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From the Publisher's Desk

NTPC's exemplary role in attaining our energy transition goals

Everything changes with time, thus, it is true for the electric power generation companies too. The way the number of black dots (indicating coal-based power plants) is being superseded by the number of green dots (indicating renewable-based power plants) in the NTPC's power station map, it truly demands appreciation. I don't feel the need to put even a second thought to call the Indian statutory corporation a forward looking Indian power generation company after seeing its recent move. Yes, I'm referring to its step to sign a Memorandum of Understanding (MoU) with Energy Vault Holdings, Inc. The objective of the MoU is to collaborate and formalize a long-term strategic partnership for deployment of Energy Vault's EVx gravity-based energy storage technology and software solutions based on the outcome of a joint feasibility study. The technology will also offer beneficial utilization of coal ash for manufacturing of composite blocks for Energy Vault's gravity-based energy storage system.

Recently, Gurdeep Singh, the CMD of NTPC Ltd., has stated, "As a large, integrated power producer, it is critical for NTPC to have a diverse clean energy portfolio to decarbonize India's economy. We have enhanced our renewable capacity addition targets to spearhead India's energy transition goals and we are focusing on Solar, Wind, RTC and Hybrid projects to achieve the targets. The collaboration with Energy Vault will help NTPC in furthering its energy transition goals through a sustainable approach by way of utilizing coal ash for manufacturing of composite blocks. Accordingly, this collaboration will also promote a circular economy." I feel his view is quite admirable at this juncture, when the entire world's focus is on decarbonisation and the Russia-Ukraine war has affirmed the ground to accelerate the process.

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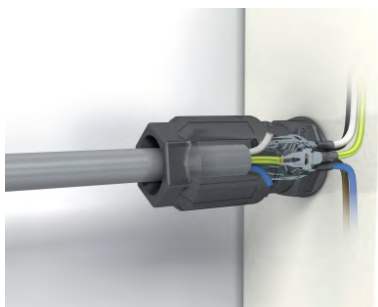
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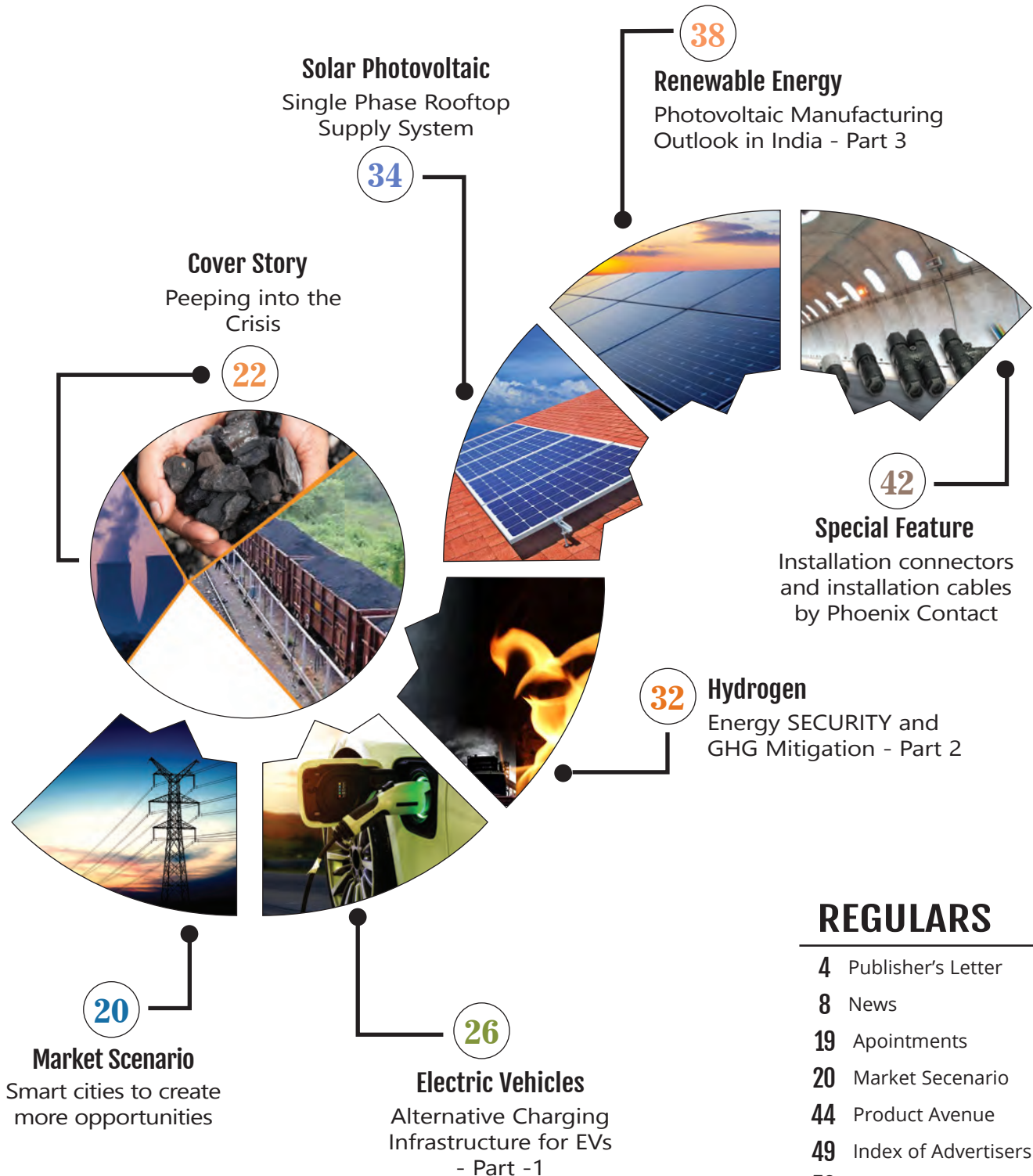
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NTPC, GGL TO BLEND GREEN HYDROGEN IN PIPED NATURAL GAS

With the continued focus on a clean environment, NTPC has taken up the initiative of blending green hydrogen in Piped Natural Gas (PNG) network of GGL (Gujarat Gas Limited) at NTPC Kawas. A formal agreement between the two companies has been signed recently in the

presence of Mohit Bhargava, CEO, NTPC REL & ED RE, NTPC; and Sanjeev Kumar, MD-GGL & GSPL.

Green hydrogen will be produced by using electricity from the existing 1 MW floating solar project of NTPC Kawas. This will be blended with PNG in a predetermined proportion and will be used for cooking applications in NTPC Kawas Township. Initially, the percentage



A view of the agreement signing ceremony...

of hydrogen blending in the PNG shall be around 5% and after successful completion, it shall be further increased.

NTPC is the premier energy utility in the country with an installed capacity of 69 GW, with a diversified fuel mix. The NTPC group plans to achieve 60 GW of RE in a decade and is executing several pilot projects in the green hydrogen space.

GGL is India's largest City Gas Distribution (CGD) company and has a presence across 43 districts in 6 states and 1 Union territory.

This hydrogen blending project at NTPC Kawas is a pioneering effort and the first of its kind in the country. This is a step toward the decarbonization of the cooking sector and self-sufficiency for the energy requirements of the nation.

INVESTMENT IN THE INTER-STATE TRANSMISSION SECTOR IS ADEQUATE TO MEET THE REQUIREMENT

According to the Union Minister for Power and New and Renewable Energy, R. K. Singh, several steps were taken to improve the Indian transmission sector..

At present, the inter-regional transmission capacity of the National Grid is about 1,12,250 MW (76,300 MW added since April, 2014). Considering the anticipated growth in generation and demand, sufficient transmission capacity has been planned in the country for evacuation of power from generating stations to the load centres including strengthening of existing transmission system.

During the year 2021-22, the Central Government has carried out following major reforms in the Transmission Sector:

Electricity (Transmission Planning, Development and Recovery of ISTS Transmission Charges) Rules, 2021 was issued on 01.10.2021. These Rules enable introduction of General Network Access, so that power sector utilities can have easier access to electricity transmission network across the country.

Planning and approval process of ISTS was simplified. Dual consultation for ISTS planning at regional level has been done away with and powers to approve ISTS system up to Rs. 500 crores have been delegated to Central Transmission Utility and National Committee on Transmission.

Central Transmission Utility (CTU) function has been separated from POWERGRID and Central Transmission Utility of India Ltd started function as CTU w.e.f. 1st April 2022.

Standard Bidding Documents for selection of developers for ISTS project have been revised to promote ease of doing business for private developers in transmission sector, address concerns of developers on risk sharing, encourage competition in transmission, and facilitate timely completion of transmission lines. All these provisions would bring in more private investment in transmission sector.



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INDIA'S SEMICONDUCTOR PURSUIT GETS A STRONG PUSH

The Semiconductor Industry Association (SIA), the top trade association representing the U.S. semiconductor industry, has recently signed a Memorandum of Understanding (MoU) with the India Electronics and Semiconductor Association (IESA), the premier trade group representing India's semiconductor and electronics

systems design and manufacturing industry, to foster collaboration and identify potential opportunities between the two countries in the semiconductor sector.

Headquartered in Washington D.C., SIA represents 99% of the U.S. semiconductor industry by revenue and nearly two-thirds of non-U.S. chip firms, while IESA is the premier Indian trade body committed to the development of a vibrant Indian semiconductor and Electronics System Design and Manufacturing (ESDM) ecosystem and promoting Brand India.



A view of the MoU signing ceremony between SIA and IESA...

Under the MoU, both associations will assist each other as the main counterpart organization on semiconductor-related matters within India and the United States – and will co-organize meetings between member companies to promote cooperation on issues of mutual interest.

Both organizations will also co-organize joint events (virtual or in-person) to explore

potential opportunities for U.S.-India cooperation within the global semiconductor value-chain.

Commenting on the MoU, John Neuffer, President and CEO of SIA, said, “We are delighted to sign this MoU with IESA and welcome India’s goal to become both a more powerful digital economy and a hub for electronics and semiconductor innovation within the broader global value chain. This MoU will help SIA establish and build relationships with key stakeholders and, for our members, gain a better understanding of the market in India.”

NATIONAL OPEN ACCESS REGISTRY (NOAR) GOES LIVE SUCCESSFULLY

Administration of short-term open access in inter-state transmission system automated Payment gateway provided...

National Open Access Registry (NOAR) has successfully gone live from 1st May 2022. NOAR has been designed as an integrated single window electronic platform accessible to all stakeholders including open access participants, traders, power exchanges, national/regional/state load despatch centres for electronic processing of short-term open access application thereby automating the administration of the short-term open access in inter-state transmission system.

The NOAR platform shall act as a repository of information related to short term open access in inter-state transmission including standing clearance issued by RLDCs or SLDCs and short-term open access granted to the open access customers etc., and make such information available to the stakeholders online. Payment gateway provided for making payments and

integrated with NOAR shall facilitate financial accounting and tracking of short-term open access transactions.

National Load Despatch Centre (NLDC) operated by Power System Operation Corporation Limited (POSOCO) has been designated as the nodal agency for implementation and operation of NOAR. NOAR would be the key to facilitate faster electricity markets and enable integration of Renewable Energy (RE) resources into the grid. NOAR will enable seamless market participation by the open access consumer with easier and faster access to the short-term electricity market, comprising of about 10% of all India demand.

NOAR is part of the Ministry of Power, Government of India’s initiative and the required regulatory framework has been notified by the CERC through operationalization of the 5th Amendment Regulation of Open Access in inter- State Transmission.



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OFFGRID ENERGY TO COMMERCIALLY LAUNCH ZINCCEL PRODUCTS IN INDIA BY NEXT YEAR

Offgrid Energy Labs, a young IIT Kanpur backed innovator and disruptor in the battery technology segment has developed its innovative ZincGel Battery Technology to strengthen India's EV battery swapping segment with sustainable batteries. The start-up will be targeting mobility partners to bring forth solutions for fleets operating low-powered electric vehicles like two-wheelers and three-wheelers. ZincGel Battery Technology, in comparison to lithium-ion and lead-acid material batteries, are non-flammable and reduce the damaging impact on the environment. Offgrid Energy Labs plans to commercially launch ZincGel products in India by next year.

ZincGel Battery Technology is a highly efficient alternative to the costly imported batteries that are currently available in India. It will balance the performance and pricing of batteries with the introduction



Tejas Kusurkar, Co-founder & CEO,
Offgrid Energy Labs

of zinc-based non-toxic materials. The first-of-its-kind technology has promising concepts and designs to address most of the issues faced by Li-Ion batteries especially in battery swapping sector. The efficient energy storage batteries developed by Offgrid Energy Labs can transform the energy landscape not only in India but around the world, fostering the growth of renewable energy and supporting the transition to clean energy.

Commenting on their work, Tejas Kusurkar, Co-founder & CEO, Offgrid Energy Labs, said, "We are super-excited to tweak ZincGel for battery swapping application. We have designed ZincGel as a modular platform that can be modified based on application requirements. With the ability to prioritize between charging speed, temperature stability and energy density, our innovation is focused on addressing a wide variety of stationary & low powered mobility applications." **EI**

EX-INDIAN CRICKET CAPTAIN SOURAV GANGULY BECOMES BRAND AMBASSADOR OF LLOYD

The association with superstar cricketer Sourav Ganguly will help Lloyd achieve its next phase of growth in the Eastern Market...

Lloyd, one of India's leading consumer durable brands of Havells India, has selected former Indian cricket captain Sourav Ganguly as the Brand Ambassador for markets in eastern part of India. As a part of the association, Sourav will endorse Lloyd range of consumer durables, through promotion, advertising and marketing.

Commenting on this decision, Anil Rai Gupta, Chairman & Managing Director, Havells India Limited said, "Lloyd believes in providing the best products to its customers with its focus on innovations, superior technology and after sales customer support. The brand sees Sourav Ganguly as an inspiration that portrays a rare blend of talent, class, intelligence, and popularity that complements Lloyd's legacy and brand ethos. We are confident that this association will enable

us to explore new avenues for our continued growth and success and further strengthen our positioning in the consumer durables segment."

Expressing his feelings, Sourav Ganguly said, "I am thrilled to collaborate with a brand like Lloyd that has such an incredible line of products with top-of-the-line features and superb quality. Lloyd has established itself as one of the most reliable consumer durable brands in India with its constant focus on innovations, superior technology and after sales customer support. Associating with such a brand is indeed an honour and I am looking forward to working with the brand."

With its product portfolio including state-of-the-art Air Conditioners, Washing Machines, Refrigerators and LED TVs, Lloyd is a leading brand in consumer durable segment. **EI**

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DANFOSS SILICON POWER, SEMIKRON TO ESTABLISH THE ULTIMATE PARTNER IN POWER ELECTRONICS

SEMIKRON and Danfoss Silicon Power have announced a merger to create a joint business specialized in Power Electronics focusing on power semiconductor modules. With an existing workforce of more than 3,500 dedicated power electronic specialists, the new SEMIKRON-Danfoss will provide world-class technology expertise as the leading partner in Power Electronics. The merger comes with a firm commitment to future investments, paving the way for green growth and a more sustainable, energy efficient and decarbonized future. SEMIKRON-Danfoss will be a central enabler of this transition.

The electrical power will be in the future the most important energy source. The power semiconductor module is at the heart of all power electronic solutions.



(LtoR): Claus A. Petersen, General Manager, Danfoss Silicon Power GmbH; Dominik Heilbronner, Shareholder, SEMIKRON International GmbH; Karl-Heinz Gaubatz, CEO/CTO, SEMIKRON...; Jorgen Mads Clausen, Shareholder, Former Chairman of Danfoss A/S; Bettina Martin, Shareholder, SEMIKRON...; Dr. Felix Hechtel, Head of Supervisory Board, SEMIKRON...; and Kim Fausing, President and CEO, Danfoss A/S...

The module is built of power semiconductors that make it possible to convert and control the electrical power.

With the rise of e-mobility, the demand for electric vehicles is expected to increase by 30% each year over the next years. This speaks to the enormous growth potential of power modules as they are a key component for powering the electric motor and in vehicle chargers.

SEMIKRON-Danfoss will leverage its strong core business in industrial- and renewable power module applications and will utilize the partnership to target a leading position in Automotive power modules.

SEMIKRON-Danfoss will set the trend and drive the technology shift into Silicon Carbide solutions in both industrial and automotive applications. ❶

BOLT DEPLOYS THE PIXIS AI INFRASTRUCTURE AND WITNESSES INCREDIBLE RESULTS

The company has received 10,000 EV charger orders within 3 months of deploying the Pixis AI infrastructure...

BOLT - India's largest EV charging network recently leveraged AI to supercharge their demand generation by 6X. With an estimation of 102M EVs to be set up in India by 2030, the startup is braced to provide the charging infrastructure that is so integral to the smooth running of EVs.

Amidst all its disruptive plans, BOLT recently announced its appointment as principal sponsor for Delhi Capitals, and is continually working towards spreading awareness about the sustainability benefits of transitioning into EVs. As part of its demand generation efforts, BOLT took to adopting the Pixis AI infrastructure to battle the challenges of finding and reaching its audience at scale.

Bolt needed to increase awareness about its products to increase its market penetration across

India. To do this, it was important they cater to India's various cultures and languages through its marketing communications. Considering the scale of the pan-India campaign and the challenges involved, Bolt zeroed in on using the Pixis AI infrastructure to successfully execute its marketing strategy.

Speaking about the results of the AI-led campaign, Amin Shaikh, Head of Digital Marketing at Bolt said, "BOLT's audience reach increased by 68% and our sales grew by 6X in two months. Additionally, we also surpassed the CTR benchmark of 0.3% to 80% and received more than 10,000 EV charger orders within three months of the campaign's commencement. These are incredible results that were made possible through the Pixis AI Optimizer." ❷



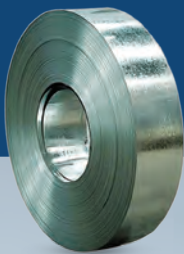
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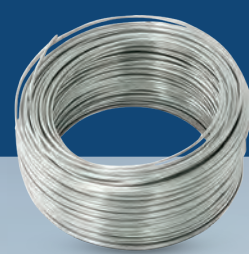
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MITSUBISHI ELECTRIC TO DEVELOP I&C SYSTEM DESIGN FOR HOLTEC INTERNATIONAL'S SMR-160

Mitsubishi Electric Corporation's U.S. subsidiary Mitsubishi Electric Power Products, Inc. (MEPPI) has received a contract from Holtec International (Holtec) to expedite the design engineering of the digital instrumentation and control systems (I&C) for Holtec's SMR-160 small modular reactor – which is a next generation small reactor with superior safety and reliability levels, featuring a natural cooling ability in case of any accidents.

Mitsubishi Electric and Holtec began developing preliminary designs for the SMR-160's I&C under an agreement signed in 2016 and will now accelerate these activities. Holtec, which aims to secure a SMR-160 construction license in 2025, is now considering deployment of a demonstration reactor.

In December 2020, Holtec was selected as an



MELTAC Nplus S digital safety I&C controller for SMR-160...

awardee by the U.S. Department of Energy Advanced Reactor Demonstration Program (ARDP) to design, engineer and license development of the SMR-160. Pursuant to the ARDP selection, Holtec issued the purchase order to Mitsubishi Electric to develop a control-room simulator that will be used to verify I&C design and review operation.

Holtec selected Mitsubishi Electric's MELTAC controls for the

SMR-160 design based on the company's long experience with nuclear power plant controls. In 2018, Mitsubishi Electric's MELTAC Nplus S safety control platform was favourably evaluated for use in U.S. nuclear power plants by the U.S. Nuclear Regulatory Commission.

Mitsubishi Electric is one of the world's leading names in the manufacture and sales of electrical and electronic products and systems used in a broad range of fields and applications. E1

INGERSOLL RAND'S CHANGZHOU FACILITY IN CHINA GOES SOLAR

As outlined in Ingersoll Rand's 2030 & 2050 Environmental Goals, the company aims to reduce GHG emissions by 2030 and realize net-zero GHG emissions by 2050...

Ingersoll Rand's Power Tools & Lifting facility in Changzhou, China recently completed the implementation of solar energy. The extensive project included the installation of over 3,500 square-metres of solar panels that will provide approximately 40-50% of average annual energy consumption by the facility. The facility can now generate 0.85 million kWh every year, saving approximately \$23,000 and reducing 700 tons of CO₂ emissions annually. In addition to providing cost savings, solar energy not consumed in the plant will feed the country's national electric grid to benefit other communities.

The project supports Ingersoll Rand's 2030 and 2050 Environmental Goals and aligns with local community environmental efforts and China's Blue Sky initiative, the country's shift to prioritize greener manufacturing methods.

Ingersoll Rand's internal conservation goals are tied to cost-saving through investment and footprint optimization. Investments in solar energy have proven to be impactful. In addition to the Changzhou facility, a new solar energy plant in Naroda, India is expected to reduce dependence on conventional energy by almost 40% with almost 1,800 solar panels totaling a capacity of 800 kWp. Three Italian operating sites have also gone solar, reducing annual energy consumption by 30%; energy gathered on non-operating days is also fed into the national grid for neighbouring communities.

With the purpose to make life better with sustainable solutions and innovative products that help customers with their own environmental goals, the company also targets to reduce the GHG emissions from customers by 15% by 2030. E1



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SIEMENS ENERGY TO START INDUSTRIAL-SCALE PRODUCTION OF ELECTROLYZERS FOR GREEN H₂

Siemens Energy will locate the industrial production of electrolysis modules in Berlin and is thus taking the centerpiece of its hydrogen technology to the capital. Start of production at the location Huttenstrasse in Berlin's Moabit locality is scheduled for 2023. At this site the complete infrastructure of an existing production hall can be used.

New production lines for the electrolyzers are being set up on 2,000 square metres at a cost of around 30 million euros. Today, the site mainly manufactures gas turbines, which are among the most powerful and efficient ones in the world. These can already be operated with up to 50% hydrogen, and by 2030 complete hydrogen operation should be possible.

Siemens Energy is now pooling its expertise in both these areas in Berlin to ensure a reliable and



Thomas Bagus (L) will head industrial production of the electrolyzers at Siemens Energy in Berlin...

successful energy transition to a new energy mix. This also includes the business field of energy transmission: At the Siemens Energy Switchgear Plant Berlin innovative high voltage products are manufactured, ensuring that electricity reaches consumers reliably.

Commenting on the plan, Christian Bruch, President and CEO of Siemens Energy, said, "With the new production

facility for hydrogen electrolyzers, we are reinforcing our claim to play an active role in shaping the energy transition. To this end, we are pooling our knowledge in the field of various energy technologies in Berlin. For us, hydrogen is an important component of the future energy world. For this to be economically viable, the manufacturing costs for electrolyzers must be significantly reduced."

UL CERTIFICATION FOR ES EQUIPMENT SUBASSEMBLIES HELPS SHORTEN PATH TO ESS COMPLIANCE

UL established the market-leading testing and certification offerings for ESS, contributing to the simplification of complex certification activities...

UL has created a certification service for Energy Storage Equipment Subassemblies (ESES) to evaluate for compliance to UL 9540, the Standard for ESES. This allows manufacturers of large energy storage assets to procure certified (listed) components from the battery supplier and the power conditioning equipment supplier to create the Energy Storage System (ESS).

UL certified three ESES for NHOA Energy (formerly Engie EPS), NHOA Group's Global Business Line dedicated to stationary energy storage that designs and delivers turn-key storage systems, helping independent power producers to achieve their renewable targets.

The ESES Certification program makes it easier for Direct Current (DC) storage system manufacturers, code authorities and owners of ESS assets to: Demonstrate DC storage systems meet UL 9540; Have

flexibility when pursuing UL's Battery and ESS Testing and Certification services; Find suppliers within UL Product iQ; and Navigate a rapidly changing code and regulatory compliance environment.

Commenting on the development, Maurice H. Johnson, a product manager for batteries and energy storage systems in UL's Energy and Industrial Automation group, said, "Through the new ESES Certification, a DC storage system manufacturer has an easier and faster path toward Certification to UL 9540. This is another example of how our cost-effective and time-sensitive certification strategies deliver the utmost flexibility and superior certification methods, accelerating time to market. UL is first to offer this type of Certification, and we are proud that we can pair it with our world-class fire propagation testing."

K. KASOTIA TAKES OVER AS COO – WIND, HYBRID & STORAGE OF AMP ENERGY INDIA



He has worked with leading renewable energy developers such as Sembcorp Green Infra and Vena Energy...

Amp Energy India, a leading renewable energy company has hired Kapil Kasotia as Chief Operating Officer (COO – Wind, Hybrid & Storage) in line with its growth in providing renewable energy solutions through wind, hybrid and storage. Kasotia has been brought on board to focus on the evolving wind, hybrid and storage portfolio of the company and strategic investments in line with the evolving nature of the market needs, the company is replicating its business offerings in wind, hybrid and storage.

Kasotia, an alumnus of IIM Calcutta, has brought over two decades of experience in delivering 3-4 GWs of projects across wind, solar & hybrids. Commenting on Kasotia's appointment, Pinaki Bhattacharyya, Amp Energy India–Co-Founder, MD & CEO, said, "We are happy to have Kapil on board as he brings in decades of experience in the renewable energy sector and government engagement to ensure our growth targets are met and exceeded."

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S. SINHA, CHAIRMAN AND CEO OF RENEW POWER, BECOMES THE NEW PRESIDENT OF ASSOCHAM



He is a passionate advocate for solutions related to climate change and sustainable development...

Sumant Sinha, Founder, Chairman and CEO of ReNew Power – one of the country's largest clean energy companies, has taken over as President of the Associated Chambers of Commerce and Industry of India (ASSOCHAM). Sinha founded ReNew Power in January 2011, with a vision to transform the way energy is produced and consumed in India. Under his leadership, ReNew Power has grown into India's premier renewable energy company with an aggregate portfolio

of more than 10 GW spread over more than 100 sites.

Commenting on his strategy, Sinha said, "During my tenure as ASSOCHAM President, my colleagues at ASSOCHAM and I will support corporates, MSMEs, smaller entrepreneurs, and artisans in working collaboratively with the government to ensure India's products reach "every nook and corner of the world", as per the Honourable PM's just-stated vision for 'local' to become 'global'."

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R. K. PARAKH OF VIKRAM SOLAR GETS PROMOTED TO THE RANK OF COO



He has an exceptional leadership track record as the CFO of Vikram Solar...

Vikram Solar has recently appointed R. K. Parakh as Chief Operating Officer (COO) for the Engineering, Procurement and Construction (EPC) division. Parakh has been associated with the company since 2017 as the Chief Financial Officer (CFO). He has been at the helm of driving several strategic and financial planning initiatives at Vikram Solar.

Commenting on Parakh's appointment, Gyanesh Chaudhary, Vice Chairman and Managing Director, Vikram Solar, said, "Mr. Parakh has led the organization as

the CFO and has complete overview of our global operations, projects, business development, Research & Development (R&D). The solar sector is at an inflection point with government's policy impetus and the demand surge for solar globally to accelerate the clean energy transition. At this juncture, we will immensely benefit from Mr. Parakh's deep industry knowledge to further strengthen our track record and leadership in solar EPC, which significantly contributes to our overall revenues."

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Smart cities to create more opportunities

As per the report published by The Brainy Insights, the global Power Transmission Lines & Towers market is expected to grow from USD 90.07 billion in 2020 to USD 210.25 billion by 2028, at a CAGR of 10.43% during the forecast period 2021-2028...

Increasing electricity demand and integration of a sustainable electrical network are some of the factors that are driving power transmission line & towers market. The smart cities project in many developing economies will increase the demand for electricity, which will ultimately create wide opportunities for power transmission lines & towers industry.

Market Driver

Transmission lines are used as a medium to send the power from one place to another. It is not necessary the source of power generation should be the place where it is consumed. As it is far away from the place where it is consumed, the land would be much cheaper here. Also, according to government policy, such loud and polluting stations should be far away from the cities, the place for consumption of electricity. Hence the power transmission lines would be used for transmitting power from the source to the cities, where there would be load centers and the power will be consumed. The power transmission system includes short transmission lines, medium transmission lines and long transmission lines. Transmission tower supports the transmission lines from the generating power stations to source substations and satellite substations in cities. The surging demand for electricity, the infrastructure and initiatives given by the government, to spread the electricity all across the country are the factors driving this market. The increase in peak load demand, because with an increase in disposable income, the

standard of living has changed, the lifestyle has changed, this has given them access to all the comfort giving consumer products, which the people are using to feel comfortable and to enjoy quality life. This factor has also driven this market.

Improved Technology

The technological evolution across the developing region is slow. The big problems in the developing regions are they have infrastructure issues, and the pace of urbanization is increasing fast. So, the organization primarily concentrates more on setting the infrastructure and urbanization, rather than on the technological evolution. Thus, this can act as a restraint for power transmission lines & towers.

Prominent Players

Key players operating in the global power transmission line & towers market include MasTec, Sterling & Wilson, Skipper, KEC, Prysmian, Sumitomo Electric, Southwire, Nexans, CG Power, ABB, GE, Siemens, Sterlite, Zhejiang Shengda, Artech and Adani among others.

The key players are now concentrating on implementing strategies such as adopting new technology, product innovations, mergers & acquisitions, joint venture, alliances and partnerships to improve their market position in the global power transmission lines and towers industry. In February 2019, Adani Transmission had acquired KEC Bikaner Sikar Transmission Pvt Ltd. By this acquisition of the company, the cumulative network will reach around 13,450 ckt km.

In August 2018, Artech introduced smartVAR IC range, combining harmonic filters and capacitor banks in ISO/DV standard, which provides harmonic filtering and reactive power compensation across renewable generation plants.

Traditional setup

The conventional segment held the highest market value of USD 52.86 Billion in 2020. The conductor segment is divided into conventional, high temperature and others. The conventional segment held the highest market value of USD 52.86 Billion in 2020. This is because of the efficient electrical conductivity.

The PVC segment held the highest market value of USD 42.59 Billion in 2020. The insulation segment includes PVC, XLPE and Rubber. The PVC segment accounted for USD 42.59 Billion of market value in 2020. This is due to its many properties like high mechanical strength and its fire-retardant nature etc.

The 221 kV to 660 kV segment held the highest market

value of USD 46.16 Billion in 2020. The voltage segment includes 132 kV to 220 kV, 221 kV to 660 kV and > 660 kV. The 221 kV to 660 kV segment accounts for the highest market value of USD 46.16 Billion in 2020. This is due to the increase in the deployment of HV electric network.

The HVDC segment held the highest market value of USD 55.12 Billion in 2020. The current segment includes HVAC and HVDC. The HVDC segment accounts for USD 55.12 Billion of market share in 2020. This is because rapid urbanization has created demand for energy which is leading to the requirement of extra and ultra-high-tension transmission infrastructure.

The Ultra High Tension segment accounts for the highest CAGR of around 15.33% in the forecasting period. The application segment includes high tension, extra-high tension and ultra-high tension. The Ultra High Tension segment accounts for the highest CAGR of around 15.33% in the forecasting period. This is due to the surging demand for energy by the industrial and commercial sector.

EB






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— Supporting —



PEEPING INTO THE CRISIS

At this moment, the supply of coal to our Thermal Power Plants (TPPs) has been drastically affected. However, it is a combined effect of several factors, out of which the unexpected rise of mercury was not at all controllable. The union government is trying its best to mitigate the crisis...

- P. K. Chatterjee (PK)

Although the mid-May is well known as the hottest season in Northern India and for the western and southern regions it is April to beginning of May, this year (2022) has already broken several past records as far as the day temperatures at different parts of India are concerned. On April 28, Ahmedabad recorded 44.4°C maximum temperature, on the very next day Gwalior witnessed 45.2°C maximum temperature, both are the highest in the last 10 years.

Obviously, the situation has led to the unprecedented need for cooling, unexpectedly heightened need of irrigation et al., which have

ultimately increased the demand of electricity when the industries are starting their full-fledged operations after the COVID-infested slow down. However, because of the shortage of coal, most of our thermal power plants are now running at low capacity and the total supply of power is around 70% of the total peak demand. This is causing around 2 to 8 hrs., of power cuts at different parts of our country.

According to the Union Government sources, the maximum all India power demand met is 201.066 GW at 14:51 hours on April 26. It has surpassed last year's maximum demand met of 200.539 GW, which occurred on 7th July 2021. The rising power demand reflects the economic growth in the country. In the month of March this year, the growth in energy demand has been around 8.9%. Further, the demand is expected to reach about 215-220 GW in months of May-June. The Union Government and other stakeholders are working together to ensure unhindered power supply and efforts at all fronts are being made and measures are being taken for better utilisation of various resources.

A few examples of shortage of coal from different states in April 2022

Uttar Pradesh: As of April 25, 11 out of 13 coal fired power plants have reached critical coal stock level (i.e. less than 25% of normative coal stock.)

Rajasthan: As of April 18, all the 7 thermal power plants of the state have reached critical coal stock level.

Haryana: As per the available report on April 18,

Yamuna Nagar TPP and Panipat TPP had coal stocks respectively for 8 days and 7 days.

Punjab: As per the available report on April 18, 2 units of GVK Goindwal Sahib TPP were temporarily shut down. On the same day, Guru Gobind Singh TPP was left with a stock for only 8.6 days and Guru Hargobind TPP was left with a stock for only 6.3 days.

No of plants having critical stock *	
Plants based on domestic coal	88
Plants designed on imported coal	12
Plants currently not in operation	8
Total	108
*Plant has been shown critical, if the coal stock is less than 25% of normative coal stock.	
Source: CEA	

A few major causes behind the power demand-supply gap

First of all our power demand has increased from 106.6 BU per month in 2019 to 132 BU per month in 2022. Secondly, the crisis is continuing from the previous year 2021. In last October, the stock of coal in many TPPs stood at a level for only 4 days. It was due to delay in shipment. Also, because of heavy rainfall at different coal fields, the coal extraction job was affected badly. Thirdly, because of the Russia-Ukraine war, many Captive Power Plants (CPPs), which earlier depended on the imported coal, are now looking at the domestic supply for their operation. Last but not the

A glimpse of the situation as on 28.04.2022
(Source: Daily Coal Stock Report by Central Electricity Authority)

Plant Category	Capacity (MW)	Daily Requirement (TT)	Total Stock (TT)
Plants based on domestic coal	183051	2548	19780
Plants designed on imported coal	17255	160	1233
Plants currently not in operation	3041	40	0
ALL PLANTS	203347	2748	21012

Plants as per Pithead/Non-Pithead

Mode	No. of Plants	Capacity (MW)	Daily Req (TT)	Total Stock (TT)	Normative Stock (TT)	% of Actual Stock vis-à-vis Normative Stock
Pithead	18	39222.5	546.9	7257.1	9296.6	78%
Non-Pithead	147	164124	2201.4	13755	57236	24%
TOTAL	165	203347	2748.3	21012.2	66533.1	32%

Source: CEA



R.K. Singh is addressing the issues of ICB plants...

least reason is the decision of the Central Government that led to 43.6% reduction in power generation from imported coal. It added an extra demand of 17.4 MT of domestic coal.

Steps taken by the Union Government to improve coal supply to TPPs

According to the sources, "In line with various measures being taken in view of increasing power demand, Power Ministry has amended the methodology for use of coal (allocated to states) by Private Power generating stations (IPPs). Larger visibility has been given to the power plants by extending the period of supply of coal from 1 year to 3 years. The power ministry has further made amendments in the timeline of bidding process, which has been reduced from 67 days to 37 days. The measures have been taken for ensuring more efficient utilisation of domestic coal.

The union government has taken these measures in order to optimally utilise the railway infrastructure for maximum transportation of coal to the power plants. According to the MoP, this would enable states to optimally utilize their linkage coal in the plants nearer to the mines – as it would be easier to transmit electricity instead of transporting coal to far off states.

Power Minister R.K. Singh and Union Minister for Railways Ashwini Vaishnaw held a meeting recently to discuss short term and long term strategies for dealing with increasing power demand.

Power Secretary Alok Kumar, Coal Secretary A.K. Jain and senior officials from Ministry of Power, Coal and Ministry of Railways were also present there. Representatives from Coal and Power PSUs and states of Madhya Pradesh, Rajasthan, Gujarat and Maharashtra joined the same virtually.

Singh urged all stakeholders at the centre and state level to work hand in hand for unhindered power supply. He urged the Power GENCOs to own freight rakes under the scheme of Ministry of Railways to deal with logistic constraints in coal supply. Issues discussed included increasing operational efficiency for loading and unloading of coal, increasing percentage of rakes allotment for power sector, and other logistics issues.

Indian Rail is also trying now to provide their best support to goods trains carrying coal. The railways are now giving preference to coal carrying rakes over passenger trains wherever required. They are also keeping track of the mechanical condition of these rakes.

With a view to increasing the coal supply to TPPs, Break Power Certificates (BPC) of rakes has been extended. Earlier the rakes used to be sent to garage after completion of every 7,500 km, but now the same is being done after running 10,000 km.

Concluding statement

The harsh climate change has created an unexpected pressure on the Indian power sector. The MoP has been actively trying to remedy the crisis of shortage of coal in TPPs, however, as the challenge is quite big, it will take some time.

If monsoon comes in time, intensity of the challenge will partially reduce, however, the power, coal and railway ministries will have to more meticulously pursue the matter of supplying coal to the existing TPPs.

Running any plant at low capacity or shutting down the same for coal supply shortage is an economic loss for the nation. During 'Azadi Ka Amrit Mahotsav', we must ensure this aspect.



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Part - 1

Alternative Charging Infrastructure for EVs

Albert Einstein said, “We cannot solve our problems with the same thinking we used when we created them.” Thus, a big shift in paradigm is absolutely essential to overcome the challenges and speed up the deployment of Electric Vehicles (EVs) on all roads on the surface of the earth...

Starting from early 19th century, the invention of EV has a long history & is attributed to various people. However, it was sometime around 1828, when a Hungarian priest and physicist Ányos Jedlik invented an early type of electric motor and then went on to create a small model car powered by his new motor. Probably this was the beginning of EVs. In 1835, Thomas Davenport (the inventor of the first DC electric motor in America), from Brandon built a small-scale electric car. During the same period (between 1832 and 1839), Scottish inventor Robert Anderson also invented a crude electric carriage. In 1835, Professor Sibrandus Stratingh of Groningen, the Netherlands, and his assistant Christopher Becker from Germany also created a small-scale electric car, powered

by non rechargeable₁ primary cells. In 1891, the first regular electric car in the United States was developed by William Morrison, which was a six-passenger wagon capable of reaching a speed of 23 kmph (14 mph). It was the period (1878~1882), when Thomas Edison also developed and started selling viable electricity. With two mutual supportive technologies rising at the same time, the EVs started getting prominence. By 1895, engineers began to devote their attention to EVs as even in their primitive forms also these EVs were much better than the prevailing horse-driven & steam-propelled carriages. With increased interest in EVs, many innovations followed in the late 1890s to early 1900s making EVs a preferred mode of transportation – on road, on the rail, and even a combination of both in form of trams.

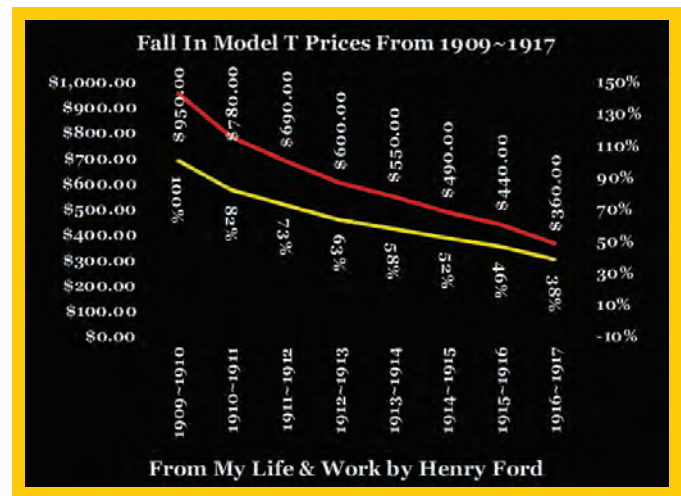
Even when the early ICEVs started appearing on road, post the patent of the first tricycle by Carl Benz on 29th Jan 1889, the EVs were still found & preferred as they were much better₂ compared to primitive ICEVs. By 1912, since many homes in the USA had electricity, the period saw a surge in the popularity of EVs & by the turn of the century, with 33,842 registered EVs & 32% market share in the USA, EVs were hot cakes in the mobility market (Steam cars 40%/ ICEVs 22%) despite the fact that most of these early EVs were massive, bulky & expensive (but so were steam cars & ICEVs), slowly, EVs were gaining acceptance, making them popular. Sales of these EVs peaked in the early 1910s when there were over 300 listed manufacturers in the USA who produced EVs.

However, the fall of EVs came much quicker than expected from 1910 to 1930 – a period, during which many innovations related to ICEVs improved their performances & created exponential growth of their market. While, many prevailing political factors also supported & promoted the growth of ICEVs, the technology & infrastructure needed for EVs also lagged than that of ICEVs. As the road system in the USA started growing (1880 onwards), connecting widely spread cities, the need for a vehicle, which could travel longer distances with ease of fuel supply, arose. This need was well matched by the timely discovery of crude oil in the Texas area (1901).

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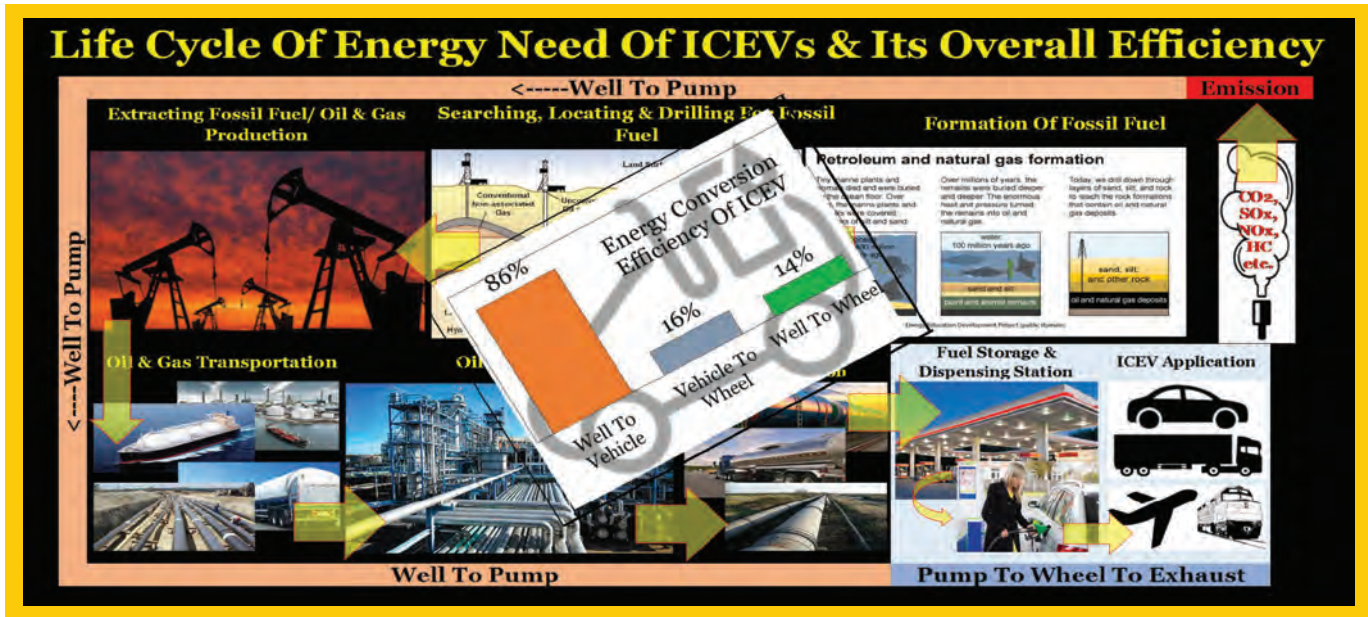
their market. While, many prevailing political factors also supported & promoted the growth of ICEVs, the technology & infrastructure needed for EVs also lagged than that of ICEVs. As the road system in the USA started growing (1880 onwards), connecting widely spread cities, the need for a vehicle, which could travel longer distances with ease of fuel supply, arose. This need was well matched by the timely discovery of crude oil in the Texas area (1901).

The continuous reduction in the prices of oil as well as that of ICEVs, thanks to Henry Ford who introduced the concept of the “interchangeability of parts” and the “moving assembly line” between 1917 and 1928, and went on to churn out more than 15 Million Units of Model T from his factories. Both factors created a mutually supportive loop for the growth of the ICEV market. Once the invention of the electric starter (by Charles Kettering) in 1912, eliminated the need for the hand crank to start these ICEVs (a major deterrent for female & aged drivers), there was no stopping for ICEVs for the next 100 years.



On the other hand, since neither the battery technology was improving in those times nor the EV's control systems, due to which EVs lacked the power, needed long charging time & offered lower travel range, which curtailed their growth and in a short span of 50 years, beginning from early 1880, the EVs, having attained their peak in 1910, literally got eliminated from the mobility market by the end of 1929 when the last Detroit EV under Anderson was shipped in November 1929. Finally, EVs completely disappeared by 1935.

Over the next 100 years, an incredibly large and complex infrastructure grew & strengthened to harness



& distribute fossil fuel, primarily focused around ICEV based mobility systems. Such infrastructures include oil fields, pipelines, refineries, storage, transportation & distribution systems. This fuel cycle has a very complex “Life Cycle” from its source to final use as shown below.

Energy Needs: Here, it is pertinent to note that all kinds of energy sources when used, generate some or the other kind of heat & greenhouse gases yet the energy is certainly needed for the growth of the society. Unfortunately, the explosion in the numbers of ICEVs brought the burning of fossil fuel “within the society”. With a huge number of ICEV built since 1900 (by a rough estimate there are approximately 1.2 billion automobiles are on the road across the globe burning the fossil fuel, leaving aside another large number of equipment/ machines run by ICEs and this number is expected to grow to 2 billion at least by 2040₃). While the emission from these ICEVs/ ICEs has always been a major concern, the ICEVs also brought many other kinds of environmental issues, such as land & water contamination, high noise levels, and deterioration in AQI, etc. With times, these issues attained monstrous proposition impacting the whole plant and started affecting all forms of lives (human, animal, marine & vegetation, etc.). It has been well recorded that the GHG emitted during the current industrialization has already raised the average global temperatures by about 0.6 DegC (compared to pre-industrialization times) and it continues to rise. This temperature change has a far-reaching impact on the whole eco-system affecting farming, wildlife, sea levels and is altering the

natural landscapes as ICEs only contribute about 1/5th of this total global warming pollution.

On the other hand, electrical energy is one of the most compact, portable, cleanest & safest forms of energy, which can also be generated from many renewable energy sources such as hydropower, sunlight, wind, rain, tidal waves, and geothermal heat without even burning fossil fuels. With technological advancements in recent times, all these energy sources are now being extensively tapped across the world to generate electricity (the share of renewable energy in global electricity generation has jumped to 29% in 2020, up from 27% in 2019₄ and is expected to increase to more than 35% in 2022.)

The electricity from any of sources mentioned above (which do not require any burning of fossil fuels), once fed into electricity grids, can be used by the EVs. Commercial viability of these energy sources and increasing awareness about global warming and environmental degradation, pushed the revival of EVs, and they started receiving fresh attention for revival. Slowly, multiple technologies combining electricity with ICE started coming into prominence in mobility systems e.g. BEVs, HEVs, PHEVs & FCEVs but BEVs (or simply EVs) were yet to bounce back.

Rise of BEVs: The rise of EVs can be attributed due to the culmination of many unrelated technological innovations that merged with geopolitical incidents happening between 1940~1980. While some of the important technological innovations included the invention of the transistor (1947), MOSFET (1959), Li-ION battery (1980), the

geopolitical incidents included the Gulf Oil Crisis (1970) & the rise of environmental consciousness in society across the globe. The first revival of EV was tried out in 1997 when GM had rolled out its EV₁, though it did not succeed₅ but certainly it created a buzz on the great future possibility of these EVs by showing their superiority over ICEVs. By 2004, when the advancement in the solid-state electronics, controller, and drives as well as in the batteries seemed to have reached that threshold at which no one could stop the rise of EVs, came the Team Tesla backed by Elon Musk who, like Henry Ford [whose focused approach on creating an affordable ICEV for masses was responsible for altering the face of mobility world forever, when he created Model T], was also focused on creating an affordable EV for masses. Under Elon Musk, Tesla invested heavily in the Giga Factories between 2003~2005 to produce its first EV (Roadster), having a travel distance of 394 km on a single charge (under test conditions), a travel range unprecedented for any production EV till date. Tesla went on to develop cutting-edge battery technologies as well-matched electric powertrain needed for new-age EVs. From there, Tesla designed its bestselling premium all-electric sedan Model S, which could compete with any existing ICEVs on safety, performance, and efficiency. The acceptability of the Tesla Model S opened the flood gates for the EV market.

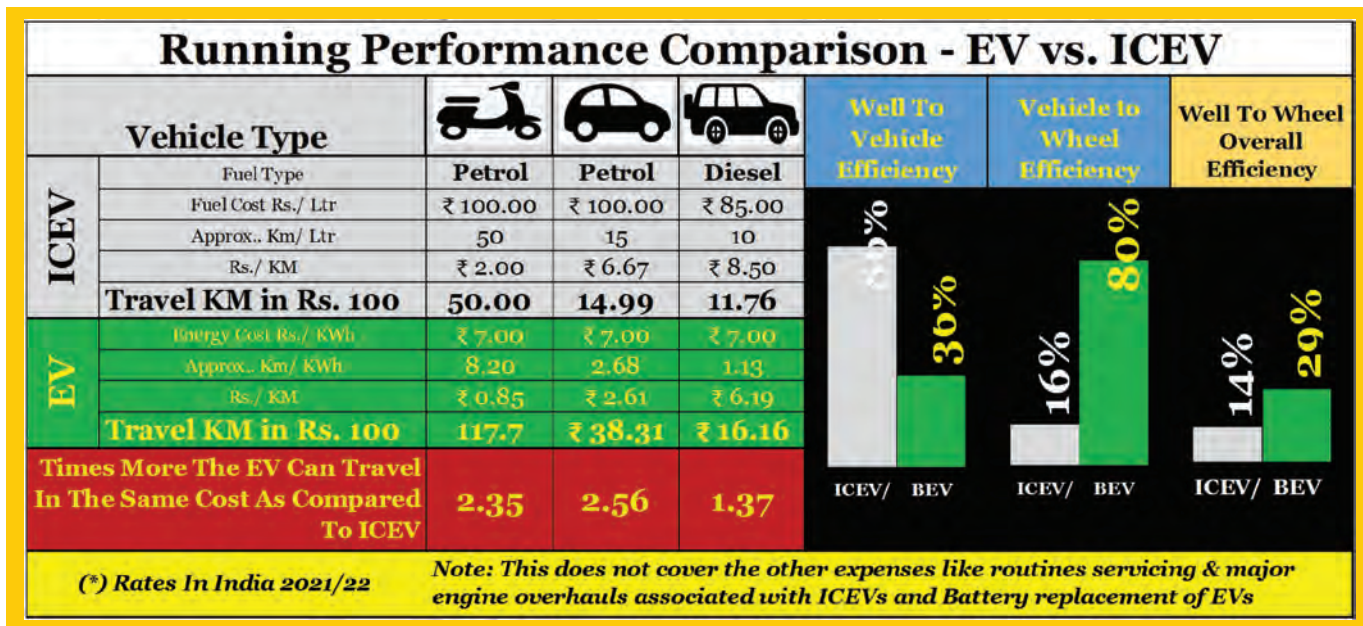
On 04 Dec 2018, the UN Secretary-General, António Guterres in his speech₆ at the E-Mobility event of COP24, had also pointed this shift "...Many are putting in place the policy frameworks and infrastructure needed for sustainable transport. A growing number of countries and regions have announced plans to phase out fossil fuel vehicles and to shift to e-mobility. Others are putting in place targets for the absolute number or overall share of electric vehicles by 2020 or 2030... These policy initiatives have spurred market growth for electric vehicles. There is increasing demand and many businesses are embracing e-mobility and its new economic opportunities. According to Bloomberg, by 2040, 55% of all new car sales and 33% of the global fleet will be electric."

The snapshot at the bottom of this page gives a broad timeline set by various global automobile manufacturers to phase out the ICEVs while some of them have still not made up their long term plans on this issue.

Economics of Running BEVs: While, on one side EVs have much lower number of moving parts (e.g. just in the drivetrain in an ICEV, there are typically 2,000+ moving parts, whereas the drivetrain in an EV contains around 20+ parts making them more reliable), the EVs also have low maintenance cost as compared to ICEVs both in terms of serviceability & consumables. With this, while on one side the EVs have much lower maintenance costs,

Some Of The Global Automakers & Their Plan On Moving To EVs											
OEM Manufacturers	2021	2022	2023	2024	2025	2026	2029	2030	2032	2035	2040
BMW Group			25		15%-25%			10			
BAIC Group	2				1.3	X		50%			
Changan Automobiles					33					X	
Daimler		10				X					
Dongfeng Motor Co.	1	30%	1		1		1	1			??
FAW					40%			60%			??
Ford		40						100%	X		
GM group			22		30	1		1		X	
Honda								40% (T)			X
Hyundai-Kia					1						X
Mazda		1			29			5%			??
Renault-Nissan		20							X		
Maruti-Suzuki	1	20%						1-5			??
SAIC					30%			30		X	
Stellantis					38% (*)			70% (*)	X		
Toyota Group	1				31% (**)			35% (**)			
Volkswagen					15	X		>1			
					20%			70% (*)			
					3		26	50% (**)			X
					75						
Volvo (Geely Group)	1	1	1	1	50%			100% (*)	X		
% Of EV Sales					* EU Market Only						
Annual Sales (Million)					** Chinese & US Market Only						
New EV Model Numbers					T Included both EVs & FCEVs						
Cum. Sales (Million)					X Stoppage Of ICEV						

Ref: <https://www.automotiveworld.com/news-releases/growing-momentum-global-overview-of-government-targets-for-phasing-out-sales-of-new-internal-combustion-engine-vehicles/>



even the main drive of EVs being an electric motor, also has only one moving part, the shaft and is proven over the years for its reliability & robustness. While the controller and charger are fully solid-state electronic devices, the state-of-the-art new-age batteries (Ni-Cd, Ni-MH, Al-Air, Li-S, or even proven Pb-Acid battery) are also more or less maintenance-free. However, on one side while the evolving new battery technologies can extend the driving range of EVs, with improved battery management systems, they are also able to extend the useable life of the battery packs. In times to come when the future EVs are fitted with these advanced batteries based on cutting-edge technologies, they may not require any replacement during the life of the EVs (as is expected in today's EVs). While the battery life & performance are affected by multiple factors (which may also include driving conditions, driving habits as well as operating weather conditions) and hence depending upon its deterioration, it will certainly require periodic replacement.

In India, while current regulation demands any ICEV to be scrapped after a fixed time frame (15 years for Petrol ICEVs/ 10 years for diesel ICEVs), the life span of EVs is yet to be notified, yet it would certainly be more than 15 years. While the EV battery life is yet to ascertain, a consumer report (USA), estimates the average life of EV present-day battery pack to be around nearly 17 years (while many other technical experts estimate the EV these batteries to last somewhere from 10~20 years) before they run out to store & effectively deliver energy for driving EVs. Here it is worth mentioning, while the

EVs are not only easier and cheaper to maintain, they are also more efficient than the ICEVs by a reasonable margin (2W: ~2.35 times, Car: ~2.56 times, SUV: ~1.37 times). However, on an average, the EVs have twice the Well-to-Wheel energy conversion/transfer ratio compared to the same ration for ICEVs (29% for EVs again 14 % for ICEVs).

...To be continued 📖

1. The first rechargeable batteries based on lead (Pb) chemistry were invented in 1859 (by French physician Gaston Planté) while rechargeable batteries based on nickel-cadmium battery (NiCd) chemistry were invented by Waldemar Jungner (Sweden) in 1899, however, their technologies needed time to mature for being used in EVs.
2. The EVs almost had no emission (except small battery fumes), had much lower NVHS (noise, vibration, harshness & smell) levels, needed lower maintenance, had a self-starting feature (it wasn't available in ICEVs till almost 1912/14), had fewer rotary parts and did not require gear changes during the drive.
3. <https://www.un.org/sg/en/content/sg/speeches/2018-12-04/remark-e-mobility-event-cop24>
4. <https://www.iea.org/reports/global-energy-review-2021/renewables>
5. See Epilogue
6. <https://www.un.org/sg/en/content/sg/speeches/2018-12-04/remark-e-mobility-event-cop24>



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ENERGY SECURITY AND GHG MITIGATION PART 2

Two of the biggest challenges humans are continually facing in this century are ‘waste disposal’ and ‘climate change’. This trend is unlikely to change unless some serious action is taken. India with its fast urbanising population will be at the forefront of this challenge. ‘Waste Disposal’ often seems like a futile argument but very few people realise the gravity of the problem. At 500g per person, India produces about 6.5 million tonnes of waste, every single day. Thanks to the adoption of a western lifestyle, we are seeing an exponential growth in waste generation. Landfill and incineration processes do not ease our problem as they emit more greenhouse gases and pollute our air. A sustainable waste management system blended with the adoption of a much cleaner fuel, Hydrogen, can help overcome much of the problems we are going to face in the near future. Hydrogen sourced from energy recovery processes and conversion of waste materials is a clean and green alternative. Waste-to-hydrogen, therefore, can become a part of the zero-carbon future energy mix and serve as one of the cleaner hydrogen sources, which is economically viable and environmentally friendly...

Conversion of waste into hydrogen first requires the production of a synthesis gas (syngas), composed of CO and H₂. Gasification is used to directly convert solid waste materials into syngas at high temperatures using controlled conditions. The process of changing over organic or fossil-based carbonaceous materials at high temperatures (>700°C), without combustion, with a controlled measure of oxygen and additionally steam into carbon monoxide, hydrogen, and carbon dioxide is called gasification. The carbon monoxide then, reacts with water to produce carbon dioxide and more hydrogen by means of a water-gas shift response. Hydrogen from this gas stream can be separated by absorbers or special membranes.

An alternate approach, is to partially convert the waste in a pyrolysis unit to produce vapours and char. The char may be combusted separately to provide the energy required for pyrolysis and the volatile vapours can be immediately reformed with steam (or CO_2) over a catalyst to produce a H_2 rich syngas. The syngas is further conditioned to maximize the H_2 content using the water gas shift reaction and is then separated.

Plasma gasification is a relatively new technology, which has advantages over conventional thermal gasification. The plasma is formed using torches and peak temperatures may reach over $5,000^\circ\text{C}$. The advantages include lower emission, the formation of inert ash, fuel flexibility, very high-temperatures and lower reaction time. Also, the very high temperatures result in a clean syngas composed of almost only CO and H_2 . Major advantage is that only minimal feedstock preparation or separation is required as it gasify PCB, medical wastes, metallurgical waste, incineration fly ash and low-level radioactive wastes. High electricity is required for plasma gasification and the technology is very expensive.

Anaerobic digestion followed by Methane reforming or Partial Oxidation or Methane Pyrolysis is possible from biomass or waste via anaerobic or aerobic processes. Anaerobic digestion is simple in application and highly efficient, since up to 88% conversion efficiency can be reached with appropriate substrate. Anaerobic digestion consists of a complex series of reactions which are catalysed by a mixed group of microorganisms. In these reactions organic matter is converted in a stepwise fashion to methane and carbon dioxide. Polymers such as cellulose, hemicellulose, pectin and starch are hydrolysed to oligomers or monomers, which are then metabolised by fermentative bacteria with production of hydrogen, carbon dioxide and volatile organic acids. The volatile organic acids other than acetate are converted to methanogenic precursors (H_2 , CO_2 and acetate) by the hydrogen producing organic acid oxidiser. Finally, the methanogenic bacteria produce methane from acetate or $\text{H}_2 - \text{CO}_2$. The generated bio-methane can be converted to hydrogen by steam methane reforming, Partial oxidation of methane or by methane pyrolysis as explained below:

Steam methane reforming

Steam Methane Reforming (SMR) was the first industrial method of hydrogen production, and has been used since

1930. Today, most of the commercially available hydrogen is produced through this matured process, which has an efficiency of 70-80%.

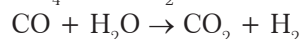
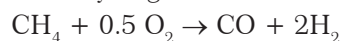
The process takes place in two steps: SMR reaction and water gas shift reaction.

- SMR Reaction: $\text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO} + \text{H}_2$
- Water gas Shift Reaction: $\text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}_2$

First, natural gas – which contains hydrocarbons such as methane - is made to undergo a thermochemical reaction in the presence of a catalyst (nickel) using high temperature steam ($700\text{-}1000^\circ\text{C}$ under 14-20 atmosphere of pressure) to produce hydrogen, CO , and CO_2 . Then, a water-gas shift reaction takes place, and CO and steam are reacted using a catalyst to produce CO_2 and more hydrogen. The challenge associated is production of CO_2 with this process. Around 1 ton of hydrogen production produces 9 to 12 ton of CO_2 .

Partial oxidation of methane

In partial oxidation, methane reacts with a limited amount of oxygen, which is not enough to completely oxidize the reactants to carbon dioxide and water [77]. As shown in Reaction (10.9), methane is oxidized to hydrogen and carbon monoxide with less than the stoichiometric amount of oxygen available. Subsequently, the carbon monoxide reacts with water to form carbon dioxide and more hydrogen in the water–gas shift reaction.



...To be continued 



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This article presents a comprehensive overview on state of the art topologies used for single phase solar photovoltaic (PV) rooftop supply systems – and its control for non-isolated conventional boost converter based double stage single phase solar PV rooftop supply system. The system extracts maximum power from PV panels and delivers it into the utility grid complying with international standards of power quality...

India is one of the economically developing countries with growing populations, thus the demand for electrical energy is rapidly increasing here. To fulfill this growing electrical energy demand, fossil fuel energy, nuclear energy and renewable energy sources are utilized. The fossil fuels are limited in nature and produce greenhouse gases that are responsible for global warming. Moreover, their prices are continually increasing. The nuclear energy looks promising, however; it is not reliable from safety point of view. The renewable energy resources are freely available, pollution free and not emitting green houses gases. Thus, renewable energy based electricity generation systems are more reliable for safety of society, environment protection and competitive prices.

There are various kinds of renewable energy sources available in nature; solar energy is one of them. India is a tropical country and over India's land; vast solar energy about 5,000 trillion kWh per year is incident. Therefore, the Govt. of India targets to achieve the ambitious goal of 100GW installed capacity from solar energy till the end of the year 2022. Out of this, till the end of November 2021, 48.55 GW of solar plant has been installed including large and small scale with 'on grid' as well as 'off grid' systems. To achieve the targeted goal, the Govt. of India has launched various schemes such as, Solar City Program, Pradhan Mantri Solar Panel Yojana, Grid Connected Solar Rooftop Scheme and so on. However, the growing population, limited land and electrical energy demands are major

challenges. The small scale solar photovoltaic roof-top systems play an important role to cater the above issues.

The 'on grid' solar photovoltaic roof-top supply systems are integrated with three phase and single phase utility grid. At small scale level; solar photovoltaic rooftop systems are mostly integrated with single phase utility grid and applied for residential applications. According to the power conversion stage, these are classified into two categories, 1) Single stage and 2) Double stage as shown in Fig. 1. They have their own features and drawbacks compared to each other as given below,

- The single stage topologies are less complex than double stages.
- Power conversion efficiency of single stage topologies is higher than double stage.
- In single stage topologies, PV panels suffer from a double line frequency component that reduces the life of PV panels, but double stage topologies offer less effect on double line frequency component due to two power processing stages.

Further, it has been classified into two categories, isolated and non-isolated. In isolated topologies, galvanic

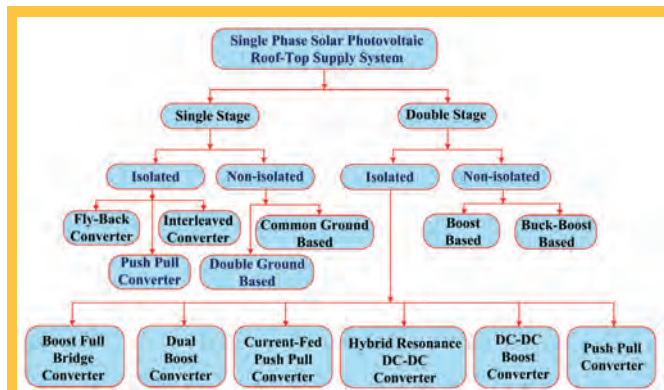


Fig. 1: Classification of single phase solar PV rooftop supply systems...

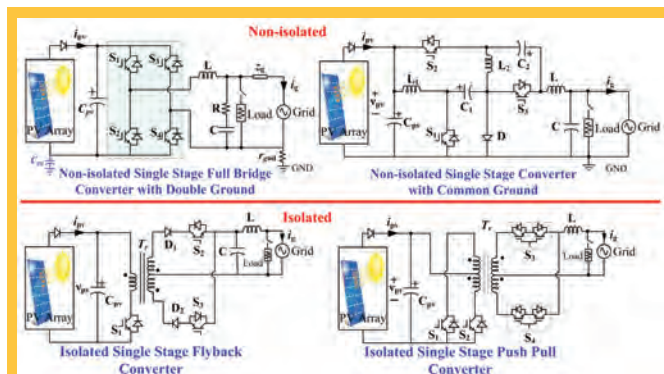


Fig. 2: Topologies of single stage solar PV rooftop supply system...

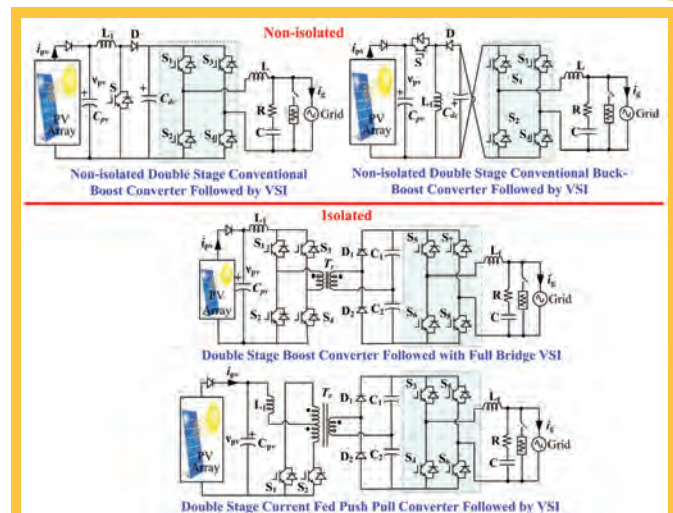


Fig. 3: Topologies of double stage solar PV rooftop supply system...

isolation between PV panels and utility grid is provided by a transformer (High frequency or low frequency). Moreover, in non-isolated topologies galvanic isolation between them is unavailable. The isolated topologies improve the safety concern, however; its efficiency is less than non-isolated topologies. Various topologies of single stage and double stage conversion including isolated and non-isolated converters are given in Figs. 2 and 3 respectively.

Overview of non-isolated double stage solar PV rooftop supply system

Fig. 4 shows the boost converter based non-isolated double stage solar PV rooftop supply system. It is implemented in the laboratory for small scale rating of 640W and 110V 50Hz AC supply system. The prototype is developed using a solar simulator (as a Solar PV panel), boost converter, full bridge voltage source inverter (VSI), gate driver circuit, AC filters, sensor circuits and microcontroller. Detailed specifications of the prototype are given in Table 1.

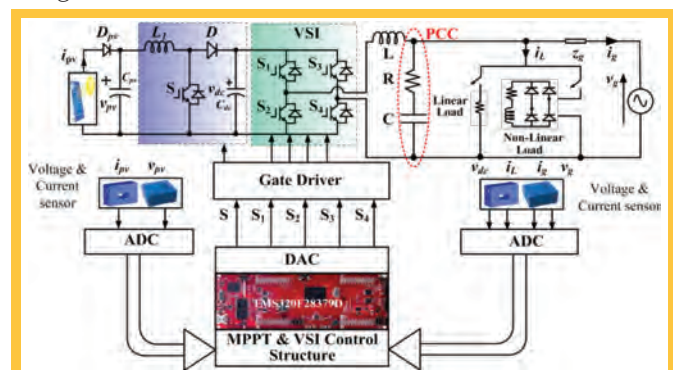


Fig. 4: Non-isolated double stage solar PV rooftop supply system with its controller...

Performance analysis

The performance of developed system is obtained in both steady state and dynamic conditions. It is presented in details in the next few paragraphs:

Steady state performance: Steady state performance of a developed system is obtained at constant solar irradiation i.e., 1000W/m² with 109 W non-linear loads

Elements	Specification/ Rating	Make /Part No./Values	
PV panels	640W	Solar Simulator (Delta Elektronika)	SM 660AR11
Sensors	Voltage	LEM-LV25P	
	Current	LEM-LA25N	
Power switches	IGBT	FGA25N120	
	Diode	RHRG30120	
Gate driver	TLP250		
Boost converter inductor	L _i	3mH	
DC link capacitor	C _{dc}	1000μF/450V	
AC filter	Inductor	L	5mH
	R-C Filter	R	1Ω
		C	10 μF
Controller	TMS320F28379D		

at Point of Common Coupling (PCC). Fig. 5 shows the performance at PV panel terminals. It shows that the PV panel delivers maximum PV power through a derived control algorithm implemented on the microcontroller.

Under the similar conditions, grid side performance is recorded and depicted in Fig. 6. As the proliferation of non-linear loads in the grid system creates power quality issues, the non-linear loads are considered at PCC. It is noticed that the load demands power of 109W as shown in Fig. 6(a) and the load current is non-sinusoidal in nature and its Total Harmonic Distortions (THDs) are 27% as shown in Fig. 6(b). Under similar conditions, power quality of grid supply voltage is recorded and its THDs are 2.1% as shown in Fig.6(c). Fig. 6(d) shows the grid supply voltage and current injected to it. The additional generated power (i.e., 500W) is injected to the grid supply as shown in Fig. 6(e). The grid current THDs are 4.9% as shown in Fig. 6(f) i.e. under limits of

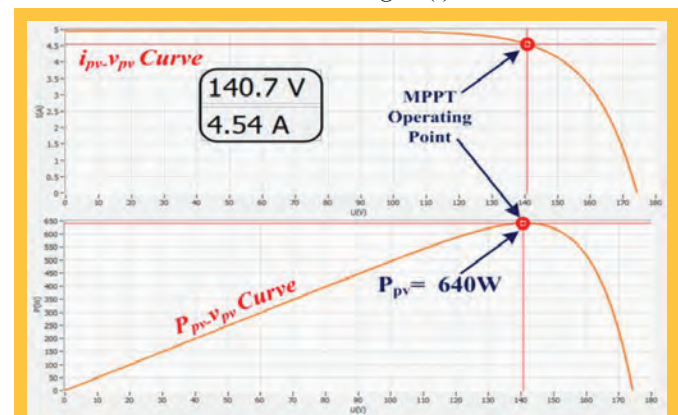


Fig. 5: PV panel performance at rated solar irradiation...

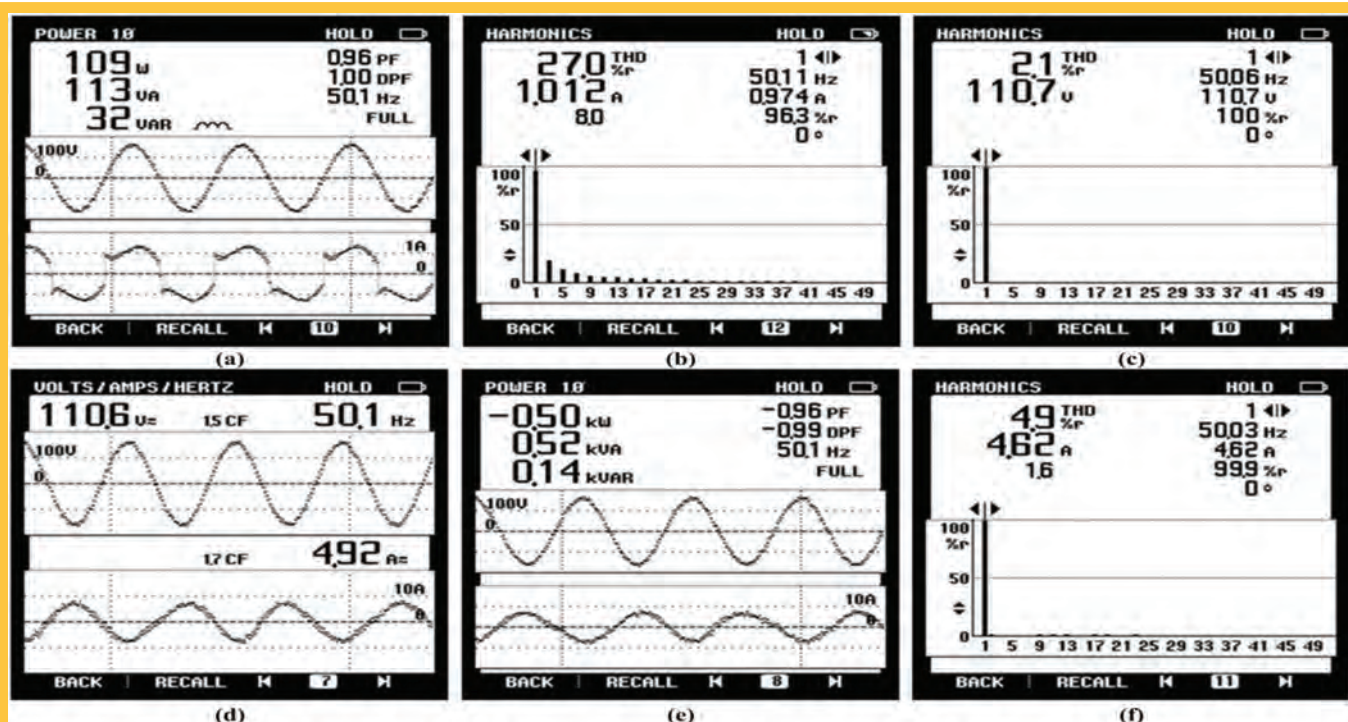


Fig. 6: Grid side performance rated solar irradiation with non-linear load demands...

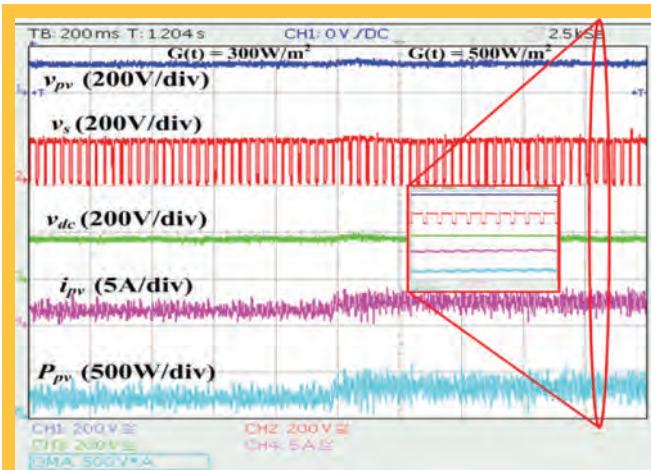


Fig. 7: Boost converter performance, under dynamic change in solar irradiation...

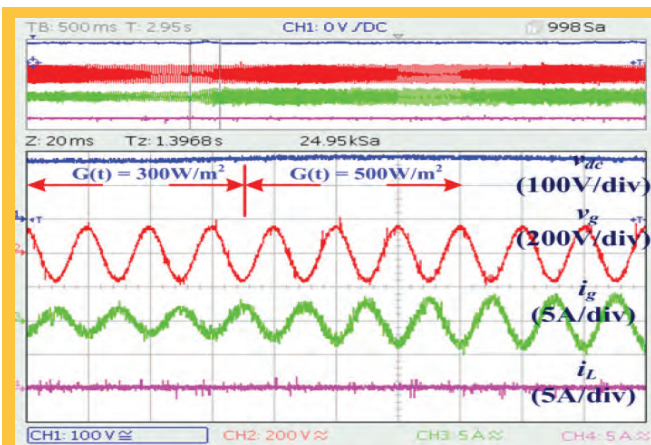


Fig. 8: Grid side performance, under dynamic change in solar irradiation...

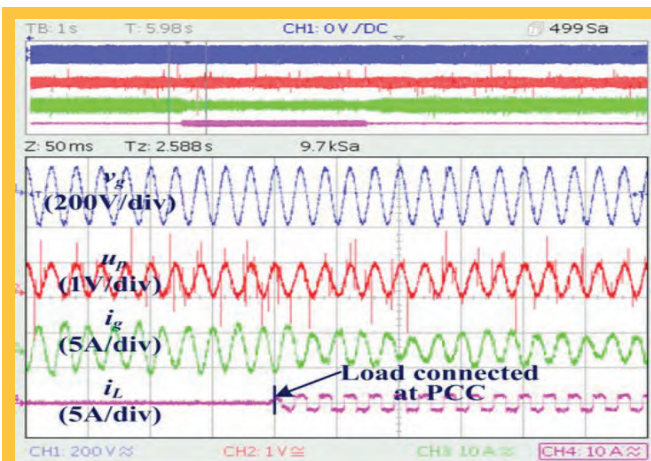


Fig. 9: Dynamic performance, under change in load demands ...

international standard IEEE-519 and it is done due to proper control of VSI.

Dynamic performance: Dynamic performance is obtained under dynamic change in solar irradiation and

load demands. It is noticed in terms of boost converter performance and grid side performance as shown in Figs. (7-9). Figs. (7&8) show the dynamic performance under dynamical change in solar irradiances from 300W/m² to 500W/m². Under increases in solar irradiation, current delivered from PV panels and power generation increase as shown in Fig. 7. Fig. 8 presents the grid side performance under same solar irradiation conditions with zero load demands. Under rise in solar irradiation current as well power injected to the grid also increases as shown Fig. 8.

Fig. 9 shows the grid side performance under dynamic change in load demands at constant solar irradiation of 1000W/m². When load is connected at the PCC current injected to the grid reduces as the PV power is constant. As the connected load is non-linear in nature, its current shape is non-sinusoidal. Moreover, current injected to the grid is purely sinusoidal due to proper VSI control.

Conclusion

This article has given an overview of the state of the art topologies of single phase solar photovoltaic roof-top supply systems. It also presented performance validation of a developed prototype of boost converter-based double stage single phase solar PV roof-top system in the laboratory. Its performance is obtained satisfactory under different operating conditions.



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PHOTOVOLTAIC MANUFACTURING OUTLOOK IN INDIA -PART 3



As prolonged dependence on the imports raises the severity of the associated risks, India needs a sustainable, vertically integrated domestic solar manufacturing ecosystem. In addition to the PV manufacturing landscape, this article delves into other key aspects...

The Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) scheme was launched in 2019 and in FY2020/21 was expanded to add a total solar capacity of 30.8GW by 2022, up from the initial target of 25.7GW. The total central financial support allocated under the scheme is Rs34,035 crore (~US\$4.6b). With proper execution of the government scheme under the Domestic Content Requirement (DCR) purview, domestic manufacturers can boost their visibility, potentially exposing themselves to greater demand opportunities in the Indian market.

The scheme is divided into three components.

- Component A: Setting up of 10,000MW of decentralised ground-mounted grid-connected solar or other renewable energy-based power plants

- Component B: Installation of 2 million standalone solar agriculture pumps
- Component C: Solarisation of 1.5 million existing grid-connected agriculture pumps

Using DCR cells and modules is mandatory for components B and C. As of November 2021, under Component A, only 20MW had been installed out of the sanctioned capacity. Out of the sanctioned units under Component B, 75,000 standalone solar pumps had been installed in various states. Under Component C, solarisation of more than 1 million grid connected pumps had been allocated under two variants, individual pump and feeder level. Of the allocated units, only 1,000 had been installed.

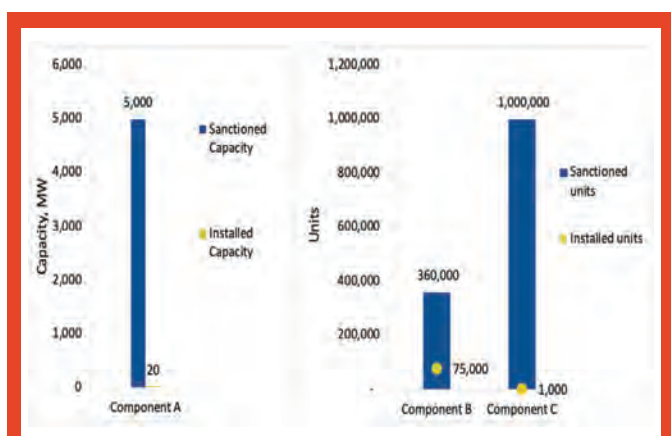


Figure 16: Sanctioned Capacity Under PM-KUSUM Scheme, as of November 2021

Source: JMK Research.

Note: Installed units under Component C indicate solarised pumps under individual pump solarisation variant of Component C. Implementation of feeder level solarisation variant under Component C (introduced in December 2020) has not been considered in the figure above.

Grid-connected Rooftop Solar Program

In December 2015, phase 1 of the program was launched with the intent of providing incentives for residential, institutional and social segments. For the government segment, achievement-linked incentives were provided. Phase 2 was approved in February 2019 with a target of 40GW of cumulative capacity from rooftop solar (RTS) projects by 2022. Within the ambit of phase 2, incentives in the form of Central Financial Assistance (CFA) were designed on the basis of RTS capacity.

- For RTS systems up to 3kW capacity – CFA of 40%
- For RTS systems beyond 3kW and up to 10kW capacity – CFA of 20%
- In addition, CFA of up to 20% for RTS, limited to

500kW capacity, for supply of power to common facilities of Group Housing Societies (GHS) and Residents Welfare Associations (RWA).

Discoms of various states and Union Territories (UTs) are implementing the RTS program. The DCR mandate applies for the program's residential sector, with the aim of spurring development of domestic PV manufacturing. Of the phase 2 target of 4GW set for the residential sector, 3.4GW has been allocated to various states and UTs and of this allocation, 1.07GW had been installed as of November 2021.

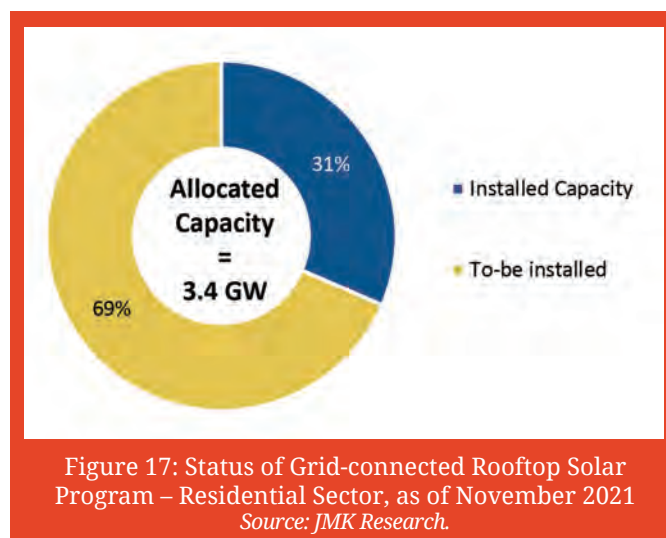


Figure 17: Status of Grid-connected Rooftop Solar Program – Residential Sector, as of November 2021

Source: JMK Research.

A parliamentary panel noted that the target set for solar rooftops cannot be achieved without proper implementation of net/gross metering and there is a need to maintain uniformity in terms of regulations/model operating procedures/online unified portals etc.

Production-Linked Incentive (PLI) Scheme

The Government of India's Production-Linked Incentive (PLI) scheme, National Program on High Efficiency Solar PV (Photovoltaic) Modules, was officially approved in April 2021. The scheme, with a financial outlay of Rs 4,500 crore (US\$616 million), was intended to support 10 GW capacity of integrated solar PV manufacturing plants.

In relation to this, additional direct and indirect benefits were foreseen as:

- Direct investment of about Rs17,200 crore in solar PV manufacturing projects
- Demand of Rs17,500 crore over five years for Balance of Materials
- Direct employment of about 30,000 and indirect employment of about 120,000

Renewable Energy

- Import substitution of about Rs17,500 crore every year
- Impetus to R&D to achieve higher efficiency in solar PV modules

In May 2021, the Indian Renewable Energy Development Agency (IREDA), a PSU under the Ministry of New & Renewable Energy (MNRE), invited bids under the PLI scheme for integrated solar manufacturing units.

The total bids received were 54.8GW, resulting in more than fourfold over-subscription. Bidders were shortlisted based on two parameters, extent of manufacturing integration (or extent of integration of manufacturing stages) and manufacturing capacity.

Shirdi Sai Electricals, Jindal India Solar Energy and Reliance New Energy Solar were selected as the PLI beneficiaries for setting up stages 1-4 (Polysilicon + Ingot-Wafer + Cell + Module) integrated manufacturing. Jindal and Shirdi Sai were awarded 4GW each and Reliance secured 2,483MW.

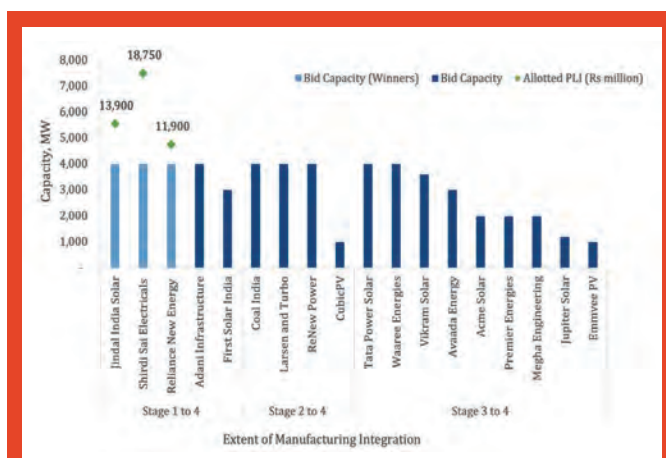


Figure 18: Capacity Allocation Under Solar Manufacturing PLI Scheme
Source: IREDA, JMK Research.

India's high import dependency for high-efficiency solar PV products makes it critically susceptible to supply chain disruption and market price shocks. The PLI scheme can help mitigate the PV supply chain risks.

However, a cumulative ~10GW of PV manufacturing distributed between three players (the PLI awardees) cannot translate to adequate economies of scale, despite incentives for vertical integration. Additionally, projects under PLI scheme are expected to have a latency period of at least 18-24 months prior to initiation of the manufacturing process.

Moreover, the existing PLI-linked 10GW capacity is now anticipated to be quadrupled with the additional infusion of Rs 19,500 crore into the solar PV PLI budget. This would help in creating a huge demand potential for the PV ancillary market (solar glass, ethylene vinyl acetate [EVA], backsheet, etc.) and skilled workforce. The direct investment in the country on account of the PLI budget expansion could potentially rise to about Rs 90,000 crore.

Basic Customs Duty

On March 9, 2021, the Ministry of Finance approved the imposition of 25% Basic Customs Duty (BCD) on solar cells and 40% on solar modules, with effect from April 1, 2022. The BCD was aimed at improving the price competitiveness of domestic PV products, though the industry regarded it as a counterproductive measure.

Safeguard Duty (SGD) applied for two years, ending in July 2021, on imports from China, Thailand and Vietnam. BCD remains applicable to all imports, regardless of the country of origin, and this has specifically become an additional cause of concern for solar equipment manufacturers in Special Economic Zones (SEZs).

Goods and services from SEZs, when offered to entities in the domestic tariff area, are considered imports and so subject to customs duty. More than half of India's solar cell manufacturing units and about 40% of solar panel manufacturing units are situated in SEZs. SEZ PV products would become even more expensive than during the duty-free period.

Purchase Preference to Local Suppliers

In a wider decoupling exercise, as part of India's economic response against China, firms defined as Class 1 local suppliers are the only ones eligible to bid for public procurement contracts if there is sufficient domestic capacity for the nominated product. Class 1 takes in local suppliers or service providers whose goods, services or works offered for procurement have local content of at least 50%.

Solar PV modules are among the products identified as having sufficient local capacity and competition.

Approved List of Models and Manufacturers (ALMM)

The MNRE has made it mandatory for solar cell and module manufacturers to register under the ALMM. The list consists of eligible models and manufacturers of solar cells and modules complying with the Bureau of Indian Standards (BIS) Standards. The objective of ALMM is to enhance domestic manufacturing and to have a quality

benchmark for cells and modules. The ministry released the first list of photovoltaic module manufacturers at the beginning of March 2021.

The latest list issued in December 2021 includes 41 module manufacturers and a total capacity of 10.9GW. Standard bidding guidelines from April 10, 2021 require procurement of modules from the approved list.

Validity of models will be for two years from the date of being listed. ALMM consists of a mix of multi-Si and mono-Si (including mono PERC) technology-based modules. Vikram Solar is the sole listed manufacturer with bifacial-type models.

In January 2022, the MNRE amended the list to broaden the ambit of project type for which ALMM models would be eligible. It added open access and net metering projects (in addition to government projects, government-assisted projects, projects under government schemes and programs, the latter including projects set up under Component A of PM-KUSUM).

The amendment will cover renewable energy projects that apply for open access or net metering facility from April 2022.

First Ever Project Development Tender With Manufacturing

In SECI's 12GW Solar PV (manufacturing linked) tender, Adani Green Energy won a bid for solar panel manufacturing capacity of 2GW of solar and the associated generation capacity of 8GW, out of which a Power Purchase Agreement (PPA) was signed for 5.5GW. For the same tender, Azure Power won a bid for 1GW solar panel manufacturing and 4GW generation capacity, with PPA of 600MW.

Adani will develop its 2GW via its manufacturing subsidiary. Azure Power is set to fulfil its manufacturing component through its tie-up with Waaree.

Key Challenges for Indian Manufacturers

The solar market in India is currently facing more headwinds than usual, especially due to challenges owing to COVID-19. The demand-supply imbalance in terms of solar PV products, although still severe, is gradually alleviating. For domestic PV manufacturers, on the brighter side, the ongoing phase of supply slack presents an opportunity to upgrade manufacturing capabilities. Other stakeholders such as the policymakers, investors, allied manufacturers in the PV value chain etc need to provide a synergistic thrust for development of sustainable PV power in India.

Supply Chain Fluctuations

In mid-2020, the price for a Chinese multi-Si module was ~US\$0.18 per watt peak (Wp) and about 1 cent higher for a Chinese mono PERC module. A year later, the prices of the latter rose by ~30% and in December 2021, the landed price of Chinese mono PERC modules climbed to approximately US\$0.27/Wp, registering a ~42% spike from the record-low (mid-2020) price.

...To be continued 



Jyoti Gulia is the Founder of JMK Research. Jyoti has about 15 years of rich experience in the Indian renewable sector. Her core expertise includes policy and regulatory advocacy, assessing market trends, and advising companies on their business strategy.



Prabhakar Sharma is a Senior Research Associate at JMK Research with expertise in tracking renewable energy and battery storage sector. He has previously worked with Amplus Solar.



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Energy Economist **Vibhuti Garg** has advised private and public sector clients on commercial and market entry strategies, investment diligence on power projects and the impact of power sector performance on state finances. She also works on international energy governance, energy transition, energy access, reallocation of fossil fuel subsidy expenditure to clean energy, energy pricing and tariff reforms.

JMK Research & Analytics is a boutique consulting firm for all kinds of research and advisory services for Indian and International clients focusing on Renewables, Electric mobility, and the Battery storage market. For further information: contact@jmkresearch.com

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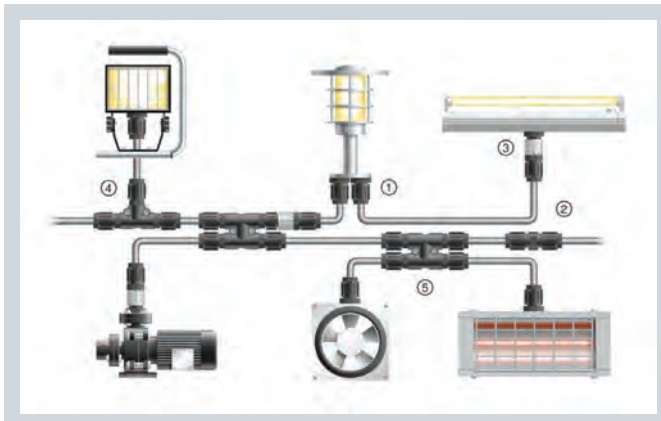


A is proof of this. Thanks to the proven QUICKON IDC displacement connection, cables up to 5 x 6.0 mm² can be connected quickly and easily, without the need for stripping or special tools. You can choose either fixed or plug-in connections to create flexible distribution solutions. Device connections can also be implemented easily without having to open the device. This means that the delicate electronics remain protected from environmental influences.

QPD product range overview:

- **Panel feed-throughs**

The panel feed-throughs are cable glands that can be connected from the outside. As a result, devices no longer need to be opened in order for cables to



be connected. This ensures that the manufacturer's specific protection class is maintained.

- **Cable connectors**

The cable connector can be used to lengthen or repair cables. When combined with connectors, cable connectors can be used as flexible coupling connections.

- **Connectors**

The connector with leading PE contact is ideal for quick device replacement in service situations or for installations with pre-assembled cables. It is coded to prevent incorrect connections.

- **T-distributors**

Installing a branch line for loads is easy with the compact T-distributor.

- **H-distributors**

The H-distributor is a compact, robust junction box that can be connected quickly. The four connections are connected in parallel to each other, which also allows them to be used as a star distributor.

QUICKON insulation displacement connection

Secure connection in just a few steps

The QUICKON fast connection is based on IDC insulation displacement connection technology and is designed for



applications where round and AS-Interface cables need to be connected efficiently on site. The connection can be disconnected at any time, which means that components can be reused. This connection system allows you to connect multi-position cables in just a few steps. The fast-connection technology automatically provides contact and strain relief when tightened. The quick and easy handling of the QUICKON fast connection means that the connection time can be reduced by up to 80%. 

For further information:

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New edition of IEC 61918 regulates SPE cabling and installation

The new edition of IEC 61918:2018/AMD1:2022 Amendment1 is the installation standard for communication networks in industrial plants, machines and automation islands. Both cabling infrastructure and the components to be used, such as cables and connection technology, are clearly defined for all automation profiles. Cabling solutions using fiber optic cables, symmetrical copper cables and for wireless media are considered...



In March 2022, the new edition of the installation standard IEC 61918:2018/AMD1:2022 Amendment 1 - "Industrial communication networks - Installation of communication networks in industrial premises" has been published. The standard describes the installation of communication networks in industrial premises. In the new version, it now also includes important key points on cabling structures based on Single Pair Ethernet. This makes it an important basis for all users who want to bring their production into the IIoT.

The new amendment to IEC 61918 addresses the new 1-pair cabling structures for Single Pair Ethernet (SPE) and the associated remote power supply PoDL (Power over Data Line). This closes the gap between classic IT infrastructure and industry, IoT/IIoT. SPE has a special significance for industry and automation. For the first time, it enables the universal application of TCP/IP-based automation protocols even for long distances, as in process automation or for the simple connection of sensors and actuators up to the industrial field level. Higher data rates, more power transmission and greater ranges than with classic fieldbuses pave the way for the IIoT and Industry 4.0.

Users' benefits

This provides the users clear specifications for infrastructure components that are identical and

compatible with ISO/IEC 11801-3 (industrial buildings). Annex 1 (AMD1) references the cable standards for 1-pair data cables according to IEC 61156-11/12/13/14 and the standard for the 1-pair data connectors according to IEC 63171-6. This gives system designers and users a stable basis for selecting suitable cables and interfaces, and the implementation of SPE technology in the automation world can begin.

The new version of IEC 61918 now provides a clear and unambiguous normative description of how and with which components a sensor-to-cloud data infrastructure in industrial applications must look. The tools for the implementation of IIoT are now available - device suppliers can now start the development and production of SPE devices with internationally ensured compatibility and investment security.

A common denominator

No matter whether PROFINET, EtherCAT or other Industrial Ethernet protocols - this new IEC 61918 is a common denominator for all automation profiles.

HARTING and its offerings

The HARTING Technology Group is one of the world's leading providers of industrial connection technology for the three lifelines of Power, Signal and Data and has 14 production plants as well as branches in 44 countries. Moreover, the company also produces retail checkout systems, electromagnetic actuators for automotive and industrial series use, charging equipment for electric vehicles, as well as hardware and software for customers and applications in automation technology, mechanical and plant engineering, robotics and transportation engineering. In the 2020/21 business year, some 6,200 employees generated sales of EUR 869 million.

More information can be found here: <https://webstore.iec.ch/publication/74769> 

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From old to new: igus is making e-chain recycling even easier

The igus installation service will now have old energy chains collected...

Since 2019, igus has been using its chainge recycling programme to give old energy chains a new life. Now, the motion plastics specialist is taking things a step further. Recycling

begins at assembly. To avoid industrial waste, igus is organising return delivery of worn-out energy chains - and returning them to the material cycle.

Sooner or later, every machine and every component reach the end of its service life. Manufacturing companies then face the question of whether to modernise or acquire new equipment. Sustainability plays an increasingly important role here. After all, according to the Global E-waste Monitors, 53.6 million tons of electronic waste was generated worldwide in 2019 alone. A more environmentally friendly upgrade for old machines is the so-called retrofitting: instead of buying new machines, companies can have existing equipment converted or refurbished so that it meets the latest standards. However, this does not solve the problem of where to put discarded components.



Recycling made easy: the igus installation service picks up old material

For new installation, retrofitting or maintenance, igus focusses on recycling instead of disposal - starting way back in assembly planning. The recycling service is offered automatically with each new assembly order and entails no additional costs or effort for the customer. igus takes care of the scrap material in four simple steps: first, igus removes the worn-out energy chain, then disassembles it into smaller pieces and packs it into Big Bags. Finally, igus organises the return transport and logistics. The installation coordinator commissions the forwarding company, which collects the discarded energy chains. That way, the customer has only to provide the scrap material for collection and load it. It is then taken away and recycled as part of the igus chainge programme. This service is offered for both igus e-chains and chains from other manufacturers. Customers receive a voucher based on the weight of the chains. The discarded plastics are separated by type, cleaned and re-granulated. 

For further information: E-mail: sgeorge@igus.net,
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KUSAM-MECO the leader in portable electronic Test & Measurement Technology, has introduced a new MilliAmp (mA) Process Clampmeter designed to help technicians test critical automation & control circuits without breaking the circuit or interrupting operations. The new KUSAM-MECO mode KM 071 Clampmeter adds to the large range of clamp meters. Now technicians in process plants, industrial plants, commercial buildings & automation commissioning teams can choose exactly the range of capabilities they need, at a very competitive



price. The meters are designed to accurately measure the low current (4 to 20 mA signals) that flow through control system circuits with high accuracy, without having to shut down the system, break the circuit & insert a test instrument. Instead, sensitive current clamps placed on the wire detect & measure the current flowing through. The result can be a significant savings in time and money that is more important than ever in tough economic times. The Model features mA measurements without breaking the loop; simultaneous mA and % span readings; 0.01mA resolution on 20mA applications; built-in flashlight; and IP 40 ratings. 

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