

Zinc-Based Batteries — The Future of Energy Transition in India



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As India accelerates its clean energy transition, the demand for safe, affordable, and sustainable energy storage solutions has never been greater. While lithium-ion batteries have dominated the global conversation, alternative chemistries are beginning to take center stage, especially those aligned with India's unique climate, resource base, and economic priorities. Among them, zinc-based batteries are emerging as a game-changing option, offering not only superior safety and cost-effectiveness but also significant environmental benefits.

With India being the world's largest integrated zinc producer, the nation is uniquely positioned to leverage its abundant reserves for building a self-reliant and resilient energy storage ecosystem. Zinc batteries are non-flammable, non-toxic, and recyclable, with lifespans of up to 20 years—making them particularly suited for India's extreme weather conditions and long-duration backup needs. Beyond technology, their adoption can strengthen supply chains, reduce reliance on critical imports like lithium and cobalt, and generate large-scale employment through manufacturing and recycling clusters.

As global economies look for sustainable and inclusive energy solutions, zinc-based storage is steadily gaining momentum across renewable energy, telecom, defense, and even electric mobility applications. However, unlocking its full potential will require collaborative innovation, policy support, and rapid scaling of manufacturing capabilities.

In a recent interview, spoke with **Arun Misra**, CEO of **Hindustan Zinc**, and discussed how zinc-based batteries can redefine India's clean energy future, the country's progress in research and development, potential applications across industries, and the broader socio-economic opportunities they present.

What are the key advantages of zinc-based batteries over other batteries, particularly in the context of India's climate and resource availability? Could you elaborate on the safety, cost-effectiveness, and environmental benefits?

Zinc-based batteries are uniquely suited to India's needs, offering safety, affordability, and sustainability. With high power output, low maintenance, and lifespans of up to 20 years, they outperform conventional storage technologies. Unlike lithium-ion, zinc batteries are non-flammable, inherently stable, and reliable even in extreme climates.

From a cost perspective, India's abundant zinc reserves reduce dependency on expensive and geopolitically sensitive imports such as lithium and cobalt. This ensures a more secure supply chain and lowers production costs. Zinc batteries also provide exceptional corrosion resistance, 100% recyclability and operate efficiently across a broad temperature range, offering reliable backup power for extended durations. Their non-toxic, non-reactive components produce no hazardous fumes, reinforcing their safety profile.

With a greenhouse gas footprint up to six times lower than alternatives, zinc batteries strengthen India's energy security while advancing renewable energy and net-zero goals.

As the world's largest integrated zinc producer, how do you think India fares in terms of research and development on zinc-based battery solutions compared to some of the bigger economies?

India is emerging as a global leader in zinc battery research and development (R&D), supported by a strong production base and vibrant innovation ecosystem. With ambitious renewable energy targets, the nation needs scalable, cost-effective storage, and zinc batteries are well-suited for both grid and off-grid use. At Hindustan Zinc, we are partnering with leading institutions like IIT Madras and JNCASR Bangalore to develop next-generation zinc batteries that are durable, affordable, and scalable.

While countries like the United States have been pioneers in zinc battery research, zinc-based primary batteries have enjoyed a longstanding global presence, with stable chemistries in use since the 1800s. India's rich resource base, strong scientific talent, and

supportive policies enable rapid innovation. Partnerships with global leaders like US-based AEsir Technologies are driving advanced nickel-zinc battery solutions for defense, aerospace, renewable energy, and telecom sectors.

Indigenous development of these technologies will not only strengthen our supply chain but also deliver substantial savings for the exchequer. Nickel-Zinc, Zinc-Air, Zinc-Ion and Zinc Sulfur chemistries are among the promising variants advancing on our innovation horizon.

What are the most promising applications for zinc batteries in India, considering the country's specific needs and challenges?

Zinc-based batteries have immense potential to power India's clean energy ambitions across multiple sectors. Their long cycle life, intrinsic safety and high-temperature resilience make them ideal for renewable energy storage, grid stabilization, telecom towers, data centers, defense applications, three-wheeler vehicles and essential 5G networks. In electric mobility, zinc-air batteries present a transformative opportunity by offering a locally sourced alternative to imported lithium-ion cells.

Addressing India's unique environmental, economic, and energy needs calls for innovation, and zinc batteries deliver with unmatched stability and durability across diverse climates. By harnessing India's abundant zinc reserves, we can cut import dependence, reduce costs, and enhance energy security in line with Atmanirbhar Bharat. At Hindustan Zinc, we are championing this transformation by investing in meaningful R&D collaborations with academic institutions that focus on developing zinc battery technologies that are both cost-effective and scalable. This commitment positions India to build a world-class, self-reliant energy storage ecosystem for the clean energy transition.

Beyond the technical aspects, how can zinc-based battery manufacturing create jobs and boost economic growth in India, especially in the context of a "just transition" and skilling the workforce for green technologies?

The shift to zinc-based battery manufacturing offers far-reaching socio-economic benefits beyond environmental impact. These opportunities encompass a wide range of skilled and semi-skilled roles, including metal production, battery component assembly, quality assurance, equipment maintenance and operational management. The development of industrial parks and battery manufacturing clusters creates entire ecosystems involving product processing, component suppliers, logistics, recycling and specialty Small and Medium Enterprises (SMEs), which in turn generate a multiplier effect with vast indirect job creation. Strategic collaborations within the industry open pathways for highly skilled careers in material science, engineering and product innovation.

The circular economy potential of zinc battery recycling further promises sustainable, long-term job growth. Government initiatives such as the [Production Linked Incentive \(PLI\)](#) scheme underscore a firm commitment to develop integrated battery manufacturing hubs, potentially driving hundreds of thousands of jobs by 2030. Crucially, a 'just

transition' means reskilling India's diverse talent pool across various industries through focused training programs in assembly, maintenance and recycling. This approach ensures that the benefits of India's clean technology transformation are inclusive, fostering economic empowerment and driving regional development.

What is the biggest roadblock for widespread and faster adoption of zinc-based batteries?

The primary challenge lies in transitioning zinc-based batteries from promising prototypes to large-scale commercial production. Although research and innovation have progressed significantly, the necessary manufacturing facilities, standardized quality controls and robust supply chains for large-scale production are still being developed. That said, the landscape is evolving rapidly, driven by growing investment and focused industry efforts.

In India and globally, substantial investments supported by government incentives and strong industry partnerships are accelerating capacity expansion. Regulatory frameworks are adapting to zinc battery technology, streamlining certification and market entry. Given zinc's lower raw material costs, along with its inherent safety and environmental advantages, these challenges are well within our ability to overcome.

Overcoming them will require coordinated efforts that combine policy support, industry investment in manufacturing scale-up and continued technological innovation to enhance performance and reduce costs. With the right ecosystem and collaboration among key stakeholders, zinc-based batteries can move from niche applications to mainstream energy storage solutions faster than many anticipate, playing a critical role in powering India's clean energy transition.