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"The Future of Steel Lies in Integrated Energy and Industrial Infrastructure"

Atanu Mukherjee is the CEO of M. N. Dastur & Co. and Dastur Energy, a global technology, engineering, and advisory firm serving the metals, mining, energy, and industrial sectors. He provides strategic leadership on industrial transformation, steel decarbonisation, energy systems, and next-generation infrastructure.

He has led major project and policy initiatives with global industrial enterprises, the U.S. Department of Energy, G20 Presidency, NITI Aayog, and the Government of India on clean steel, carbon capture, gasification, low-carbon fuels, renewable integration, and grid modernisation.

Earlier, he held senior leadership roles at Microsoft Corporation and Digital Equipment Corporation. He holds a joint graduate degree in Engineering and Management from MIT and is a Graduate Fellow at Stanford University in Energy & Chemical Engineering.

With over 100 publications and several patents, Atanu combines deep technical expertise with strong commercial insight to address complex challenges in global energy transformation.

Outside his professional work, Atanu is an avid golfer, pianist, and private pilot, and divides his time between Austin, Texas and India.

THE GLOBAL steel industry is entering a defining decade where decarbonisation, energy transition, and competitiveness must move together rather than as separate priorities. For emerging economies like India, the challenge is particularly complex-balancing rapid steel capacity expansion with the need for lower emissions, stronger infrastructure, and long-term industrial resilience. Unlike developed markets, India's steel ecosystem must navigate both large integrated blast furnace operations and a highly fragmented secondary sector, each requiring very different transition pathways.

In this interaction with Steelworld, Mr. Atanu Mukherjee, Chief Executive Officer of M. N. Dastur and Dastur Energy, shares his perspective on practical decarbonisation pathways for steelmaking, the evolving role of coal, hydrogen, and renewables, the scalability of CCUS, and how policy and industrial systems must work together to create sustainable growth. His insights highlight the importance of moving beyond theoretical transition models toward solutions that are technically viable, commercially scalable, and aligned with India's industrial realities.

The global steel industry is under increasing pressure to decarbonise while maintaining competitiveness. From your perspective, what are the most viable pathways for reducing carbon emissions in steelmaking, particularly in emerging economies like India?

Decarbonisation in steel cannot be approached through a single global template; it must reflect the structure of each economy. In India, the industry is divided between integrated blast furnace-based steel, which accounts for roughly 55 percent, and a secondary sector of about 45 percent. The pathways for these two segments are fundamentally different.

For the integrated sector, the most viable approach is progressive decarbonisation of the blast furnace route. This includes improving burden quality, reducing coke rates, optimising PCI, recovering and utilising top gas, and, over time, integrating carbon capture. These are long-lived assets, so the objective is not replacement but systematic reduction in emissions intensity while preserving scale and competitiveness.

For the secondary sector, dominated by coal-based rotary kilns, the issue is more structural. These units are fragmented and emissions-intensive, and incremental improvements are not enough. The transition must move toward controlled reduction environments-specifically coal gasification to produce syngas feeding vertical shaft furnaces, supported by cluster-based infrastructure.

Where immediate replacement is not feasible, oxy-enriched and recycled gas kiln configurations can serve as interim solutions. Hydrogen-based steel will play a role in the future, but India's immediate priority is scalable and economically viable emissions reduction aligned with cost, competitiveness, and domestic resource realities.

Energy transition is reshaping industrial sectors worldwide. How do you see the role of coal, natural gas, hydrogen, and renewable energy evolving in the steel industry's transition towards low-carbon production?

It is important to recognise that what we call an energy transition is not usually subtractive. Historically, energy systems evolve in an additive manner-new energy sources are layered onto existing ones rather than fully replacing them. In that sense, this is better understood as an energy transformation. In steel, this is even more evident because it is fundamentally a thermochemical process.

Coal and coke in blast furnace-based pathways will remain central in India and much of Asia, but their role will evolve towards becoming more of an engineered reductant with efficient use, including gasification, oxygen enrichment, and eventual carbon management.

Natural gas plays an important role globally, but in India it is constrained by availability and price volatility and therefore cannot anchor the transition to gas-based direct reduction.

Hydrogen is strategically important, but its deployment depends on the economics of hydrogen-based reduction, availability of very low-cost clean baseload power, installed capital costs, hydrogen transport infrastructure, storage, and electrolyzer utilisation. It will scale selectively rather than uniformly and should be seen as a complement to other pathways. Renewables will expand significantly, but mainly as an enabler of cleaner electricity systems-supporting electric arc furnaces, auxiliary loads, and eventually hydrogen production.

The system does not move from one fuel to another; it becomes more layered, more integrated, less emissive, and more complex over time.

Technologies such as carbon capture, utilisation and storage (CCUS) and hydrogen-based steelmaking are gaining attention. How do you assess their practical scalability and economic feasibility, especially in real operating conditions?

There is a clear distinction between technical feasibility and system-level scalability.

CCUS is one of the most practical and underappreciated solutions, particularly for large integrated steel plants. Its adoption and economics improve significantly when deployed at cluster scale, where multiple industries share capture, transport, and storage infrastructure.

The next step is to treat CO_2 transport and storage as a policy-enabled regulated utility, similar to power or pipeline networks. Once this infrastructure has defined tariffs, access frameworks, and long-term liability structures, the economics become far more predictable and bankable. The challenge is not the technology itself, but policy, institutional design, financing, and coordination.

Hydrogen-based steelmaking is technically viable but remains economically constrained in most real operating conditions, particularly in India. It requires sustained access to low-cost hydrogen, reliable renewable power, and significant capital investment. Issues such as intermittency, utilisation, and total system cost become critical.

For the secondary sector, gasification-based syngas pathways offer a more immediate and scalable solution. They align better with the domestic resource base and can be progressively integrated with carbon management over time.

India is targeting significant growth in steel production alongside infrastructure expansion. What

structural or policy-level interventions are required to ensure that this growth remains both sustainable and globally competitive?

India needs to move from technology selection to system-level policy design.

First, the policy framework must explicitly recognise the dual structure of the industry, with differentiated pathways for integrated and secondary sectors.

Second, a cluster-based approach is essential. Shared infrastructure for gasification, oxygen supply, CO_2 transport, and logistics can significantly reduce the cost of transition and enable scale.

Third, CCUS must be developed as a regulated infrastructure utility. This requires frameworks for CO_2 pipelines, storage hubs, and shared access so that individual plants are not burdened with the full cost and risk.

Fourth, the secondary sector requires a structured transition pathway-from rotary kilns to gasification-linked systems-supported by financing mechanisms and phased regulatory standards.

Finally, enabling systems such as power quality and cost, raw material beneficiation, logistics, and industrial infrastructure must be strengthened. Without these, even well-designed decarbonisation strategies will struggle to scale.

Looking ahead, how do you see the iron and steel industry evolving over the next decade in terms of technology adoption, energy use, and global trade dynamics?

The next decade will be shaped by the interaction of technology evolution, energy transformation, and regional trade structure.

On technology, the global system will largely remain anchored in blast furnace production, which still accounts for roughly 70 percent of steel, but with increasing efficiency and gradual integration of carbon management. At the same time, electric arc furnace and DRI routes will expand where supported by natural gas abundance, scrap availability, energy systems, and economics. In India, this translates into a dual evolution-modernising the integrated sector while structurally transforming the secondary sector.

Regions that develop CCUS clusters as regulated utilities, along with shared energy and feedstock systems, will be able to decarbonise more efficiently and at lower cost.

On energy, the system will evolve in an additive manner. Coal, renewables, and eventually hydrogen will coexist within a more integrated framework. The shift will be toward how energy is used-moving from combustion and reduction to more controlled, efficient, and engineered systems. A key differentiator will be industrial infrastructure. Regions that develop CCUS clusters as regulated utilities, along with shared energy and feedstock systems, will be able to decarbonise more efficiently and at lower cost.

On global trade, steel is often described as a global commodity, but in practice it is regionally structured. East Asia dominates both production and intra-regional trade, while North America and Europe operate largely as internal markets. The Middle East is emerging as a strategic production and export hub.

India is structurally different. With most of its steel production consumed domestically, it remains a demand-driven system rather than an export-led one. Competitiveness will increasingly be defined by cost adjusted for carbon, energy reliability, and system resilience.

The winners will be those who align technology, energy systems, infrastructure, economics, and policy into a coherent and scalable industrial strategy.

M. N. Dastur and Dastur Energy have long been associated with engineering consulting and are now increasingly engaged in energy transition solutions. How are your current offerings evolving to address the changing needs of the iron and steel industry, and what areas will be the focus going forward?

Our work is evolving from traditional advisory to enabling integrated industrial transformation.

In the integrated steel sector, we focus on blast furnace optimisation, energy integration, material optimisation, and CCUS-ready pathways, including cluster-level infrastructure design and implementation.

In the secondary sector, we are working on structural transition pathways-from coal-based rotary kilns to gasification-linked systems-supported by detailed techno-economic analysis, financing frameworks, and execution strategies.

More broadly, we combine engineering, iron and steelmaking technologies, energy systems, carbon strategy, economics, and policy alignment to deliver solutions that are technically sound, economically viable, and commercially scalable.

The emphasis is always on implementation under real operating conditions, not just conceptual transition models. The objective is to help industry move from strategy discussions to practical execution. ■