtOmau4ym1Q or Google Eaton+AFDD

Standards guide-books. Training of electricians and engineers:

- Indian Standards and IEC Standards: There are no guides book or training. How to understand?
- I am familiar with British Standards 7671:2018, "Recommendation for Electrical Installation" and "National Electrical Code (NEC), USA".
- BS7671:2018 is as per IEC standard, have 9 Guides and online training. Refer to www.electrical.theiet.org.

Electricians training as per standard and examinations to get license:

- "Building Regulations Electrical Work Standard" UK for electricians. This is developed for Building.
- In UK, there are many private institute schools for online training for electricians and Engineers.
- In UK, Electricians to pass examinations and license to work. In India, this is not required.
- Introduce Electrical Installation course in college for Engineers and electricians as per Indian Standards
- Training, pass examination and license for Electricians to work
- Regulations and standard for electrical installation in Residential Building as in UK.

Summary:

- SHOCK: Mandatory, ELCB 30mA or RCBO 30mA for all lights and sockets circuits. Cost Rs 1000/- each

ELCB 30mA: Main purpose protection against shock. Additional protection against fire from earth fault.

- FIRE: Mandatory, combustion Materials storage: Textile, wood, papers. To install 300mA RCD, Rs. 5000/-

Arc fault Protection Device (AFDD): Prevent fire due to ARC in the flat. Cost Rs. 8000/ each.

- Leakage Current Residual Current Monitoring (RCM) Alarm: Center control indications: Recommend to install in commercials and high rise for alarm against ARC due to earth leakage current.

References:

1. Online free, Consumer Guide, www.electricalsafetyfirst.org.uk.

2. Online free, "Electrical Installation Guide to IEC, 2018", Schneider Electric, France, 500 Page. Design Guide.

- Go to general contents, page 5 (7/535). Click, Chapters F, Protection against electric shocks and electrical fires. Chapter Q, Residential premises and other special locations, (High shocks risk).
- https://www.se.com/ww/en/work/products/product-launch/electrical-installation-guide/

3. www.theiet.org: British Standards, "Recommendations of Electrical Installations, BS7671 2018 and 9 guides.

4. Book, free online or Amazon: "Guide to the Wiring Regulations 17th Edition IEE Wiring Regulations (BS 7671: 2008)". By Electrical Contractors' Association (ECA), UK. Written by practical engineers. Rs.2,500.

Mobile Applications:

- "Electrical Calculations", by Ettore Galine: Free online, Pro Rs 190. Cable size and etc.
- Mobile Electrician": Anatolly Trasenko, Click IEC, Pro version, Rs. 120.

NEW RENEWABLE SOURCE DEVELOPMENTS

Solar and wind energy farms are becoming common, but current energy systems by themselves will not be able to meet entire requirements of the world, considering the limitations of these sources as also those of energy storage systems. These may not be sufficient to reach goal of pollution free energy, and there is scope for some new additional technologies, if the goal to make fossil fuels extinct has to be achieved in good time. There have been efforts by a number of researchers and organizations to develop newer sources and methods of energy generation and storage.

New technologies are being used in heat pumps, electronic equipment as also in solar and wind systems to improve their efficiencies and output. Following technologies are being added to the cart in energy development systems:

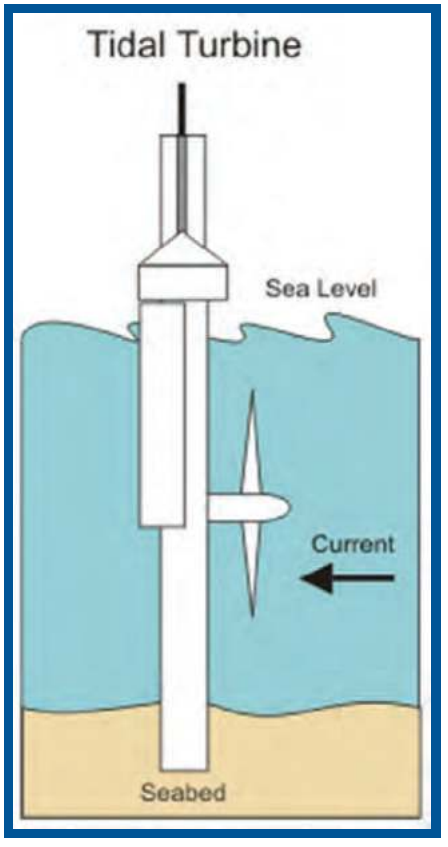
Tidal energy

Tidal energy is one of the major renewable sources in the world, but as yet in infant stages. Motion of natural water currents and rivers can be used to run mechanical devices to produce power. This can be done in number of ways.

- **Tidal stream generators** use kinetic energy of running water to power tidal turbines, similar to wind turbines. This method is preferred due to its lower cost and

least ecological impact. Dynamic tidal power uses both the kinetic and potential energy of moving water. This is done by creating very long dams across coasts right into the sea, without specifically enclosing an area. This method has a downside in that it can have adverse effects on natural habitat and ecology.

- **Tidal barrages** are built across full width at mouth of an estuary. Water is stored in barrages on high tide. Difference in levels during low tides is used for generating electricity similar to hydropower plants. This method has limitations due to lack of enough available sites worldwide and may also affect the ecology of river system.
- **Oscillating water column** uses waves to compress air in a closed chamber to generate wind and run turbine. Wind is created when water enters and recedes from chamber. Turbine is designed so that its direction does not depend on wind direction. One such plant of 500 KW capacity is in operation since 2000 in Scotland at Islay island.
- **Tapered channel (TAPCHAN) devices** use waves to pump seawater to an elevated reservoir. By energy conservation principle, as the wave width decreases, the amplitude increases, enabling the wave travel up a ramp and pour into the reservoir. Trapped water is then released back to run a turbine for generating electricity.

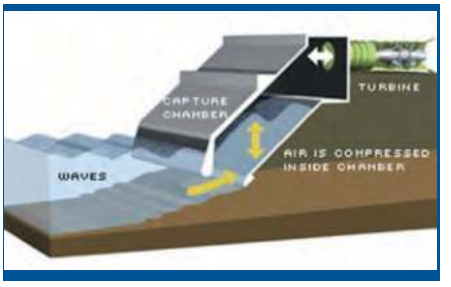


Benefits of tidal energy

- Tidal power is not much vulnerable to weather and season, and power is uniform all the year (since tides are predictable), with only minor variations.
- No fuel needed to operate, and no waste products.
- Long term and operating costs are low compared with conventional energy sources.

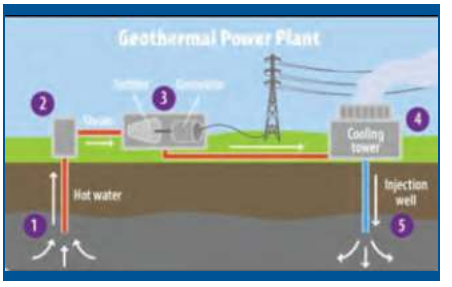
Gestation periods for these plants are quite long, and no power can be generated till they are complete. Payback periods are therefore longer. Batteries cannot be placed near them in sea. Though a new technology, it has high potential. UK is looking forward to 200-300 MW tidal wave generation capacity by 2020, and see a potential of up to 27 GW by 2050. This will be enough to meet 12% of current UK demand.

Blue Shark Power System, France has signed a MOU with the Republic of Djibouti for supply of 495 of River Tidal Turbines, with a capacity of 240 kW each, making a total capacity of 120 MW. They have planned to test



one turbine in the first half of 2019. First 80 machines are scheduled for the first half of 2020. The country will become energy independent once the project is completed.

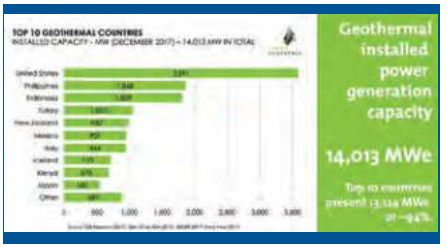
Credit for the largest tidal project in the world goes to South Korea at the Sihwa Lake Tidal Power Station, with an installed capacity of 254MW. Built in 2011, this also used a 12.5km long seawall built in 1994 to protect the coast against flooding and to support agricultural irrigation.



Orbital Marine Power, UK, is developing a tidal turbine system, which is claimed to be "most powerful tidal generating platform in the world". They plan to deploy their 2MW Orbital O2 turbine at the European Marine Energy Centre, in Orkney, in 2020. This will be 73 m long floating structure having two turbines of 1MW each, with 20 m rotor diameter. The capacity is rated for wave speed of 2.5 m per second, and adds up to generation of 48,000 KWH per day at full load.

Geothermal energy

Geothermal energy from hot springs and geysers has been historically



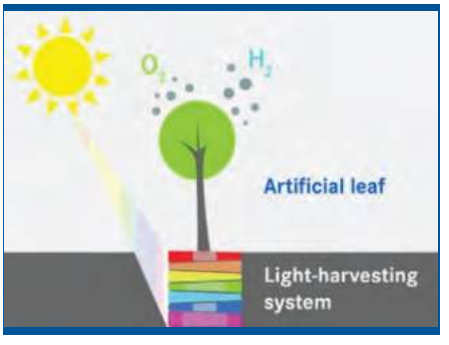
used for cooking, bathing and heat. Civilizations have used it throughout past 10,000 years, as is known from history. Number of places on earth use it today, mainly for heating and cooking purpose. At many places, hot water comes naturally to surface, and its use is easy. Sources for geothermal energy can be from shallow hot water springs and rocks, to few kilometers down the earth surface as extremely hot molten rock.

Efforts are on to pump water deep into rocks in dry land areas, and circulate the water to get heat to surface. Direct use of geothermal energy applications give heat at 50 -150°C, and can be used for room or space heating, and some low temperature applications. In Iceland and New Zealand, among others, buildings are heated by this hot water, and about 50% energy approximately gets trapped this way. This system has problems of salts and impurities, which need to be returned to earth.

Geothermal heat pumps at shallow depths can be used to heat buildings or houses. At these depths of under 6 meters, temperatures are more or less stable all the time, and direct heat exchangers can be used to cool or warm the rooms depending upon season and location, and also by circulating air from house through underground pipe system. This takes all the load of air conditioning.

Another method collects rising steam from depths by pumping water in, and use it to run turbines in power generation plant. Pressurized high temperature water is drawn from deep under the earth, and subject it to sudden decrease in pressure to vaporize it. Steam is then used for power plant. It is also possible to circulate heat exchanger fluids to these depths to heat water into high pressure steam for use in power plants.

Geothermal power plants have been in operation in New Zealand, California since 1960s, and today over 80 countries are using geothermal energy. Leaders in the field are China, Turkey. Hungary, U.S.A. and Iceland. Worldwide installed geothermal electrical power plant capacity in 2017 was about 14,000 MW, producing about 84.8 TWh. Waste heat from these plants



can be used for low temperature applications before recirculating the heat exchanger fluids through earth. Largest power plant complex is operating at Geysers, U.S.A., consisting of 22 plants, with 1.5 GW capacity.

Geothermal plants can be normally used for 20-30 years, and energy output may decrease with time. Environmental effect of geothermal heat extraction is minimum.

Artificial photosynthesis

Artificial photosynthesis is a chemical process mimicking natural photosynthesis process to use CO2, water and sunlight to generate carbohydrates and oxygen. Plants use sunlight and perform huge conversion of over 1000 billion tons of CO2 into organic matter and oxygen every year. They do this using only 3% of sunlight reaching the earth. Artificial photosynthesis system or photo-electrochemical cells mimicking the plants can create endless source of inexpensive never-ending source of gas and electricity, that too, in storable form.

Joint Center for Artificial Photosynthesis, U.S., came up with an artificial leaf, which uses sunlight to convert energy from sunlight to isolate hydrogen from water. They made prototypes with 3D printers, and in 2015 created system to separate CO2 before it is released into atmosphere, and convert to fuels and other products. Efficiency is claimed at 3%, and they feel it will be viable when the efficiency goes up to 10%.

Most water-splitting devices are made of a stack of light-absorbing materials. Each layer absorbs different wavelengths of full solar spectrum from infrared light to visible or ultraviolet light and generates voltage. These individual voltages together give enough one voltage to split water into oxygen and hydrogen fuel. The problem with this is performance potential of silicon cells is compromised in this system.

Converting seawater into jet fuel

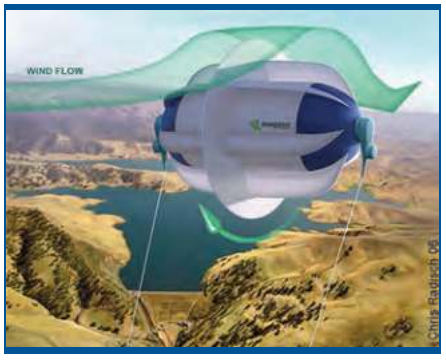
U.S. is the largest consumer of fuel in the world, with jet fuel accounting for over 70% of petroleum products. Though submarines can run on nuclear power, jet fuel for aircraft is still needed in large quantities.

They were looking for development a process for synthesizing fuel on board, so that dependence on oil tankers to fuel jets could be eliminated. Material science and technology division of Naval Research Laboratory, U.S. has reported developing a way to separate CO2 and hydrogen from seawater and convert these into liquid fuel.

NRL has filed a patent for a process to produce fuel from sea water. They claimed success with 92% efficiency in CO2 removal, and used the fuel to power a remote-controlled sustained flight. The process involves conversion of carbonates and bicarbonates to CO2, with simultaneous production of hydrogen using metal catalyst in reactor and convert the gases into liquid hydrocarbons. Sea contains over 140 times the concentration of CO2 compared to air.

Sea water is first acidified through ion exchange reaction to pH of 6.5 or lower by exchanging H+ ions for Na+ ions. It is then degassed to obtain CO2, and fed to a reactor to produce jet hydrocarbons. The carbon dioxide obtained by degassing is fed to a reactor with hydrogen to produce hydrocarbons, such as jet fuels. Hydrogen for reactor is also produced from sea water. Cost of jet fuel with this process is claimed to be $3-6 per gallon.

Flying wind farms



A large number of entrepreneurs are targeting the sky to harvest high amounts of energy in winds there. High up in the sky, ground resistance decreases, and winds blow at very high speeds, exceeding 150 Kmph. NASA is reserving funds of $100,000 for research for exploring high altitude wind farms. Idea is to have air borne turbines at 30,000 ft above ground level. At these heights, wind has more power and velocity, can be

predictable, and power generated can be 8 to 27 times that produced at ground level. Researchers estimate potential of such high-altitude wind turbines to be over 100 times that needed for the entire planet.

One benefit naturally is it will not take any ground space. Turbines may be housed using kites, or can be kept floating using helium filled balloons. NASA is trying with kite designs. The M.A.R.S. (Magenn Power Air Rotor System, in picture) is a helium filled device capable of harnessing wind energy and transporting it down via 330-meter rope. This 4 KW unit is likely to start production soon, and they expect to have 7 more models in coming years.

One major limitation is airspace restrictions in place so that they do not obstruct or interfere with air traffic. Currently, these limit the heights of turbines to 2000 ft and below. Winds at 2000 feet are 20 times stronger than for land-based turbines at 350 feet high. Theoretically, wind energy grows exponentially with speed.

Sky Windpower, a San Diego is developing a Flying Electric Generator (FEG), a kite-like 1,100-pound air-borne wind turbine expecting to build stable flying wind farms in future. This technology will act like vehicles in air space conforming to strict air traffic monitoring so that it does not become hazardous to other flying objects. There is also a challenge in transporting energy harnessed in skies above the oceans towards land-based power plants.

Please Note: The following is the Part 1 of the complete article. The article shall be completed in the Part 2 version which will be continued in the next issue

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- This article has been authored by

R. P. Deshpande,

B.Tech. Hon. (Elec.), IIT(Bom); F.I.E.

ALL INDIA INSTALLED CAPACITY (IN MW) OF POWER STATIONS
(As on 31.05.2020)

Region	Ownership/ Sector	Mode wise breakup								Grand Total
		Thermal					Nuclear	Hydro	RES * NRE)	
		Coal	Lignite	Gas	Diesel	Total				
Northern Region	State	16659.00	250.00	2879.20	0.00	19788.20	0.00	5777.25	701.01	26266.46
	Private	22425.83	1080.00	558.00	0.00	24063.83	0.00	2817.00	15790.10	42670.93
	Central	14354.96	250.00	2344.06	0.00	16949.02	1620.00	11491.52	379.00	30439.54
	Sub Total	53439.79	1580.00	5781.26	0.00	60801.05	1620.00	20085.77	16933.26	99440.08
Western Region	State	21740.00	1040.00	2849.82	0.00	25629.82	0.00	5446.50	555.54	31631.86
	Private	32847.17	500.00	4676.00	0.00	38023.17	0.00	481.00	24858.27	63325.46
	Central	18347.95	0.00	3280.67	0.00	21628.62	1840.00	1695.00	666.30	25829.92
	Sub Total	72935.12	1540.00	10806.49	0.00	85281.61	1840.00	7622.50	26080.11	120787.24
Southern Region	State	19512.50	0.00	791.98	159.96	20464.44	0.00	11774.83	586.88	32826.15
	Private	12747.00	250.00	5340.24	273.70	18610.95	0.00	0.00	41359.38	59970.33
	Central	11835.02	3240.00	359.58	0.00	15434.60	3320.00	0.00	541.90	19296.50
	Sub Total	44094.52	3490.00	6491.80	433.66	54509.99	3320.00	11774.83	42488.16	112092.98
Eastern Region	State	7450.00	0.00	100.00	0.00	7550.00	0.00	3537.92	275.11	11363.03
	Private	6153.00	0.00	0.00	0.00	6153.00	0.00	96.00	1214.56	7463.56
	Central	13682.05	0.00	0.00	0.00	13682.05	0.00	1005.20	10.00	14697.25
	Sub Total	27285.05	0.00	100.00	0.00	27385.05	0.00	4639.12	1499.67	33523.83
North Eastern Region	State	0.00	0.00	533.86	36.00	569.86	0.00	422.00	233.25	1225.10
	Private	0.00	0.00	24.50	0.00	24.50	0.00	0.00	101.39	125.89
	Central	770.02	0.00	1253.60	0.00	2023.62	0.00	1155.00	30.00	3208.62
	Sub Total	770.02	0.00	1811.96	36.00	2617.98	0.00	1577.00	364.64	4559.61
Islands	State	0.00	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	0.00	7.84	7.84
	Central	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.10	5.10
	Sub Total	0.00	0.00	0.00	40.05	40.05	0.00	0.00	18.19	58.24
ALL INDIA	State	65361.50	1290.00	7154.86	236.01	74042.36	0.00	26958.50	2357.03	103357.89
	Private	74173.00	1830.00	10598.74	273.70	86875.45	0.00	3394.00	83394.69	173664.13
	Central	58990.00	3490.00	7237.91	0.00	69717.91	6780.00	15346.72	1632.30	93476.93
	Total	198524.50	6610.00	24991.51	509.71	230635.72	6780.00	45699.22	87384.02	370498.95

Figures at decimal may not tally due to rounding off

Source: CEA

Energy Power Supply Position (Provisional)

Figures in MU net

States	May, 2020				April, 2020 to May, 2020			
	Energy Requirement	Energy Supplied	Energy not Supplied		Energy Requirement	Energy Supplied	Energy not Supplied	
	(MU)	(MU)	(MU)	%	(MU)	(MU)	(MU)	%
Chandigarh	119	119	0	0.0	195	195	0	0.0
Delhi	2,524	2,523	1	0.0	4,194	4,193	1	0.0
Haryana	3,899	3,899	0	0.0	6,412	6,412	0	0.0
Himachal Pradesh	683	682	1	0.2	1,122	1,118	4	0.3
UT of J&K and Ladakh	1,620	1,309	311	19.2	3,189	2,581	607	19.0
Punjab	4,107	4,107	0	0.0	6,394	6,394	0	0.0
Rajasthan	6,714	6,710	4	0.1	11,581	11,575	6	0.1
Uttar Pradesh	10,336	10,227	109	1.1	18,531	18,346	186	1.0
Uttarakhand	898	**898**	**0**	0.0	1,572	1,572	0	0.0
Northern Region	**30,900**	30,473	427	**1.4**	**53,190**	**52,386**	**804**	**1.5**
Chhattisgarh	2,372	2,372	0	0.0	4,508	4,508	0	0.0
Gujarat	9,541	9,541	0	0.0	17,038	17,038	0	0.0
Madhya Pradesh	6,193	6,193	0	0.0	11,553	11,553	0	0.0
Maharashtra	13,294	13,294	0	0.0	24,736	24,736	0	0.0
Daman & Diu	128	128	0	0.0	198	198	0	0.0
DNH	245	245	0	0.0	330	330	0	0.0
Goa	316	316	0	0.0	597	597	0	0.0
Western Region	**32,088**	**32,088**	**0**	**0.0**	**58,960**	**58,960**	**0**	**0.0**
Andhra Pradesh	5,565	5,565	0	0.0	10,353	10,353	0	0.0
Telangana	4,819	4,819	0	0.0	9,600	9,600	0	0.0
Karnataka	6,305	6,305	0	0.0	12,473	12,473	0	0.0
Kerala	2,191	2,190	1	0.0	4,237	4,235	2	0.1
Tamil Nadu	8,776	8,776	0	0.0	16,010	16,010	0	0.0
Puducherry	226	226	0	0.0	378	378	0	0.0
Lakshadweep #	5	5	0	0	10	10	0	0
Southern Region	**27,881**	**27,880**	**1**	**0.0**	**53,050**	**53,048**	**2**	**0.0**
Bihar	2,740	2,740	0	0.0	5,057	5,056	0	0.0
DVC	1,297	1,297	0	0.0	2,154	2,154	0	0.0
Jharkhand	707	707	0	0.0	1,403	1,382	21	1.5
Odisha	2,270	2,270	0	0.0	4,351	4,351	0	0.0
West Bengal	3,505	3,505	0	0.0	7,167	7,155	12	0.2
Sikkim	38	38	0	0.0	80	80	0	0.0
Andaman-Nicobar #	29	27	2	7	58	54	4	6.7
Eastern Region	**10,557**	**10,557**	**0**	**0.0**	**20,210**	**20,177**	**33**	**0.2**
Arunachal Pradesh	54	54	0	0.4	90	88	2	1.7
Assam	733	682	50	6.9	1,349	1,241	108	8.0
Manipur	70	70	0	0.4	135	134	2	1.1
Meghalaya	147	144	3	2.2	262	255	7	2.8
Mizoram	51	51	0	0.5	101	100	1	1.3
Nagaland	63	63	0	0.4	122	121	1	0.9
Tripura*	122	121	1	0.6	226	224	2	1.0
North-Eastern	1,240	1,185	55	4.4	2,285	2,162	123	5.4
All India	**102,666**	**102,183**	**482**	**0.5**	**187,696**	**186,733**	**962**	**0.5**

Lakshadweep and Andaman & Nicobar Islands are stand- alone systems, power supply position of these,does not form part of regional requirement and energy supplied. * Excludes energy exported to Bangladesh.

Note: Power Supply Position Report has been compiled based on the data furnished by StateUtilities/ Electricity Departments.

Source: CEA

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3 YEARS	18	2000.00	2900.00	3500.00	2000.00	3900.00	4500.00
5 YEARS	30	3000.00	4500.00	5500.00	3000.00	6000.00	7000.00
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w: www.alliedpowersolutions.co

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Smit Kubadia, (Sales and Digital Marketing Executive) +91 8097169519, smit@charypublications.in

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