



Engineering A Growing India

The CEO and MD of Tata Consulting Engineers on how India's infrastructure ambitions are placing the country at the heart of the global industrial future

BY TANMOY MITRA

India is on the verge of a major industrial transformation, transitioning from a system dominated by thermal power to one driven by renewable energy. This transition is not merely a policy objective but one of the most complex engineering challenges ever attempted. At the helm of navigating this complexity is **Amit Sharma, Managing Director and CEO of Tata Consulting Engineers (TCE)**. Drawing on his experience with large-scale infrastructure and industrial projects, Sharma offers a practical yet forward-looking view on how to reshape the nation's energy future.

In this exclusive dialogue with **ET Edge Insights**, Sharma delves into the intricate mechanics of grid stability, the strategic imperative of Bharat Small Modular Reactors (SMRs), and the evolution of Indian engineering as a global benchmark for excellence. He argues that the future belongs to those who can embed circularity and digital intelligence into the very design of our assets. From "urban mining" to the five pillars of advanced metallurgy, Sharma outlines a future where engineering discipline serves as the ultimate evidence base for a sustainable, resilient, and competitive India.

TCE has contributed to more than 250 GW of power generation and 85 percent of India's nuclear capacity. When you look at India's energy landscape today, what do you see as the most significant engineering challenge in moving from a thermal-dominated grid to a renewable-heavy one?

India's transition from a thermal-dominated grid to a renewable-heavy system represents one of the most complex engineering shifts the country has ever undertaken. The challenge is not simply about replacing thermal megawatts with renewable megawatts but doing that while meeting

increasing energy demand of increasing availability, reliability, reach and increasing demand. Thermal systems provided inherent stability through base load generation, predictable ramp rates and embedded inertia. Renewable energy, by contrast, introduces variability, decentralisation and non-synchronous behaviour.

The most significant engineering challenge lies in redesigning the grid to function reliably under these new conditions. This demands a system-level transformation encompassing transmission planning, forecasting accuracy, grid codes, dispatch protocols, storage integration and advanced

India's first creek tunnel of 3.6 m dia at Kasheli for water transmission system

Engineered India's first 500 MW Thermal Power Unit in India

Was involved in the design and fabrication of the 2.3-meter (90-inch) Vainu Bappu Telescope (VBT), Asia's largest optical telescope

Engineered India's first Semiconductor Plant

Engineered India's first Green Hydrogen Fueling Station

Was a crucial engineering partner for ISRO's Chandrayaan-3 mission

digital control. The future grid must be flexible, resilient, and intelligent, capable of responding dynamically to both supply-side variability and rapidly evolving demand patterns. Without this holistic approach, India risks creating a grid that is rich in installed capacity but constrained in reliability.

India's electricity demand is growing faster than almost any major economy. Do you believe pumped hydro storage and large-scale battery systems can realistically provide the flexibility a renewable-led grid requires by 2030? What engineering gaps still concern you?

Pumped hydro storage and large-scale battery systems will both be indispensable in enabling a renewable-led grid, but they serve different engineering purposes. Pumped storage remains the most proven and scalable solution for long-duration energy storage, particularly well-suited to India's daily and seasonal demand fluctuations. Batteries, on the other hand, provide rapid response, grid balancing and localised stability, especially in urban and industrial clusters.

The engineering gaps that warrant attention are less about technology readiness and more about system integration. These include transmission connectivity from storage locations, harmonisation of control systems between storage assets and grid operators, realistic lifecycle cost modelling and streamlined environmental approvals. In battery systems, issues such as supply chain dependence, safety engineering and end-of-life recycling need to be addressed proactively. The success of storage deployment will depend on how well these technologies are integrated into grid operations rather than on their standalone performance.

As TCE leads the development of Bharat Small Modular Reactors, what unique design or regulatory considerations arise in the Indian context compared with emerging SMR programmes in the United States, Canada and Europe?

The development of Bharat Small Modular Reactors introduces a distinct set of design and regulatory considerations shaped by India's long-standing nuclear framework. From an engineering standpoint, the emphasis is on inherent safety, passive systems, standardisation and long-term operational reliability. Designs must be modular, factory manufacturable and adaptable to varied site conditions while maintaining high safety margins.

Regulatory engagement is deeply embedded in the design process, ensuring that compliance, safety and operational transparency are integral rather than add on elements. Compared with programmes in North America or Europe, India places greater emphasis on lifecycle accountability, domestic capability creation and integration with existing nuclear infrastructure. Engineering in this space is therefore not only about technological advancement but also about consistency, trust and long-term stewardship. Most importantly the BSR or similar SMRs should be viable, proven, affordable and reliable.

TCE has engineered landmark global facilities, from Africa's largest fertiliser plant to Ethiopia's first PVC unit and Asia's largest paint plant. What differentiates Indian engineering competencies when you compete for international EPCM and consulting mandates?

Indian engineering capabilities are increasingly recognised for their ability to manage complexity at scale



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while operating within real world constraints. When competing for global EPCM and consulting mandates, Indian firms bring a strong combination of systems thinking and execution pragmatism. Engineers in India are trained by experience to optimise designs under tight capital conditions, navigate complex stakeholder environments, ensure alignment with very demanding contractual terms and conditions, and deliver under compressed timelines. This has fostered deep expertise in value engineering, interdisciplinary integration, agility, flexibility, constant learning and relearning and adaptive problem solving. Indian organisations have also developed robust models for managing large, geographically distributed teams leveraging digital and collaboration technologies and processes. In an era where global projects face uncertainty from supply chains, geopolitics and climate risks, this adaptability has become a decisive competitive advantage.

Many global chemical and materials companies are shifting rapidly towards low-carbon feedstocks and circular production models. Is Indian industry keeping pace with this transition, or do you see a risk of technological lock-in as Europe and East Asia move ahead?

Indian industry has begun its transition towards low carbon feedstocks and circular production models, but the pace varies significantly across sectors. Progressive organisations are investing in energy efficiency, alternative raw materials and process redesign. However, there remains a risk of technological lock in if transitions are approached incrementally without a long term vision. Further such transitions must be based on scientific mathematical analysis of practical and consistent returns. Indian industries must embed circularity at the core of process and design rather than treating it as a compliance exercise. India's opportunity lies in integrating sustainability at the design stage of new facilities, where engineering decisions have the greatest influence on lifetime emissions and resource efficiency.

Early design intervention with scientific sustainability analysis is therefore critical to avoiding stranded assets in the future. It's time for Indian firms to invest in real progressive and innovative R&D, resist the urge to be conservative and indulge in superficial display only pilots, and look at rewiring their value chains, keeping circularity and sustainability as the core.

TCE has delivered more than 500 projects in metals and mining, including 150 international assignments. When you compare India's metallurgical competitiveness with that of China, Japan or Europe, where do you see our strongest advantages and most urgent weaknesses?

India's metallurgical sector benefits from strong fundamentals, yet faces an urgent need for technological advancement. The country's strengths lie in scale, access to raw materials and a large base of experienced engineers and operators. India must learn from its once advanced metallurgical prowess and globally benchmarked past, in Iron, Steel, Zinc to name a few. Indian teams have consistently demonstrated the ability to deliver large capacity plants efficiently and tailor technologies to local conditions.

To become globally competitive in jet engines, advanced thermal power, nuclear SMRs, and advanced steels, India needs deep investments in 5 interconnected metallurgical pillars. HighTemperature Superalloys & SingleCrystal Technology, Advanced Titanium Alloys & Titanium Aluminides, High-Temperature Steels & ODS (Oxide-Dispersion-Strengthened) Alloys, NuclearGrade Metallurgy for SMR Pressure Vessels & Reactor Internals, Advanced Steels for Automotive & PEB Applications

Beyond focus on above, India needs to invest in energy efficiency and the adoption of next generation metallurgical processes and recycling to be resilient and self-sufficient in rare earth and high-grade metallurgy. India must invest more aggressively in fundamental metallurgy, process innovation and low carbon steelmaking pathways. Addressing these gaps will be essential for long term competitiveness.

TCE supports both greenfield and brownfield expansions for metals clients. In a world where demand for critical minerals is rising faster than supply, do you anticipate a shift towards more urban mining and recycling-led projects in India?

Urban mining and recycling are likely to become increasingly central to India's metals strategy. As demand



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for critical minerals accelerates, reliance on primary extraction alone will be neither sufficient nor sustainable. Recycling led projects offer faster deployment, reduced environmental impact and improved supply resilience. Engineering challenges include consistent feedstock quality, material segregation and process scalability. India has the potential to develop a robust circular metals ecosystem, but this will require coordinated investment in infrastructure, clear standards and strong engineering frameworks. We expect a gradual shift towards hybrid facilities that integrate primary processing with advanced recycling operations.

Globally, engineering consultancies are embedding AI to optimise plant layouts, improve safety modelling and accelerate design cycles. In your view, where is AI genuinely adding value today, and where is it still more hype than substance?

Artificial intelligence is already delivering measurable value in specific areas of engineering, though it is not a universal solution. AI is proving effective in design automation, clash detection, predictive maintenance and safety risk analysis, where it enhances speed, accuracy and decision quality. However, there is still considerable hype where AI is applied without adequate data quality or domain understanding.

Engineering judgement remains central to complex decision making. The greatest value emerges when AI augments experienced engineers rather than attempting to replace them. Trustworthy outcomes depend on explainability, validation and seamless integration with established engineering processes. India must leverage AI backed with use of trained data models leveraging a pan-country data approach, such integration will help streamline

and optimise investments across infrastructure, advanced facilities, transportation and also ensure impactful connect between the capex and opex phases, thus delivering outcome based initiatives in a timely manner.

Decarbonisation is reshaping project economics across power, chemicals and metals. How is TCE helping clients navigate the tension between immediate cost pressures and the long-term imperative to adopt low-carbon technologies that may not yet be commercially mature?

Decarbonisation is fundamentally reshaping project economics across power, chemicals and metals, creating difficult trade offs for asset owners. Clients face pressure to control capital and operating costs while also preparing for a low carbon future. Our role is to bring clarity through rigorous analysis, scenario modelling and phased transition strategies. While some technologies are still evolving commercially, delaying action altogether often increases long term risk. We help clients identify practical no regret measures, pilot emerging solutions and design assets that remain adaptable as technologies mature. Engineering discipline provides the evidence base needed to align sustainability goals with financial and operational realities.

You have worked across markets with very different regulatory structures, capital costs and labour ecosystems. How does India's engineering and consulting talent stack up today against global competitors from Europe, East Asia and the Middle East?

India's engineering and consulting talent compares strongly with global peers and continues to evolve. Indian engineers combine solid academic foundations with extensive exposure to complex, multi sector projects. Compared with Europe and East Asia, Indian talent brings greater flexibility and cross disciplinary capability. In comparison with the Middle East, India offers deeper design and lifecycle expertise rather than execution alone. The key priority going forward is continuous upskilling in digital engineering, sustainability and emerging technologies. With sustained investment in people and systems, India is well positioned to remain a preferred global engineering partner. ●