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SWITCHGEAR: SWITCHING TO SUSTAINABILITY

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- 10th edition of Metering India Conference
- Insight: Global Shift to SF -Free Switchgear Technologies
- ELECRAMA Previews in Bhopal and Chennai
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COVER STORY

In this two-part cover story, both the Low-Voltage & Medium and High Voltage Switchgear Division Chairmen present a comprehensive outlook on the current industry status along with suggestions for the way forward.

"Transitioning to SF6-free technology is the path to managing our power demand while minimising environmental damage."

- Udai Singh, Chairman, IEEMA MV & HV Switchgear Division

"The industry has taken significant strides to embrace quality standards, though full compliance remains a work in progress."

- Nitin Rastogi, Chairman, IEEMA LV Switchgear Division

SPECIAL FEATURE

Aiming at building a sustainable energy future with top industry experts to strengthen the energy metering industry, IEEMA recently hosted the 10th edition of Metering India in Delhi.

UPDATES

Discussions revolved around achieving energy evacuation targets and the industry's commitment to capacity enhancement, among others...

Discussions revolved around upcoming IEEMA activities and ELECRAMA 2025...

CASE STUDY

This paper by **Dr. Venkatesh Raghavan, Vice President, PFC, Energy Solutions Business Division Film Capacitors Business Group, TDK India Private Limited,** describes a novel switch for transient free switching of medium and high voltage capacitor banks with pre closing resistors and a mechanism to fine tune the selection of optimal value of resistor and switch operation to obtain the least switching inrush currents.

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FROM THE PRESIDENT'S DESK

Dear Members and Readers,

India's energy demand has seen a significant 10.9 percent rise in Q1FY25 while moderating to nearly flat growth in Q2, driven by extreme weather conditions. While there is a strong pipeline of renewable energy capacity additions, mainly solar, we need a firm supply to avoid peak hour deficits.

Electricity is slowly but surely becoming synonymous with energy. The energy industry is undergoing unprecedented change. There is a definite need to reimagine how we source or produce energy and how we transmit and use it, so that it is sustainable. It has also accelerated the need for our power utilities to innovate and engage consumers in this journey.

Among the government's nine Budget priorities in pursuit of 'Viksit Bharat' is energy security. With conducive policies in the pipeline, the industry is expecting a high potential growth at about 12 percent CAGR. In the next 25 years, the vision is a more than 2x increase in energy requirement and 8x growth in per capita consumption.

At IEEMA, we are working at strengthening four core areas:

1. Strengthening indigenisation (Make in India)
2. Ease of doing business
3. Technology, quality and safety, and
4. Enhancing global footprints.

The transition to net-zero emissions in the utility sector is a critical endeavour that aligns environmental sustainability with consumer-centric approaches. As utilities strive to reduce their carbon footprints, they are increasingly adopting innovative technologies and practices that not only address climate change but also enhance customer engagement and satisfaction. The journey towards sustainable and consumer-centric utilities is integral to achieving net-zero emissions. By embracing innovation, promoting collaboration, and prioritising consumer engagement, utilities can play a pivotal role in creating a resilient and sustainable energy landscape that benefits both, the environment and society at large.

In line with this, we recently concluded the 10th edition of the Metering India Conference, marking a milestone edition of Metering India – among the most sought-after technical conferences for the metering industry. We were happy to celebrate this edition with industry experts, leaders, and policymakers present at the conference. This edition was aptly themed on sustainable, consumer-centric utilities aiming for net zero, appropriately in line with the current trend of our sector. At the two-days conference, we had discussions with CEOs of industries and utilities with five high-level panel discussions on the opportunities and challenges towards *Aatmanirbhar Bharat*; roadmap to net-zero; trends and technologies for the future; AMI journey so far under RDSS, challenges and way forward; empowering consumers along with five technical sessions.

These are times for building mindful partnerships with discoms for building consumer engagement and adopting newer technologies. Opportunities galore to leverage this technology optimally for data mining and using intelligence for network planning and business decisions.

We are also gearing up for ELECRAMA 2025 – with the theme this edition: 'Reimagine Energy for Sustainable Future'. Our industry is seeing robust growth and there is tremendous interest in India from overseas, and we are confident that ELECRAMA 2025 will generate huge business opportunities.

With this, I wish all of you a happy year-ending with more power! Happy Christmas!

SUNIL SINGHVI

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SAMVAAD

Dear Members,

Recently, at IEEMA, we had the opportunity to engage with the Hon'ble Power Minister, Shri Manohar Lal, focusing on objectives related to energy evacuation and the industry's dedication to increasing capacity, among other topics. Additionally, we met with Shri Shripad Naik, the Hon'ble Minister of State for New and Renewable Energy, to discuss forthcoming IEEMA initiatives and the upcoming ELECRAMA 2025 – the largest electrical and allied electronics exhibition in the world.

Our initiatives at IEEMA are centered around:

- Policy advocacy – By actively influencing policy decisions to create a favourable regulatory environment.
- Business development – By fostering B2B relationships, exploring new markets, and supporting member growth.
- Industry leadership – Positioning IEEMA as the leading voice of the power sector through industry forums and initiatives.
- Innovation and emerging technologies – Encouraging adoption of new technologies, engaging with startups, and promoting R&D.
- Quality, reliability, and safety – Prioritising QRS standards, implementing best practices, and fostering a strong safety culture.
- Skill development – Addressing skill gaps, promoting training programmes, and fostering industry-academia collaborations.

I am happy to share that we recently had a session with our division leadership and launched Divcon – a unique platform for all divisions to work collaboratively and cohesively to drive growth.

We are also actively engaging with the government through public policy advocacy. We have been actively engaging with the government on key industry matters and have held inter-ministerial consultations for resolution of some pressing issues.

In November, we also held the Metering India Conference 2024 – it was the 10th edition of our flagship technical programme for the metering industry. Marking a milestone for Metering India's glorious run, the two-days conference celebrated insightful discussions, innovative ideas, and collaborative efforts for the advancement of the metering industry in India and had 500+ delegates. Our chief guest at the conference was Shri Srikant Nagulapalli, Additional Secretary, Ministry of Power, and witnessed the presence of senior dignitaries from the Government of India, utility officials, delegates and committee members. The two days of technical sessions with key industry players was a dynamic hub for knowledge sharing, networking, and fostering business collaborations, all with the ultimate goal of driving a sustainable energy future. Session topics revolved around Opportunities and Challenges towards Aatmanirbhar Bharat; Roadmap to NetZero; Trends & Technologies for the Future; AMI Journey so far under RDSS, Challenges and way forward; Empowering Consumers. Technical sessions included those on Navigating the Smart Metering Landscape: Challenges, Innovations and Consumer Empowerment; Metre Data: The Fuel for Innovation in Discoms; Metering: Beyond Tariff Metering; Strategic Approaches for Efficient Utility Operation; Cybersecure Digital Transformation of Discoms.

As we gear up for the new year, at IEEMA, we are gearing up for ELECRAMA 2025. We have already held outreach programmes across the country. In November, we held previews of the mega event at Bhopal, Chennai, Nashik, Aurangabad and Agartala. As organisers, we are also taking several new initiatives to make ELECRAMA more digital, more green, more innovative and safer. We also have international pavilions from the US, the UAE, and Romania. We are also moving towards making ELECRAMA more sustainable by initiating only green electricity to be used for the show. We invite all of you to visit this huge 44,000 sqm of net exhibition space, where more than 1,100 exhibitors will showcase innovative products and technologies. We are expecting business queries worth US$ 20 billion to be generated at ELECRAMA 2025.

I wish all of you, our members and readers, a Happy Christmas and a joyous year ahead with more power and prosperity!

CHARU MATHUR

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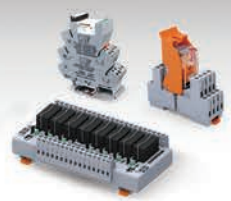

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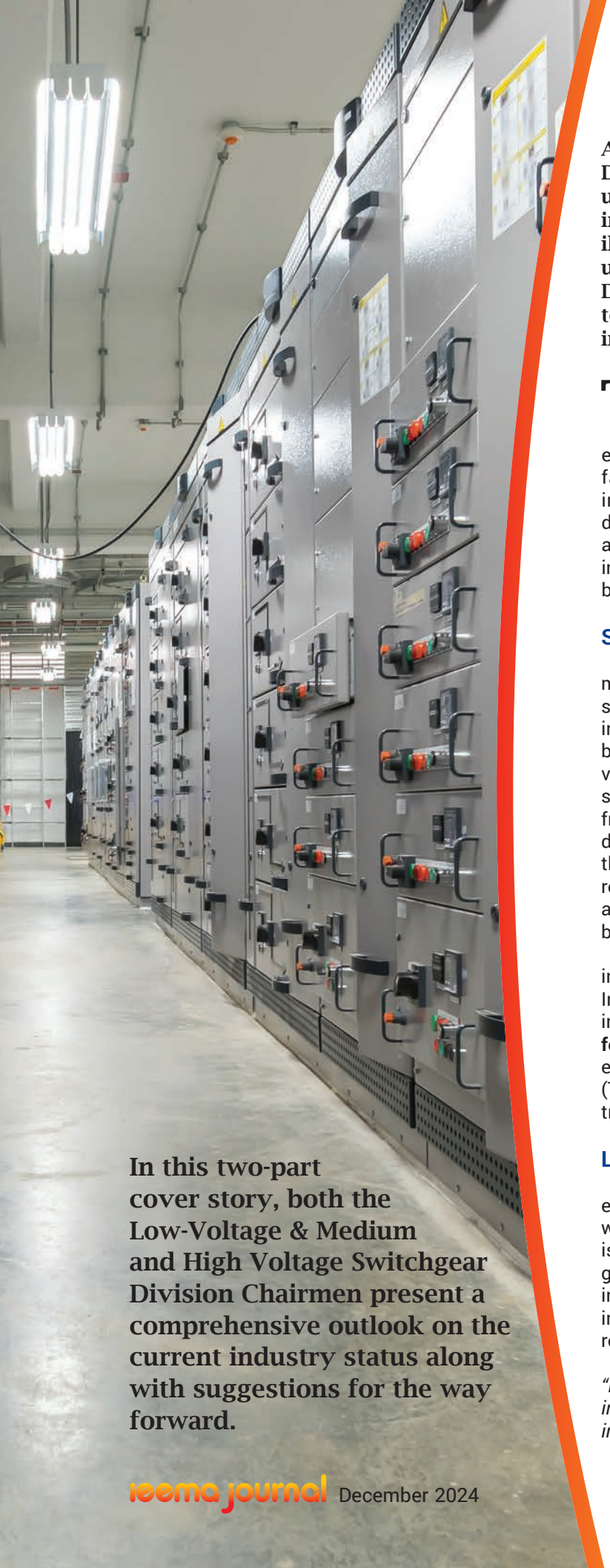
DEFINING THE NEW ENERGY LANDSCAPE



In this two-part cover story, both the Low-Voltage & Medium and High Voltage Switchgear Division Chairmen present a comprehensive outlook on the current industry status along with suggestions for the way forward.

As the IEEMA Low-Voltage Switchgear Division Chairman, Nitin Rastogi, takes us through the current state of industry, indicating trends, listing challenges, illustrating the need for R&D, commenting upon the policy front, he leads co-authors Dr Venkatesh Raghavan & Devchandra Kuril to share their vision on the emerging trends in the evolving power quality scenario.

The rockstar of a circuit breaker, an orchestra of electrical disconnects, fuses with circuit breaking, isolating and de-energising electrical equipment, allowing work to progress by clearing faults downstream—presenting 'Switchgears', indispensable not only in transmission and distribution of power but wherever there is a need to access and control electricity; and now, with recent indications, adding monitoring and signalling too as becoming integral parts of switchgears.

Switchgear Industry Status

India currently represents about 7.2% of the total manufacturing segment in India's GDP and 45% share in the capital goods sector. The switchgear industry in India manufactures the A to Z of circuit breakers from bulk oil, minimum oil, air blast, vacuum, and sulphur hexafluoride; all these as per standard specifications in the entire voltage range from 240V to 800 KV. IEEMA's two dedicated divisions, the Low Voltage Switchgear Division and the High & Medium Voltage Switchgear Division, represent this segment of the industry, producing and supplying switchgear and related items needed by the power industry and the industrial sector.

Overall, the electrical and allied electronics industry accounts for over 2.2 million (Mn) jobs in India. India has emerged as the **fifth largest economy** in the world with a projected **GDP of USD 3.7 trillion for FY 2024.** It is on track to become the third largest economy by FY 2027, with a GDP of USD 5 trillion (Tn), and potentially USD 10.4 trillion and USD 30 trillion by FY 2034 and FY 2047, respectively.

Low-Voltage Industry Update

India's low-voltage switchgear industry has been experiencing a positive trajectory in recent years, with a growth rate of 13% over last year (FY22-23). It is driven by several factors, such as industrial growth, increasing demand for electricity, infrastructure development, and government initiatives focused on energy efficiency and renewable energy.

Nitin Rastogi, IEEMA LV Division Chairman, says, *"Rapid growth in the power distribution sector and infrastructure development, renewable energy integration, smart grid initiatives with integration of*

smart monitoring and control equipment are expected to fuel the growth of the India Switchgear market for the next 6-7 years."

The switchgear industry in India plays a crucial role in the electrical power generation, transmission and distribution sectors. However, the switchgear industry is well supported by new emerging markets like solar, hydrogen, battery storage and EV. The chairman informs, *"The growth of industries like real estate, manufacturing, transportation, and utilities has significantly increased the demand for sustainable switchgear systems.*

"To address technological advancements and innovation in switchgear, manufacturers should collaborate with global technology providers or involve in joint ventures to access cutting-edge technologies."

Nitin Rastogi, Chairman IEEMA LV Switchgear Division

"These sectors rely on efficient, coordinated and communicable electrical distribution and protection systems to ensure smooth operations, safety, and compliance with industry standards, generating the need for smart switchgear."

Trending: #Smart Switchgears

Just as the electrical power grid is evolving towards digitisation, traditional switchgear too is going through a significant transformation to adopt a digital identity — a smarter version. **Traditional switchgear is evolving into "smart" systems, incorporating advanced digital technologies to enhance performance, efficiency, and reliability.**

Low-voltage switchgear ensures a stable and reliable power supply, while smart switchgear systems are more efficient in all spheres of functionality, including maintenance, time, functionality, efficiency, etc. Increasing adoption of smart switchgear systems is an industry trend that's picking up fast.

A smart switchgear is equipped with the latest digital communication abilities that enable real-time monitoring, control, and diagnostics. These technological marvels are integrated with the Internet of Things (IoT) and advanced data analytics, conceding predictive maintenance and reducing downtime and cost of operations.

Manufacturing Trends & Challenges

Adopting smart switchgear technology enhances the reliability and efficiency of the grid. It also provides better insights into power distribution networks. Manufacturers of switchgear face several significant challenges as they strive to meet the growing demand for reliable and advanced electrical systems across various industry segments.

Rastogi informs that these challenges are multifaceted, ranging from technological and supply chain issues to regulatory and market-related concerns. With strategic investments in innovation, R&D, and skilled workforce development, coupled with collaboration with global partners and alignment with government initiatives, these challenges can be turned into opportunities.

As India's infrastructure and industrial base continue to expand, the demand for advanced switchgear solutions will likely grow. This will provide significant opportunities for manufacturers who can adapt and innovate to meet these evolving needs.

Emerging Trends in LV Switchgear Considering the Evolving PQ Scenario

According to **Dr. Venkatesh Raghavan,** *"Switchgear, like most other traditional electrical apparatus, has remained essentially the same over decades: a moving contact, a fixed contact, a dielectric medium between the contacts, and an operating mechanism."* Though there have been changes in the contact metallurgy, dielectric medium, operating mechanism and even some introduction of "smartness" and "intelligence," the basic principle has remained essentially the same, notes **Raghavan**, the *Vice President, PFC, Energy Solutions Business Division, Film Capacitors Business Group, TDK India Pvt. Ltd.*

With the proliferation of non-linear loads and deteriorating power quality, increased sensitivity of connected loads to PQ aspects, increasing embedded or distributed generation, large-scale integration of renewable energy sources and changing characteristics of loads and generators, it is possible that some significant changes in switchgear are necessary and imminent.

Dr Venkatesh Raghavan enlists emerging industry trends:

- Selection and application of switchgear based on power quality aspects such as high harmonic distortion, unbalance, etc. This also includes the need and use of higher fault capacity switchgear considering increasing fault levels due to

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embedded generation and the installation of shunt capacitor banks or power conditioning devices.

- Use of FP switchgear instead of TPN and with higher neutral capacity and neutral current protection is expected considering increasing neutral currents due to increasing single-phase loads, unbalance, triplen harmonics, etc.
  The operating range of coils is expected to be wider considering neutral shifts, voltage sags or swells, the effect of harmonics and the impact of high crest factor and flat top voltages, etc. to avoid nuisance tripping and coil burnouts.

"Switchgears are expected to be designed to have low losses considering effect of harmonics on losses due to overheating (skin and proximity effects). This is to make the products greener and more reliable!"

Dr Venkatesh Raghavan, VP, PFC, Energy Solutions Business Division, Film Capacitors Business Group, TDK India Pvt. Ltd.

- Switchgears are expected to be designed to have low losses considering the effect of harmonics on losses due to overheating (skin and proximity effects). This is to make the products greener and more reliable!
- With increased switching, the demand for transient-free switches is expected to go up and increase the popularity of solid-state switchgear, point-on-wave switching and current-limiting switches.
- Increasing DC loads (SMPS, EV charging, LED, BLDC motors, etc.) and DC generation (SPV, WEG with converters, etc.) is expected to increase the demand for DC switchgear (moving away from natural "current zero" for arc interruption). Paving for new innovations in DC current interruption.
- Considering the sensitivity and criticality of loads and PQ aspects, the switchgear is expected to have faster operation or sub-cycle fault interruption and reduce nuisance tripping with advanced and intelligent fault detection systems.
- Higher reliability and safety, arc resistance characteristics, compactness and "green" switchgear would be the norm.
- Aligned to emerging maintenance practices and leveraging on IoT, the switchgears are expected to be smart and intelligent with communication facilities and diagnostic features.

Why Power Quality Matters...

Devchandra Kuril says, *"Power Quality (PQ) maximizes power uptime, improving the reliability of our facilities."* Kuril, the Product Marketing Manager - Smart Power at ABB India Ltd. further states that PQ plays a critical role in technologically advanced electrical tools and machinery that are sensitive to voltage variations, otherwise leading to expensive downtime resulting in loss of productivity and revenue.

A power supply affected by harmonics, imbalances and low power will lead to penalties on electricity bills, overloading and rapid aging of electrical infrastructure, thus increasing OPEX and equipment maintenance needs, he informs.

Global Movement Towards PQ

Global power systems are transitioning towards decarbonization of electricity production through the deployment of Distributed Energy Sources (DER). The power electronic converters connecting these systems to the grid can affect power quality. Power quality in the future is expected to be significantly affected by this shift towards a carbon-free electrical energy system. Several market trends highlight a degraded power quality in future power systems due to the integration of many power electronics devices, use of power cables at all voltage levels, increasing amounts of fluctuating production and generally reduced system strength.

PQ: Challenges

Several power quality issues impact the operation of electrical equipment and the efficiency of industrial facilities. Facility managers trained in the basic knowledge of power quality can identify operational performance improvements while being aware of potential threats and methods to mitigate them. The same can also be done with the help of consultants.

The most common problems are: •Sags/swells • Harmonic distortion • Spikes/transients • Voltage unbalance • Under/overvoltage • Voltage fluctuations (flickering) • Poor power factor (PF) • Power cuts/outages

PQ problems can originate either from the power grid—for example, due to autoreclosers clearing faults on transmission lines – or from loads within the facility or in another facility connected to the same bus. Load-generated sags arising from large DOL motors' inrush currents can also cause PQ problems. Figure 2 shows which types of loads can

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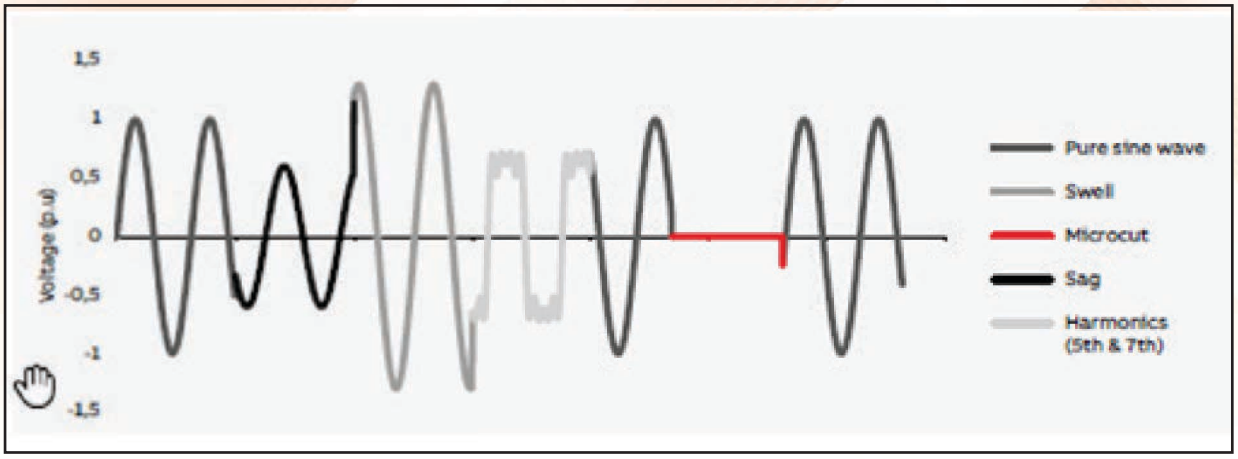

Figure 1 illustrates how some of these problems affect the shape of a pure electrical sine wave.

produce PQ problems, which are affected by PQ problems, or, in some situations, which are both source and victim. For instance, induction motors are affected by voltage unbalance and harmonics, but, on the other hand, they typically cause inrush currents during starting, thus generating voltage sags. Induction motors typically have a low power factor and require PF correction.

Impact of Poor Power Quality in Industries or Similar Loads

1. Unwanted tripping of contactors and control relays, process stoppage, production losses and data corruption
2. Overheating of three-phase motors and stress leading to mechanical failure
3. Higher CO2 emissions due to inefficient operation
4. Non-compliance with grid codes
5. Poor PF and penalties on electricity bills
6. Additional services & maintenance costs
7. Reduced equipment lifetime.

Risk Mitigation Techniques to be Deployed in Low-Voltage Side

1. *Load immunity solutions:* let us suppose the problem facing a facility is 'voltage sags' that are shallow in magnitude and short in duration. In that case, the solution could be to change the contactors or similar operating devices in the facility, which will be an optimal solution to keep the load immune to voltage sags. Product ranges or solutions need to meet the SEMI F47 conditions of use and on request.
2. *Power conditioning solutions:* voltage variations and sags represent one of the biggest threats to manufacturers and industrial facilities around the world. They can originate from:

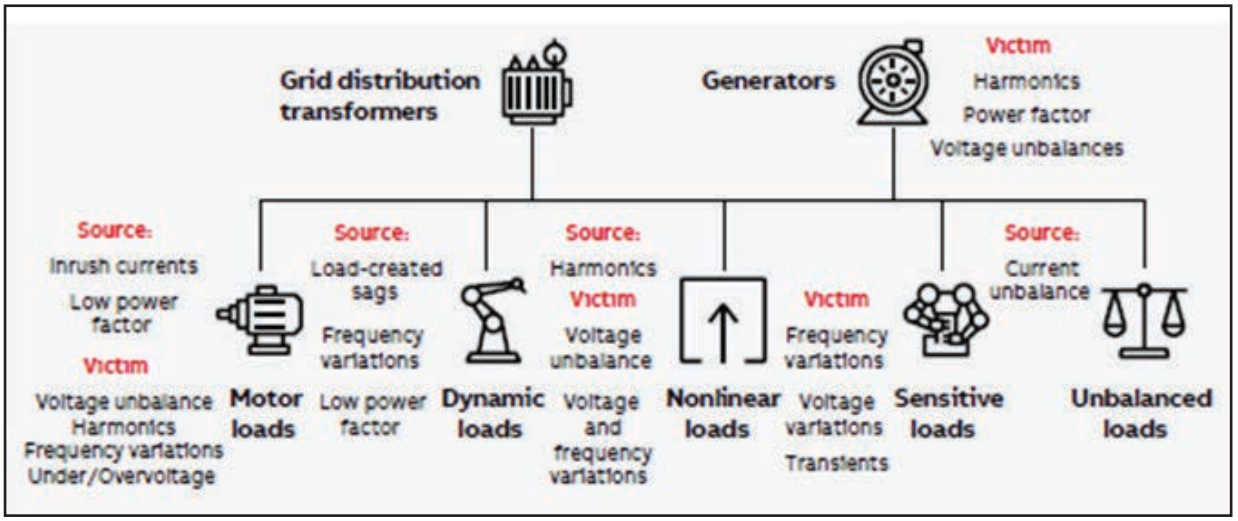

Figure 2 PQ source/victim diagram for electrical loads.

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Faults on transmission lines that are translated to voltage sags in the LV distribution system.

Weather conditions that heavily affect energy production, eg, on solar farms, where there can be voltage sags on cloudy days and voltage swell on sunny days.

Starting a large motor in a factory, which can cause a voltage drop that affects the loads connected to the same bus.

Arc welders and furnaces, which can cause rapid variations in current, leading to voltage fluctuations that affect lights and human health.

An active voltage conditioner is the best-suited solution to mitigate such conditions of power quality that are inverter-based to protect sensitive loads from voltage disturbance. Voltage conditioners are optimally designed to provide equipment with immunity from power quality events on the supply network.

After this technically rich comment on power quality by **Devchandra Kuril,** let us look at the need for and the importance of research and development in the sector.

Significance of R&D

"The global shift towards smart grid technology and digitalization demands that manufacturers upgrade their product offerings," says chairman **Nitin Rastogi**. Technological advancements and innovation in the switchgear segment demand strong and local research and development in the manufacturing segment.

Rastogi says, *"Indian switchgear manufacturers must keep up with innovations such as IoT-enabled systems, digital switchgear, and remote monitoring solutions, which are gaining popularity in developed markets. Keeping pace with such advancements requires significant investments in R&D, advanced materials, and specialized manufacturing processes.*

"Power quality plays a critical role in technologically advanced electrical tools and machinery which are sensitive to voltage variations, otherwise leading to expensive downtime resulting in loss of productivity and revenue."

Devchandra Kuril, Product Marketing Manager - Smart Power ABB India Ltd.

"To address this concern, manufacturers should focus on collaborating with global technology providers or get involved in joint ventures to access cutting-edge technologies."

Investment in R&D can help domestic and multinational manufacturers to innovate and develop cost-effective switchgear with smart solutions. Leveraging Industry 4.0 technologies like

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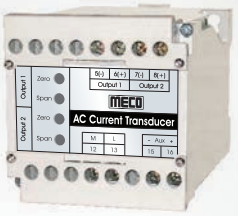
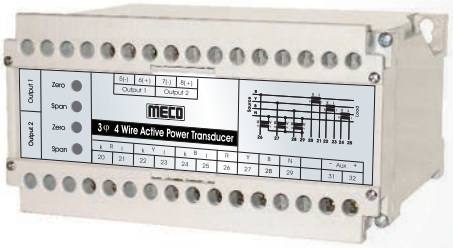


A | KV | MVAR | COSφ | MW | Hz



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automation and data analytics can improve product quality and reduce the manufacturing cost of switchgear.

On the Policy Front

The preceding analysis and projections lead to conclusions and recommendations that can be considered by policymakers engaged in different aspects of electricity system planning, regulation, and policy. These insights, as shared by the **Chairman of the LV Switchgear** division, are both of a quantitative and qualitative nature and apply both to the practice of electricity demand forecasting as well as its use in policy determination and evaluation.

India's government policies provide a favourable environment for the growth of the switchgear industry by promoting domestic manufacturing, renewable energy adoption, electrification, and smart infrastructure. The combination of the Make in India initiative, ambitious renewable energy targets, smart grid developments, and rural electrification programs will fuel demand for modern switchgear solutions.

"The country's emphasis on self-reliance, energy efficiency, and sustainability will push manufacturers to adopt more advanced technologies, produce greener products, and cater to the diverse needs of a rapidly modernizing nation."

Nitin Rastogi, Chairman IEEMA LV Switchgear Division

The Make in India policy and the Quality Control Order have encouraged global and domestic manufacturing companies to establish manufacturing facilities in India, thereby enhancing production capabilities, reducing costs, and improving the quality of locally manufactured switchgear products. It has also attracted foreign direct investment (FDI) into the sector, helping India become a manufacturing hub for electrical equipment.

Some of them are listed below:

i. The National Smart Grid Mission (NSGM)
ii. Atmanirbhar Bharat (Self-Reliant India)
iii. National Electric Mobility Mission Plan (NEMMP) & Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME)
iv. Renewable Energy Policies (National Wind-Solar Hybrid Policy, UDAY, Solar Rooftop Program)
v. Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya Scheme)
vi. Bureau of Energy Efficiency (BEE) & Energy Efficiency Services Limited (EESL) Initiatives
vii. Smart Cities Mission
viii. National Policy on Electronics (NPE)
ix. Customs and Tariff Policies

These policies, along with the increasing focus on energy efficiency and the development of smart cities, will create significant opportunities for switchgear manufacturers to expand their product offerings and market reach asserts **Nitin Rastogi**.

"Several market trends highlight a degraded power quality in future power systems due to the integration of many power electronics devices, use of power cables at all voltage levels, increasing amounts of fluctuating production and generally reduced system strength."

Devchandra Kuril, Product Marketing Manager - Smart Power ABB India Ltd.

Future & Outlook

"The future of India's power sector and the LV switchgear industry is promising and dynamic," says the **chairman**. *"As India works towards energy sustainability, modern grid infrastructure, and universal electrification, the demand for smart, eco-friendly, and efficient LV switchgear will rise,"* he adds.

For the LV switchgear industry, this creates significant growth opportunities, with technological innovations in digitalization, automation, and integration with renewable energy systems set to define the market.

The country's emphasis on self-reliance, energy efficiency, and sustainability will push manufacturers to adopt more advanced technologies, produce greener products, and cater to the diverse needs of a rapidly modernizing nation.

The Electrical Equipment Quality Control Order 2020, which is under implementation stage in the low-voltage switchgear industry, is much relevant for debate and discussion, he suggests further.

DISCLAIMER:The opinions expressed are that of the authors and not necessarily of the organization.

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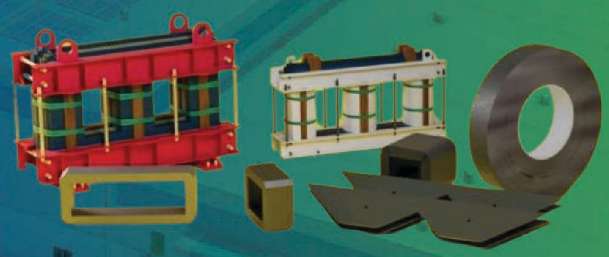

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MV-HV SWITCHGEARS
Defining the New Energy Landscape

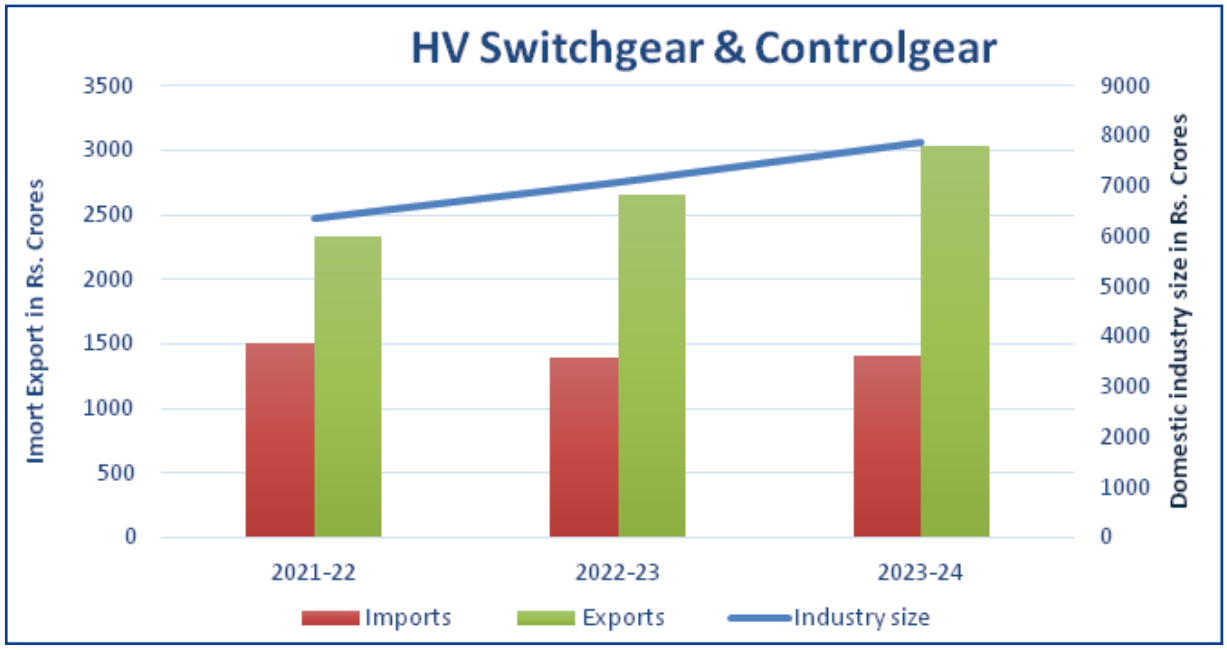
A comprehensive coverage of the medium and high voltage switchgear industry

India's switchgear industry is experiencing steady growth," says **IEEMA medium voltage and high voltage (MV-HV) Switchgear division Chairman, Udai Singh.** Noting the power consumption trend across India, he adds, "Our country consumed over 1,400 TWh of electricity in 2023, making it the third-largest consumer globally after the US and China."

Singh says, "Power demand in India is expected to grow at a rate of around 6-8% annually starting 2023 to 2029." It will be driven by infrastructure development, economic expansion, industrialization, and urbanization and lead to a rise in the energy needs of residential, commercial, and industrial sectors. The power capacity is also projected to increase significantly by 2032, with plans to nearly double the current capacity to about 900 GW. He says that the industry sentiment is positive with a focus on the following:

- Technological advancements: The adoption of advanced technologies like IoT and AI is expected to drive innovation, and the integration of intelligent sensors, communication technologies, and data analytics enables us to move from a 'reactive to predictive' maintenance.
- Energy efficiency: There is a growing focus on energy efficiency to reduce power losses and improve the overall system efficiency with government schemes such as RDSS.
- Digitization: To increase uptime and enable real-time monitoring.
- Sustainability: India's commitment to renewable energy has led to a surge in solar and wind power projects, creating a substantial market for specialized switchgear solutions.

There is a focus on SF6-free switchgear technology to minimize environmental impact, such



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as reducing greenhouse gas emissions and using eco-friendly materials. Power demand is rising because of emerging sectors like the semiconductor and data center segments. Singh notes a shift in the use of the HVDC technology for electricity transmission over long distances.

"The shift from consumer to prosumer, integration of renewables into the grid, emergence of technologies such as green hydrogen and EV charging infrastructure are leading to a 'new energy landscape,' says **Singh.**

Switchgear Market Analysis

Production in the electrical and allied electronics industry has grown at about 9.5% CAGR over the past 5 years while we account for over 2.2 million jobs, contributing by about 7.2% to the total manufacturing segment in India's GDP, contributing 45% share in the capital goods sector.

The growth index for switchgear and controlgear for FY2024 is shown in Table 0.1. The LV switchgear and controlgear segment grew by about 13.7% in FY24; last year's growth at 6.1% was much lower than this year, but the post-pandemic FY22 growth reached a whopping 25%.

This financial year, the HV Switchgear grew by 28%, a massive jump from last year's -5% growth but not as much as the 56% growth recorded in FY22.

The graphics in Table 0.1 show a concise market overview of the HV switchgear and controlgear market with imports in orange colour and exports in green. As we can see, the exports have been in a steady rise since over two-years, taking the market upward with its performance.

A look at Table 0.2 reveals the industry size in FY2023-24 as being valued at ₹7860cr as compared to ₹7095cr in 2022-2023, almost doubling the pre-pandemic number of ₹4175cr in FY2019-20.

HV switchgear imports stand at ₹1406cr in 2023-24 as compared to ₹1397cr in 2022-23 but less than ₹1585cr in 2019-20. Exports have increased to ₹3037cr in 2023-24 from ₹2650cr in 2022-23 and ₹2130cr in 2019-20.

The industry size has grown at a CAGR of 9.87% over the past five years, while imports have cut down by -6.26 and exports have increased as much by 6.75.

Challenges in the Sector

IEEMA MV-HV Switchgear division Chairman, Udai Singh, informs that issues with regulations and compliances pose major challenges for manufacturers. He adds, "Adapting to renewable resources to create sustainable practices is another current challenge, and disruptions in supply chain management, technical support, technical privacy, and security concerns are other notable challenges."

Here is a list of challenges that manufacturers face:

1. Regulation and compliance: the net-zero guideline in India is currently at a nascent stage. The absence of legally enforceable regulations is impeding the adoption of carbon-neutral or SF6-free equipment, thereby slowing the acceptance of cutting-edge technology.
2. Sustainability and environmental concerns: Manufacturers need to come up with eco-friendly and sustainable switchgear solutions to align with global environmental goals. This includes phasing out of harmful substances, such as SF6 gas, used in gas-insulated switchgear. These would require significant investments in alternative technologies.
3. Supply chain disruptions: Factors like geopolitical tensions, natural disasters, and economic fluctuations can disrupt the supply chain, leading to shortages of raw materials, components and logistics challenges. Example: COVID-19, Russia-Ukraine war.
4. Technological disruptions: The industry is constantly evolving, with new technologies like power electronics, energy storage, and smart grid solutions emerging. This can make it difficult for manufacturers to keep up with the latest trends and continuously invest in research and development to develop more efficient, compact,

HV Switchgear & Controlgear	2019-20	2020-21	2021-22	2022-23	2023-24	5-year CAGR
Industry size	4174	4187	6375	7095	7860	**9.87**
Imports	1585	1327	1499	1397	1406	**-6.26**
Exports	2130	2235	2332	2650	3037	**6.75**
Market Size	**3629**	**3279**	**5542**	**5842**	**6229**	**5.97**
Imports as % of Market Size	***43.7%***	***40.5%***	***27.0%***	***23.9%***	***22.6%***	
Trade Balance (Export- Import)	545	908	833	1253	1631	

Table 0.2

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- Control Devices & Switching Element up to 200A, 415V, AC 3 Category (IS/IEC 60947-5-1)
- Terminal Blocks up to 200A, 415V (IS/IEC 60947-7-1)

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and environmentally friendly switchgear solutions, especially in a backdrop of committed demand for these products and solutions.

5. Cybersecurity and data privacy concerns: As switchgear systems become increasingly connected and digitalized, they are exposed to cybersecurity threats like hacking and data breaches. With the increase in digitalization, protecting sensitive customer data and ensuring compliance with data privacy regulations is a growing challenge.
6. Sustaining competitiveness and profitability: As the industry undergoes continual evolution, manufacturers must adjust to emerging technologies and market dynamics to remain competitive. In India, a market sensitive to pricing and confronted with challenges like escalating costs, supply chain interruptions, and economic variability, profitability can be impacted, posing difficulties in maintaining operations within this capital-intensive industry.

"Overall, investing in R&D for LV-MV switchgear is crucial for staying competitive, meeting customer needs, ensuring safety and reliability, and contributing to sustainable energy practices."

Udai Singh, Chairman IEEMA MV-HV Switchgear Division

Potential solutions to these challenges may include collaborating with regulatory bodies to ensure compliance, diversifying supply chain sources, simplifying transactional processes, implementing sustainable manufacturing practices and differentiating through value-added services and solutions, investing in research and development for innovative technologies. It's important for manufacturers to stay agile and adaptable in addressing these challenges states the Chairman.

For cybersecurity concerns, manufacturers must come up with a proper risk assessment plan, employee training on best practices, security protocols, and the importance of data privacy to minimize human error, invest in secure infrastructure, including encryption, firewalls, and secure networks to safeguard data from unauthorized access, conduct regular audits to identify and address any potential weaknesses in the system, and work on the 'incident response plan' to respond to and recover from cybersecurity incidents, ensuring minimal impact on operations.

Research and Development

There is a significant need for R&D in the LV-MV-HV (low voltage-medium-high voltage) switchgear manufacturing segment. The country's energy landscape is rapidly evolving, with a focus on smart grids, renewable energy integration, and increased demand for electricity. To meet these challenges and maintain global competitiveness, innovation in switchgear and transformer technology is essential.

This need stems from several factors:

1. Technological advancements: R&D can drive the development of more efficient, compact, and digitally integrated LV-MV-HV switchgear solutions to meet evolving customer demands and industry standards.
2. Safety and reliability: Persistent efforts in R&D are essential to enhance the safety features and reliability of switchgear and the overall system, addressing issues such as cybersecurity and predictive maintenance capabilities.
3. Environmental sustainability: R&D can focus on developing eco-friendly and SF6-free alternatives, aligning with global environmental goals and regulations.
4. Digitalization and connectivity: Innovations in R&D can lead to the integration of smart technologies, IoT capabilities, and data analytics into LV-MV switchgear for improved monitoring, control, and predictive maintenance.

Overall, investing in R&D for LV-MV switchgear is crucial for staying competitive, meeting customer needs, ensuring safety and reliability, and contributing to sustainable energy practices. This ongoing innovation is vital for the industry's growth and success in a rapidly changing technological landscape.

Technological Support

The switchgear manufacturing industry can benefit from various technological supports to uplift its operations and products. Here is a list of areas that need tech support:

1. Digitalization and IoT: Integration of digital technologies for smart monitoring, predictive maintenance, and real-time analytics to optimize operations and reliability.
2. Automation and Robotics: Implementing automated manufacturing processes and robotics for improved efficiency, precision, and worker safety.
3. Energy-efficient solutions: Developing energy-efficient switchgear designs and components to align with sustainable energy practices and

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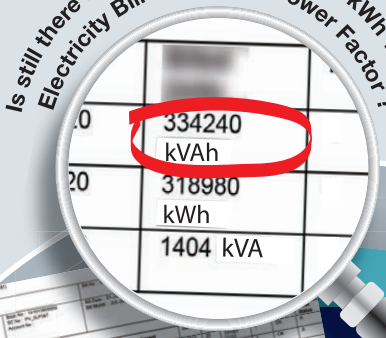

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regulations. Eg: use of low-loss insulation materials and efficient circuit breakers to minimise energy waste during operation.

4. Cybersecurity measures: Incorporating robust cybersecurity features to protect switchgear systems from cyber threats and ensure data integrity.
5. Modular and compact designs: Engineering modular and space-saving switchgear solutions to accommodate evolving infrastructure and space constraints. This can also help in easy expansion and reduced material usage.
6. Eco-friendly innovations: Researching and implementing SF6-free and environmentally friendly alternatives for insulation and arc quenching. Manufacturers can explore use of recyclable and eco-friendly materials in switchgear construction, SF6 alternatives, such as vacuum technology or other gases with lower global warming potential, to mitigate environmental concerns.

Government initiatives like "Make in India" and policies aimed at promoting renewable energy and improving infrastructure, such as Smart Cities, Make in India, Digital India, PMAY (Pradhan Mantri Awas Yojana), the Integrated Power Development Scheme, and the Atal Mission for Rejuvenation and Urban Transformation, among others is creating opportunities for the switchgear industry.

By embracing these technological advancements, the switchgear manufacturing industry can enhance product performance, safety, sustainability, and operational efficiency while staying competitive in the evolving market landscape.

Government Policies

The Indian government has launched initiatives like "Make in India" to promote domestic manufacturing, which is positively impacting the switchgear industry. Additionally, policies aimed at promoting renewable energy and improving infrastructure, such as Smart Cities, Make in India, Digital India, PMAY (Pradhan Mantri Awas Yojana), the Integrated Power Development Scheme, and the Atal Mission for Rejuvenation and Urban Transformation, among others, could also create opportunities for the switchgear industry.

The Indian government can play a pivotal role in fostering the growth and development of the switchgear industry through strategic policies and initiatives. *Here are some key areas where government intervention can create a brighter future for the industry:*

1. Funding for research: Financial support for R&D projects can encourage innovation and the development of advanced switchgear technologies.
2. Incentives for energy-efficient technologies: Providing incentives for the adoption of energy-efficient switchgear can drive demand and encourage innovation.
3. Incentives for innovation: Provide tax credits or grants for research and development in advanced switchgear technologies, such as digital and smart switchgear.
4. Sustainability initiatives: Encourage the adoption of eco-friendly switchgear solutions through subsidies or incentives that prioritize low-impact materials and technologies.
5. Skill development and training: Vocational training programs and industry-academia collaboration aligning with industrial needs.
6. Promoting export: Supporting export initiatives to help switchgear manufacturers access international markets, thereby expanding their customer base and driving industry growth.

The government can also look at increasing FDI that can in turn lead to technology transfer, improved infrastructure, and increased competition, which can benefit the switchgear industry. By implementing these policies, the Indian government can create a conducive environment for the growth and development of the switchgear industry, contributing to the country's economic progress and energy security.

Vision

The vision for the power sector involves advancing towards a more digital, sustainable, reliable, and efficient energy ecosystem, says **Udai Singh.** The goal is to meet growing energy demands while minimizing environmental impact and ensuring accessibility for all. The transformation shall aim at creating a greener and more interconnected energy landscape.

Megatrends like the shift from consumer to prosumer, integration of renewables into the grid, emergence of technologies such as green hydrogen, energy storage solutions & HVDC, emergence of new segment like data center, semiconductor, EV automobile and charging infrastructure shall lead to a new energy landscape.

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"Transitioning to SF6-free technology is the path to managing our power demand while minimizing environmental damage."

Udai Singh, ≫
Chairman, IEEMA MV & HV Switchgear Division

IEEMA JOURNAL (IJ): What are the potential environmental and economic benefits of transitioning to SF6-free gas in India's power system, and how does it align with the country's sustainability goals?

UDAI SINGH (US): India aims to achieve net-zero emissions by 2070. To achieve net zero emissions, we need to look at the entire value chain of electricity, beginning from generation and ending with consumption. This is where the regulation of SF6 comes into the picture. Historically, switchgears have leveraged SF6 gas as the dielectric to perform its critical function, to insulate and break the electrical arc, but as a potent greenhouse gas, it is on the target list of the Kyoto Protocol.

- **SF6 has a global warming potential (GWP)** 23,500 times greater than that of Carbon Dioxide (CO2), Additionally, end-of-life treatment of SF6, can be costly – about twenty per cent (20%) of the price of the equipment itself. It involves numerous steps, including collection, recovery, and neutralization before recycling or destroying the gas. SF6 end-of-life procedure is not always

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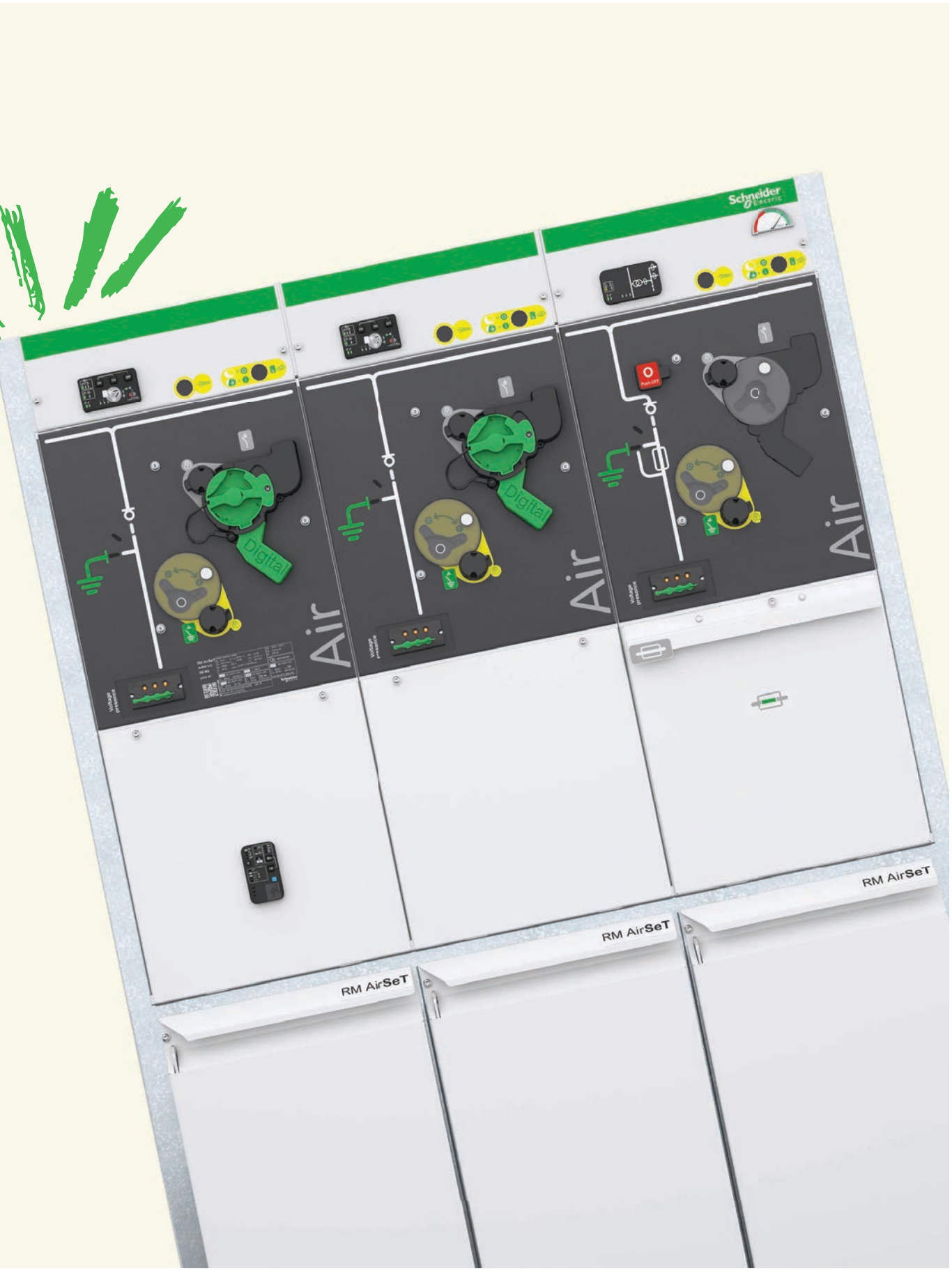
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completed, due to lack of regulations and even if they exist – they are often not properly enforced.

- **Regulators have also started recognizing this challenge in the context of climate change** and have now started introducing new policies like the F-gas regulation which was recently adopted by the EU. Indian regulatory authorities have also taken cognizance of these developments. For the first time, the SF6 emissions from electricity transmission and distribution systems will be included in National Greenhouse Gases inventory as a part of the Biennial Transparency Report (BTR) to be prepared by Ministry of Environment, Forest and Climate Change (MoEFCC) and submitted to United Nations Framework Convention on Climate Change (UNFCC).
- **India's commitment to the Paris Agreement** and achieving net-zero emissions by 2070 can be bolstered by switching to SF6-free technologies in its growing power grid. This will help meet international environmental obligations while advancing the domestic climate policies. Transitioning to SF6-free technology offers a viable path to managing our power demand while minimizing environmental damage. It aligns with India's broader goals of sustainable growth, efficient energy management, and climate leadership on the global stage.
- **The SF6-free switchgears** can lower environmental risks and reduced lifecycle costs due to fewer regulatory requirements for gas handling and end-of-life disposal. In such case, utilities can allocate more resources towards improving the grid and energy management systems, further minimizing AT&C losses.
- **SF6-free switchgear** is part of the broader movement toward greener, more sustainable energy systems. As grids become smarter and more connected, having SF6-free components ensures that India's power infrastructure is ready to handle the increasing complexity and scale of energy management with minimal losses.

IJ: How can the Indian power sector leverage emerging alternatives to SF6, such as vacuum interruption or eco-friendly gas mixtures, to reduce greenhouse gas emissions without compromising on performance or reliability?

US: The Indian power sector can leverage emerging alternatives to SF6, such as vacuum interruption technology or eco-friendly gas mixtures like pure air. These alternatives offer the potential to significantly reduce greenhouse gas emissions. Vacuum interruption technology, for instance, provides a reliable and efficient alternative for high-voltage switchgear applications. Additionally, eco-friendly gas mixtures aim to minimize environmental impact while maintaining performance and reliability standards. Embracing these alternatives aligns with global sustainability goals and promotes a greener future for the power sector.

The performance and reliability of SF6-free equipment can be enhanced using digital capabilities for smooth integration into smart grids, improved detection, and prevention of power losses, thus minimizing AT&C losses.

Adopting SF6-free technologies is key to modernizing India's electrical infrastructure. It reduces greenhouse gas emissions, improves grid efficiency, supports renewable energy integration, and drives sustainability—all of which are vital for India to meet its energy conservation goals and climate commitments. By embracing these innovations, India can lead the charge in creating a more sustainable, resilient, and future-proof energy system.

IJ: How can government support in developing advanced testing facilities and collaborative platforms help the MV and HV switchgear division to accelerate product innovation and maintain high-quality standards?

US: The government can support the MV and HV switchgear division by investing in the development of advanced testing facilities and collaborative platforms.

Currently, government labs have headroom for improvisation as they do not have proper testing facilities available at one place, neither do we have any approved private labs. For getting different certification on a single product, sometimes we have to take the product to multiple CPRI testing locations pan India. This adds to the cost and increased lead time.

Advanced testing facilities equipped with state-of-the-art testing equipment and capabilities can aid in product innovation by allowing for comprehensive performance evaluations, reliability testing, and validation of new technologies. This can help ensure that products meet the highest quality and safety standards.

Moreover, collaborative platforms, supported by the government, can facilitate partnerships between industry stakeholders, research institutions, and academia. This collaboration can foster knowledge sharing, technology exchange, and joint research initiatives, ultimately accelerating the pace of innovation within the division.

By leveraging these government-supported resources, the MV and HV switchgear division can drive advancements in product design, performance, and sustainability, ultimately maintaining high-quality standards and staying at the forefront of technological innovation.

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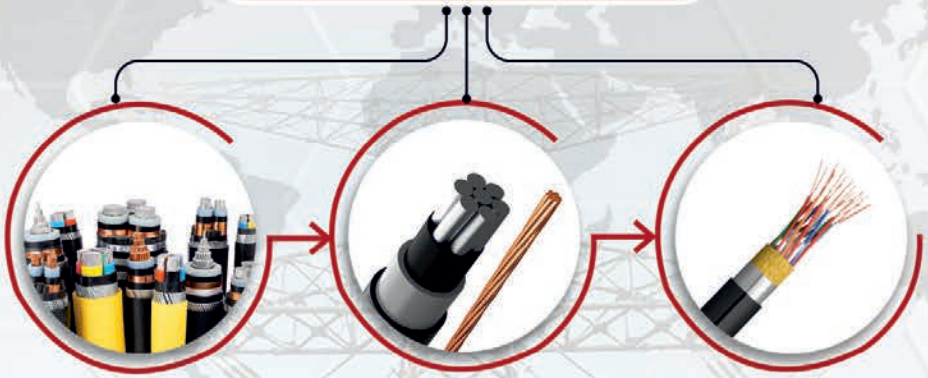

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"The industry has taken significant strides to embrace quality standards, though full compliance remains a work in progress."

Nitin Rastogi, Chairman, IEEMA LV Switchgear Division

IEEMA JOURNAL (IJ): How does the Electrical Equipment Quality Control Order aim to enhance product safety and quality standards in the low-voltage electrical equipment industry?

Nitin Rastogi (NR): The Ministry of Heavy Industry & Public Enterprises (Department of Heavy Industry), Government of India, introduced the Electrical Equipment Quality Control Order (EEQCO) 2020 for Low-Voltage Switchgear under the Bureau of Indian Standards (BIS) framework to enhance product safety, quality, and reliability in the electrical equipment industry.

This regulation applies to various low-voltage electrical equipment under IS/IEC 60947, serving as a fundamental standard for ensuring the safety, reliability, and performance of low-voltage switchgear and controlgear in industrial, commercial, and residential applications.

By mandating that products meet standards specified by the Bureau of Indian Standards (BIS), EEQCO aims to ensure that switchgear equipment manufactured, imported, and sold in India meets high safety and performance standards and reduces risks related to electrical hazards, such as fire and shock, which can result from substandard equipment. The regulation requires that all products within its scope be tested and certified by BIS, ensuring consistency, reliability, and safety in the marketplace and protecting consumers while fostering a competitive, quality-driven industry.

IJ: What measures should electrical equipment manufacturers adopt to ensure compliance with the Electrical Equipment Quality Control Order 2020?

NR: To comply with EEQCO 2020, manufacturers should:

- Obtain BIS certification: Ensure all products within the scope of EEQCO are BIS-certified, meeting the required Indian standards.
- Invest in testing and quality control: Establish in-house or partner with certified labs for pre-compliance testing, ensuring adherence to BIS standards before sending products for certification.
- Enhance product traceability: Implement robust tracking systems for quality assurance, which simplifies inspections and recalls, if required.
- Continuous training and upgrade: Regularly train staff on evolving BIS standards and invest in upgrading technology to meet new compliance requirements.

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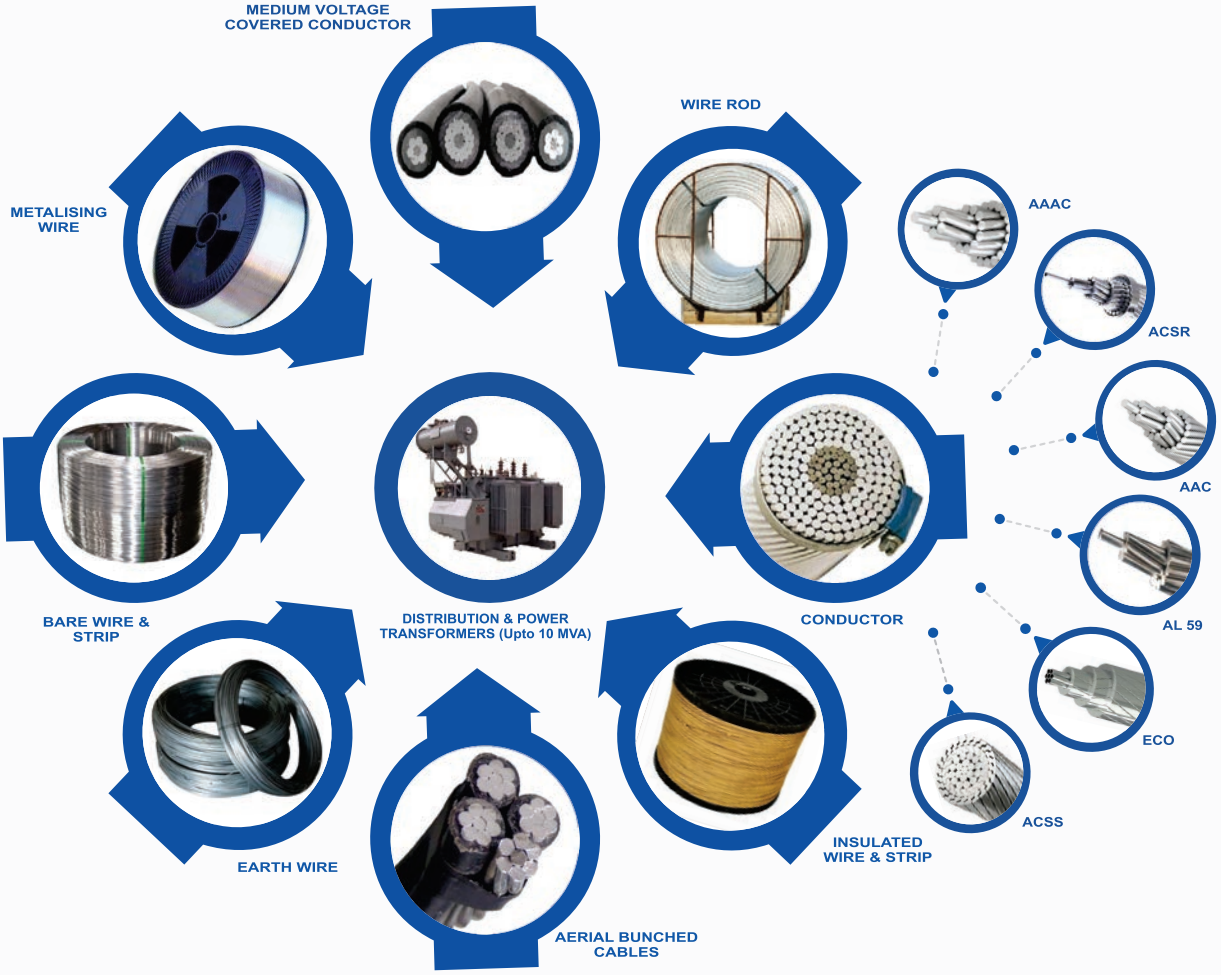

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- Maintain compliance documentation: Keep comprehensive records of test reports, certifications, and internal quality audits, which are crucial during BIS inspections and audits.

IJ: How do you rate the progress of manufacturers for EEQCO?

NR: Progress has been varied across the industry. While larger manufacturers have largely embraced EEQCO compliance, often leveraging established quality control systems and resources to meet BIS standards; smaller companies may still struggle with the costs and complexities of compliance. However, industry awareness has improved considerably, and many manufacturers are prioritizing certification efforts to avoid market disruptions. Overall, the industry has taken significant strides, though full compliance remains a work in progress for some segments.

IJ: What are the challenges encountered in complying with the EEQCO and the way forward?

NR: Key challenges in complying with EEQCO include:

- Resource constraints: Smaller manufacturers face financial and logistical challenges, including the high costs of testing and certification.
- Complexity of BIS procedures: The process for obtaining BIS certification can be time-consuming, with extensive documentation and compliance checks.
- Limited testing infrastructure: There may be limited BIS-accredited labs for certain types of low-voltage equipment, leading to delays.
- Adaptation to evolving standards: Rapid changes in standards can challenge manufacturers, requiring continuous updates to products and processes.

Way Forward

- Capacity building: Encourage government support and incentives for small and medium-sized enterprises (SMEs) to upgrade facilities and meet compliance requirements.
- Streamlined certification process: Simplify and digitalize BIS procedures to reduce wait times and ease of access to certifications.
- Enhanced testing infrastructure: Establish more BIS-accredited labs across different regions, especially in underserved areas, to reduce the burden on manufacturers.
- Awareness and training programs: Increased government-industry collaboration for training and awareness programs on compliance can further ease the transition and ensure a higher degree of compliance across the industry.

10th Edition of Metering India

Aiming at building a sustainable energy future with top industry experts to strengthen the energy metering industry, IEEMA recently hosted the 10th edition of Metering India in Delhi.

Inaugural Session

The Indian Electrical and Electronics Manufacturers' Association (IEEMA) hosted the 10th edition of the Metering India Conference – the biennial conference that has been the benchmark for innovation, collaboration, and excellence in the energy metering industry – on November 21-22 in Delhi. This unique platform brought together more than 500 delegates, including top industry leaders, policymakers, and experts to discuss latest innovations and advancements in energy metering.

With the theme **'Sustainable and Consumer-Centric Utilities Towards Net Zero'**, this year's event focused on sharing knowledge, networking, and developing business for a sustainable energy future. The conference also touched upon the role of smart metering in sustainability and consumer empowerment as we move towards a net-zero future.

Guest of honour **Srikant Nagulapalli, Additional Secretary, Ministry of Power,** said, "With a goal of achieving 500 GW of renewable energy by 2030, initiatives like the RDSS scheme and the rollout of 22.7 crore smart meters are transformative steps. Smart metering is not just about efficiency – it is about empowering consumers, reducing energy consumption, and enhancing financial viability. With a production capacity of 10 crore smart metres

Lighting of lamp...


Address by Guest of Honour,
Shri Srikant Nagulapalli, Addl. Secretary
- Ministry of Power, GoI

Industry Perspective – Opportunities and Challenges towards Aatmanirbhar Bharat

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Panel Discussion 2: Trends & Technologies for the Future

annually, India is well-positioned to become a global hub for smart meter exports. As we prioritise these installations and address challenges through consumer engagement and innovative solutions, we are charting a sustainable path toward a net-zero future."

Sunil Singhvi, President, IEEMA, stated, "The immense participation of industry leaders at the Metering India conference reflects the incredible strides we have made in the Indian power sector. As an industry, we have championed reforms, embraced cutting-edge technology, and empowered consumers like never before. India is poised to become the largest pre-payment system market globally, and we must build on this momentum by prioritising system design, data security, and collaborative innovation. Together, we can ensure that our efforts not only drive domestic growth but also position India as a global leader in energy exports and renewable advancements."

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Special Contribution to Metering Award conferred to CP Jain

Special Contribution to Metering Award conferred to RK Verma

Special Address: Shri Ghanshyam Prasad, Chairperson, CEA - Ministry of Power, GoI

Special Address by Shri BA Sawale, DG, CPRI

Technical Session 3: Metering: beyond Tariff Metering

Technical Session 4: Strategic Approaches for Efficient Utility Operation

Technical Session 5: Cybersecure Digital Transformation of Discoms

Panel Discussion 3: AMI Journey so far under RDSS, Challenges and way forward

Panel Discussion 4: Empowering Consumers

Jaideep Mukherjee, Chairman, IEEMA Meter Division, added, "The Indian power sector stands at the forefront of transformation, driving sustainability through decarbonisation, decentralisation, and digitalisation. By placing consumers at the heart of this transition, we are fostering a positive industry outlook while supporting national initiatives like the installation of 250 million smart metres. This monumental effort, underpinned by industry collaboration and government support, showcases our commitment to an *Aatmanirbhar Bharat* and a sustainable future."

With five dedicated sessions to address the challenges and solutions of smart metering, the conference served as a platform for thought leadership and action. The event saw participation from a diverse cross section of stakeholders such as utility companies, energy service providers, tariff regulators, testing institutes, consultants, academic and research institutions, industrial, building, solar and wind energy sector representatives.

With a legacy of two decades, Metering India has been driving innovation and collaboration in the power sector. The last edition in 2022 had a remarkable participation of more than 550 participants, 170 organisations and 260 representatives from 80 utilities, public-sector undertakings (PSUs) and government institutions. Since its inception in 2004, the conference has seen more than 4,000 delegates and has been a platform for knowledge sharing, networking, and business development.

IEEMA, the representative national organisation of manufacturers of electrical, professional electronics, and allied equipment in India, has played a pivotal role in shaping the Indian energy landscape. Through events like Metering India, IEEMA continues to foster innovation and strengthen the ecosystem for a sustainable energy future.

IEEMA *meets* Shri Manohar Lal, MoP

Discussions revolved around achieving energy evacuation targets and the industry's commitment to capacity enhancement, among others...

Indian Electrical & Electronics Manufacturers' Association (IEEMA) delegation, led by Vikram Gandotra, President-Elect, IEEMA and Chairman, ELECRAMA 2025, recently met the **Hon'ble Power Minister, Shri Manohar Lal.** Discussions focused on innovations for achieving energy evacuation targets, the role of electrical equipment, and the industry's commitment to enhancing capacity for Make in India and exports. Other delegation members included Siddharth Bhutoria, Vice President, IEEMA; Sandeep Zanzaria, Member of IEEMA National Executive Council (NEC); Charu Mathur, Director General, IEEMA, and other senior IEEMA representatives.

IEEMA *meets* Shri Shripad Naik, MNRE

Discussions revolved around upcoming IEEMA activities and ELECRAMA 2025…

Indian Electrical & Electronics Manufacturers' Association (IEEMA) leadership, represented by Vikram Gandotra, President-Elect, IEEMA and Chairman, ELECRAMA 2025, and Charu Mathur, Director General, IEEMA, briefed **Shri Shripad Naik, Hon'ble Minister of State (New & Renewable Energy)** on upcoming IEEMA activities and the world's largest electrical and allied electronics show – ELECRAMA 2025.

A Novel Vacuum Capacitor Switch for Minimizing Switching Inrush Currents

This paper describes a novel switch for transient free switching of medium and high voltage capacitor banks with pre closing resistors and a mechanism to fine tune the selection of optimal value of resistor and switch operation to obtain the least switching inrush currents.

In medium voltage and high voltage systems an improvement in power factors and reactive power compensation is achieved by extensive usage of switched shunt power capacitors. Switching of such shunt capacitor banks usually results in the inrush of large switching current in the capacitor. If such currents are frequent in nature and exceed the specified limit of capacitor tolerance, they can cause rapid failure in capacitor banks and associated equipment.

Apart from the potential failure of capacitor banks caused by switching inrush currents, transient currents can also cause transient overvoltage's on the capacitor bus. Magnitude of the same depends upon system fault level, presence of series reactors, etc. Transient overvoltage is injurious to other equipment connected to the same bus. High switching inrush current can cause failure of the working capacitor switches and nuisance operation of capacitor fuses. Deliberate overrating of such fuses can compromise the reliability and performance of fuses and reduce protection levels. Reducing the magnitude of switching inrush currents affects the reliability of capacitor banks and associated equipment.

Switching of other types of loads such as transformers, shunt reactors and others also exhibits inrush currents that are detrimental to power equipment and the system. Important aspects of power system operations include limiting switching inrush currents associated with all types of loads or power equipment such as capacitor banks, transformers, reactors and inductors, motors among others.

Prior Art: Reviewing Current Techniques

Four basic technologies are available to limit the switching inrush current in a capacitor bank. Each technology has advantages and disadvantages.

Type 1: Use of current limiting inductors: In this first type of current limiting technology, a series (current limiting / damping reactors) reactor limits the switching inrush current. Occasionally, it is dimensioned to configure the capacitor bank as a detuned or a tuned harmonic filter to protect the capacitor banks against harmonic overloading or resonance or to filter the system harmonic currents. Such series reactors are permanently connected in a series with the capacitors and though they reduce the switching inrush currents, they tend to increase the transient and the steady state voltage across the capacitor thus requiring the capacitors to be designed and rated for higher voltages. Series reactors have a significant power dissipation depending upon XL and the Q factor. Since these reactors are permanently connected in the circuit they consume significant energy.

Reactors connected in the line end of the capacitor banks are bulky, generally sized to carry the full system fault current, and expensive. While such reactors can be realized with cores made of magnetic steel or air, air core reactors are popular as they do not saturate and offer high linearity. They require many clearances (amongst reactors of three phases and from grounded metallic objects) to satisfy the minimum magnetic clearances reactors (apart from electrical and thermal clearances) and thus tend to be bulky requiring a large volume or a big footprint.

Such current-limiting technology, though very old and well established, has its own limitations. The magnitude of inrush current depends upon many factors, such as the size of the capacitor bank, the rating of the series reactor, the system fault level, the number of parallel connected capacitor banks, the residual voltage on the capacitor when it is switched on, the point on the wave of the system voltage at which the switch closes (which is uncontrolled and is a random phenomenon), the configuration of the capacitor bank, the pole discrepancy of the electromechanical switch among others.

Sometimes there is sustained oscillation for a longer duration due to the energy oscillation between the two series connected energy storage elements of capacitor and inductor. Oscillations are not damped effectively since the series inductors are designed with a high 'Q' factor to reduce the losses and heat generation (mainly a requirement from the thermal class of insulation used in such inductors).

Series reactors like the toroidal-core-wound zero-flux reactors are used in some variants. Though the reactance or inductance of this series reactor is high only during the duration of the switching transients, it automatically reduces to a lower value during steady-state balanced operation. This results in reducing the steady-state over-voltage on the capacitors. Such arrangements are effective only for certain configurations of capacitor banks, such as three-phase star (wye) connected banks with grounded neutral. The efficiency also depends upon the pole discrepancy of the electromechanical switch.

Type 2: Use of Solid-State Switches / Zero Current Switching: In the second type of current-limiting technology, semiconductor switches (such as thyristor) are used to switch on capacitor banks. These switches work swiftly and instantly. They are switched on to limit the switching inrush current when the voltage across the semiconductor switch is at a minimum or ideally at zero, or the minimum required for the forward biasing of the semiconductor switch. Closing instantly offers minimum switching inrush current also called zero-voltage switching. When capacitor banks use electronic or semiconductor switches, they work faster, enabling frequent operation.

Thyristor switched capacitor banks are expensive and require complex control or trigger circuits. They are known to be very lossy as well as the losses in a semiconductor are much more than in conductors. These are not generally used owing to their higher power loss and cost, unless other application or performance requirements dictate usage of semiconductor switches.

These capacitor banks when switched through electronic or semiconductor switches also offer the ability for faster and frequent operation of capacitor banks. Thyristor switched capacitor banks are known to be expensive and require complex control and trigger circuits and loss inducing, as the losses in a semiconductor are more than those in the conductors. Unless other application requirements dictate the use of semiconductor switches, usage is avoided due to higher power loss and cost.

In some variants the semiconductor switches are bypassed to reduce the steady state losses, instead electromechanical switches are used after switching. This requires additional switches and control mechanisms that are not popular and are limited to low voltages (less than 1kV).

Type 3: Use of Point on Wave Selector Switching: In the third type of current-limiting technology, a point-of-wave selector is used. In this case, the opening and closing times of the electromechanical switches are precisely controlled and monitored along with the voltage on the capacitor bank, which is switched 'On' when the voltage on the capacitor bank is close to the system voltage so that the inrush current is limited as the differential voltage across the switch is minimal or almost nearing zero (zero voltage switching).

Advance monitoring techniques and learning algorithms are available to monitor the changes in the operating speeds of the switch mechanism and to make corrections. For the time lag from command to actual closing to achieve near zero voltage differential, the performance is affected by many factors such as aging of mechanism, contact erosion, operating temperature etc. Such technologies are very expensive and are deployed only in select cases where tolerance to inrush current is very low.

Type 4: Use of Pre-Closing (Pre-Insertion) Resistor Switches: In the fourth type of current-limiting technology, the electromechanical switch has two contacts, a main contact and an auxiliary contact. The auxiliary contact is first closed through a series resistor (pre-closing resistor), which effectively limits and damps the switching inrush current. After a certain time lag, generally in the order of 1 to 20 ms, the main contact is closed to bypass the pre-closing resistor or the series combination of the pre-closing resistor and the auxiliary contact. Thus, the current-limiting resistor comes into play only during the initial switching operation and is effectively bypassed, thus eliminating the continuous steady-state power loss in the resistor. Such switching arrangements with pre-insertion and/or pre-closing resistors are popular across a wide range of system voltages, covering low voltage, medium voltage, and high voltage.

In such cases, there are two inrush currents, first

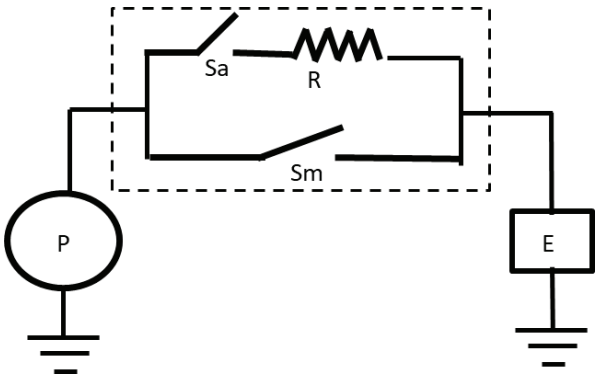

Figure 1. Switch configuration type 1

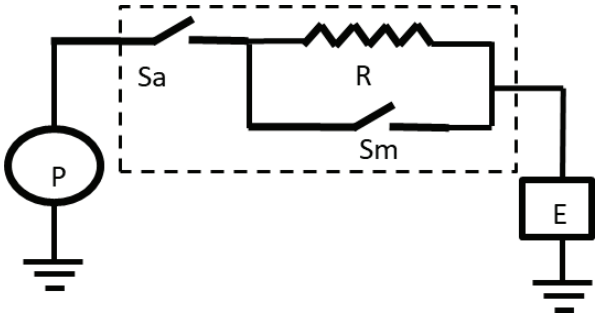

Figure 2. Switch configuration type 2

while closing the auxiliary contact and second while closing the main contacts. The magnitude of inrush currents depends upon the point on wave when closing the first auxiliary contact, capacitance value, residual voltage on the capacitor when closing the first auxiliary contact, value of resistance, time lag between the closing of the first auxiliary contact and the second main contact, system fault level, and presence of parallel-connected capacitor banks.

The value of the pre-closing resistor depends upon the capacitance of the capacitor bank and some other aspects. Generally, low-value resistors are used for larger capacitance values. The other aspects that dictate the choice of resistor value include time differences between closing the auxiliary and main switch, power loss in the pre-closing resistor, inrush current limit required, size limitations, cost limitations, etc. The typical value of resistances is in the range of 1 to 20 Ohms for low voltage (230V to 1000V) and 3Ohms to 120Ohms for medium voltage (3.3kV to 40kV); (generally, the capacitance values are much higher in low-voltage banks for a given kvar to be delivered).

There are two different types of configurations, which can be used in MV (3.3kV to 40kV) and HV (52kV to 170kV) applications, as shown in figures 1 and 2. In both configurations, switch 'Sa' (auxiliary switch) is first closed so the inrush current into the capacitor bank is limited by the resistor, 'R'. The presence of the resistor effectively damps the oscillations, and, in most cases, the combination of RLC values represents an overdamped system. After some time (with a predetermined time lag), the switch 'Sm' (main switch) is closed. Since the voltage across the capacitor would now be closer to the system voltage, this would reduce the second inrush current.

In both types of configurations, there will be two instances of switching inrush current, the first one when 'Sa' is closed and the second one when 'Sm' is closed. Sometimes the second inrush could be more than the first! Also, generally, the first inrush current exhibits an overdamping nature as compared to the second inrush current due to the presence of a resistor.

The value of inrush currents depends upon many factors such as value of capacitance (C, size of capacitor bank), value of resistance, instant of closing for first switch (Sa), time lag between closing of first and second switch, system fault level at PCC, presence of parallel connected energized capacitor banks, pole discrepancy, configuration of capacitor bank, presence of lumped / distributed series reactors, etc. For a given set of operating conditions, the selection of value of the pre-closing resistance (R) and time difference between the closing of 'Sa' and 'Sm' determines the values of inrush currents for a given value of capacitance (C) and is an optimization problem!

For a given value of capacitor (rating of capacitor bank), there exists an optimal value of resistance lowering the first and second inrush currents. For example, as a first approximation or simplification, a lower value of 'R' could result in a larger first inrush but will result in a lower second inrush current. Similarly, a larger value of 'R' may limit the first inrush but could result in a larger second inrush current. The optimal value of the resistance depends upon the capacitance value. Typically, a larger rating of the bank (higher value of C) has a lower value of resistance, and vice versa.

The value of capacitance (bank rating) can be anything depending upon customer requirements, and it is difficult to have so many variations of 'R' in the switch, and it is possible that the customer may change the rating of the capacitor banks during its service life and thus would need a new switch with a different resistor value for optimizing the inrush currents. In most cases, it is observed that the second inrush current (during closing of the second or main contact) is greater than the first inrush current (during closing of the first or auxiliary contact) and exhibits an oscillatory nature, thus

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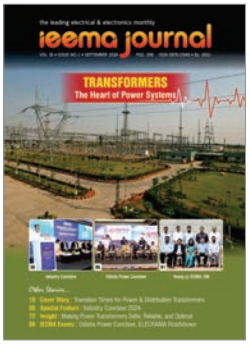

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subjecting the devices to prolonged exposure to higher values of current.

The phenomenon causing this is easily explained as the pre-closing resistor effectively limits the first inrush current. After the first or auxiliary switch is closed, the capacitor starts getting charged and tries to reach the instantaneous system voltage. The charging time constant depends upon the 'RC' time constant (product of the capacitance value of the capacitor bank and the pre-closing resistor).

Moreover, due to the voltage drop across the series resistor, the capacitor cannot reach the exact and required voltage in the system. This voltage drop across the pre-closing resistor is an important aspect that governs the second inrush current. For a given capacitor bank, the larger the value of the resistor, the higher the voltage drop across this resistor and the higher the second inrush current, and vice versa. For a given resistor value, the voltage drop is higher for larger capacitor banks due to higher currents.

For a given capacitor, the higher the value of pre-closing resistor, the lower would be the first inrush current. But the capacitor will also take a longer time to reach the system voltage due to a higher time constant. Due to the larger voltage drop across this resistor, as its value is higher, the capacitor will not reach the exact system voltage. This implies that the second or main contact cannot be closed for a longer time until the voltage across this switch becomes near zero, and in extreme cases, the voltage would never become zero due to the high voltage drop across this pre-closing resistor due to higher resistance values.

Typical time lag between the first auxiliary and second main contacts is generally in the range of 1 to 20 ms. This implies that the RC time constant should be such that the capacitor should reach the applied system AC voltage so that the voltage across the second main contact is (near) zero or as low as possible so that when this second switch (Sm) is closed there is the lowest possible inrush current. Another manner of visualizing this is that when the value of resistance, R, is higher, this would produce a higher voltage drop across it, and when the second main switch is closed, this would result in a larger inrush current. Conversely, reducing the value of the pre-closing resistor will facilitate capacitor voltage to reach system voltage faster and a lower voltage across it when the second main switch is closed, thus reducing the second inrush current; this could result in a higher first inrush current due to the lower pre-closing resistor. So there exists an optimal value of resistance and time lag between the two contacts closing for a given value of capacitance that could offer low first and second inrush currents. Generally, the time lag is fixed depending upon the operating mechanism; the value of the pre-closing resistor is chosen at the installation stage based on the power output (capacitance value) of the capacitor bank. Since the time lag is fixed, the values of pre-closing resistors are inversely proportional to the capacitance value to obtain a RC time constant within a small band aligned to the time lag.

Though the use of pre-closing resistors offers a simple and effective solution against switching inrush currents, current technology poses a limitation that the value of the resistor is factory set or chosen and is available in discrete values and thus provides optimal or lower inrush current only for a very narrow band of capacitance values or equivalent power ratings of capacitor banks. This also limits the ability of the end user to change the rating of the capacitor bank, as this would require changing the resistor value to maintain the same levels of inrush currents and an optimal time constant to align with the time lag between two switches. All current products offer a fixed value of resistance for a range of capacitances (capacitor bank ratings) and thus do not offer optimal performance for all the capacitor bank ratings within the specified limits. RC values are optimized to offer low inrush currents at extremes of range or a midpoint. This is not an optimal design, as the rating of the capacitor bank can have any value between the specified extreme limits.

Novel Switch Design to Optimise Inrush Current

In the novel switch a simple method is provided to vary the value of the pre closing resistance by a simple arrangement so that a wider range of capacitance values / capacitor bank ratings can be optimized for inrush current performance. Apart from this selectable / variable preclosing resistance, the novel configuration also facilitates an easy method to configure the switch either as type 1 or type 2, based on a simple interconnection. Further reduction / optimization in inrush current is achieved by a user settable time lag between the auxiliary and main contacts and such a time lad realized by either electromechanical or electronic means. The construction also provides a design using two poles per phase of the switch to enhance the esthetics and operational performance characteristics such as seismic performance, simplicity of operating mechanism etc. The basic design concept is illustrated in figure 3.

In one variant the links can be metallic busbars (with low ohmic resistance) or can be configured as discrete resistors to obtain additional resistance combinations (apart from R1, R2 and R3). A typical practical realization of the switch is illustrated in figure 4.

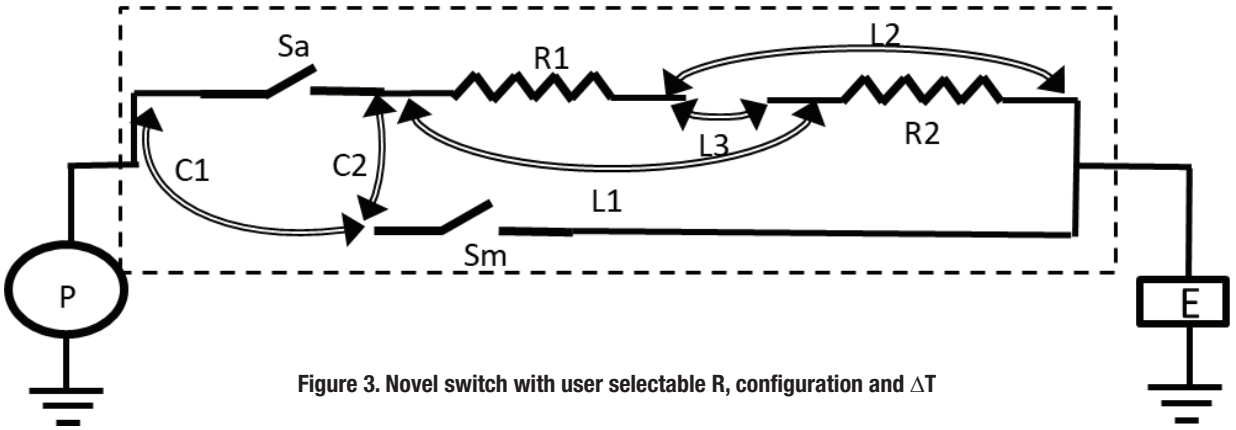


Figure 3. Novel switch with user selectable R, configuration and ΔT

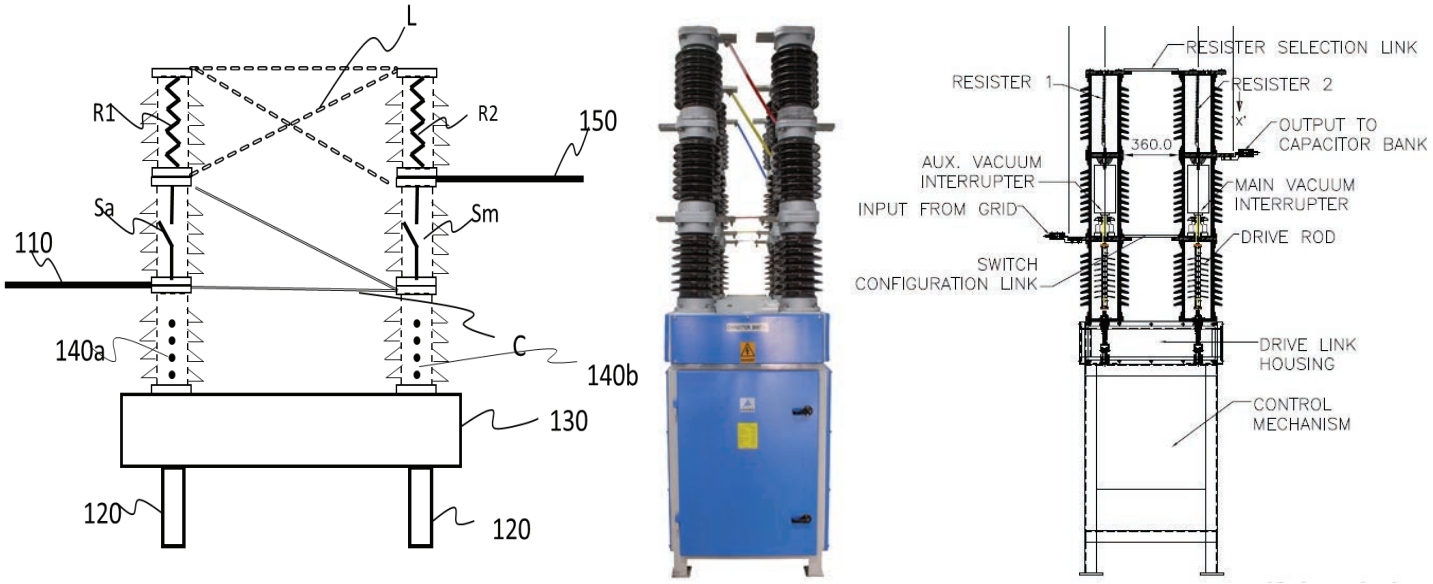


Figure 4. Practical realization of the novel switch

Basic Analysis and Simulation:

The characteristics equations associated with the computation of inrush currents are indicated along with summary of simulation results in this section.

Typical equations associated a series RLC circuit are as indicated below:

$V_s(t) = V_m \sin(\varpi t + \Phi) = V_s(t) = V_m \sin(\varpi t)$, assuming $\Phi = 0$

$I_c(t) = V_s(t) / Z = V_m \sin(\varpi t) / Z$, $Z = R + j\,Xc = R + 1/(j\varpi C)$

$I_{p1} = f(V_s, t_1, R, C)$

$V_c(t) = I_c(t)\,X_c$, $X_c = 1 / j\,\varpi\,C$, $\Delta V(t) = V_s(t) - V_c(t)$

$I_{p2} = f(\Delta V(t))$

Considering the nominal self-inductance (or any lumped inductor in the system), the equations get modified as:

$I_c(t) = V_s(t) / Z = V_m \sin(\varpi t) / Z$, $Z = R + j\,X_L - jX_c = R + j\,\varpi L - 1/(j\varpi C)$

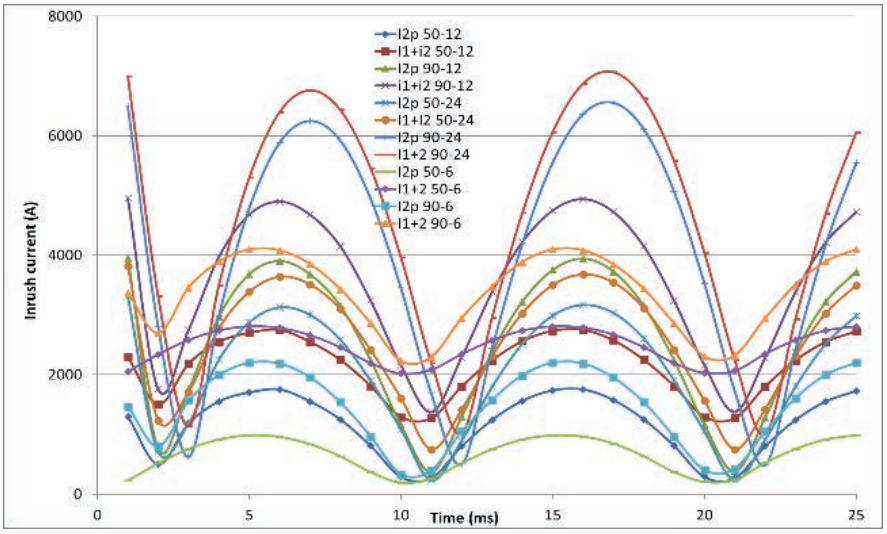
$V_s(t) = L\,di/dt + i_R + V_c(t)$

$I_c = C\,dv_c/dt$

These characteristic equations indicate the presence of optimal values of R and Δt for a given capacitor bank to obtain optimal switching inrush current values.

A computer simulation was carried out to check the inrush current performance as a function of different variables and a summary is indicated below and a sample result in figure 5:

- Target function. Ip1, Ip2, (Ip1+Ip2)
- Variables considered for simulation:
  - C (uF, bank kvar at specified un)
  - R (value of reclosing resistor. Consider 3 different values)



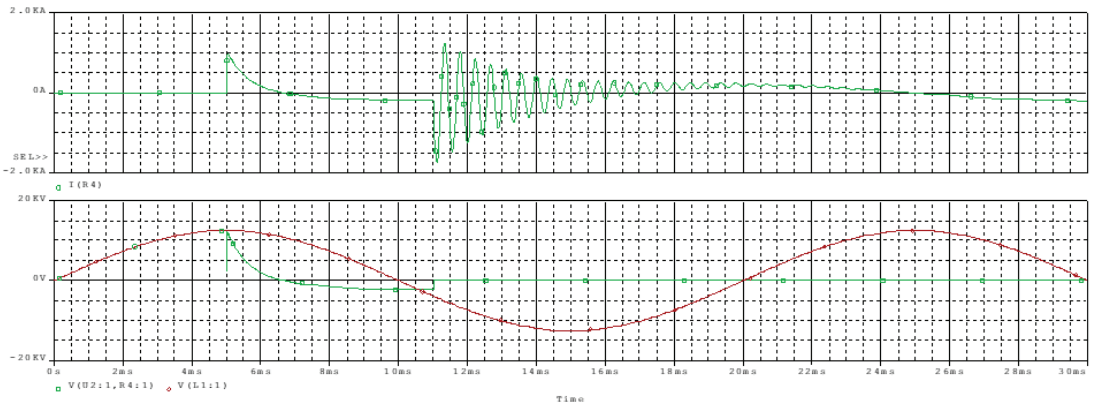


Figure 5. sample simulation result

- ϕ (point on wave for first switch closing) (0 to 20 ms for 50 Hz wave)
- Δt (time difference between first switch and second switch, 0 to 20 ms)
- Source impedance (three different fault levels, 10 kA to 40 kA)
- Parallel banks (0 to 4)
- Series inductance (0 uH to 2000 uH)

Principle of Operation

As illustrated in the figures, depending upon the actual rating of the capacitor banks, the most optimal value of pre-closing resistor from the possible three different values can be selected by a mere connection of a link. This facilitates additional or deletion of capacitor units in a bank after installation and future expansion, increasing customer flexibility and optimized values of inrush current at a minimum of three different operating points (three different bank ratings) as against a single point (one bank rating) in current designs. Replacing metallic links by discrete resistors can increase the resistance value combinations from 3 to 6 different values. The resistances are so arranged that facilitates easy selection and gives the structure good symmetry, ease of manufacturing and maintenance and better seismic performance.

The various resistance values that can be chosen are as indicated in table below:

Link	L1	L2	L3
Resistance value	R2	R1	R1 + R2

Further fine-tuning of the inrush current is facilitated by adjusting the time delay between the closing of two switches using an appropriate mechanism, which could be either electronic time delays or mechanical time delays. Prototype designed with electronic time delays and mechanical time delays offer similar performances and can be chosen based on techno-commercial aspects.

Various combinations of switching sequences are as indicated in table below:

Configuration type	Closing operation	Opening operation
Type 1	Sa first and then Sm after predetermined time delay	Sm first and then Sa
Type 2	Sa first and then Sm after predetermined time delay	Sm first and then Sa OR Sa first and then Sm

The Closing Sequence and Aspects

Configuration Type 1:
Closing Operation: Sa, first, and then Sm after a predetermined time delay.

When Sa is turned off, the capacitor gets connected to the power supply through the preclosing resistor, and this resistor limits the inrush current. The voltage across the capacitor raises and tends to follow the supply voltage, and the value of resistance in combination with the value of capacitance determines the initial charging time constant. The current through the capacitor leads the voltage across the capacitor by 90 degrees, and this current through the RC series combination leads the system voltage by an angle determined by the power factor of this RC circuit.

The first peak switching inrush current is determined by the instant at which the switch Sa is turned off, the value of capacitance c, and the value of resistance R (ignoring the system fault level and presence of parallel connected capacitor banks).

For a given set of system conditions and capacitance value, it is evident that the larger the value of R, the lower will be the first switching inrush current. Assuming the worst-case closing time of voltage peak and virtual short circuit of capacitor due to high frequency of switching transient, the peak of the first switching inrush current would be Ip1 = Vm / R.

The initial switching transient delays in a short time (few ms), determined by the values of circuit inductance, resistance, and capacitance. The current flowing into the capacitor also flows through the pre-closing resistor and produces a voltage drop across it. This exhibits a damped sinusoidal characteristic.

After a delay (typically in the range of 2 to 10 ms), the second switch, Sm, is closed to bypass the pre-closing resistor and the first switch, Sa.

The second inrush current depends upon the voltage drop across the resistor, which depends upon the value of resistance and the value of current flowing through it, which again depends upon the time instant and the value of capacitance. For a given set of conditions (capacitance value, closing time instances), the voltage drop across the resistor is directly proportional to the resistance value, and thus a higher value of resistance, though would limit the first inrush current, would lead to a higher second inrush current.

Configuration Type 2
Closing operation: Sa, first and then Sm after a predetermined time delay.

The operation is like configuration type 1, except that the switch Sm bypasses just the resistance and not the combination of resistance R and first switch Sa. Since the contact resistance of switch Sa is very low (in the order of a few micro-Ohms) compared to the resistance R (in the order of Ohms), all the aspects and parameters are the same as a first approximation.

The Opening Sequence and Aspects

Configuration Type 1
Opening: Sm first and then Sa

When Sm is opened, the current transfers to the path through Sa and resistance. This also improves the power factor of the load circuit, which now comprises the switched capacitor bank and the resistor. Sa is then opened. Sa is configured to have a higher opening speed and higher transient voltage withstand characteristics to avoid flashover.

Configuration Type 2
Opening: Sm first and then Sa OR Sa first and then Sm
Opening: Sm first and then Sa

When Sm is opened, the current transfers to the path through Sa and resistance. This also improves the power factor of the load circuit, which now comprises the switched capacitor bank and the resistor. Sa is then opened. Sa is configured to have a higher opening speed and higher transient voltage withstand characteristics to avoid flashover.

Opening: Sa first and then Sm

When Sa opens, the current transfers to the path through Sm. After certain periods, Sm opens to break the capacitive current.

In type 2 configuration, in both cases, for a certain duration of time (in ms), both the switches (Sa and Sm) are in series, and the voltage are shared, thus minimizing the probability of a restrike. Though this is an advantage, for operational reasons both the switches must be rated for full system BIL and capacitor bank current to ensure reliability under all operating conditions.

Under Steady State Operations

Configuration Type 1

Steady state rms currents flow through Sm, and Sm is rated for the full capacitor bank current, including overcurrents due to system overvoltages, harmonics, etc. Since Sa will carry currents for a very short duration (few ms during the closing and opening operations), Sa can be configured for a much lower current capacity.

Fault currents will be flowing through just Sm (neglecting the rare probability of Sa closing on faults wherein the currents would be limited by the pre-closing resistance), and hence Sm is rated to handle full fault currents and Sa is rated for much lower currents.

Effect of fault currents on mechanism, force, speed, and travel:

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Since Sm is rated to carry full load currents and fault currents, the interrupter is designed for higher currents, and the mechanism is also for handling such higher currents and thus has a higher force. The travel of Sm can be lower, but the associated mechanism has a higher force to manage high currents. Sa is designed to have higher speed, travel, and voltage characteristics, and this is used for closing and opening operations and does not carry the load current or fault currents.

Configuration Type 2

Steady state rms currents. Since both the switches (Sa and Sm) are in series and carry the full load current, these have to be designed for the rated current of the capacitor bank, including overcurrents associated with overvoltage, harmonics, etc. Fault currents. Since both the switches (Sa and Sm) are in series and carry the full fault current, these have to be designed for the rated fault current of the system.

Effect of fault currents on mechanism, force, speed, and travel:

Since both the switches (Sa and Sm) are in series and carry the full fault current, these have to be designed for the rated fault current of the system. This could make the mechanism bulkier and sluggish for Sa or increase the cost or size to get better performance.

In type 1, switch Sa is expected to carry the switching inrush current, which would flow for a few milliseconds. This switch can be selected to have a higher voltage rating (to prevent a restrike), higher closing and opening speeds, and a lower rms and fault current. Since the rated continuous and fault currents are lower, the mechanism can be lit and thus can facilitate faster operating speeds and longer strokes. Switch Sm is selected or designed to carry the continuous rms current and the system fault currents and can be bulkier.

In type 2, since both the switches are expected to carry the rated continuous current as well as fault current, both the switches must be rated for full rated as well as fault current. Though they are in series during opening and are expected to share the opening voltages, from a prudent design aspect, both switches must be rated for the full system rating, minimal voltages and basic insulation level.

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In type 2, since both the switches are expected to carry the rated continuous current as well as fault current, both the switches must be rated for full rated as well as fault current. Though they are in series during opening and are expected to share the opening voltages, from a prudent design aspect, both switches must be rated for the full system rated minimal voltages and basic insulation level.

In configuration type 1, though both the switches can be of the same or similar characteristics, a further optimization can be obtained by selecting switch Sa with higher voltage performance characteristics (such as higher BIL, faster opening or closing speeds, higher travel or stroke, higher restrike voltage) and switch Sm with higher current performance characteristics (such as higher rate current, higher fault current capability, etc.).

Summary

The paper describes a vacuum capacitor switch with a construction that facilitates the selection of three different values of pre-closing resistors by the customer to get optimal inrush current performance over a wide range of capacitor bank ratings. Two different discrete resistor values are provided, and the user can select either one of them or both in series to get three different values of resistance. The design also facilitates additional resistance combinations with a minimum of 6 values that are possible by configuring the shorting links as resistances. The design and construction also facilitate selection of configuration type 1 or type 2 by a simple link.

The design incorporates a mechanism to adjust (user settable) the time lag between the closing of auxiliary and main contacts, thereby further optimizing the switching rush current for each capacitor bank. This time delay is realized by a mechanical means or an electronic means.

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ii. Patent application No 202021047088 A, filing date 20/12/2020, publication date 24/06/22, The patent Office Journal No. 25/2022 dated 24/06/2022.

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Towards a Greener Grid: The Global Shift to SF6-Free Switchgear Technologies

This article spotlights global trends toward SF6-free switchgear exploring environmental and regulatory pressures, technological development, and the evolving landscape of SF6-free technologies.

The global power industry is focused on transitioning away from SF6 (sulfur hexafluoride) gas in switchgear owing to its environmental impact. This highly potent greenhouse gas boasts a Global Warming Potential (GWP) thousands of times higher than CO2 as an insulating and arc-extinguishing medium inside medium-voltage and high-voltage switchgear. An increasing demand for sustainable technologies calls forth utilities, manufacturers, and regulatory agencies across the world to be open to SF6-free alternatives. Let us explore trends in this growing segment.

Overview of SF6 in Switchgear

SF6 has been the industry standard for decades due to its exceptional dielectric strength, chemical stability, and capability of arc quenching for MV and HV switchgear. Its high insulating properties helps in maintaining compact designs of switchgears and safe operations at higher voltage levels.

Despite these advantages, one significant disadvantage is that SF6 has a very high GWP of about 23,500 over a 100-year lifetime compared to Carbon Dioxide (CO2). Even a minor leak contributes significantly to atmospheric greenhouse gas levels, and with the expending switchgear market the overall impact of SF6 emissions is a major global issue. Atmospheric lifetimes for SF6 are calculated as over 3,200 years, so every release may be considered essentially permanent by human timescales.

One kilo of SF6 emitted to the atmosphere is equivalent to the emission of burning 2.6 metric tons of coal. Because SF6 switchgear has been installed in gigantic amounts worldwide, the impact of SF6 emissions has been cumulative.

Regulatory Drivers of SF6-free Switchgear

With countries striving to meet the Paris Agreement climate goals, the elimination of SF6 is a critical part

of reducing greenhouse gas emissions. This transition is also reinforced by the regulatory and corporate sustainability agenda.

a. International Agreements and Regulations

The governments and environmental organizations have set up challenging targets for the reduction of greenhouse gases, and SF6 with a high GWP is a point of focus. A few of the key regulations include:

- **Kyoto Protocol and Paris Agreement:** With 190+ signatories, these two international treaties require to meet targets on emission reduction and compelling signatories to explore SF6-free alternatives.
- **The European Union's F-gas Regulation:** The EU F-gas Regulation demands gradual reductions in the use of fluorinated gases, including SF6. Quotas and reporting will increasingly be more stringent; hence, these regulations push the switchgear industry hard to innovate and embrace SF6-free technologies.
- **National and Regional Policies:** Specific regulations limit the usage of SF6 in Germany, Switzerland and Japan. Moreover, certain regions prohibit new SF6-based equipment for certain applications.

One kilo of SF6 emitted to the atmosphere is equivalent to the emission of burning 2.6 metric tons of coal.

These regulatory pressures reflect the importance of sustainable technologies, creating an urgent need for the power industry to innovate and adopt environment-friendly switchgear.

Challenges of Transitioning Away from SF6 in Switchgear

The replacement of SF6 with alternative insulating media poses significant challenges. Safety, reliability, and compactness features for SF6-free switchgear will be the same while conforming to environmental requirements. Amongst these, a few identified key challenges include:

- **Insulation and arc-quenching requirements:** SF6 has superior insulating and arc-extinguishing properties, and this is the reason compact switchgears are feasible. Therefore, any substitute must provide similar performance without a compromise on safety or increased equipment size.
- **Space and design limitations:** Because SF6 has a high dielectric strength, the switchgear is compact. Such compact designs are well-suited to densely populated urban environments or confined industrial environments. Alternative technologies may require greater space or reengineering to match performance.
- **Cost and lifecycle implications:** Newer SF6-free technologies may be more expensive upfront or have different maintenance requirements. Some alternatives, for example, may necessitate more frequent monitoring or additional lifecycle management strategies.
- **Performance in various environmental conditions:** SF6-free switchgear must be suitable to multiple environments and climatic regions, from humid tropical areas to dry arid regions, while maintaining its performance and stability.

Leading SF6-free Technologies

The development of SF6-free switchgear has gained momentum over the last decade, with several commercially viable technologies available. Each solution has specific advantages and associated trade-offs. The major SF6-free technologies are as follows:

I. Gas Mixtures with Lower GWP

Overview: Numerous manufacturers are in the process of designing alternative gas mixtures with lower GWP compared to SF6. Some of these alternatives are Novec 5110, C4-fluoronitrile (C4-FN), and others, including other fluorinated gases.

Advantages

- **Performance similarity:** They offer insulation and arc-extinguishing properties similar to those offered by SF6. This makes the design compact.
- **Environmental benefits:** These have a lower GWP compared to SF6 and contribute to an overall decrease in greenhouse gas emissions.

Challenges

- **Cost:** Alternative gases are more expensive to produce and manage than SF6.

II. Alternative Air-Insulated Solutions

Overview: The advancement of technology in air-insulated switchgear leads to the development of synthetic air (pure oxygen and pure nitrogen)-based switchgear.

Advantages

- **Resource accessibility:** Natural resources leading to no extra investments associated with gas development.
- **Consistency with existing standards:** Complying with regulations across the global framework in greenhouse gas production.

Disadvantages

- **Design constraint:** A need for innovative engineering and design solutions to achieve the same level of compactness and performance as their SF6 counterparts.

III. **Solid Insulation Systems**

Overview: The solid insulation system uses solid dielectric materials in the form of epoxy resin or polymeric compounds, which insulate the switchgear.

Advantages

- **Reliability:** The thermal stability of the solid insulation material gives high reliability over long time periods of operation.
- **No gas leakages:** Due to the absence of gases, there is no danger of emissions and thus environment friendly.
- **Compactness:** This switchgear is designed to be compact, thus useful for applications where the available space is less.

Disadvantages

- **Thermal management:** Heat dissipation management is quite essential because the material used can be sensitive to temperature changes.
- **Material limitations:** The electrical properties of insulators might not be as effective as SF6 in all cases, and hence further research is required in this field for betterment.

IV. **Hybrid Technologies**

Overview: Hybrid technologies combine multiple forms of insulation and interruption. For instance, vacuum can be combined with air-insulation or solid insulation, to fulfill the requirements.

Advantages

- **Flexible solutions:** The hybrid systems can tailor performance characteristics to match needs of specific applications, by integrating strength from various technologies.
- **Environmentally friendly:** Hybrid solutions can minimize the usage of high GWP gases and comply with environmental and regulatory constraints.

Challenges

- **Complexity:** Multiple technologies may complicate the design and manufacturing processes, adding to the cost and maintenance.
- **Standardization issues:** Hybrid systems create problems in ensuring standard performance in different applications due to variability.

The Future: An Outlook on SF6-Free Switchgear

The global switchgear industry environment is getting tougher with the implementation of high regulatory and increased demand for greener solutions; this trend towards SF6-free switchgear is going to accelerate. Key future trends expected:

- **Continued technological advancements:** With continued research, the industry can anticipate improvements in alternative insulation materials, better dielectric performance, and enhanced arc-quenching solutions that lead to more efficient and compact SF6-free designs.
- **Increased regulatory stringency:** International regulations are expected to be more stringent in their usage of SF6, thus motivating manufacturers and utilities to switch to solutions that are SF6-free. This regulatory momentum will also drive investments in R&D for alternative technologies.
- **Cross-industry adoption:** The switchgear market is going to be on the rise with urbanization, renewable energy integration, and transport electrification. These sectors are expected to adopt SF6-free technologies, due to their benefits for sustainability and regulatory compliance.

The Way Ahead

Despite challenges, the shift towards SF6-free switchgear offers a chance for the electrical industry to innovate and contribute toward the fight against climate change. Companies should prepare by investing in research and development, establishing partnerships with alternative technology providers, and educating customers on the benefits of SF6-free solutions.

Utilities and industrial players will need to adapt their procurement processes and infrastructure planning to the new regulatory landscape. Retrofitting existing installations or adopting modular designs that allow for future upgrades might be a key strategy in managing the cost and complexity of the transition.

Training engineers and maintenance executives will be imperative, and specialised training programs, the norm. SF6-free technologies require new skill sets and approaches in installation, operation and maintenance.

AUTHOR

Vikas Gupta has over 26 years of experience in the switchgear industry and is Sr. G.M. – Sales & Marketing, [GIS Products] at Stelmec Limited, Mumbai. He has a keen interest in sustainability and emerging technologies.

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Integrating New Energies and Technologies

Through this report, IEEMA JOURNAL discusses the integration of renewable energy sources, energy storage, data centres, and advanced technologies into the power grid

India has a unique position in the global landscape of new energies and technologies. The country is projected to surpass the US in terms of energy consumption by 2050 due to its rapid growth and commitment to COP28 targets. By 2047, India will require 1,400-1,500 GW of renewable power.

"We need wind, solar, storage, transmission, gas, coal. And more than anything, we need renewables to step up and now take centre stage," says **Anish De, Partner, KPMG.** He adds that renewable energy (RE) sources need to be prioritised to meet the country's increasing energy demands and reduce carbon emissions.

De shares an interesting point: India generates less from wind, solar, and hydro – together as a proportion – than we did in 1975. "In 1975, we used to generate more from clean energy sources than we do today. This needs to change."

Energy storage solutions, such as batteries and green hydrogen, are crucial for ensuring energy security and grid stability, opines De.

Scaling up

While earlier, 500 GW sounded like a massive number and adding 50 GW every year in renewable sounded distant, in four months of this fiscal itself, solar capacity addition has gone up by more than 5 GW – this is second highest to China. "We are aiming for 25-30 GW of solar this year. Wind too stands at 1.2 GW in the first three to four months of this fiscal. This too, will hopefully be 5 GW and above," shares **Parag Sharma, Founder & CEO, O2 Power.**

"Why is India able to do 25 GW plus this year?," he questions. "Because 5 GW alone is coming from a single solar park of Khavda. We need more Khavdas," he responds. "What is required is to ask all state nodal agencies to identify barren land and then allocate this land to developers who will start developing big solar in wind parks. Only then will we be able to cross 50 GW plus," he adds. India has the potential to achieve its RE targets by utilising barren land and leveraging large-scale industrial projects.

Sharma adds that localisation of RE components is essential for reducing costs and ensuring energy independence.

Improving Energy Efficiency in Data Centres

Explosion of demand is exactly why we need to supply. "The biggest explosive element in this demand is now computer data centres," believes De.

Sunil Gupta, Managing Partner & CEO, Yotta Infrastructure, has seen the evolution of data centres, given he has been running these for the past 30 years. "From the late 90s, when Internet and data centres came into our lives, to today, there is a significant change in how digitisation is impacting our lives. Every click on a mobile is consuming a lot of computer power in some data centre.


PARAG SHARMA


ANISH DE

And that computing needs power. And when it computes power, it uses power, it generates heat. For cooling it, power is needed again," he points out.

Data centre growth in India has increased from 200 MW in 2013 to 1,200 MW today. "You multiply this by at least 1.5 and this is the total power that data centres are consuming," he adds. "The growth rate of data centres is proportional to the growth rate of digitisation, much faster in comparison to the growth rate of power generation in the country."

Gupta shares that, today, data centres take up about 0.5 percent of the power generation capacity in the country. "This is expected to become at least 3-4 percent, which means that data centres may take up the total power generation capacity in India. This is the where the concern rises. Predictions also say that data centres may end up taking 15 percent of the total world power. Here is where concerns come in."

For this, he suggests we optimise the use of power in data centres, in terms of the type of chips we use, the way we cool our data centres, and most importantly, the type of power we use. "Instead of using thermal and coal power, we must start using green power. Essentially, solar and wind with a combination of energy storage is the right solution for our long-term needs," believes Gupta. He also delved into challenges posed by AI, which is expected to significantly increase data centre energy demands.

Improving energy efficiency in data centres is crucial for reducing their environmental impact and India needs to invest in infrastructure to support the growth of data centres and ensure reliable power supply.

Efficient Mobility

India is making significant strides in electric vehicle (EV) adoption, with 30 percent penetration expected by 2030. "But, why does a country like India need e-mobility?," questions **Kartikey Hariyani, CEO, Chargezone.** "Because energy security


KARTIKEY HARIYANI


SUNIL GUPTA

can be improved and input bills can be reduced, he responds.

If the aim is to, by 2030, have 30 percent of new vehicle sales as EVs, it will require about 7-8 percent of new energy requirement from the grid, effectively translating into about 20 GW power that the EV industry will require. We must be concerned about commercial mobility, he highlights, adding that it was among the main points that prompted Chargezone to launch an electric truck platform in the country. The company recently ran the first electric truck between Bengaluru and Chennai, a 19-tonner and a 55-tonner.

Notably, trucks and buses consume 40 percent of diesel every day and only 30 percent of these have become electric. "Isn't it far more motivating on why we should start addressing commercial mobility in the country!," he exclaims.

That said, Hariyani points out that in the last two quarters, the cost of battery has, for the first time, reached a US$ 200-mark and a US$ 200-per-kWh mark for the mobility application. "For energy storage, we have now seen several new rounds of tenders and power purchase agreements (PPAs) signed under the round-the-clock (RTC) mechanism. The cost of battery reducing for the first time is good news. And hence, we are seeing a new round of tenders in GCCs." Energy storage challenges for EV charging infrastructure also needs to be addressed through industry collaboration, suggests Hariyani.

We need 20-25 GW of new-age power in the e-mobility sector, he avers. Speaking on green hydrogen, Hariyani shares that in the Indian agriculture industry, which is run on urea or fertilisers or inorganic fertilisers, the ammonia consumed is hardly produced in the country. "To produce ammonia, we need NH3. Nitrogen is available from here. Hydrogen can be produced from the electrolysis of water. And electrolysis of water is nothing but using electricity. If we use green power, it becomes green hydrogen."

He further explains that for producing every million of green ammonia, RE equivalent to 6 GW is required. Hence, 30 million tonne of ammonia is what will be required. "In other words, green ammonia will consume about 35-40 percent of the RE addition until 2030. We need to put the country first in terms of energy security by means of new energy strategies through the adoption of e-mobility, especially for commercial cases, and green hydrogen, especially for green ammonia application.

Undoubtedly, integrating new energies and technologies must be our next stop for achieving energy security.

How a STATCON is Transforming Power Quality!

Here's a case study on how the Axpert-i-Sine STATCON is helping the Amdavad Municipal Corporation provide fast-acting reactive power compensation, improve power quality and stabilise the power factor…

The Amdavad Municipal Corporation (AMC) is responsible for managing the civic infrastructure and administration of Ahmedabad. The Water Production & Supply Department within AMC coordinates with the state government to source raw water from the Narmada main canal. This raw water undergoes treatment in various plants to be converted into potable water in compliance with Central Public Health and Environmental Engineering Organisation (CPHEEO) norms. AMC operates more than 200 water distribution stations with a combined capacity of 1,816 megalitre per day (MLD).

One of the key distribution stations, the Dudheshwar Water Works (DWW), is centrally located and has a capacity of 100 MLD. DWW receives electrical power at 11 kilovolt (kV) from Torrent Power, which is then stepped down to 415 volts alternating current (VAC) for distribution to various pumping stations via distribution transformers. To manage reactive power (kVAR) compensation, automatic power factor correction (APFC) panels and fixed capacitors are installed on the low-voltage side at these pumping stations.

The pumping stations function according to scheduled water supply timings. However, during non-operational periods, the power factor at the 11 kV incoming side (metering side) deteriorates due to unloaded conditions. The AMC had been keeping some capacitors switched on to compensate for kVAR, but this approach did not maintain the power factor at the desired level, resulting in unnecessary charges on the electricity bill.

Challenge

The AMC team was actively seeking solutions for improving reactive power compensation and maintaining the power factor close to unity under both, loading and unloading conditions. This new system must integrate seamlessly with the existing reactive power compensation setup.

Torrent Power recently revised its method for calculating the power factor as follows:

New power factor formula:

$$\text{Power Factor} = \frac{\text{kWh}}{\sqrt{\text{kWh}^2 + (\text{kVAr}_{\text{lag}} + \text{kVAr}_{\text{lead}})^2}}$$

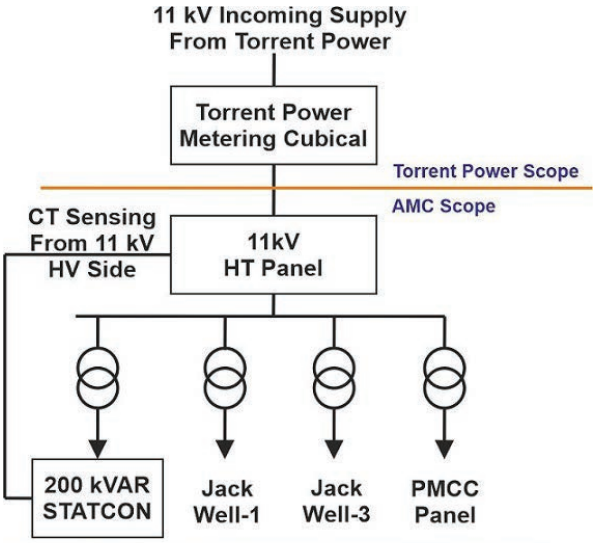
Old power factor formula:

$$\text{Power Factor} = \frac{\text{kWh}}{\sqrt{\text{kWh}^2 + \text{kVAr}_{\text{lag}}^2}}$$

Previously, the leading power factor was not factored into the power factor calculation, and penalties were primarily imposed for lagging power factor. Under the new regulations, penalties apply to both, leading and lagging power factors. Additionally, the energy billing system is transitioning from kilowatt hour (kWh)-based to kilovolt ampere hour (kVAh)-based billing, necessitating the maintenance of a power factor close to unity by consumers.

Solution

To address these challenges, the AMC team explored different solutions and had extensive technical discussions with the Amtech Electronics' team. The team visited the site and analysed operating conditions to determine the optimal solution and discussed pros and cons of each solution. Finally, the AMC team decided to install Axpert-i-Sine Series Active Static VAR Compensator (STATCON). The STATCON provides fast-acting reactive power compensation, improving power quality and stabilises the power factor.



Integrated the system with existing reactive power compensation setups.

Implementation

The Amtech Electronics (India) team designed and installed 200 kilovolt ampere reactive (kVAR) STATCON system tailored for the DWW facility. It configured the STATCON system to ensure that the reactive power (kVAR) requirements at the 11 kV side are maintained.

Ther team integrated the system with existing reactive power compensation setups. Final parameters of the STATCON system were finetuned to dynamically adjust reactive power compensation, maintaining the power factor near unity under both, loading and unloading conditions.

Results

The deployment of the STATCON system has enhanced the ability of DWW to maintain a stable power factor, minimising penalties under the new electricity regulations and ensuring efficient energy usage.

Conclusion

Power factor, which in the previous system stood at 0.30-0.40 during unloading conditions, is now observed above 0.997-0.999 continuously, irrespective of load conditions.

AMC receives benefits (rebate) in power factor adjustment charges in electricity bill after implementing this STATCON. This has reduced its operating cost.

Implementing this STATCON has also resulted in energy saving due to the reduction of I2R losses in the system. It also helps improve voltage stability.

16th Edition
ELECRAMA
Powering the Future of Energy

ELECRAMA 2025: Innovation, Investment, Growth

With previews held across cities, ELECRAMA 2025 is fostering collaboration to build an ecosystem that drives innovation, investment, and growth in the electrical and power sectors…

ELECRAMA, the flagship showcase of the Indian electrical and allied electronics industry, held previews of the mega event in November in cities including Bhopal, Chennai, Nashik and Agartala, highlighting the latest advancements and innovations in the electrical sector.

ELECRAMA is the flagship showcase of IEEMA, bringing together the complete spectrum of solutions that powers the planet – from source to socket and everything in between. ELECRAMA is a platform that connects the world with the Indian industry, in terms of technology, new trends, and innovation for future energy transition.

ELECRAMA Preview in Bhopal

On November 8, 2024, IEEMA organised a preview of ELECRAMA 2025 in Bhopal, Madhya Pradesh, with the support of the Govindpura Industries Association, Bhopal, and the Association of All Industries, Mandideep.

The event commenced with an overview of ELECRAMA 2025, highlighting key themes and opportunities for industry stakeholders.

Mihir Merchant, Vice Chairman, ELECRAMA 2025 RBSM Committee, welcomed and thanked the delegates for their enthusiastic participation in the preview event. He noted that with the anticipated growth in the power sector, IEEMA members are continually working at enhancing their products and driving innovation within the industry. He also invited all attending industries to join IEEMA, highlighting the benefits of the association's membership, including access to extensive resources, valuable networking opportunities, and a platform to share their perspectives and influence policy decisions.

Sanjay Kulkarni, Chairman, IEEMA Western Region Committee, thanked the dignitaries for honouring the programme with their presence. He emphasised that this roadshow's primary goal is to connect with key stakeholders across the state, fostering collaboration to build an ecosystem that drives innovation, investment, and growth in the electrical and power sectors. He highlighted that ELECRAMA 2025 – the premier showcase of the electrical and electronics manufacturing industry – offers a fresh growth perspective for participating industries. He noted key areas of interest, including

new energy solutions, electric vehicles (EV) charging infrastructure, battery storage systems, and opportunities for startups to present their innovations – positioning ELECRAMA 2025 as a vital platform for the future of the energy sector.

Special Guest and Keynote Speaker SM Ramanathan, Executive Director, Bharat Heavy Electricals (BHEL), Bhopal, in his address, commended IEEMA for partnering with Bhopal's industry associations for the event. The preview event demonstrated a strong commitment to engaging local industries and updating them on technological advancements through ELECRAMA. He highlighted BHEL Bhopal's longstanding

collaboration with local industries in sourcing high-quality components and emphasised that with rapid growth in the power sector, improving component quality will enhance partnerships and reliability.

Ramanathan urged local industries to scale up their production capacity to meet the rising demand for power equipment like transformers and reactors. He also encouraged their support in indigenising critical components for traction motors, such as silicone impregnating resin and polybutadiene varnish, currently imported from Germany and the US. He commended IEEMA's efforts to tackle challenges in the transformer industry, such as the shortage of critical raw materials like cold-rolled grain-oriented (CRGO), conductors, bushings, and insulation. He also recommended developing a specialised polyvinyl chloride (PVC) formula standard for hydro generators and large LIS motors.

The event also featured addresses by **Neeraj Goyal, Past Chairman, IEEMA Power Transformer Division; Yogesh Goel, Secretary, Govindpura Industries Association;** and **Dr. Rajeev Agarwal, President, Association of All Industries, Mandideep.**

Mihir Merchant presented the vote of thanks for the programme, expressing gratitude to all dignitaries on the dais for their participation. He also extended special thanks to Vijay Gaur, President, Govindpura Industries Association, for his active interest and his valuable support to IEEMA in making this initiative a success.

The event saw participation of 89 delegates, including senior officials from BHEL, IEEMA members and non-members, engineering, procurement and construction (EPC) representatives, and delegates from industrial clusters across Madhya Pradesh.

ELECRAMA Preview in Chennai

IEEMA Southern region organised a preview of ELECRAMA on November 8, 2024, at Hilton, Chennai. The event saw participation of more than 250 delegates, including utilities, members and non-members comprising electrical equipment manufacturers, data centres, start-ups, mechanical, electrical and plumbing (MEP) consultants, traders and dealers, among others.

The roadshow saw participation from officials of the TamilNadu Electrical Installation Engineer's Association 'A' Grade, Thirumudivakkam Industrial Estate Manufacturer's Association (TIEMA), Ambattur Industrial Estate Manufacturers Association (AIEMA), and The Madras Electric Trades Association.

The Guest of Honour was renowned MEP consultant **Stephen Micheal, Founder, SM Engineers & Consultants**.

He said, "ELECRAMA provides an opportunity to all stakeholders to see all the equipment at one place, where one can see new developments and witness new product launches. It also provides a platform to all in the industry to meet their acquaintances and friends." He wished the organising committee the best, adding, "I hope they conduct several more exhibitions and enable the industry and users and specifiers to meet and share their knowledge and experiences."

Watch out for the enlightening sessions of ELECRAMA roadshows (including the ones held in Nashik on November 27 and Agartala and Aurangabad on November 29) in the next edition!

Empowering Electrical Innovation

A glimpse at how ERDA's Centre of Excellence for Switchgear is empowering electrical innovation...

ERDA's Centre of Excellence for Switchgear, a globally recognised laboratory, holds accreditation from the National Accreditation Board for Testing and Calibration Laboratories (NABL), under the Government of India (GoI), and is also recognised by the Bureau of Indian Standards (BIS). The lab is also accredited by Intertek (ASTA) and approved by Dubai Electricity & Water Authority (DEWA), Distribution Code Review Panel (DCRP) (Oman), and Tenaga Nasional Berhad (TNB) (Malaysia). ERDA's pioneering research has garnered international acclaim, particularly for developing innovative silver-nano particle contact material.

Testing and Evaluation: State-of-the-art Facilities

ERDA offers unmatched facilities for testing and evaluation, including India's largest online short-circuit test station and Asia's largest ingress protection (IP) test facility. Major facilities include:

- India's largest on-line short circuit test facility
  - AC short circuit facility – 120 kA, 570 V-1 no. Lab and 50 kA, 470 V-2 no. labs
  - DC short circuit test facility: 0.5kA up to 30 kA at 280-690 VDC and 0.5 kA to 10 kA at 690-1,500V DC, DC withstand current: 30 kA for 3 sec.
- High voltage laboratory with impulse generators of rating 2400 kVp, 120kJ (one no.), 1,600 kVp, 80 kJ (two nos.) and 800 kVp, 40 kJ – one no.
- Parallel computerised eight nos. of test bays for temperature rise test with capacity of 2 kA, 5 kA, 10 kA, 20 kA, and circuit breaker endurance facility up to 145 kV, 1250 A.
- Making and breaking test (0.1 kA to 120 kA at 440 V AC).
- Electrical endurance test (up to 2.5 kA at 440 V AC).
- Time-current characteristics (up to 40 kA).
- High voltage one minute power frequency test, dry and wet – 700 kV, 350 kVA.
- Ring wave-cum-current surge generator.

- Asia's largest IP test facility with payload capacity of 40 tonne and 6.8 m x 5.8 m x 5.0 m chamber size.
- Partial discharge laboratory for up to 400 kV class products.
- Computerised environmental test chambers with range of –40oC to +180oC with maximum chamber size of 350 mm x 1,150 mm x 950 mm.
- Facility for temperature rise test on distribution switchboards with up to 16 outgoing terminals.
- 10 metre semi-anechoic chamber having shielding effectiveness from 10 kHz to 40 GHz and turn table payload capacity of 3,000 kg for EMI/EMC tests.
- Full facility for type testing of protective relays.
- Type test facilities for sub-station systems. Full type test facility for low voltage assembly.
- Complete facility for evaluation of IPCs.
- Solid insulating materials test laboratory.
- Testing of relays along with IEC 61850 communication protocol.

Panel temperature rise test

HT breaker mechanical endurance test setup

40 tonne IP chamber

Short circuit test laboratory

The lab supports a wide range of products, including ACB/MCCB, RCCB, RCBO, MCB, contactors, starters, LT/HT panel assemblies, bus bar trunking systems, HT circuit breakers, VCB, SFU, SDF, power connectors, isolators/disconnectors, and air-break switches. In line with India's Electrical Equipment Quality Control Order (EEQCO), ERDA offers comprehensive testing solutions to help manufacturers meet the rigorous IEC/IS 60947 series for low-voltage switchgear.

Over and above the domestic market, ERDA caters to testing requirements from international customers, having completed evaluation of more than 200 panels and 75 bus ducts as part of ASTA certification and direct testing requirement from international clients. ERDA has more than 80 customers across the Gulf region, Singapore, Malaysia, and Sri Lanka for their switchgear testing requirements.

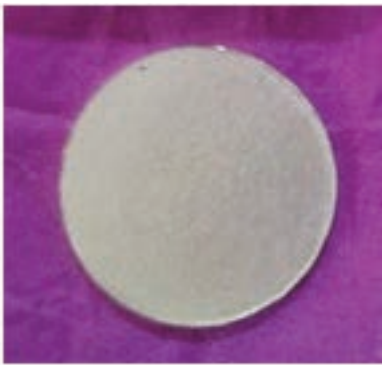
Field Services: Ensuring Reliability on the Ground

ERDA's field services provide third-party inspections, relay testing, dynamic contact resistance measurement (DCRM), timing

measurement on CB, and mechanical endurance tests for critical switchgear and control gear, supporting safety and reliability standards across industries.

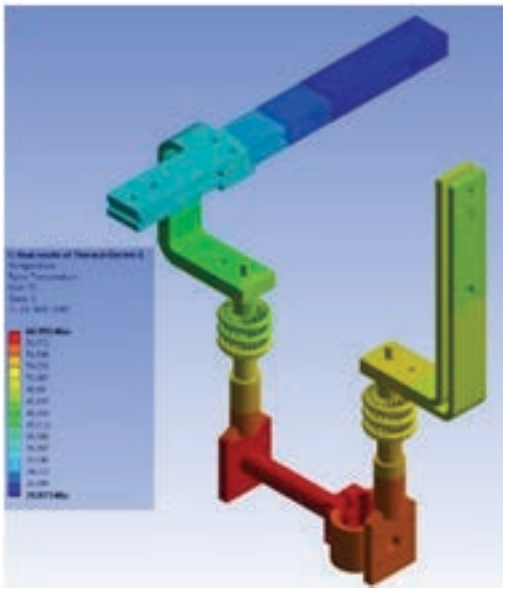
R&D and Expert Services: Leading with Innovation

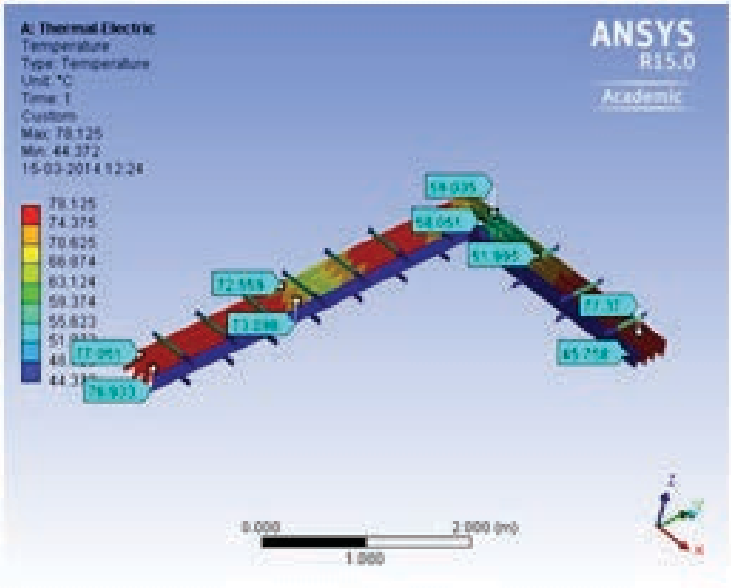
ERDA's research and development (R&D) initiatives have led to advancements in the development of Silver-Nano (CNT, graphene, carbon, oxides)-based

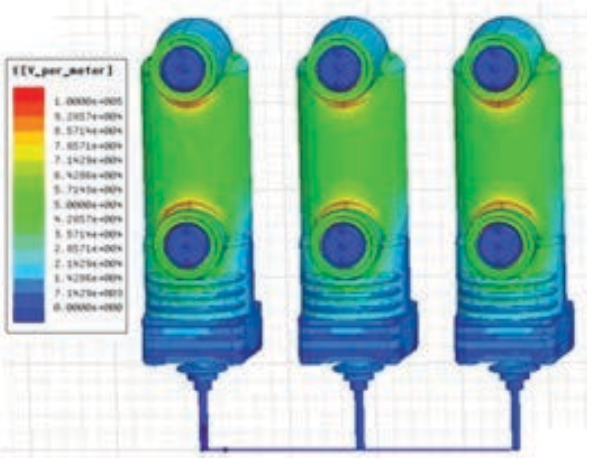


Nano Silver Tin-Oxide Contact

Silver Nano-Carbon Contact







contact materials through novel route and new insulating materials for breaker components, including arc chutes.

Additionally, ERDA offers expert services in the following areas:

- Optimal design of busbars using electromagnetic and thermal analysis with FEA multiphysics codes.
- Electromagnetic and thermal analysis of distribution panels using FEA/MATLAB for design optimisation.
- Electromagnetic and thermal modelling of switching operations in switchgear and control gear.

From groundbreaking research to comprehensive testing services, ERDA's Centre of Excellence for Switchgear plays a pivotal role in shaping the future of electrical safety and performance across industries, nationally and globally.

Accreditation and Recognition

ERDA's Centre of Excellence for Switchgear holds key national accreditations from NABL and BIS with approvals/utilisation from certification agencies like Intertek (ASTA)UK and UL, alongside international recognition from DEWA (Dubai), DCRP (Oman) and TNB (Malaysia), highlighting its global standards in testing and certification for electrical equipment.

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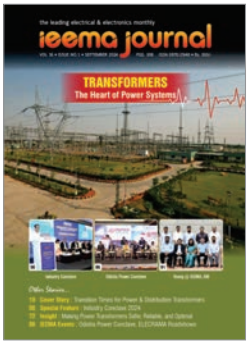

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Established in 1948

Centre to launch PLI scheme for power transmission sector by FY25-end

The Ministry of Power (MoP) will reportedly launch a production-linked incentive (PLI) scheme by this fiscal-end to localise and promote transmission equipment manufacturing. This is amid the supply-chain constraints faced in the power transmission sector due to higher demand, leading to soaring prices of key equipment. India imports most of its power transmission

equipment, including transformers, circuit breakers and switchgears. As reported, the proposed plan comprises over 191,000 circuit kilometre (ckm) of transmission lines and 1,270 GVA of transformation capacity to be added in 10 years from 2022-23 to 2031-32 (at 220 kV and above voltage levels). In addition, 33 GW of high-voltage direct current (HVDC) bi-pole links is also reportedly being planned. The transmission plan covers cross-border connections with Nepal, Bhutan, Myanmar, Bangladesh and Sri Lanka as well as potential interconnections with Saudi Arabia, the UAE, among others, as per reports.

CEA approves Uniform Protection Protocol on pan-India basis

The National Power Committee (NPC), in consultation with RPCs, has reportedly prepared the Uniform Protection Protocol for users of Indian grid for implementation on pan-India basis and has received approval at the 15th National Power Committee Meeting held in November in Maharashtra under the chairmanship of Ghansyam Prasad, Chairperson, Central Electricity Authority (CEA). The uniform protection protocol aims at ensuring grid stability, reliability, and security and also greatly supports the Government of India's vision for integrating 450 GW of RE into the National Grid by 2030 and its ambitious target of 2,100 GW of RE by 2047. The aim is to ensure adequate available disturbance data for facilitating grid event analysis. Such analysis helps monitor the performance of the protection system, thus providing information related to the system's correct behaviour, the adoption of safe operating limits, and the isolation of incipient faults. The Uniform Protection Protocol will apply to all regional entities; Central, state, and private generating companies and generating stations; SLDCs, RLDCs, CTU, STUs, transmission licensees, and RPCs, connected at 220 kV (132 kV for NER) and above. The protocol addresses the protection requirements for thermal and hydro generating units, renewable energy generations (REGs), battery energy storage systems (BESS), substations, transmission lines, and HVDC terminals.

MoP to introduce Rs1,000-crore scheme for energy efficiency in MSMEs

The MoP will introduce a Rs1,000-crore scheme called Assistance in Deploying Energy Efficient Technologies in Industries & Establishments (ADEETIE) for encouraging energy efficiency in micro, small and medium enterprises (MSMEs). As per reports, the government will provide financial support in the form of interest subsidy of 5 per cent and 3 per cent to small and medium enterprises, respectively, on loans taken to implement energy-efficient technologies. A few of the technologies likely to be supported by the scheme include automation systems, combustion control systems for boilers, methane capture and air dyeing. The ADEETIE scheme will be managed by the Bureau of Energy Efficiency (BEE) and aims at ensuring reduced energy costs and emissions. Reports indicate that guidelines for the scheme have already been prepared and is to be soon shared with the industry for implementation.

Rajasthan Government to launch scheme to boost RE investments

The Government of Rajasthan has reportedly released the Rajasthan Investment Promotion Scheme (RIPS). The move aims at boosting renewable energy (RE) investments and leveraging the state's potential with 24.22 GW of solar energy and 5.19 GW of wind energy. As reported, the scheme provides incentives to enterprises that are investing in solar, wind, hybrid, and energy storage projects such as battery energy storage systems (BESS) and biomass. Moreover, it offers a 100-percent subsidy on cross subsidy surcharge and additional surcharges for RE used in producing green hydrogen within the state for seven years. The policy also provides exemptions on transmission and wheeling charges for RE integrated storage projects and standalone battery storage systems, encouraging green energy development.

India, ASEAN can work on regional policy framework for green energy transition: CERC member

India and Association of Southeast Asian Nations (ASEAN) can work together to create a regional policy framework for green energy transition by increasingly using small modular nuclear reactors, reportedly stated Harish Dudani, Member, Central Electricity Regulatory Commission (CERC). The region provides several opportunities for mutual cooperation to make low-carbon energy transition less disruptive. At the recent Singapore International Energy Week, the CERC member reportedly noted that ASEAN countries, including India, are showing increasing interest in small modular nuclear reactors (SMRs) as part of their broader strategy to diversify energy sources and meet growing energy demand while reducing carbon emissions. SMRs can be deployed in smaller, more localised grids, particularly in remote or rural areas where traditional large nuclear reactors are not feasible. This can greatly benefit the ASEAN region, where regional energy access and grid infrastructure vary widely.

India's climate policies expected to reduce CO_2 emissions by around 4 billion tonne by 2030

A study by Delhi-based independent think tank Council on Energy, Environment and Water (CEEW) indicates that India's current climate policies are projected to reduce carbon dioxide emissions by around 4 billion tonne from 2020-2030, and drive a 24-percent reduction in coal-based power generation. As per the study, policies for India's power, residential and transport sectors have already saved 440 million tonne of carbon dioxide from 2015-2020. The report indicates that in the power sector alone, policies promoting RE are expected to drive a 24-percent decline in coal-based electricity generation by 2030, relative to a no-policy scenario. This is equivalent to avoiding 80 GW of coal-based power plants, which would have otherwise been installed to meet India's burgeoning power demand. Moreover, the combined share of solar and wind power in India's energy mix is projected to rise to 26 percent by 2030 and 43 percent by 2050, up from only around 3 percent in 2015.

NATIONAL

CERC notifies the CERC (Indian Electricity Grid Code) (First Amendment) Regulations, 2024

The Central Electricity Regulatory Commission (CERC) has notified the CERC (Indian Electricity Grid Code) (First Amendment) Regulations, 2024. Key changes include a reduction in the allowable period for injecting infirm power from one year to 45 days for renewable energy generating stations and energy storage systems, with provisions for extending this period by three months through requests to the regional load dispatch centre or longer extensions to the CERC. Additionally, hydropower stations can now declare their commercial operation date (COD) even when water levels are low, demonstrating capabilities with available water, and are obligated to fully test once conditions improve. Thermal power plants not operating at full capacity will receive compensation based on their contracts, with specific terms defaulting to the CERC's 2010 grid code if not outlined. New operational limits require generating stations to maintain minimum generation levels during off-peak hours while remaining flexible for peak demand. Moreover, revisions in capacities are now capped at four per day for most generating stations and six for lignite, gas, and hydro stations, with maximum monthly limits set at 60 and 120, respectively.

NTPC to produce green hydrogen from world's first plasma oxy gasification plant

NTPC Limited will be setting up a green hydrogen production plant through its research and development (R&D) wing, NETRA, to utilise plasma oxy gasification of municipal solid waste (MSW) and agri-waste technology. The plant is expected to produce approximately 1 tonne of green hydrogen per day. This will be done by gasifying about 25 tonne per day of MSW/agri-waste. In addition, carbon monoxide will be extracted from the hydrogen recovery system and harnessed to produce electricity via a low-calorie gas engine.

CEA issues revised draft guidelines for periodicity of type tests for major electrical power system equipment

The Central Electricity Authority (CEA) has released revised draft guidelines for the periodicity of type tests for major equipment used in electrical power systems. These guidelines aim at harmonising the validity period of type test results, reducing unnecessary repetition, and promoting uniform practices across the power sector. The proposed revisions are expected to address concerns raised by stakeholders about inconsistencies in type test requirements for equipment across generation, transmission, and distribution segments. Furthermore, the guidelines aim at mitigating overloading of testing facilities and optimising resources. It includes provisions for extending the validity of type test reports for equipment of similar design and stress levels, ensuring uniformity in periodicity, and rationalising the conditions under which type tests need to be repeated. The draft also outlines specific conditions under which repeated testing may be waived, such as cases where there are no significant changes in design, materials, or manufacturing processes.

MoEFCC streamlines compliance for renewable energy projects

The Ministry of Environment, Forests, and Climate Change (MoEFCC) has streamlined compliance for renewable energy projects by exempting solar module manufacturing units, solar and wind power projects, and mini hydel projects under 25 MW from obtaining both, environmental clearance (EC) and consent to establish (CTE). Reportedly, projects with an EC will no longer require a CTE or consent to operate, reducing duplication and easing the compliance process. As

reported, a standard operating procedure (SOP) will be implemented to integrate the CTE considerations into the EC process. State Pollution Control Boards (SPCBs) will be consulted during the EC process to ensure environmental safeguards, although industries must still pay the CTE fee to maintain state revenue.

MNRE sets guidelines for real estate developers to avail CFA under PM Surya Ghar

The Ministry of New and Renewable Energy (MNRE) has set specific terms for real estate developers and promoters to avail central financial assistance (CFA) under the PM Surya Ghar: Muft Bijli Yojana (PMSGY). As per the new guidelines, developers and promoters must submit an undertaking confirming that the rooftop solar asset, supported under the PMSGY, will be handed over to the group housing society or residential welfare association. Developers must also ensure that benefits from the rooftop solar subsidy are passed on the residents through reduced charges or tariffs for electricity used in common facilities within housing complexes.

INTERNATIONAL

India, Nepal, Bangaldesh inaugurate first trilateral power transaction

India, Nepal, and Bangladesh have jointly inaugurated the first trilateral power transaction, allowing electricity to flow from Nepal to Bangladesh through the Indian grid. Announced in 2023, the trilateral power deal will involve exporting up to 40 MW of electricity from Nepal to Bangladesh. Post this, a tripartite power sales agreement was signed in October this year between NTPC Vidyut Vyapar Nigam Limited, Nepal Electricity Authority, and Bangladesh Power Development Board. This marks a significant step in regional energy cooperation. The initiative will enable cross-border electricity trade using Indian transmission lines. Nepal will export 40 MW of electricity to Bangladesh during the monsoons, from June 15 to November 15, with an estimated export of 144,000 MW-hours and projected earnings of US$ 9.2 million.

Tata Power and DGPC partner to develop 5,000 MW of clean energy projects

Tata Power Company Limited has partnered with Druk Green Power Corporation Limited (DGPC) to develop 5,000 MW of clean energy projects in Bhutan. The partnership will focus on developing 2,000 MW of hydropower, 2,500 MW of pumped storage, and 500 MW of solar energy, ensuring round-the-clock energy supply for Bhutan and

India. Key projects under this initiative include the 1,125 MW Dorjilung hydroelectric project, the 740 MW Gongri reservoir, the 1,800 MW Jeri pumped storage project, and the 364 MW Chamkharchhu IV hydropower project. Tata Power Renewable Energy Limited, a wholly owned subsidiary of Tata Power Limited, will develop solar projects.

IndiGrid partners with BII and Norfund to launch EnerGrid

IndiGrid has partnered with British International Investment (BII) and the Norwegian Climate Investment Fund, managed by Norfund, to launch EnerGrid. The platform will focus on bidding for and developing new transmission and standalone battery energy storage system projects in India. With EnerGrid, IndiGrid, BII, and Norfund, along with Kommunal Landspensjonskasse have committed about US$ 300 million, with each partner contributing approximately US$ 100 million through this joint venture (JV). This funding will help EnerGrid target projects worth around US$ 1.2 billion in coming years. Once these projects commence commercial operations, IndiGrid will acquire them fully at a pre-set value.

ONGC and NGEL form JV to develop renewable energy projects in India and abroad

ONGC Green Limited and NTPC Green Energy Limited (NGEL) have formed a 50:50 joint venture (JV) called ONGC NTPC Green Private Limited to develop renewable energy projects in India and abroad. With an authorised share capital of Rs 1

million, the venture will focus on greenfield projects, acquisitions, and offshore wind projects. The JV aims at supporting renewable energy needs for ONGC and NTPC subsidiaries, exploring opportunities in energy storage, e-mobility, and ESG-compliant projects, and participating in offshore wind tenders. The JV also plans on utilising carbon and green credits for promoting a low-carbon economy.

Rajasthan Government signs Rs 3 trillion investment MoU with UAE in renewable energy

The Rajasthan Government has signed a memorandum of understanding (MoU) with the United Arab Emirates (UAE) for an investment of Rs 3 trillion in renewable energy. The MoU aims at setting up projects with a total capacity of 60 GW in solar, wind, and hybrid energy across western Rajasthan. Under the agreement, the UAE will appoint a qualified developer to oversee project governance and administration, ensuring faster implementation.

CORPORATE

ABB India upgrades historic Faridabad plant to enhance sustainability efforts

ABB India's IEC LV motors business is expanding and transforming the company's long-established manufacturing facility in the country. Started in 1951, it now boasts of an expanded modern workplace facility with upgraded shopfloors. IEC LV motors are known as the workhorses of Indian industries and play a crucial role across sectors. The facility has evolved over the decades into a hub for IE3 and IE4 high-energy efficient motors, as well as specialised motors like flameproof motors, smoke extraction motors, crane duty motors, brake motors, among others. With a strong commitment to sustainability, the 36,000 sq m Faridabad facility has taken the lead in promoting practices that align with this vision. It has embraced renewable energy usage and improved energy efficiency across the plant to achieve a low carbon operation. The realisation of RE100 global commitment to eliminate Scope 2 GHG emissions from its operations was achieved with the utilization of renewable electricity including inhouse solar power generation of 180 MWh in 2023. The facility's dedication to environmentally friendly practices has earned it the 'Platinum level Green Factory Buildings' certification from the Indian Green Building Council (IGBC). Additionally, the facility has diverted about 99 per cent of its waste away from landfill, aligning with the company's long-term sustainability targets of zero waste to landfill.

Sterlite Power completes Goa's first-ever 400 kV GIS

Sterlite Power has completed the Goa-Tamnar Transmission Project, through its special purpose vehicle (SPV) – Goa-Tamnar Transmission Project Limited (GTTPL). The project, at Dharbandora, is Goa's first-ever 400 kV gas-insulated substation (GIS). The substation, along with other transmission elements, is expected to improve power reliability across industrial, commercial, and residential sectors in South Goa. It will provide high-quality electricity at 400 kV and reduce dependence on existing substations, helping make the network more resilient. With three components already operational, the final Xeldem-Narendra transmission line will be completed soon.

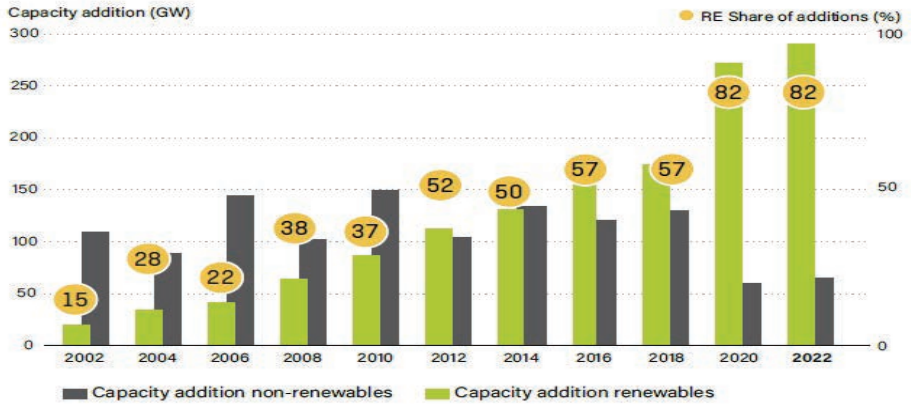
Servotech launches new solar products line and battery energy storage systems

Servotech Power Systems Limited (Servotech) has launched new line of solar products, including solar on-grid inverters with a capacity range of 1 kW to 100 kW, solar hybrid inverters ranging from 2 kW to 7.5 kW for single-phase and 10 kW to 22.5 kW for three-phase applications, and solar micro inverters available in 800 W and 1,600 W. The lineup also features battery energy storage systems with capacities from 1.2 kWh to 15 kWh for domestic users, as well as a 5.1 kW model designed for e-rickshaws, and solar pump controllers suitable for water pumps ranging from 2 HP to 10 HP.

Global Scenario

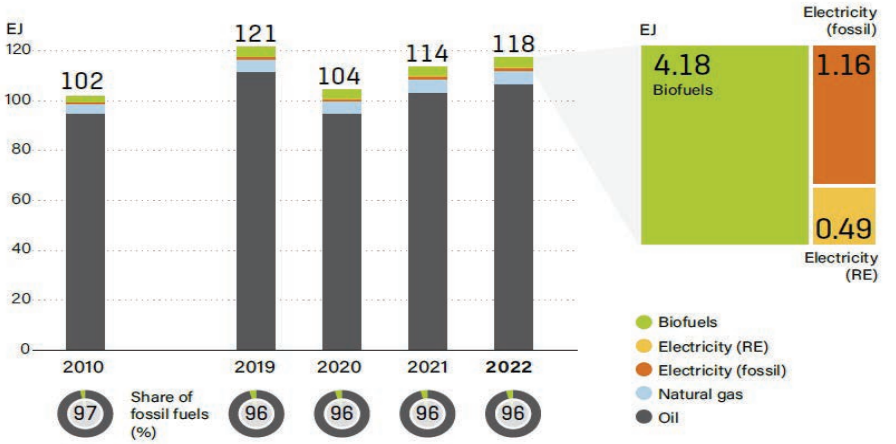
New Energies

Annual power capacity expansion, 2002-2022



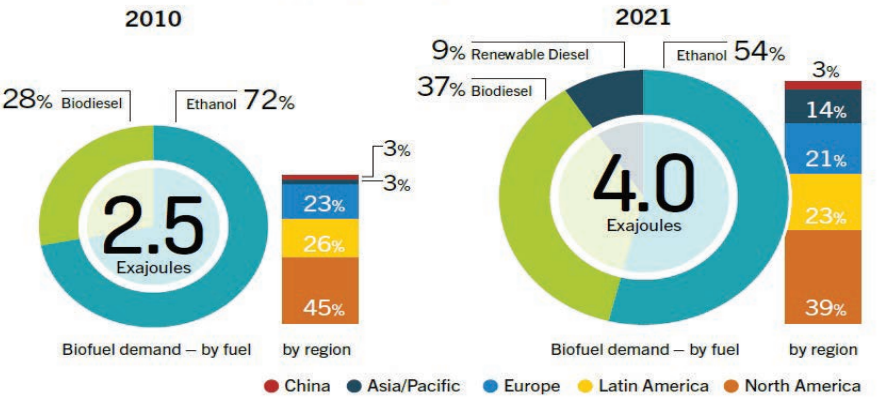
Note: GW = gigawatt
Source: IRENA.

Global transport energy demand by fuel type, 2010-2022



Source: IEA.

Global biofuel demand by fuel type and region, 2010 and 2021



Source: IEA.

Source: REN 21, Global Report

Transmission Line

Table 5.10 (a) Transmission lines and sub-station capacity addition by 2026-27

Transmission System Type / Voltage Class	Unit	At the end of 2016-17 (31.03.2017)	Addition during 2017-22	At the end of 2021-22 (31.03.2022)	Likely addition during 2022-27	Likely at the end of 2026-27 (31.03.2027)
TRANSMISSION LINES						
(a) HVDC ± 320 kV/ 500 kV/800 kV Bipole	ckm	15556	3819	19375	4300	23675
(b) 765 kV	ckm	31240	19783	51023	35005	86028
(c) 400 kV	ckm	157787	36191	193978	38245	232223
(d) 230/220 kV	ckm	163268	29072	192340	46027	238367
Total–Transmission Lines	**ckm**	**367851**	**88865**	**456716**	**123577**	**580293**
SUBSTATIONS						
(a) 765 kV	MVA	167500	89700	257200	319500	576700
(b) 400 kV	MVA	240807	152306	393113	268135	661248
(c) 230/220 kV	MVA	312958	107679	420637	123305	543942
Total – Substations	**MVA**	**721265**	**349685**	**1070950**	**710940**	**1781890**
HVDC						
(a) Bi-pole link capacity	MW	16500	14000	30500	12000	42500
(b) Back-to back capacity	MW	3000	0	3000	0	3000
Total- HVDC	**MW**	**19500**	**14000**	**33500**	**12000**	**45500**

Table 7.3: Transmission lines and transformation capacity under ISTS and intra-state

		At the end of 2016-17 (31.03.2017)	Addition during 2017-22	At the end of 2021-22 (31.03.2022)	Planned addition during 2022-27	At the end of 2026-27 (31.03.2027)	At the end of 2026-27 (31.03.2027)
Transmission lines (ckm)	ISTS	165,654	40,379	206,033	53,132	259,165	**580,293**
	Intra-state	202,197	48,486	250,683	70,445	321,128	
Transformation capacity (MVA)	ISTS	302,803	172,325	475,128	438,675	913,803	**1827,390**
	Intra-state	437,962	191,360	629,322	284,265	913,587	

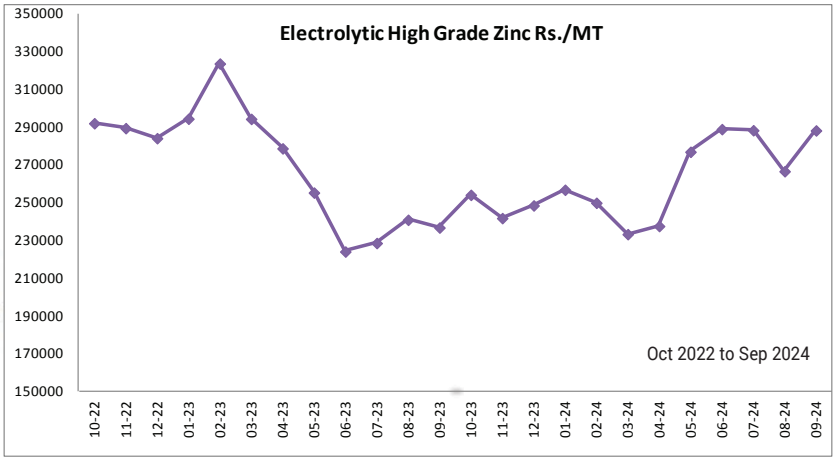
The estimated ckm and MVA addition during the period 2027-32 is given below:

Tentative addition of transmission system in 2027-32	
Transmission Line (ckm)	105000
Transformation capacity (MVA)	595000

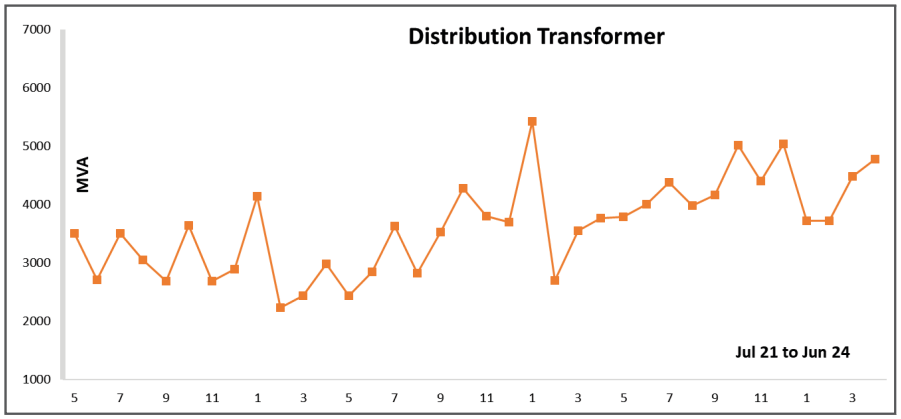
Source: CEA

Basic Prices and Indices

	as on Sep 1, 2024
IRON, STEEL & STEEL PRODUCTS	
BLOOMS (SBLR) 150mmX150mm	44,233.00
BILLETS (SBIR) 100MM	45,924.00
CRNGO Electrical Steel Sheets M-45,C-6 (Ex-Rsp)	108.75
CRGO Electrical Steel Lamination	644,701.00
NON-FERROUS METALS	
Electrolytic High Grade Zinc	288,300.00
Lead (99.97%)	199,200.00
Copper Wire Bars	822,575.00
Copper Wire Rods	838,894.00
Aluminium Ingots - EC Grade (IS 4026-1987)	252,287.00
Aluminuium Properzi Rods - EC Grade (IS5484 1978)	262,120.00
Aluminium Busbar (IS 5082 1998)	309,300.00
OTHER RAW MATERIALS	
Epoxy Resin CT - 5900	736.00
Phenolic Moulding Powder	118.00
PVC Compound - Grade CW- 22	158,325.00
PVC Compound Grade HR - 11	159,325.00
Transformer Oil Base Stock (TOBS)	96,859.00
OTHER IEEMA INDEX NUMBERS	
IN-BUSDUCTS (BASE July 2000=100) FOR THE MONTH July 2024	371.49
IN - WT (BASE JUNE 2000=100)	364.01
Wholesale price index number for 'Insulators' (Base 2011-12 = 100) for the month July 2024	127.70
Wholesale price index number for 'Manufacture of Basic Metals (Base 2011-12 = 100) for the month July 2024	140.80
Wholesale price index number for' Fuel & Power (Base 2011-12 = 100) for the month July 2024	148.20
ALL INDIA AVERAGE CONSUMER PRICE INDEX NUMBER FOR INDUSTRIAL WORKERS (BASE 2016=100) July 2024	142.70
# Estimated, NA: Not available	



Production Statistics



Name of Product	ACC Unit	Production		Highest Annual Production
		For the Month June-24	From June 2023 to June 2024	
Electric Motors				
AC Motors - LT	000' KW	1,700.00	19,510.00	19,195.00
AC Motors - HT	000' KW	477.00	4,763.00	5,273.00
DC Motors	000' KW	33.00	455.00	618.00
Switchgears *				
Contactors	000' Nos.	1,547.00	17,573.00	16,503.00
Motor Starters	000' Nos.	236.00	2,508.00	2,427.00
SDF	000' Nos.	50.00	692.00	752.00
Circuit Breakers DIN Rail Mounted	000' Poles	21,010.00	226,499.00	221,179.00
Circuit Breakers - LT	Nos.	531,667.00	5,910,527.00	5,703,052.00
Circuit Breakers - HT	Nos.	7,173.00	119,684.00	119,282.00
Custom Built Product	Rs. Lakhs	25,594.00	287,220.00	452,536.00
HRC Fuses & Overload Relays	000' Nos.	1,364.00	15,307.00	17,246.00
Power Cables *	KM	103,793.00	1,102,944.00	1,052,205.00
Power Capacitors - LT & HT	000' KVAR	4,569.00	64,411.00	65,385.00
Transformers *				
Distribution Transformers	000' KVA	4,776.00	55,905.00	58,341.00
Power Transformers	000' KVA	18,209.00	191,781.00	234,922.00
Instrument Transformers				
Current Transformers	000' Nos.	457.00	2,213.00	1,390.00
Voltage Transformers	Nos.	16,848.00	218,788.00	217,752.00
Energy Meters	000' Nos.	2,593.00	30,257.00	28,579.00
Transmission Line Towers *	000' MT	89.00	1,044.00	1,250.00

Weighted Production

Hitachi Energy introduces Grid-enSure™

Grid-enSure™ is a fully integrated portfolio that enhances grid flexibility, resilience, and stability to accelerate the sustainable energy transition. It brings a new holistic approach to designing, planning, and operating present and future power systems. The portfolio is based on Hitachi Energy's extensive advisory and consulting services for grid development and modernisation, an in-house verticalised value chain for power electronics and advanced control systems, and strong power system domain and control engineering expertise. Grid-enSure will address challenges in integrating renewables into power systems. This innovative solution portfolio will play a pivotal role in strengthening the grid ecosystem in the country.

Grid-enSure's power electronics solutions include advanced semiconductor technology – entirely manufactured in-house – allowing fast and secure conversion and control of energy flows, thanks to higher power density and optimal switching frequency.

Hitachi Energy's consulting services also help customers understand future challenges and the relevant Grid-enSure solutions to address them. The solutions combine Hitachi Energy's existing and future power electronic solutions such as high-voltage direct current (HVDC), static compensators (STATCOM and enhanced STATCOM), static frequency converters (SFC), medium-voltage direct current (MVDC), energy storage solutions and semiconductor technologies.

The cutting-edge control systems provide a microsecond response to address the grid's needs, providing the required flexibility with the help of advanced control functionalities such as grid-forming, synthetic inertia, fast-frequency response, voltage control, interoperability, and more.

Hitachi Energy Launches Relion REF650

Hitachi Energy has launched Relion REF650 – a versatile protection and control relay designed for multi-application use. Tailored specifically for the medium-voltage power distribution grid, it stands out for its enhanced flexibility, modularity, and robust security features.

REF650 enhances the precision of distribution grid management, enabling autonomous and responsive operations to ensure a stable and reliable power supply. It offers significant new features and benefits for the protection and control of primary distribution systems in key areas. These include:

- Cost-efficiency: A single-device modular design is ideal for long-term deployment with scalable and flexible features.
- Ease of use: The new human machine interface (HMI) touchscreen shows machine status and real-time voltage/current data while giving an operator interactive control.
- Performance and interoperability: REF650 is certified to the latest industry standards (IEC 61850 Ed 2.1), with PCM600 3.1, compatible across vendors.
- Simplified engineering: Streamlined configuration and parameterisation allow for easier settings changes, simplifying testing and maintenance processes.
- Compact form factor: Smaller size significantly reduces the space needed for installation, especially in space-constrained environments.
- Sustainable, safe, and secure: It provides increased uptime with modular, user-exchangeable hardware modules and supports extended operating temperature ranges and vibration classes.
- Enhanced after-sales service: It can be reconfigured and extended with hardware modules, offering flexibility in incorporating late project-or-design changes.

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SHOCKS and SPARKS

Made famous by the late ***Ram Keswani***

Humour @ Seminars & Conferences

Since 1980, IEEMA has been organising seminars on various subjects, where serious discussions are held. But there is always a lighter side, a bit of humour lurking in the background. Here are some samples.

We have to reject large number of papers for various reasons. However, the Indian authors are not used to such refusals. One indignant author wrote to me "I had submitted an exhaustive paper for the seminar but have been informed that the paper has not been accepted by the scrutinising committee. Looking at the returned manuscript, I don't think that they have even taken the trouble to go through my paper completely, and how they have formed an opinion about it, is beyond my comprehension."

I drafted a reply and sent it to the IEEMA office to forward to the aggrieved author.

"Sir, I eat half a boiled egg for my breakfast. When I open the egg, I don't have to eat the whole thing to discover that I don't like it." The reply was however rejected by our Secretary-General.

In one seminar, I was having a chat with one author during the lunch break. He confided in me that he wrote his papers with great difficulty as he did not know the correct spelling of several English words. Fortunately, he had a colleague whom he consulted very often — but one day he irritated him so much that the colleague burst out, "Why don't you buy a dictionary?"

I asked him, "What was your answer?"

He said that his reply was, "What would I do with a dictionary? If I can't spell the words, I won't be able to find them in a dictionary."

The other day, I attended a Seminar on Non-conventional Energy. There were discussions on solar energy, wind energy and other forms of energy, and their developments in other countries. We were informed that experts and scientists overseas had realised the seriousness and were moving very fast, while we in India were moving at snail's pace which was dangerous for the country.

The speakers with their solemn faces, were vying with each other in predicting a doom for India in the next 25 years, if we do not achieve a break-through in new sources of energy.

Everybody was gloomy and depressed. To bring cheer, I wanted to say something and even raised a hand by a few millimetres, but this went unnoticed.

It was concluded that dynamic steps should be taken to avoid this doom and government should immediately set up an expert committee.

At another seminar held earlier this year, experts had shed tears on our low production and consumption levels. Speaker after speaker came on the dias, and explained with graphs and charts that we were producing and consuming 1/10, 1/100, or even 1/1000 of what was being consumed in developed countries, be it electricity, steel, cars, etc. We were exhorted to increase production and government was advised to set up a panel.

Through Indians are known talkers, I feel shy to even open my mouth at such meetings.

Another author, a doctorate in engineering, related his experience. His wife overheard her maid answering the telephone, "Yes, Dr. …stays here, but he is not the doctor that does anybody any good."

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