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Transforming Transmission

Inaugural Session

V.K. Singh, Member, Power Systems, Central Electricity Authority (CEA), delivered the inaugural address at the Power Line TransTech India 2025 Conference and Exhibition. He opened his address by outlining the key priorities and evolving requirements of the transmission segment, stating that transmission serves as the backbone for evacuating renewable energy from resource-rich regions to load centres. He noted that India's energy transition is being propelled by rapid capacity growth in solar, wind and hydropower. He also emphasised the need for a strong, flexible and future-ready grid to ensure grid reliability and resilience, optimal utilisation of renewable energy, reduced curtailment, and the integration of technologies such as battery storage, green hydrogen and offshore wind.

Singh stated that India operates the largest synchronous grid globally. As of end-October 2025, the national transmission grid spans nearly 498,000 km of 220 kV voltage and above lines, and around 1,400 GVA of transformation capacity, including high-voltage direct current (HVDC) systems. Interregional transmission capacity has expanded significantly to around 120 GW and is expected to reach 167 GW by 2031-32, enabling reliable power transfer from generating points to load centres across regions.

India's current renewable capacity of 250 GW is projected to rise to 500 GW by 2030 and around 600 GW by 2032, with long-term projections till 2047 indicating an 80 per cent renewable energy share in the power mix. This growth will require unprecedented scaling and modernisation of the transmission grid. The CEA has estimated a requirement of about 650,000 ckt km of additional transmission lines and 2,412 GVA of transformation capacity, including HVDC, by 2032.

Singh outlined several initiatives taken by the Ministry of Power (MoP) and the CEA to improve transmission planning and address industry challenges. Transmission planning is now based on renewable energy potential. This approach ensures visibility for projects expected by 2032 and synchronises transmission readiness with renewable capacity additions. This alignment is aimed at reducing mismatches and avoiding renewable energy curtailment.

Singh also emphasised the role of the tariff-based competitive bidding model in enabling faster and

cost-effective development. Several states have adopted this model, particularly for projects above defined thresholds. In addition, he highlighted the national single-window clearance system introduced by the CEA to eliminate physical submissions and streamline approvals.

He further discussed the MoP's recent right-of-way (RoW) compensation guidelines, which provide 100 per cent compensation for tower base footing and 30 per cent for corridors. Nine states have already adopted this central framework, with Rajasthan enhancing compensation to 200 per cent for tower footing and 60 per cent for corridors.

Large renewable and storage-based hybrid projects are being developed across Rajasthan, Gujarat, Andhra Pradesh and Karnataka. Following the publication of the resource adequacy plans last year, the CEA has guided states in publishing intra-state transmission plans through joint studies with their respective state transmission utilities. Plans for the north-eastern and most eastern states have been completed, while the remaining are expected by January 2026. These plans are expected to provide enhanced visibility to the industry.

Singh also highlighted other key challenges for the segment, such as RoW and land acquisition issues, delays in obtaining permits and environment clearances, long lead times for manufacturing transformers, reactors and equipment, and the limited domestic capacity for cold-rolled grain-oriented steel. These issues are being addressed and high-level monitoring of environmental clearances is underway, with participation from senior officials, including district collectors, to resolve issues.

Further, Singh observed that the shortage of skilled manpower is a key challenge, particularly the availability of technical manpower for transmission line erection. To this end, new skill development centres have been planned in some states. He also urged the industry to build and establish their own training facilities.

> "Transmission is the backbone for evacuating renewable energy from resource-rich regions to load centres and for this, a strong, flexible and future-ready grid is required."
>
> **V.K. Singh**

He stated that the integration of vast amounts of variable renewable energy requires stronger forecasting, reserves and balancing mechanisms, along with cybersecurity and resilience for critical infrastructure. He emphasised the need for better coordination among generators, transmission planners, load centres and state regulators.

Singh called upon the industry to ensure timely commissioning, quality execution, safety and long-term reliability. He pointed to the increasing incidents of transformer and tower failures and stressed that quality should not be compromised. He also highlighted the importance of adopting new technologies such as HVDC, reconductoring (and advanced conductors) integrating storage, and strengthening local supply chain manufacturing to reduce dependency and lead times.

Singh concluded that the MoP's ongoing initiatives, along with collective industry support, will help build a robust infrastructure by 2032, realise the Viksit Bharat@2047 vision, and meet long-term net-zero commitments.

Pratik Agarwal, Managing Director, Sterlite Electric, and Chairman, Resonia and Serentica Renewables, delivered the inaugural remarks at the PowerLine TransTech India 2025 Exhibition and Conference. Acknowledging the strong performance of India's transmission sector, he noted that the transmission network has expanded significantly over the last few years, providing gigawatt-scale connectivity – a rare achievement across the world.

Agarwal credited POWERGRID for its leadership and sustained investment in bringing in new technologies to the sector. He added that India is one of largest countries in the world to have successfully implemented the tariff-based competitive bidding (TBCB) model, which has encouraged private participation and innovation, and led to cost reduction in projects. Over 100 projects have been commissioned or are under construction through the TBCB route. He also noted that India's planning and market systems have become more robust, setting the stage for further growth and modernisation.

Agarwal also noted that, while developers often face RoW challenges, India's legal framework – particularly Section 164 of the Electricity Act, 2003 – provides strong powers that enable the delivery of electricity transmission infrastructure projects with ease, a rarity among democratic nations. Domestic suppliers, technology players, R&D, academia, EPC companies and OEM companies have created a thriving ecosystem and led to significant capex in transmission at both the centre and state levels.

He noted that India's transmission sector is entering a new growth phase, with the focus shifting from central network expansion to strengthening state transmission systems. Significant investment will be needed at the state level to enhance load-handling capacity and align state grids with the national grid over the next seven to ten years. The TBCB model will need to be extensively implemented at the state level.

A major strategic opportunity, he highlighted, lies in regional and international interconnections, in line with India's "One Sun, One World, One Grid" vision. With round-the-clock power becoming viable at a price that is globally competitive, India could become a global energy powerhouse, exporting green electrons through HVDC and submarine cable networks. This will enable India's grid to be connected to not just neighbouring regions, but also westward to the Middle East and eastward to Southeast Asia, including Thailand, Singapore and eventually Japan. He envisioned a scenario where renewable energy generated in Jaisalmer in Rajasthan could someday power homes in Japan, illustrating India's potential as an exporter of affordable, clean energy. This would need policy support and investment in submarine cable infrastructure, underscoring the need to develop indigenous HVDC and manufacturing capabilities, he added.

> "Initiatives such as One Sun, One World, One Grid offer strategic opportunities for India to become a global renewable energy hub."
>
> **Pratik Agarwal**

Mr Agarwal noted that despite India's strong progress in transmission development, project delays remain a major concern. He stated that nearly 90-95 per cent of projects face delays of at least a year, with 30-40 per cent facing delays of over two years. Although India's four-year average completion period is still among the best globally, it must be shortened to three years or less to meet future demand.

He observed that RoW issues cannot be resolved through financial compensation or enforcement alone; they require systematic stakeholder engagement built on trust and communication. He highlighted Resonia's efforts in creating a structured stakeholder management playbook, which has been developed to engage with local communities and address their concerns, fostering collaboration and smoother execution. He also credited the Ministry of Power's efforts in ensuring that the compensation being paid for RoW has increased almost tenfold in the last 10 years, and is now truly reflective of the value loss to the landowner.

The second major challenge he highlighted is the shortage of skilled labour and low mechanisation in transmission construction. The development of 1 km of a 400 kV double-circuit line still takes about 1,300-1,500 man-days in India, versus around 700 man-days in Brazil or Thailand and only 150 man-days in Europe. To close this gap, Mr Agarwal stressed the need for both skill development and technology-driven mechanisation to lower labour intensity. To this end, all EPC partners can collaborate in building a fully mechanised, tech-enabled transmission construction ecosystem in India, targeting the global efficiency standards of about 200 man-days per km.

Another key measure he highlighted for growth is sweating the transmission assets and utilising the inherent hidden capacity in the transmission system. Given India's rapid renewable capacity addition, adopting digital solutions can enhance grid flexibility and also protect project returns.

Ending on an optimistic note, he reflected on India's transformation from a country once perceived as "decades behind" to one now achieving global leadership in sectors such as digital infrastructure. He asserted that India is emerging as a global powerhouse in electricity, delivering 15-20 GW of round-the-clock green power annually – a scale unmatched among democratic nations. He stressed that India's unique capability to support upcoming high-demand sectors such as data centres positions the country as a potential global hub owing to its ability to deliver reliable, affordable and renewable power faster than most economies.

Agarwal concluded with a reminder that while achieving global leadership is difficult, sustaining that position requires continuous innovation, faster project execution, adoption of advanced technology and progressive policy frameworks. Expressing confidence in the industry's collective capability, he envisioned India at the forefront of global electricity systems, with transmission as the central pillar, enabling that future.

1 NATION GRID FREQUENCY

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Transmitting Power, Transforming Lives

One of the World's Largest
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- Sub-stations - **286**
- Transformation capacity - **5,77,331 MVA**

CONSULTANCY

- Transmission related consultancy: 250 clients
- Global footprints in 25+ countries
- POWERGRID Academy of Leadership : 550+ courses catering to professionals across the world

TELECOM

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- Leading consultant in NKN and NOFN implementation

FUTURE READY

- Data Centre Services
- Solar Power Generation
- Battery Energy Storage System
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POWERGRID, A Maharatna Public Sector Undertaking of Ministry of Power, Government of India, is engaged in project planning, designing, financing, constructing, operating and maintaining power transmission projects across India and undertakes operations in the Indian telecom infrastructure sector.

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View From the Top

The session, "View From the Top", featured a panel discussion among Manish Agrawal, Chief Executive Officer, APAR Industries; Venu Nuguri, Managing Director and Chief Executive Officer, Hitachi Energy India; Arun Sharma, Chief Executive Officer, Resonia; and Sandeep Zanzaria, Chief Executive Officer and Managing Director, GE T&D India Limited. The panellists discussed critical issues in the transmission sector including transmission line bottlenecks, right-of-way (RoW) constraints, technological innovation and the need for faster project execution timelines. They explored how digital transformation, advanced technologies such as monopoles and gas-insulated substations, and policy reforms can help address the massive infrastructure gap. They also examined both immediate challenges and emerging trends shaping India's transmission landscape. Edited excerpts…

According to Manish Agarwal, with accelerating renewable integration, the Indian transmission sector is witnessing both structural challenges and key opportunities. He noted that the Ministry of Power's policies and the Make in India initiative have enabled a significant expansion of domestic manufacturing capabilities, including the ability to supply high-voltage technologies of up to 1,200 kV for both Indian and overseas projects. Furthermore, agencies such as the Central Electricity Authority have been instrumental in mitigating supply chain bottlenecks, and assisting manufacturers and developers in fast-tracking delayed projects.

Agarwal highlighted that the success of renewable energy deployment critically depends on overcoming the slowdown in transmission line additions, as the evacuation of renewables is critical for the viability of the sector. He underscored the need for transmission line reconductoring across existing transmission corridors. With the country's large population and limited land area, augmenting capacity on already-built lines offers one of the fastest and most cost-effective means of strengthening the grid. Thus, going forward, a policy for reconductoring will be beneficial for the sector. Agarwal added that several existing corridors have operated for 40-50 years, and the upgradation of these ageing assets must become a priority to ensure long-term reliability.

He further pointed out that RoW challenges can be minimised with the deployment of advanced conductors on new lines. In addition, utilities should be encouraged to adopt technologies such as monopoles, insulated cross-arms and dynamic line rating systems, which enable optimal asset utilisation and can significantly improve operational flexibility.

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>
> **Manish Agarwal**

Another focus area is loss capitalisation, which he described as a missing link in current procurement practices. By systematically measuring and valuing losses, utilities can justify the adoption of products with higher current-carrying capacity and lower losses within the same physical parameters, leading to better payback and reduced emissions. Noting that aluminium production generates substantial carbon emissions, he said that utilities globally are now prioritising products incorporating recycled aluminium, and Indian suppliers must align with this shift to meet emerging sustainability expectations.

Agarwal also underscored the importance of quality, training and safety. He emphasised the need for certified master installers and structured training programmes to ensure consistent installation quality and reduce risks during execution.

According to Venu Nuguri, the transmission segment continues to grapple with challenges rooted not only in the conventional demand-supply imbalance, but also in the way the sector plans and executes projects. Historically, the industry has oscillated between phases of excess supply and low demand. Today, perception has shifted to high demand and inadequate supply, yet the core issue remains the legacy approach to sector planning. Lengthy approval cycles, slow bidding processes and prolonged execution windows continue to delay projects, creating systemic inefficiencies.

The transmission ecosystem is characterised by multiple layers of project approval. Compressing timelines at every stage of transmission line construction is essential for the sector to function in a more efficient and balanced manner. This includes improvements by technology providers and EPC players through greater mechanisation, higher productivity and stronger skill sets. He also noted that there is a clear need for process improvements.

> "Compressing timelines at every stage of transmission line construction is essential for the sector to function in a more efficient and balanced manner."
>
> **Venu Nuguri**

He highlighted that a major opportunity lies in the rapid rise of data centre demand. He shared that data centres, which once operated in the 10-40 MW range, now often exceed 100 MW and are moving toward gigawatt-scale at single locations. The load from artificial intelligence (AI) operations is creating momentary spikes that significantly increase energy requirements, yet this surge is not adequately reflected in current load forecasts and planning frameworks. AI data centres require four to five times more transformers than conventional setups and are expanding at a pace that the transmission industry is not fully prepared for.

He also emphasised the growing role of digitalisation across the energy value chain. With renewable energy capacity rising rapidly, real-time visibility of power flows has become essential. Grid management now depends heavily on forecasting tools, asset performance management systems and digital platforms supported by AI. Global and Indian examples demonstrate how generation, transmission and distribution data can be integrated into centralised energy platforms to improve predictability and demand management. Digital transformation will be a key driver for the transmission sector in the coming years.

The next major wave of opportunities in the transmission sector is expected to emerge from the states. In addition, clear multi-year planning remains essential so that technology providers and EPC players can prepare adequately for upcoming requirements. Furthermore, adherence to national standardisation frameworks remains key going forward.

Arun Sharma highlighted that the biggest challenge today is the pressure of project timelines. Projects must be completed within the period assumed in the financial model, as both funding and equity commitments are timebound. India's decarbonisation pathway requires large-scale deployment of technologies such as green hydrogen, wind and electric mobility. However, several of these technologies are still maturing. For these to succeed, the transmission network must expand at the same pace. The demand on transmission has risen significantly and the way to address it is through de-bottlenecking at every stage.

He also highlighted the need to adopt new technologies to address land-related challenges. He pointed out that advanced substation technologies, such as gas-insulated substations, can significantly reduce space requirements and expedite implementation. He added that streamlining regulatory processes – similar to those used in the renewable energy sector, including automatic land-use conversion – could also help accelerate progress in transmission infrastructure deployment. He also pointed to the rising relevance of monopole structures, noting that supportive policy decisions are expected to drive wider adoption. Monopoles, in his view, will play a significant role in overcoming right-of-way challenges in the long term.

According to Sharma, the biggest opportunity in the transmission sector lies in significantly accelerating project execution. Given the extensive network additions required in the coming years, there is a pressing need to reduce man-hours and man-days at the site level. This makes the adoption of new technologies essential, as conventional construction methods will not be sufficient to support the country's target of achieving 500 GW of non-fossil capacity by 2030.

Sharma emphasised the importance of strengthening state-level transmission networks through greater private sector participation. States such as Gujarat and Maharashtra are already leading this shift, with tariff-based competitive bidding and PPP models becoming more prevalent. While the central 765 kV schemes are functioning well, he noted that investment at lower voltage levels remains insufficient, and these projects cannot be supported by government funding alone. Increased private equity participation will therefore be critical. A PPP-led approach to asset creation, he said, is the most practical way forward, building on the success seen in interstate transmission development.

Sandeep Zanzaria observed that a more balanced risk-reward structure, along with equity-based engagement models, will make states far more attractive to serious players and enable smoother execution of upcoming transmission expansion programmes.

According to him, even though manufacturers are rapidly scaling up capacity and aligning with long-term sectoral requirements, inefficiencies continue to arise as many developers are securing equipment before acquiring land. This results in manufacturers' capacities being blocked by projects that are not yet land-ready, preventing the diversion of transformers and other equipment to regions where demand is

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>
> **Arun Sharma**

more urgent. He noted that the reluctance of developers to invest before ensuring land readiness, combined with their unwillingness to release booked capacity, creates systemic constraints despite the industry's growing capability.

Zanzaria highlighted several opportunities, particularly as the grid expands rapidly and becomes more complex. He observed that reliability and availability have now become the defining priorities for developers. Substation project sizes are increasing significantly, raising the stakes of downtime. In this context, he emphasised that asset performance management (APM) is poised to become one of the biggest opportunities in the sector. APM, he noted, can predict failures, optimise maintenance schedules and improve long-term financial outcomes, especially for assets that operate over 35-year horizons.

Looking ahead, he said that the demand environment is set for a dramatic shift. Major technology companies are committing significant investments for deployment within the next three to four years. These will create substantial new load pockets driven by data centres and digital infrastructure. He stressed that transmission planning must begin immediately in coordination with these consumers; otherwise, the sector risks being unprepared for meeting their power requirements. Moreover, while HVDC adoption continues to rise, a far more critical requirement in the coming years will be reactive power compensation. With renewable penetration increasing sharply,

> "With renewable penetration increasing sharply, stable and reliable grid operation will depend heavily on robust static and dynamic compensation systems, grid-forming inverters, and storage-linked solutions."
>
> **Sandeep Zanzaria**

stable and reliable grid operation will depend heavily on robust static and dynamic compensation systems, grid-forming inverters, and storage-linked solutions. Citing global events such as grid disturbances in Spain and Bangkok, he emphasised that these technologies are no longer optional – they are essential for future grid stability.

Zanzaria urged state utilities to revisit the commercial terms embedded in their procurement frameworks. Current conditions often allocate a disproportionate share of risk to vendors, discouraging participation from large domestic and multinational companies. A more balanced risk-reward structure, along with equity-based engagement models, will make states far more attractive to serious players and enable smoother execution of upcoming transmission expansion programmes. Without such reforms, vendor engagement will remain challenging despite strong sectoral demand.

EPC Perspective

The EPC Perspective session featured a panel discussion among Rajeev Dalela, President (Domestic and SAARC), Kalpataru Projects International; Venkat Muvvala, President and Chief Business Officer – Infra and EPX Business, Jakson Group; Akhilesh Pathak, Executive Director, PMD, POWERGRID; Manish Shrivastav, Business Head, T&D Projects, APAR Industries; and Prashant Sinha, Chief Operating Officer, Resonia. The session focused on key industry challenges, the strategies and road maps to address these challenges, and the need for digital interventions and project execution oversight.

Rajeev Dalela highlighted that a series of tenders being floated simultaneously is creating capacity constraints in terms of manpower and manufacturing, particularly for transformers and switchgear. While efforts have been made to train and develop new manpower, and some success has been achieved, the process is still ongoing as such skill sets cannot be developed overnight and remain geographically concentrated in a few states.

He added that most projects come with constrained timelines of 21–23 months, which also include the monsoon season. In regions such as Gujarat, where monsoon extends from mid-June to October, project locations become inaccessible, effectively reducing the working period to about 12 months. Within this limited window, EPC players are expected to complete 120-130 km of transmission lines, making the challenge even more severe. While capacities have improved, Dalela noted that the industry is still not fully equipped.

He pointed out that major customers such as POWERGRID and ReNew have acknowledged these issues. POWERGRID has addressed cash flow constraints by removing the requirement for bank guarantees in favour of insurance bonds. It has also incorporated mechanisation requirements in its contracts, mandating the use of cranes. Meanwhile, ReNew has encouraged the adoption of new technologies.

Dalela highlighted that the adoption of new technologies is gaining momentum, but India's diverse geography requires tailor-made solutions, with projects in different states demanding different approaches. A major challenge lies in the adaptation of labour to mechanisation. With continued efforts by EPC players, the workforce is gradually adapting. Dalela observed that many new developers entering from unrelated sectors may not fully understand ground realities, but this should not stop the industry from pursuing mechanisation, which he described as the only solution given the sector currently operates with just 30-40 per cent of the required skilled manpower.

Right-of-way (RoW) is a major challenge, imposing significant costs on EPC players with limited compensation mechanisms. India's federal structure results in varying rules across states, making transmission line construction comparatively easier in some states and extremely difficult in others. Dalela added that states must actively facilitate execution, but this is not happening consistently. On a positive note, he stated that there have been notable improvements over the past four to five years on the digital front, particularly with the introduction of faceless billing.

> "RoW is a major challenge that imposes significant costs on EPC players, with limited compensation mechanisms."
>
> **Rajeev Dalela**

> "There is a need to find the right balance between financial strength, technical capability and project management capability."
>
> **Venkat Muvvala**

According to Venkat Muvvala, a key challenge for EPC players is cash flow. For EPC contracts, maintaining liquidity is essential. Earlier, advance payments used to attract interest charges, but this has now been rationalised, ensuring smoother capital flow. According to him, national utilities are increasingly receptive to understanding the specific pain points EPC contractors face and are willing to design measures that address them.

Another challenge is the project delivery for 400 kV substations due to certain requirements on part of developers. In this regard, POWERGRID has taken the lead and implemented a workable solution that prevents the situation from extending to a 36-month delivery cycle from OEMs. The issue has been resolved for 400 kV projects and a similar solution is expected for 765 kV systems in the near future.

Muvvala emphasised that the adoption of new technologies and digital tools will be central to achieving the speed required for future transmission build-out. Integrated programme management with digital visualisation will enable better coordination and faster decision-making.

He also noted that RoW difficulties continue to slow project execution, and the most effective mitigation measure would be for the nodal agency to take responsibility for land acquisition. If land is secured several years in advance, developers can begin work without delays, creating substantial efficiency gains across the transmission ecosystem.

He also stated that competitively bid projects typically reward experience; however, there is a need to find the right balance between financial strength, technical capability and project management capability as well. India needs to construct nearly 25,000 km of new transmission lines annually - two to three times the pace achieved in recent years. He argued that state transmission companies must adopt frameworks similar to POWERGRID and NTPC, with an emphasis on predictable payments to ensure contractor cash flow.

Over the past 18 months, material costs have risen sharply, and incorporating price variation clauses into state-level contracts is essential to prevent undue exposure for EPC players. Muvvala also pointed to supply chain challenges. According to him, the solar sector scaled rapidly because capacity addition was planned and incentivised in a coordinated manner through the PLI scheme. In his view, the PLI framework should be leveraged more for the transmission sector to accelerate equipment availability and reduce lead times.

Akhilesh Pathak noted that one of the key challenges for the segment is the increase in the quantum of renewable energy projects, which the transmission sector is working to integrate. The rapid increase in renewable energy capacity over the past four to five years has created compressed project timelines for transmission infrastructure. Unlike thermal or hydro projects that have gestation periods of 5-12 years, renewable energy projects are commissioned within 9-15 months, demanding that transmission systems be completed at the same pace.

This has also created competing workforce pressure, as developers are under intense pressure to commission transmission projects in record time to match renewable energy generation schedules. The renewable energy sector is absorbing much of the equipment, supply chains and skilled labour that has traditionally supported transmission infrastructure, as suppliers prefer quick-turnaround of renewable energy contracts. Skilled manpower availability has dropped to 30-40 per cent of the required level.

Another key challenge is the escalation in RoW constraints. The simultaneous development of multiple infrastructure projects has increased RoW issues. Pathak also highlighted that affected communities, now more aware of their rights, often cause projects to be delayed in pursuit of higher compensation.

> "By 2032, investments of over Rs 9 trillion are expected in transmission infrastructure."
>
> **Akhilesh Pathak**

> "A project succeeds only when developers and EPC contractors work as one team, understand each other's constraints and share ownership."
>
> **Prashant Sinha**

India's renewable expansion is commendable; however, the transmission ecosystem must rapidly adapt through better supply planning, manpower development and synchronised project scheduling to sustain the pace of the energy transition.

Pathak also outlined the significant digital transformation and operational initiatives undertaken by POWERGRID to improve efficiency, transparency and speed in project execution. POWERGRID has now incorporated mechanisation requirements directly into tender documents, making it mandatory for vendors to adopt modern construction technologies for the projects.

Another initiative is the establishment of the centralised and regional project monitoring control centre system at POWERGRID's headquarters. This platform provides 24-hour live camera feeds from substations and transmission lines, allowing real-time supervision of site activities, safety compliance and execution progress. It allows the senior management, including directors and regional heads, to directly access this live feed for oversight.

He further described the PG Nirman app, a digital tool for live progress tracking and quality assurance documentation across all projects. It enables contractors to upload daily updates, generate quality forms online and reduce manual paperwork. Complementing this are POWERGRID's internal dashboards, also accessible by the Ministry of Power, which display milestones, critical issues and overall project performance.

He also emphasised the move toward faceless digital payments, positioning POWERGRID among the first PSUs to fully automate vendor billing and payment processing. This has enabled the contractors to upload bills digitally, track their progress in real time and receive payments quickly without human intervention, a system that, he noted, has significantly improved transparency and turnaround time.

He urged EPC partners to scale up capacity, especially in equipment manufacturing, to meet rising national demand. By 2032, investments of over Rs 9 trillion are expected in transmission infrastructure. Further, several HVDC projects, targeting around 80 GW of future hydro capacity, have been proposed in the Northeast, and therefore preparedness and proactive scaling is important.

Finally, he called for stronger adherence to safety norms at project construction sites and stressed the requirement of improved project management capabilities. He under-

lined that project managers today must act not only as engineers but also as "human managers", capable of navigating RoW challenges and addressing local community concerns effectively.

Prashant Sinha observed that while the sector regularly acknowledges issues such as manpower shortages, RoW constraints and the steep rise in project volumes, several fundamental gaps continue to remain outside the mainstream discussion.

One of these is the scale of work, which has multiplied nearly tenfold in both transmission and renewable energy compared to the pre-Covid-19 period. To meet this unprecedented growth, the sector needs strong programme management. This must be paired with a decisive push towards mechanisation, as manpower-based solutions can produce only incremental gains, while the industry now needs exponential improvements.

He also shared that Resonia has been working closely with forward-looking EPC partners to accelerate the adoption of global best practices. Mechanisation has been introduced not only in tower erection activities but also in stringing. The broader strategy, he said, is to collaborate only with EPC contractors who share a long-term vision of productivity enhancement.

He highlighted that quick entry and quick exit at sites are essential to minimising RoW complexities, which intensify as execution slows. He acknowledged the role of POWERGRID as a key enabler, noting that the organisation is partnering with several EPC players on scaling-up initiatives.

Sinha also pointed to the exceptionally low penetration of cranes in India, estimated at barely 10 per cent, due to terrain challenges and resistance among traditional work groups. To overcome this, Resonia is incentivising behavioural change and driving a shift towards crane-based erection, guided by the simple economic principle that people respond to incentives. Resonia is also experimenting with helical and pre-cast solutions in partnership with an international technology provider. The target is to reduce foundation timelines from the current 15 days to just one day, which could transform project schedules.

He highlighted that EPC companies often focus excessively on margins instead of asset turnover. Decisions delayed in pursuit of theoretical margins eventually erode profitability. Timely decision-making and fast execution, he said, are far more valuable, enabling companies to complete projects sooner and redeploy resources efficiently.

He concluded that project success depends on developers and EPC contractors functioning as a single team. Both sides must understand each other's constraints and work with shared ownership, as only strong execution and collaborative intent ultimately shape outcomes.

Manish Shrivastava noted that the transmission sector is facing growing difficulties in developing greenfield projects. Land constraints, environmental approvals and RoW hurdles have made new corridors harder to build, pushing utilities to look for ways to maximise existing infrastructure. This shift has strengthened the case for reconductoring, which enables higher power transfer capacity.

As a result, advanced conductors such as aluminium conductor composite core are becoming central to utilities' plans. What was once seen as a constraint for the broader industry has therefore become a growth driver for companies focused on brownfield capacity enhancement.

Shrivastava underlined that the sector still faces structural challenges that affect execution. Insufficient planning in the early stages of projects often leads to avoidable bottlenecks during implementation. At the same time, the availability of skilled manpower remains a persistent issue. With reconductoring set to grow further, the demand for specialised skills will only increase. APAR is working to expand and upgrade its workforce capabilities to address this need.

He adds that the success of such projects depends on two critical phases: pre-bid assessment and execution. In the pre-bid stage, accurate understanding of tower strength, terrain and site conditions is crucial. APAR uses tools such as light detection and ranging surveys and drone-based mapping to enable more precise planning. During execution, the priority is completing projects on or ahead of schedule, which is a common challenge in transmission works due to terrain conditions, access issues and coordination requirements.

To support timely delivery, the company has developed a "master installer" model to build a highly trained pool of specialists who can manage complex installation tasks efficiently.

> "Land constraints, environmental approvals and right-of-way hurdles have made new corridors harder to build, pushing utilities to look for ways to maximise existing infrastructure."
>
> **Manish Shrivastava**

APAR has also adopted innovations that streamline field operations, helping reduce delays and improve overall project reliability.

Looking ahead, Shrivastava said that the company is evaluating technologies that can help utilities manage rising demand without expanding transmission footprints. He emphasised that utilities and policymakers should increasingly consider reconductoring as the first option before approving new lines.

He added that timely execution will remain the central challenge for EPC players. Utilities can also enable smoother execution by revisiting payment structures, particularly retention percentages and milestone-linked holdbacks. Faster and more flexible payment mechanisms, he noted, would ease cashflow pressures and support better project outcomes. Across all stages, Shrivastava reiterated the importance of safety, quality and forward-looking practices to ensure the sector is prepared for future requirements. ■

Interview with Ghanshyam Prasad

"India has performed remarkably well in the renewable energy sector"

In a recent interview with *Power Line*, Ghanshyam Prasad, Chairperson, Central Electricity Authority (CEA), shared his views on the performance of the power sector over the past year and the progress towards the country's clean energy goals. He also discussed the challenges in renewable energy integration, the growing focus on hydro pumped storage projects (PSPs) and advances in transmission planning. Edited excerpts…

What is your assessment of the current state of the power sector? How has the sector performed in the past one year or so?

The power sector has performed exceptionally well, particularly in the past year. We successfully met the highest-ever peak demand of 250 GW without any load shedding. A key achievement was our ability to shift demand during solar hours, which is crucial for supporting the energy transition as more solar capacity is integrated into the grid. Over the past decade, solar capacity has expanded from a negligible base to 123 GW, while wind capacity has reached around 53 GW.

Today, our total installed renewable capacity stands at about 195 GW and installed non-fossil fuel generating capacity stands at about 251 GW, that is, more than 50 per cent coming from non-fossil sources. This has enabled us to achieve our NDC (nationally determined contributions) commitment of 50 per cent non-fossil capacity nearly five years ahead of schedule. Notably, the earlier 40 per cent target was also achieved nine years in advance.

In 2024-25 alone, we added a record generation capacity addition of 34 GW. This year, as of August 2025, 27.7 GW has already been commissioned, and we are likely to cross 40 GW in a single year – setting a new record. These achievements have been supported by dynamic resource adequacy planning for generation, carried out in consultation with distribution utilities and the states. The plan is revised annually for a rolling 10-year horizon. The latest plan extends up to 2034-35, and work is under way for 2035-36, expected to be completed by November 2025.

We have accelerated the pace of adding renewable energy resources and are now considering revising our commitments upwards. Another important focus area is waste-to-energy (WtE). The current installed capacity in this segment is quite small – around 854 MW across the country – but there is significant potential, particularly in large cities. A joint programme of the Ministry of Power (MoP) and the Ministry of Housing and Urban Affairs is aimed at scaling up WtE plants, helping manage urban waste and saving land for dumping of waste.

What are the biggest challenges and opportunities in the sector?

The biggest challenge facing the sector is the variability of renewables. To address this, we are accelerating hydropower development, with a strong focus on PSPs. Policy reforms over the past four years have helped unlock this potential in a big way.

Until 2024-25, pumped storage capacity was nearly stagnant at 4.7 GW, with little progress over the past decade. This scenario is now changing.

In the current year, 2025-26, we will be commissioning 2.68 GW, followed by 2.92 GW in 2026-27. During 2028-29, annual additions are expected to be around 6.35 GW and from 2029-30, they will be 13 GW or more, taking the total PSP capacity to 57 GW or more by 2032.

In the past, hydropower development was largely concentrated in the Himalayan states, including Arunachal Pradesh, Himachal Pradesh, Uttarakhand, and Jammu & Kashmir. Geological complexities and infrastructure bottlenecks in these regions often caused significant delays. We broke this dependency by encouraging closed-loop, off-stream PSPs, which face fewer environmental challenges and have faster project timelines of three to four years.

We persuaded the Ministry of Environment, Forest and Climate Change to delink closed-loop PSPs from the conventional hydro clearance process, recognising them as "water batteries" and renewable sources. Further, PSPs have now been classified into three categories – closed-loop off-stream, open-loop and conventional – with priority accorded to closed-loop off-stream projects to accelerate development.

Several other measures have also been introduced to accelerate pumped storage development. These include financial support of up to Rs 10 million per MW for enabling infrastructure; streamlining the appraisal process through the "Jalvi Store" portal; simplifying detailed project report requirements; granting early excavation permissions to speed up project timelines; and making concurrence optional for closed-loop PSPs. These reforms have encouraged private sector participation and shifted the development of PSPs to mainly the peninsular region, where the geology and infrastructure are more favourable.

India has also performed remarkably well in transmission development compared to other countries. On average, we are able to commission transmission lines within 24-36 months, ensuring timely connectivity. While occasional delays occur in one or two projects due to right-of-way (RoW) issues, the sector has largely delivered consistently on this front. This has helped in the faster development of renewable energy projects.

However, new challenges are emerging. In states like Rajasthan and Gujarat, renewable capacity now requires high-voltage direct current (HVDC) transmission lines. These projects are far more complex and typically take at least five years to complete, creating bottlenecks in the evacuation of renewable energy resources.

To address this, we have started optimising intra-state transmission networks. In Rajasthan, for instance, our analysis has shown that up to 32 GW of renewable power can be accommodated through shorter transmission lines, reducing dependence on long HVDC corridors. A similar exercise is under way in Gujarat and other states.

Another challenge comes from the growing demand for renewable power from emerging industries such as green hydrogen and data centres. Meeting this demand requires very long transmission lines to deliver renewable power to industrial hubs. This is undoubtedly a complex task, but we are actively engaging with stakeholders to find practical solutions. Encouragingly, most discussions so far have led to constructive outcomes, helping ensure that India's transmission expansion keeps pace with the green energy transition.

What is the expected growth in the transmission network, and what will be the investment requirement?

Earlier, we had estimated an investment requirement of roughly Rs 9 trillion in the transmission segment alone. Since then, we have begun conducting resource adequacy studies for transmission. This exercise, which we are now undertaking with all the states, will help assess the intra-state requirements as well. We expect the overall investment requirement to remain in the same range, or slightly higher.

A positive development at the state level is the shift towards tariff-based competitive bidding (TBCB). This allows private players to participate and invest in transmission projects, ensuring faster roll-out even when state utilities face financial constraints. This is similar to the success achieved earlier in the interstate transmission system (ISTS).

Another important intervention is the push for technological solutions to address RoW challenges. We are encouraging the use of monopoles and other innovative structures to minimise the RoW footprint. In addition, new guidelines have been introduced, enabling compensation at market rates for landowners. Looking ahead, we are also planning to upgrade system voltage levels from the current 765 kV HVAC to 1,200 kV HVAC.

What are your thoughts on the India Energy Stack and the ongoing digital transformation in the power sector?

The India Energy Stack is certainly a positive step forward. While sectoral databases already exist, integrating them onto a common platform could create significant value. That said, the usefulness of such integration will depend on how it is structured. Power plants, for instance, generate an enormous amount of operational data, but not all of it is required for managerial decision-making. At the senior level, what matters are key datasets that provide actionable insights. If the stacking framework focuses on compiling only these critical data points, it can become a powerful tool to support better, faster decisions. This will require substantial expenditure. A cost-benefit analysis should also be done to prepare an optimal plan so that it does not raise the cost of power to consumers.

What are the CEA's long-term priorities?

In the long term, the CEA's priorities are aligned with Viksit Bharat by 2047 and India's net-zero target for 2070. For 2047, the CEA has prepared detailed projections that now serve as benchmarks for the MoP and the Viksit Bharat task force. For the 2070 net-zero scenario, the CEA conducted the first comprehensive study for the power sector and shared it with NITI Aayog, where it is being integrated into the broader energy roadmap.

In the transmission segment, India has built an extensive network of 497,372 circuit km with 1,375,418 MVA of transformation capacity and 120 GW of interregional links as of August 2025. This has enabled the vision of one nation, one grid, one frequency and even one price, with congestion levels down to just 0.02 per cent, a performance far ahead of many advanced countries. So, practically, we have only one bidding zone in the country.

A key shift has been potential-based transmission planning. With solar and wind coming online in just 12-18 months, we now plan and build transmission systems proactively in high-potential zones, ensuring generation and evacuation stay aligned.

The grid itself has become far more sophisticated, integrating STATCOMs, synchronous condensers and harmonic filters to enhance quality and stability.

Finally, cross-border interconnections are gaining traction. Interconnections with neighbouring countries – Nepal, Bhutan, Bangladesh, Myanmar and Sri Lanka – are expanding, further strengthening regional energy cooperation. We may interconnect the South Asia grid with the Southeast Asia grid. This will be aligned with our vision of One Sun, One World, One Grid (OSOWOG). ■

Interview with Anil Sardana

"The sector is firmly on track to deliver reliable, affordable and cleaner energy"

In a recent interview with *Power Line*, Anil Sardana, Managing Director, Adani Energy Solutions Limited and Adani Power Limited, shared his views on the current state of the Indian power sector. He spoke about the key strengths of the sector as well as the challenges and measures needed to address them. He also discussed the emerging opportunities and future outlook for the sector, and the Adani Group's priorities and initiatives in this space. Edited excerpts…

What are the bright spots in the Indian power sector?

India's power sector has demonstrated significant progress and has come a long way in the past decade, driven by strong policy support, large investments and solid execution. Scale has clearly been the north star. Installed capacity is now close to 500 GW, with about half of it, about 242 GW, coming from non-fossil sources. Renewables remain the biggest success story. Solar capacity has crossed 120 GW and wind is above 50 GW, with nearly 30 GW of green capacity added in the last financial year alone.

The next bright spot is planning and intent of execution. Despite peak demand touching 250 GW, the country maintained zero demand deficit thanks to robust planning and adequate fuel availability. Transmission expansion has clear visibility through the National Electricity Plan, with about Rs 9.15 lakh crore of investment planned to integrate renewables and deliver power to new demand hubs.

The country has also doubled down on integrating technological innovations like smart grids and high-voltage direct current (HVDC) transmission links, which improve grid stability and reduce transmission losses. Progress on smart metering has picked up, with implementation under way in all major cities, improving billing and collections. Government initiatives such as the Revamped Distribution Sector Scheme (RDSS) and the PM Surya Ghar: Muft Bijli Yojana have enhanced both access and affordability.

Third, the market is maturing. We see a deepening of renewable energy tenders with innovative structuring to suit discom needs. Battery and pumped storage systems have been mainstreamed, along with the introduction of a live carbon market framework.

In a nutshell, the power sector is firmly on track to deliver reliable, affordable and cleaner energy for India's economic development.

What are the challenges and concerns?

While the sector's progress is impressive, challenges persist. Despite gains under the RDSS, the financial health of several utilities remains a concern. Sector-wide aggregate technical and commercial (AT&C) losses are still in the mid-teens, and delayed cost recovery continues to constrain new investment and weaken the credit profile for long-term financing. This financial instability hampers the signing of new power purchase agreements (PPAs), stalling renewable energy projects despite ambitious national targets.

Simultaneously, grid integration is becoming more difficult in the short to medium term, as the growth in renewables outpaces the addition of storage, flexible generation and transmission capacity. Thermal power generation, primarily from coal, remains the backbone of electricity supply. Coal currently plays a dual role of serving the critical base load and meeting evening peaks; however, flexible operations with indigenous coal remains a constraint.

Despite advances in round-the-clock tenders, renewables combined with storage are still not the most reliable or affordable solution.

On the supply chain side, dependence on imports for critical minerals such as lithium and rare earths could impact future manufacturing of clean technologies.

Finally, land availability, permitting delays and fragmented regulatory frameworks in certain states continue to create implementation challenges. Addressing these through steady reforms, domestic capability building, disciplined resource adequacy and faster decision-making in states can pave the way forward.

What are the steps that are needed to address these challenges?

Overcoming the sector's constraints requires a multi-pronged and collaborative approach. Financial discipline at the distribution level must be deepened. Smart metering roll-outs, performance-linked support and competition through parallel licences can improve collections, reduce losses and give consumers a choice.

The priority should be to hardwire resource adequacy, ensuring every discom contracts firm, flexible capacity on time. The framework has been notified and preliminary studies are nearly complete; it now needs rigorous enforcement in the states. This will also require rapid scaling-up of energy storage – both battery and pumped hydro – to at least 74 GW by 2032, as per the National Electricity Plan. The battery viability gap funding programme and Solar Energy Corporation of India's (SECI) storage tenders should lead to timely awards, low tariffs and bankable contracts, while pumped storage needs continued fast-track concurrences and streamlined clearances.

Second, modernise the grid and markets. The National Electricity Plan provides the transmission blueprint. Implementation must stay ahead of renewables build, with aggressive efforts to develop planned corridors and HVDC links for renewable hubs such as Khavda in Gujarat and in Rajasthan. This should include ancillary services and time-of-day pricing.

In the near and medium terms, the thermal fleet should be upgraded to improve cycling. On the supply side, backward integration into the value chain of modules, batteries and transmission equipment through production-linked incentives should continue expanding to reduce import reliance.

What key trends, in your opinion, can we expect in the future?

India's power sector is poised for transformative growth, driven by rapid renewable energy expansion targeting 500 GW by 2030. This will entail increased investments in power transmission, with over Rs 9 lakh crore planned by 2032 to connect large renewable energy hubs and move power across states and even across countries.

The next decade is expected to be the decade of storage, with batteries and pumped storage systems scaling up sharply to manage grid balancing and long-duration supply, enabling renewables to deliver round-the-clock power more economically each year. There will also be a stronger case for the adoption of green hydrogen to unlock industrial decarbonisation, with recent bids in India painting a very optimistic narrative globally.

Smart grid technologies including smart metering, artificial intelligence (AI)-based grid management, internet of things-enabled infrastructure and decentralised energy solutions such as rooftop solar (PM Surya Ghar: Muft Bijli Yojana) will drive efficiency, resilience, better forecasting as well as improved access to power.

Demand will also shift shape. Data centres and AI workloads will add steady, high-quality load, while additional loads like cooling and transport electrification will contribute to peak demand. This will require the addition of high-quality, affordable and reliable generation technologies such as nuclear.

Together, these trends will redefine the power landscape and open new business models, ushering the way for a smarter, flexible and diversified power system.

What are the big opportunities that are likely to present themselves over the medium and long terms?

India's power sector presents significant medium- and long-term opportunities, driven by rising demand, clean energy transition and infrastructure modernisation. Over the next decade, the sector is expected to attract Rs 40 trillion (over $460 billion) in investments, with the major growth areas including renewable energy, transmission, energy storage and green hydrogen.

The push for 500 GW of renewable capacity by 2030, combined with a plan to invest Rs 9.15 lakh crore in transmission infrastructure by 2032, will strengthen the availability of affordable power to the remotest corners of the country and beyond.

Battery and pumped storage projects, with government-backed viability gap funding, will also emerge as major growth avenues. Further, the deepening of the electricity markets along with ancillary and carbon markets, will entail additional revenue streams and new frameworks for financing of these projects.

Emerging demand drivers such as electric vehicles and data centres are expected to contribute significantly to power demand growth by 2035, creating new load profiles and investment avenues. Additionally, the rise of open access and power/energy trading platforms will enhance competition and efficiency in the sector.

With the country's energy consumption growing at a compound annual growth rate of 6-7 per cent, and peak demand projected to reach 458 GW by 2032, the sector offers robust opportunities for utilities, investors and technology providers alike.

What, in your view, is the most promising technology of the future?

Several emerging technologies will serve as key building blocks for India's energy system over the next decade. First, storage. Battery energy storage systems (BESS) and pumped storage projects (PSPs) are essential for managing the intermittency of renewables, especially as India targets 500 GW of renewable capacity by 2030. With peak demand already crossing 250 GW, these technologies will support load balancing, peak shaving and grid stability. Policy support and a strong project pipeline are already in place.

While coal will continue to play the primary role in meeting India's baseload needs, nuclear is set to play a growing support role. With the government targeting 100 GW of nuclear capacity by 2047 and opening the sector to private participation, nuclear offers affordable, clean, and firm power. India currently has around 8 GW of nuclear power capacity, with plans to expand to 22 GW by 2035 and eventually 100 GW by 2047, providing a stable, low-carbon alternative to coal.

Green hydrogen will be critical for hard-to-abate sectors, enabled by low-cost renewables and domestic manufacturing. It offers a long-term decarbonisation pathway for industry and heavy transport, with India aiming to produce 5 million metric tonnes annually by 2030 under the National Green Hydrogen Mission.

Smart grids will tie these elements together, using metering, automation and market mechanisms to maintain reliability at the lowest cost. These are pragmatic, scalable levers for India's energy transition and growth story. ■

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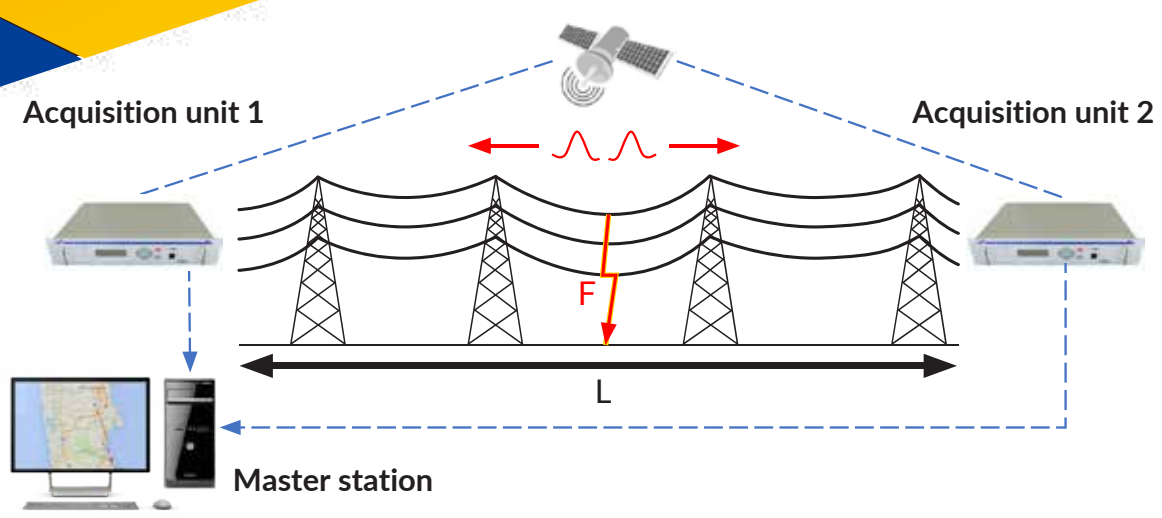

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Interview with Rohit Gupta

"The Indian market is highly competitive"

In a recent interview with *Power Line*, Rohit Gupta, Managing Director, Litmus Industries Limited, shared his perspective on the company's expanding role in Nepal's power infrastructure and its growing operations in the Indian market. He discussed the company's key offerings and solutions as well as its vision and future plans. Edited excerpts…

Could you briefly highlight Litmus Industries' key offerings and solutions?

Litmus Industries Limited has been serving Nepal's electrical infrastructure sector for nearly five decades with a strong commitment to quality, reliability and innovation. As the country's largest manufacturer of wires, cables and conductors, we offer a comprehensive portfolio that covers the entire spectrum from transmission lines and distribution networks to household electrification.

Over the years, we have continuously evolved our capabilities to meet the growing needs of the nation and various industries. Our focus on technological advancement has allowed us to stay ahead of market requirements. Most recently, we have commissioned a state-of-the-art continuous casting and rolling (CCR) plant to produce high-quality aluminium and alloy rods, strengthening backward integration and ensuring superior control over raw material quality.

As Nepal's largest manufacturer, you are now entering the Indian market. How do you view this market, and what challenges do you foresee?

For us, India is a natural extension of

our ambitions beyond Nepal. Over the past five years, we have significantly expanded our production capacity and strengthened product innovation to serve larger markets. While Nepal has immense hydropower potential, the scale of transmission and distribution (T&D) projects is still limited, and entering India allows us to fully utilise our capabilities.

We have already delivered major T&D projects for the Government of Nepal and recently secured the Nepal–India cross-border transmission line project with Power Grid Corporation of India Limited. We are also supplying aluminium and alloy rods to leading conductor manufacturers in India.

The Indian market is highly competitive, particularly on pricing. Our integrated rod manufacturing capability, however, provides us with a solid cost structure and quality consistency. Continued progress on policy facilitation in Nepal will further support our expansion, and we are engaging constructively with the government in this regard.

What makes your aluminium and alloy rods stand out in terms of quality and performance, and how do you see the growing demand for advanced alloys like AL-59 and T4?

Our aluminium and alloy rods are manufactured through advanced continuous casting and rolling technology, supported by one melting furnace and two holding furnaces, online degassing, ceramic foam and a 17-stand rolling mill. This integrated process ensures excellent grain structure, superior conductivity, consistent tensile strength and cleanliness levels below 30 ppm. Whether it is EC-grade, T-4 or AL-59, every rod meets stringent ASTM, IEC and IS standards.

At the same time, we are seeing strong demand for high-strength, high-conductivity alloys such as AL-59 and T4. With the need for lighter conductors, reduced line sag and higher power transfer capacity, utilities in both Nepal and India are rapidly shifting towards these advanced materials. As Nepal expands hydropower evacuation and India accelerates transmission upgrades, our CCR plant is well-positioned to support this industry-wide transition.

What message would you like to convey to your customers, and what are Litmus' future plans?

Litmus has always stood for quality, reliability and innovation in Nepal's wires, cables and conductors industry. Building on that legacy, we are now entering the Indian market, which is an important step for establishing credibility and trust beyond our borders. Beyond India, we have our eyes on global markets, including the Middle East, but our immediate focus is on building a strong presence and reputation in India.

We take pride in the fact that our partners and clients recognise our commitment to excellence. As we expand, we remain dedicated to delivering world-class quality at competitive prices, upholding our values and seizing new opportunities for growth. ■

Interview with Krishna Kumar Thakur

"India's power transmission sector is at a transformational stage"

In a recent interview with *Power Line*, Krishna Kumar Thakur, Vice President - Customer Assurance & Business Development, Diamond Power (DICABS), shared his views on the key challenges and opportunities in the power transmission sector as well as the new and emerging technologies shaping the industry. He also discussed Diamond Power's offerings and solutions, areas of expertise and top priorities going forward. Edited excerpts…

What is your view on the current state of India's power transmission sector?

India's power transmission sector is at a transformational stage, driven by rapid growth in renewable energy, rising power demand, and the need for grid reliability across regions. Transmission is no longer merely a support function — it has become a strategic pillar of the country's energy transition. With solar and wind projects coming up in geographically distant regions, efficient long-distance power evacuation has become critical. The country is witnessing significant investments in green energy corridors, interstate networks and grid digitalisation. At the same time, India is emerging as a strong global manufacturing base for transmission equipment. Overall, the sector is moving toward high-capacity, high-reliability and technology-driven transmission systems.

What are the key challenges and opportunities in the sector?

The key challenges include severe right-of-way limitations, transmission readiness lagging behind renewable installations and increasing

system complexity due to the variability of renewable energy. However, opportunities are substantial in reconductoring, renewable evacuation infrastructure, high voltage (HV) and extra high voltage (EHV) upgrades, and grid digitalisation. Utilities are moving from traditional expansion to performance-based infrastructure, creating demand for advanced conductors and cable systems.

> "With solar and wind projects coming up in geographically distant regions, efficient long-distance power evacuation has become critical."

> "Transmission is no longer merely a support function; it has become a strategic pillar of the country's energy transition."

What are the new and emerging technology trends in the transmission space?

Key trends include high temperature low sag (HTLS) conductors for corridor optimisation, the expansion of HVDC networks and the adoption of higher voltage levels such as 765 kV. Dynamic line rating, real-time monitoring systems and predictive maintenance technologies are also transforming grid operations. The future grid will be high-efficiency, compact and driven by digital intelligence.

Could you give us an overview of Diamond Power's key offerings and solutions in the transmission space? What are your key areas of expertise?

Diamond Power focuses on advanced conductors and high-performance cable systems. Our portfolio includes conventional conductors (ACSR, AAAC and ACAR), HTLS conductors, gap-type conductors and AL59 alloy conductors. Alongside this, we offer HV and EHV cable systems supported by application engineering, installation guidance and quality testing. Our collaboration with TS Conductors strengthens our advanced conductor capabilities with global technology expertise.

What are the company's top priorities going forward?

Our priorities are technology leadership through the expansion of advanced conductor and EHV cable capacity, strategic partnerships such as TS Conductors, execution excellence and quality leadership, and sustainability through efficient materials. We aim to achieve Rs 10,000 crore in revenue by 2030, driven by renewable evacuation projects, reconductoring demand and grid modernisation. ■

Incident Analysis

CEA releases report on EHV transmission tower failures

The Central Electricity Authority (CEA) has released its latest report on failures in extra high voltage (EHV) transmission line towers across India, covering incidents from January 2025 to June 2025.

The report highlights key structural, environmental and operational challenges, consolidating data from 11 utilities to analyse failure patterns, compliance gaps and risk factors. Many failures were attributed to high-intensity winds, sabotage, foundation instability, ageing infrastructure and inadequate maintenance. The findings highlight the need for enhanced infrastructure resilience and updated technical standards. The report also provides recommendations for preventing recurring failures and ensuring long-term grid stability.

Tower failure patterns

From January 2025 to June 2025, a total of 22 EHV tower failure incidents were reported, involving 75 towers (59 suspension type and 16 tension type). At the 765 kV level, nine suspension towers failed across three transmission lines. At 400 kV, there were 57 tower failures (47 suspension and 10 tension) across 12 transmission lines. At the 220 kV level, 11 suspension towers and six tension towers failed across nine transmission lines. The majority of failures occurred in towers within Wind Zones 3 and 4, which also cover the most geographical area.

The Standing Committee of Experts constituted by the CEA underlined the growing concern of tower failures occurring much earlier than expected. Although the design life of a transmission tower is 35 years, most failures are being recorded within 10-15 years of commissioning. Out of the 22 incidents examined, 16 fell within this early-failure window, indicating systemic issues that require urgent corrective action. The committee has noted that the failure rate of suspension-type towers is significantly higher than that of tension-type towers. This is primarily because transmission lines in normal terrain typically use more suspension towers. Additionally, these towers are not designed to withstand horizontal forces in the longitudinal direction, making them vulnerable to cascading failures when even one tower collapses.

Observations of the committee

The committee noted that failures of EHV transmission line towers across voltage levels generally fall into a few recurring patterns. These include deformation in tower legs and the cage portion near the bottom cross-arm, buckling at the stub level leading to full tower collapse, and buckling above the first panel of normal towers, with or without foundation damage. Instances were also recorded where buckling occurred from the bottom or top cross-arm or at the peak, without affecting the lower structure or foundation. In several cases, foundations and tower bodies were damaged due to rising water levels, high flow velocity, soil erosion and inadequate protection works. Shearing of stubs of tower leg members was also observed.

While high-intensity wind has been cited as the primary cause of tower failures, many utilities were unable to substantiate this claim due to the absence of wind data for the affected locations. The committee emphasised that whenever wind is reported as the cause, the utility must obtain representative wind speed data from India Meteorological Department (IMD) observatories, nearby airports, wind farms or the State Irrigation Department. It acknowledged that storm-related wind velocities or localised whirlwinds may have exceeded tower design limits, but this requires verification using reliable meteorological data, including satellite or radar information.

The committee underlined that tower integrity depends on multiple factors. These include the adequacy of technical standards and codal provisions used in design, material quality, construction methodology, workmanship and erection quality, as well as the utilities' operation and maintenance practices.

Indian standards for tower design have been revised several times, and such updates are meant to be implemented prospectively. Strengthening of existing towers, where codal provisions have evolved, may be considered on a case-by-case basis, particularly in lines witnessing repeated failures. The committee stressed that towers erected during restoration must follow the latest standards, and spare towers procured by utilities should also conform to current norms.

Committee recommendations

The committee, after detailed deliberations, has outlined a set of recommendations and remedial measures for utilities to strengthen transmission tower performance and enhance system resilience.

Utilities must not only report tower failure incidents as per Regulation 48 (8) of the CEA (Measures relating to Safety and Electric Supply) Regulations, 2023, but also submit a closure report within three months, capturing all relevant details and records. Timely compliance with these requirements has been stressed. The committee has further highlighted the need for utilities to prioritise the digitalisation of spares and inventory management for transmission assets through suitable software platforms such as SAP.

The committee has advised utilities to consider the recommendations of the Task Force on Cyclone Resilient Robust Electricity Transmission and Distribution Infrastructure in coastal areas, issued in May 2021, and adopt them wherever relevant. In addition, utilities have been asked to build in-house capabilities equipped with tower design software to simulate, analyse and address design-related issues in failed structures.

Given the shifts in wind intensity observed across several regions due to climate change, the committee noted that while the Structural Engineering Research Centre (SERC) updated the wind map in 2016 and the Bureau of Indian Standards incorporated it into the National Building Code, the revised map is yet to be reflected in IS 875. SERC, in coordination with IMD, has been requested to update the map. Till IS 875 is revised, utilities have been advised to follow the wind map in the National Building Code for tower design.

After each failure, the concerned utility must submit information on the actual wind velocity recorded in the affected area, using support from IMD, nearby airports, wind farms or the State Irrigation Department. Towers designed under older standards should be reviewed and strengthened based on current norms. For towers with special designs, such as those with high extensions or power line crossings, the committee has recommended a higher reliability level to ensure better structural stability, with CPRI consultation where required. It also suggested explicitly specifying reliability levels for power line crossings in RFPs.

For towers located in overlapping wind zones, the committee recommended considering the higher wind zone if the structure lies within 50 km of the boundary. With increasing incidents of high winds, utilities must intensify line patrolling, promptly replace missing members or bolts, and address issues such as bent members, incorrect cross-arm attachments, rusted stubs and poor erection practices, all of which have been observed during site inspections.

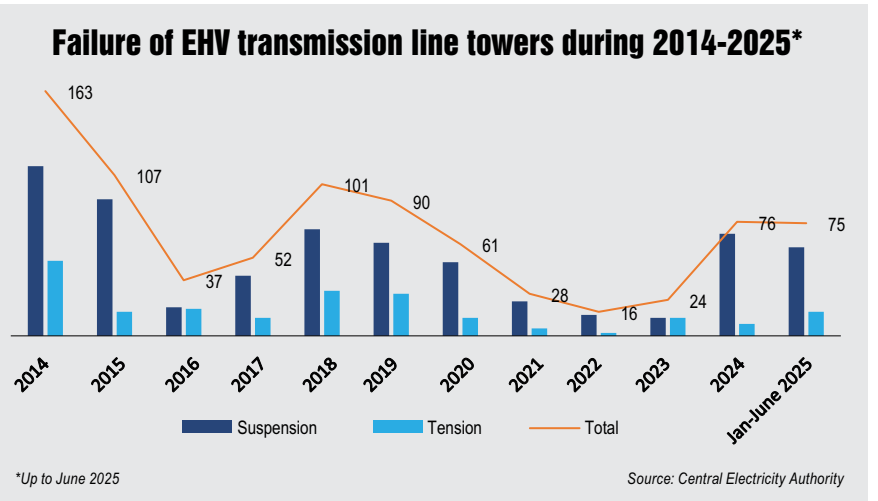
For towers in riverbeds, creek beds or riverbank areas with scourable soil conditions or changing river courses, the committee recommended the use of pile-type foundations based on detailed soil investigations, historical flood discharge, water flow velocity, flood levels, scour depth and the river morphology of at least the past two decades. Towers near riverbanks should be patrolled frequently, with assessments made to anticipate course changes and deploy necessary protective measures.

Where foundation damage occurs, utilities must examine the foundation design. Material test reports of failed towers must also be reviewed to determine material quality. The committee emphasised the need to clear encroachments on the right of way and improve erection, patrolling and O&M practices. Regular patrolling remains essential for the reliable operation of transmission lines, and any unauthorised construction, use or storage under or around towers should be immediately reported to local authorities for action.

Conclusion

With climate variability and extreme weather events occurring more frequently, transmission utilities are expected to incorporate resilience into their core planning and asset design processes. The recurring failure of suspension towers highlights underlying structural and operational issues that require proactive, long-term solutions rather than reactive measures.

Going forward, utilities will increasingly adopt data-driven design validation, enforce strict adherence to updated technical standards, and strengthen coordination with meteorological and planning bodies. Timely reporting, proactive risk assessment and investment in modern monitoring tools will be critical to enhancing infrastructure durability. As the grid faces growing environmental and operational challenges, building a robust and adaptive transmission system will be key to ensuring long-term reliability and system security. ■



Voltage-wise tower failure from January 2025 to June 2025

Voltage level	Number of towers failed			
	Number of affected lines	Suspension towers	Tension towers	Total number of towers
765 kV	1	1	0	1
400 kV	12	47	10	57
220 kV	9	11	6	17
Total	**22**	**59**	**16**	**75**

Source: Central Electricity Authority

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Grid Upgrades

Reconductoring to unlock additional capacity

India's transmission system is under increasing pressure as electrification accelerates, renewable projects scale up and urban demand continues to rise. Traditionally, network capacity enhancement has relied on building new lines or reconstructing existing ones, solutions that require high capital, entail long execution timelines and face persistent right-of-way (RoW) challenges. In this scenario, reconductoring has gained prominence as a practical and economical solution. By retaining existing structures and replacing old conductors with high-capacity alternatives, utilities are unlocking additional transmission capacity without large-scale civil works or prolonged outages. As a result, transmission planners are increasingly placing greater emphasis on network expansion and optimisation through reconductoring.

Transmission utilities are increasingly undertaking reconductoring projects. A case in point is the Lara–Raigarh reconductoring project in Chhattisgarh. Under the regulated tariff mechanism (RTM), Power Grid Corporation of India Limited (Powergrid) is reconductoring its existing 400 kV double-circuit line, connecting the Lara Super Thermal Power Station to Raigarh (Kotra). The 20 km line is being upgraded with twin high-temperature low-sag (HTLS) conductors capable of at least 2,100 MVA per circuit at nominal voltage. Another initiative is Gujarat Energy Transmission Corporation Limited's completion of India's first reconductoring project by Gujarat Energy Transmission Corporation Limited using ACCC® Daman composite-core conductors.

Technical guidelines

The Central Electricity Authority's (CEA) Transmission Planning Criteria (2023) and its draft paper on reconductoring provide the technical foundation for project implementation. Key planning considerations include verifying that the new conductor's ampacity meets projected demand, ensuring acceptable sag and tension parameters, maintaining mechanical integrity for long spans (especially across rivers and valleys), and verifying compatibility with existing foundations.

One of the key challenges in reconductoring is the additional load it can impose on terminal equipment, which may require strengthening or replacing breakers, protection relays, bay components and busbars. Reconductoring multi-circuit or multi-voltage lines is particularly challenging when adjacent lines must remain energised, requiring live-line working techniques and additional safeguards.

Regulatory frameworks

Reconductoring is typically treated as a technical upgrade and carried out under RTM, where the licensee of the original line is responsible for execution. However, industry associations have raised concerns about limited transparency in this process and the risk of cost overruns.

The tariff-based competitive bidding (TBCB) route offers an alternative, allowing private firms to bid under the build-own-operate-maintain model. The two approaches vary in terms of execution timelines, ownership structure, coordination and cost dynamics. Under TBCB rules, all transmission assets, including substations and RoW, must be transferred to the Central Transmission Utility or its nominated successor 35 years after the commercial operation date, free of encumbrances. The CEA recommends that reconductoring and associated bay upgrades during an asset's useful life be carried out by the same transmission service provider, preferably through the RTM route. This approach ensures technical coherence, continuity of documentation and minimal disruptions. For projects already implemented through RTM, carrying out further upgrades or reconductoring under the same mechanism supports consistent cost recovery.

Technology trends

The most commonly deployed conductor technologies in India include HTLS conductors, high-temperature superconductors, advanced aluminium conductor steel-reinforced cables and composite-core variants. These conductors are designed to operate at higher temperatures, deliver lower line losses and improve overall grid efficiency. Urban centres such as Delhi and Mumbai have increasingly adopted such technologies due to limited RoW availability and rising load densities. India's planning approach has also evolved, with utilities now encouraged to assess conductors on a total cost-of-ownership basis rather than on upfront capital cost alone.

Outlook

India's grid needs are rapidly evolving, with increasing emphasis on efficient asset utilisation, cost control and timely capacity augmentation. Reconductoring fits squarely with this requirement, enhancing corridor capacity while avoiding steel-intensive rebuilds. With rising demand in cities, renewable energy-rich states and industrial regions, reconductoring is set to play a critical role. The momentum will only increase with upcoming requirements under GEC-III, storage-linked renewable projects and the shift towards 24×7 green power procurement. Supported by CEA guidelines, enabling state-level policies and wider adoption of advanced conductor technologies, reconductoring is expected to become a key driver in strengthening India's transmission backbone over the coming decade. ■

Key Statistics

Transmission growth across states/UTs and developers

Transmission line additions in 2025-26 (ckt km)*

	State/UT/Developer	220 kV	230 kV	400 kV	765 kV	Total
State	Andhra Pradesh	17				17
	Chhattisgarh	33		14		47
	Haryana	209				209
	Himachal Pradesh			2		2
	Jharkhand			13		13
	Karnataka	121				121
	Kerala	57				57
	Maharashtra	360				360
	Odisha	161				161
	Punjab	59				59
	Rajasthan	61		491		552
	Tamil Nadu		12	16		28
	Telangana	79		309		388
	Uttar Pradesh	157				157
	West Bengal	62		21		83
Centre	POWERGRID	142		301	368	811
	DVC	86				86
Private	Adani			11		11
	Juna Renewable Energy	16				16
Total		**1,620**	**12**	**1,178**	**368**	**3,178**

**Up to October 2025*

Transformation capacity addition in 2025-26* (MVA)

	State/UT/Developer	220 kV	230 kV	400 kV	765 kV	Total
State	Andhra Pradesh	850		185		1,035
	Bihar	920				920
	Chhattisgarh	320		945		1,265
	Gujarat	870		685		1,555
	Haryana	1,160				1,160
	Karnataka	1,650				1,650
	Madhya Pradesh	40		500		540
	Maharashtra	675				675
	Odisha	240		500		740
	Punjab	1,060		500		1,560
	Rajasthan	900		185		1,085
	Tamil Nadu		460	2,085		2,545
	Telangana	700				700
	Uttar Pradesh	900				900
	West Bengal	630		1,000		1,630
Central	POWERGRID	320		2,685	25,500	28,505
Private	Adani	160		1,000	4,500	5,660
	Hazira			500		500
Total		**11,395**	**460**	**10,770**	**30,000**	**52,625**

**Up to October 2025*
DVC: Damodar Valley Corporation; POWERGRID: Power Grid Corporation of India Limited
Source: Central Electricity Authority

Smaller Footprint

Monopoles emerge as a space-efficient transmission solution

The expansion and modernisation of electricity come with several constraints, such as land acquisition hurdles, installation challenges in highdensity areas, difficult terrains and long installation times. In light of these challenges, the power sector is witnessing the emergence of monopoles as a viable alternative.

A transmission monopole is a tall, self-supporting steel or concrete pole that can carry long overhead power lines, and it comes with a simpler structure and smaller footprint than traditional lattice towers. Monopoles are suited for installation in congested sites, where delays in land acquisition or environmental clearance might be major hurdles. For example, one key design distinction is that while typical lattice tower installations require around 245 square metres of land for the base foundation, monopoles can operate on just 33 square metres of land.

As per a technical paper, "Advantages of Monopole Transmission Tower with New Generation Conductor", published in the International Journal of Advanced Research in Engineering and Technology, monopole transmission towers require less right of way (RoW), provide better aesthetic appeal and allow faster installation due to fewer components.

One of the most compelling use cases for monopoles in India is in forest and wildlife landscapes. Conventional lattice towers could lead to deforestation, habitat fragmentation, wildlife-corridor disruption and increased bird mortality, resulting in instances such as the Great Indian Bustard Challenge. This is largely because they require wide RoW clearances and extensive land diversion burdens.

By contrast, monopoles allow significantly narrower RoW by offering a 40-60 per cent reduction in the forest clearance area and an 80-90 per cent improvement in wildlife permeability. Although the upfront capital cost of monopoles is higher by 30-50 per cent, life cycle modelling shows that over a 25-year horizon they deliver net savings due to reduced compensatory afforestation obligations, lower operations and maintenance, and avoided delays linked to land/forest clearance.

Increasing urban adoption

With increasing urbanisation, monopoles are emerging as an effective solution due to their lower land utilisation in urban layouts. In a recent example, Punjab State Power Corporation Limited is set to replace conventional towers with monopoles in Ludhiana, in order to reduce the risk of low-hanging wires and wire entanglement with traffic and building encroachment.

Another example is the 400 kV double-circuit line between Sector 148 and Sector 123 in Noida by UP Power Transmission Company Limited. This project features a monopole transmission spanning 39.640 ckt km in a high-density zone.

Increasingly, in urban and peri-urban environments where RoW and land use pressures are high, monopoles have been deployed by utilities to reduce footprint. For instance, Power Grid Corporation of India Limited (POWERGRID) has been installing monopoles since 2008-09 to save space and avoid the felling of trees. In 2021, POWERGRID commissioned the ±320 kV Pugalur (Tamil Nadu)-Thrissur (Kerala) voltage source converter-based high voltage direct current system, which deployed monopoles.

Additionally, thanks to smaller foundations, monopoles can be installed on highways or canals. With urban cities set to witness a higher residential power demand due to growth in electric vehicles, data centres and distributed renewable energy installations, transmission utilities need to proactively include more monopole projects in their network.

Monopole structures, when combined with dynamic line-rating and travelling-wave fault-locators, allow for improved real-time capacity utilisation and faster fault detection. They can also facilitate multiple circuits on a single slender pole by conserving RoW in dense or greenfield corridors.

Challenges and the way forward

Despite the benefits, monopoles come with several challenges. First, monopoles can cost up to 50 per cent more than traditional lattice towers. Additionally, local utilities may lack the required experience with monopole design and specifications since the standard guidelines in India are yet to mature as compared to lattice towers. Consequently, the maintenance of a monopole structure is also more challenging. When compared to lattice towers, which have a lifespan of up to 50 years, monopoles have a lifespan of 30 years and a lower recycling value.

While these factors may significantly affect the project economics of a monopole compared to a lattice tower, we must look at their installation from the dual context of rapid grid expansion as well as improved efficiency and lower social and environmental costs. For utilities and policymakers, it is important to recognise monopoles as a strategic complement to existing tower systems. With the right regulatory and policy support, monopoles could become an important component of India's strategy to modernise the grid. ■

Snapshots from Day 1











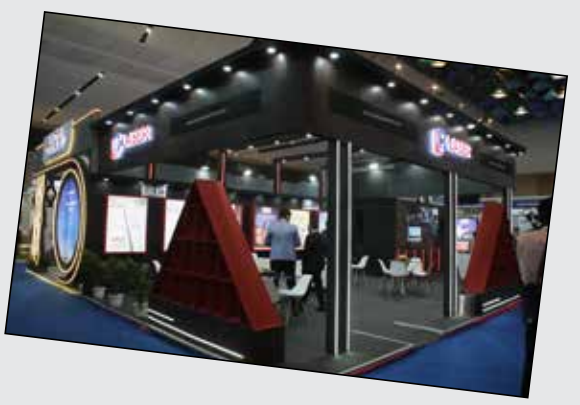
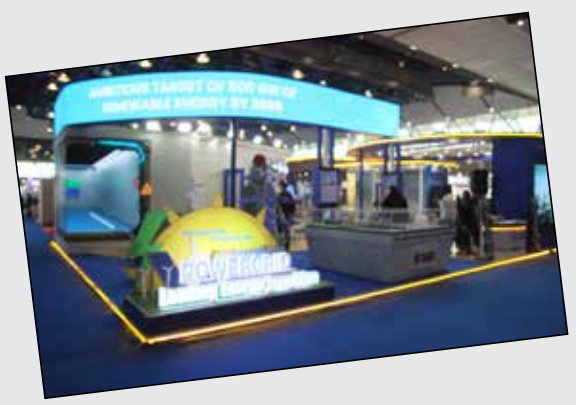


Snapshots from Day 1

TransTech India 2025

Agenda: Thursday, December 11, 2025 (Day 2)

Time: 9:20 AM-9:30 AM Recap of Day 1

Recap by *Power Line*

Time: 9:30 AM-10:30 AM

O&M Best Practices

- Dr Nilesh Kane, Chief Distribution, Tata Power
- Sanil Namboodiripad, Chief Operating Officer, IndiGrid
- Sandip Maity, Senior Vice President, Design and Engineering, Resonia
- Nihar Raj, Head – O&M, Adani Energy Solutions

Time: 10:30 AM-11:10 AM

Special Session With Director Operations, POWERGRID

- Naveen Srivastava, Director (Operations), POWERGRID

Time: 10:00 AM-11:30 AM *(Parallel Track)*

Workshop by Bentley

Power Line Systems: Recent Features in PLS-CADD, Tower & PLS-POLE

Time: 11:10 AM-11:50 AM

Exhibition Viewing, Tea/Cofee and Networking Break

Time: 11:50 AM-12:50 PM

Technology Showcase

- Presentations by Kanohar Electricals, Bajel, Enline, Indore Composite, Elegrow Technology

Time: 12:50 PM-1:10 PM

Innovation in Action

- Presentation by Chandan Kalra, AVP, Resonia, and Divya Manchanda, EVP, Amber Wings

Time: 1:10 PM-2:10 PM *(Parallel Tracks)*

Cables and Conductors

- Abhishek, Chief General Manager, POWERGRID
- S.K. Jana, Senior Vice President, R&D, APAR Industries
- D. Latha Vinod, Director Projects, TGTRANSCO

Time: 1:10 PM-2:10 PM *(Parallel Tracks)*

AI and Digitalisation

- Mayank Bhardwaj, Director, Power & Utilities, KPMG
- Mahendra Kr. Kaloria, Deputy GM, POWERGRID
- Nihar Raj, Head – O&M, Adani Energy Solutions

Time: 2:10 PM-3:00 PM

Exhibition Viewing and Lunch Break

Time: 3:00 PM-4:00 PM *(Parallel Tracks)*

Transformers

- Deepak Kumar Jha, CE, Bihar State Power Transmission Company
- Abhay Kumar, Chief General Manager, POWERGRID
- Dinesh Kumar Singh, Executive Director (T&D System), DVC

Time: 3:00 PM-4:00 PM *(Parallel Tracks)*

Towers

- Arup Kalita, Chief General Manager, AEGCL
- Dayanand Swamy Kuna, President and CEO, Salasar Techno
- G.P. Payasi, Chief General Manager, POWERGRID

Time: 4:00 PM-5:00 PM

Special Session

- Special Session with S.K. Soonee, Former Chairman, GRID-INDIA

Day Two Wrap-up and Closing Remarks, and Raffle Draw

High Tea, Exhibition Viewing and Networking