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5 VOICES SHAPING A CLEANER FUTURE

INSIDE - INSIGHTS & IDEAS FROM
ACROSS THE CLEANTECH INDUSTRY

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Nitin Gupta

Co-Founder & CEO, Attero

Inside Attero's Push to Build a Technology-Led Recycling Ecosystem

*This interview with **Nitin Gupta, CEO and Co-founder of Attero**, explores the company's technology-led approach to recycling, critical mineral recovery, e-waste collection, and digital scrap sourcing. Nitin also discusses second-life batteries, black mass exports, domestic refining, and recycling's role in reducing India's critical mineral import dependence.*



1. Attero has been in this business since 2008, well before EPR rules and the critical minerals conversation brought recycling into the spotlight. What's changed most about the industry in the last two or three years — and what hasn't changed as much as you'd hoped?

The biggest change is that recycling is no longer seen simply as waste management. It is increasingly being recognised as a strategic industry linked to resource security, manufacturing and the energy transition. India generated around 5 million tonnes of e-waste in FY24, almost twice the level of FY14, with a recoverable economic value of around \$20 billion.

Technology has also moved rapidly. Attero has built proprietary processes for recovering more than 20 critical minerals, supported by more than **50 global patents and over 200 patent filings across markets**.

We are also using technology to address one of the industry's longstanding challenges: collection and sourcing. Through Selsmart, Attero is bringing technology into consumer collection and take-back, while MetalMandi is creating a more organised and transparent digital channel for sourcing and trading scrap.

Together, these platforms are helping bring greater visibility, traceability and organisation to the front end of the recycling value chain.

The opportunity now is to connect these technology-led collection and sourcing systems with advanced processing, so that the same level of organisation that exists within the recycling plant extends all the way to the point where material enters the formal recycling chain.

2. Where does your raw material actually come from? Could you break down your major supplier types and roughly what share of your volume each one contributes?

The industry largely sources material through aggregators, but Attero has taken a different approach by using technology to organise the collection and sourcing layer. Selsmart is our consumer-facing take-back platform, enabling individuals and businesses to dispose of e-waste through a formal, traceable channel. MetalMandi, our digital marketplace for scrap, connects suppliers and buyers and brings greater transparency to material sourcing, pricing and transactions.

Today, **around 85% of our material comes through MetalMandi, 8% through Selsmart and 5% directly from OEMs.** This means virtually all of Attero's collections are routed through transparent and traceable digital channels. The objective is to bring greater visibility and accountability to the front end of recycling, while creating a more organised supply chain for the materials we process.

3. How do commercial terms differ across these supplier categories — say, an OEM tie-up versus an aggregator versus the open scrap market?

Commercial terms are ultimately determined by market forces. They vary depending on the quality and composition of the material, volumes, consistency of supply, logistics and prevailing commodity prices. An OEM relationship may provide greater predictability and traceability, while open-market transactions are more directly exposed to daily price movements. At the end of the day, the economics have to work for the entire value chain.

4. Is consistency of supply — both in volume and in price — a serious operational challenge for you, or is it a non-issue?

It is something we manage as an inherent feature of the business, rather than an unusual operational problem. Both volumes and prices are determined by market forces. Our approach is therefore to diversify sourcing and improve visibility on availability, quality and pricing. Having multiple sourcing channels, including digital platforms, makes the business considerably more resilient than relying on any one channel.

5. Selsmart enables consumers to sell old electronics through a fixed-price, doorstep pickup model. How do you see Selsmart changing consumer behaviour around old electronics, particularly when it comes to moving e-waste from informal channels into more organised and responsible recycling streams?

The biggest barrier is often convenience and trust. People may know they should dispose of electronics responsibly, but the informal market has historically been easier to access.

Selsmart addresses that by making the formal route simple, with doorstep collection, transparent pricing, digital payments, secure data handling and traceability. The objective is straightforward: make responsible disposal at least as convenient as selling to an informal buyer.

6. MetalMandi is your digital scrap trading platform — sellers list scrap, see live AI-driven prices, and get doorstep pickup. How do you see MetalMandi helping formalise the scrap ecosystem and create greater efficiency and transparency for sellers, dealers and businesses?

The biggest weakness in the scrap ecosystem has traditionally been the lack of reliable information about price, quality, availability and demand. MetalMandi brings these elements onto a common digital platform. AI-driven price discovery, image-based quality assessment and supply visibility allow sellers to understand the value of their material and buyers to make more informed procurement decisions.

This is also an extension of what we have been building at Attero for years. Recycling at scale requires proprietary technology inside the plant, but it also requires technology outside the plant to create a reliable flow of material. MetalMandi is part of that larger technology stack, helping bring greater transparency and traceability to a highly fragmented market.

7. What's the current transaction scale on MetalMandi and Selsmart, and where do you expect both to be in the next couple of years?

MetalMandi has scaled rapidly since its launch in 2025. It has crossed two lakh downloads, has more than **1.1 lakh registered users** and over **50,000 monthly active users**.

The platform currently facilitates around **15,000 tonnes of scrap procurement a month** across more than 28 states and 100-plus cities, and Attero is targeting around ₹10,000 crore of annual revenue from the platform over the next five years.

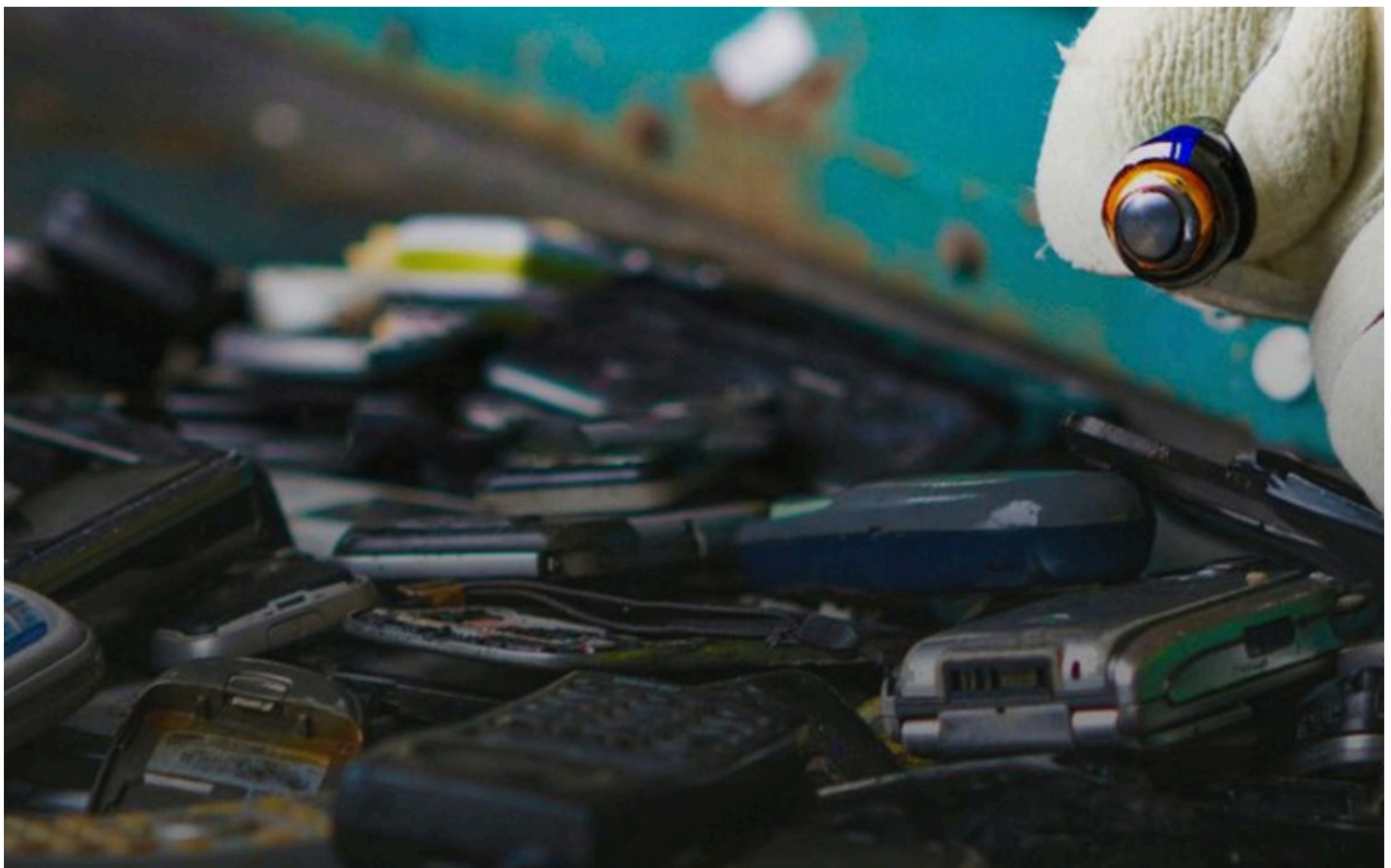


Selsmart registers more than 30,000 monthly orders and has a ₹100-crore revenue run-rate, with a stated target of 1.5 lakh monthly orders and a ₹500-crore revenue run-rate. The broader objective for both platforms is to build scale while bringing more of India's fragmented scrap and e-waste flows into organised channels.

8. Second-life use — repurposing batteries with usable capacity left into stationary storage instead of recycling them immediately — does that compete with recyclers for feedstock, or are the two complementary?

They are complementary. A battery that is no longer suitable for automotive use may still retain 70–80% of its original capacity and can potentially be used for stationary storage. The key is to assess its chemistry, degradation, thermal stability and safety before giving it a second life. Once it reaches the end of that useful life, recycling becomes the next step.

The important point is that second life should extend the useful life of the battery without delaying material recovery indefinitely. The most efficient model is first life, second life where technically and economically viable, and then recovery of the materials through recycling.



9. There's an active debate on curbing black mass exports. Domestic R3/R4 refiners say they can absorb all of it, while R2 dismantlers argue that overseas buyers pay better and recover more. Where do you stand, and what would a well-designed export policy actually look like?

Exporting black mass is counterintuitive to India's objective of building critical-mineral resilience. **Black mass is a valuable secondary source of lithium, cobalt, nickel and other critical materials**, and allowing large volumes of it to leave the country means exporting both the material and the opportunity to recover those minerals domestically.

The policy objective should therefore be to retain black mass in India and build sufficient domestic refining capacity to process it competitively. At the same time, the economics for R2 dismantlers cannot be ignored. If domestic offtake, pricing or refining capacity is inadequate, an abrupt export restriction could put pressure on the formal recycling chain and potentially push material towards informal channels.

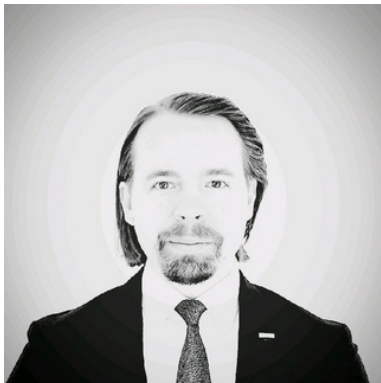
A well-designed policy should therefore combine a clear transition towards domestic processing with verified domestic refining capacity, transparent price and offtake benchmarks, quality and traceability standards, capacity audits and EPR-linked tracking. Export duties can also be used during the transition to progressively favour domestic processing without disrupting the supply chain overnight.

10. India has negligible domestic reserves of lithium, cobalt, or rare earths, and China dominates refining. How much of that import dependence can recycling realistically address over the next decade — and how much is honestly beyond what recycling alone can solve?

Recycling can make a meaningful contribution to reducing India's import dependence, but the impact will vary considerably by metal. **Based on Attero's assessment, recycling could meet around 20% of India's copper and aluminium demand, while the potential rises to around 55% for lithium carbonate and cobalt and as high as 70% for rare earth metals.**

The opportunity will increase as the installed base of electronics, batteries and EVs grows and more of these products enter the recycling stream. However, recycling has a time lag because today's products become tomorrow's feedstock.

It therefore **cannot replace primary mining, international resource partnerships** or domestic refining capacity. India's long-term critical mineral strategy will need to combine domestic resources, diversified global sourcing and urban mining, with recycling playing a much larger role in reducing import dependence.



Klas Engström

Sales Director, Nichicon

LTO Batteries: Bridging the Gap Between Supercapacitors and Lithium-Ion Batteries

*This interview with **Klas Engström at Nichicon** explores the company's shift into rechargeable LTO batteries, their advantages over conventional lithium-ion systems, and applications across IoT, asset tracking and wireless devices, while examining the technology's long-term potential and Nichicon's growth plans in India.*

1. Nichicon has a 75-year history rooted almost entirely in capacitor manufacturing, dating back to 1950. The SLB battery series, launched in 2019, marked a significant departure into an entirely new product category. What led the company to make that shift after so many decades in one line of business?

We have a very long history in capacitors, particularly aluminum capacitors, but Nichicon has also been working with supercapacitors for more than 30 years. What we developed starting in 2019 was a rechargeable battery that could fill the gap between supercapacitors and lithium-ion batteries.

With the growing number of IoT devices and the prospect of billions of devices being deployed, we saw this as an area of high importance. It also connects closely with our mission of focusing on sustainability and green technology. We saw an opportunity to provide an energy-storage solution that could support the growing IoT ecosystem.

2. Most lithium-ion battery types take their name from the cathode material — LFP, NMC and LCO, for instance — while the anode is typically some form of graphite or carbon. LTO batteries are the exception, named after the anode instead, since the graphite anode is replaced with lithium titanate oxide. Could you explain the reasoning behind that substitution and what advantages this combination delivers?

Our batteries are called LTO batteries, which stands for lithium titanate oxide. While the technology sounds similar to lithium-ion batteries, the technology is significantly different because of the electrode configuration. **This makes our batteries extremely low-resistance and very powerful, particularly at low temperatures. They are also capable of handling extremely high power and very high currents.**

Another important advantage is safety. You can **puncture these batteries, cut through them or even expose them to a torch** without the risk of fire or explosion associated with conventional lithium-ion batteries.

3. Much of the industry is focused on maximizing energy density - building smaller, more powerful batteries. Your battery takes the opposite approach, trading off energy density for other benefits. In which applications does that trade-off make your battery the clear choice?

It is true that our batteries have substantially lower energy capacity than lithium-ion batteries, but that is also where we want to be positioned. We are targeting the gap between supercapacitors and lithium-ion batteries. **Our key advantage is extremely high power density.** We have identified three main application areas.

The first is applications powered by energy harvesting. If an application is continuously harvesting energy from sources such as light, the amount of energy stored in the battery becomes less important because it can be replenished regularly. **What is important is having sufficient power density to provide the required burst current when needed.**

The second is applications that can be recharged very frequently. A restaurant pager is one example. It can go to a table, use some energy, return to the counter and then be fully charged before going out again. In such an application, high energy capacity is not necessarily required. A dentist's tool is another example. If the battery can run through one patient and then be fully charged within one or two minutes while waiting for the next patient, a large energy capacity is not necessary.

The third application is using our battery together with a larger primary battery. The primary battery provides the main energy storage, while energy is transferred to the LTO cell. When high current consumption is required, that current can be supplied by the LTO battery. This makes things easier for the primary battery and can extend its life, providing a better overall solution for the customer.

4. Your battery has been used in Samsung's Galaxy Note10 S Pen since 2019. What did the Nichicon LTO battery enable Samsung to achieve in the S Pen, and why was its combination of high power density and very small size important for enabling BLE communication with the phone?

I actually have the pen and phone here, and I still use them today. Before our solution, the pen could not communicate with the phone. What we made possible with the LTO battery was to place a very small energy-storage device inside the pen that was still powerful enough to support the burst current required for Bluetooth Low Energy (BLE) communication. So the key was high power density in a very small volume, allowing the pen to support the burst current needed for IoT-type communication with the phone.



5. Before your battery came along, the industry essentially had two options - a battery discarded once it dies, or one recharged a limited number of times before it eventually needs replacing. Would it be fair to say your battery is designed to eliminate both of those failure modes at once?

Yes. The idea is to provide a battery that can support applications over a much longer period and reduce the need for unnecessary battery replacement. Supercapacitors have been available for more than 30 years and can serve a similar purpose, but our LTO batteries provide substantially higher energy density. We can store perhaps eight times more energy than a supercapacitor, which allows the technology to be used in many more applications.

6. Let's put that into a real scenario, say a deployment of 10,000 field sensors. What's the actual operational difference between replacing batteries every two to three years versus not touching them for 15 years?

We imagine a future of having not 10,000 but billions and trillions of devices in the field, and even with an example involving 10,000 units, it doesn't make mathematical sense having to ever replace those batteries. The cost of replacing a battery once would be higher than the price Nichicon would charge for one LTO cell. The challenge is that the person making the decision about the initial investment is not necessarily the person responsible for the lifetime operating costs in the field. So while the mathematics are quite clear, the decision-making structure within companies can make it more difficult to adopt this approach.

7. Your SLB series is built on Toshiba's SCiB technology rather than something developed independently. What exactly does Nichicon contribute in that relationship, and what stops a customer from approaching Toshiba directly instead?

We use intellectual property rights from Toshiba and purchase our electrode material from Toshiba. We believe this is a very good setup because Toshiba has extensive capabilities in battery technology. There is a clear division between the two companies.

Nichicon serves the very small form-factor market, while Toshiba does not approach that market. Conversely, **Toshiba serves larger form factors**, such as battery blocks for trucks and buses, while Nichicon does not address that market.

Our experience in aluminum capacitors is particularly relevant to the smaller form factors. If you look at our LTO batteries, they resemble capacitors, and we benefit from our decades of experience manufacturing round, cylindrical, wound-foil products.

8. Nichicon runs a campaign called #Nomorebatteries, which is a bold statement for a battery company. How does the company make up for the recurring revenue that would normally come from replacement batteries, and how receptive have customers been to paying more initially?

It is a challenge because one person is often paying the initial bill, while another person is responsible for the lifetime cost in the field. From Nichicon's perspective, however, we have not been part of the battery market for a very long time. We entered this market in 2019, and we may have already sold more than 100 million batteries. For us, every newly sold battery represents additional business. We are happy to contribute to a more sustainable future where electronics can remain in use without being unnecessarily discarded and replaced many times

9. Looking at the broader lithium battery market, across consumer electronics, industrial logistics and shipping, energy storage systems, electric vehicles, retail and security - what share does LTO technology currently hold overall, what portion does Nichicon capture, and where do you see that standing by 2030?

We have delivered more than 100 million of our batteries to the market, but we are still at the very beginning of our business activities, so it is relatively difficult to forecast exactly where we will be by 2030. However, we expect substantial changes. **While we have so far sold 100 million batteries, if everything goes well, we could potentially reach a level of 100 million batteries per month in the far future.**

10. Asset tracking, smart pallets, wireless sensors and RFID form the backbone of modern supply chains. As India rapidly builds out its logistics and IoT infrastructure, where do you see the earliest real demand emerging? And separately, how significant is India as a market for Nichicon today, and what are your growth plans for the region?

Nichicon has been present in India for many years, and we see significant growth opportunities in the country. India represents a large part of the world's population and has many strong companies, so we see good potential for further growth.

Asset tracking is a good example of an IoT application where our technology fits well. These are small devices that need to operate for long periods while also supporting wireless communication that requires high burst currents.

That makes reusable asset trackers and rechargeable labels a good potential market for LTO batteries. It would be a different proposition for one-way labels that are disposed of after a single use, but for reusable labels and asset trackers that may be recharged, we see a strong application opportunity and are actively working in this area.



A. Prabhu

Executive Director – Technical (Global Operations) at Best Power Equipments (BPE)

Beyond the Tagline: Greenwashing in Energy & Storage

*This interview with **A. Prabhu, Executive Director – Technical (Global Operations) at BPE**, explores the engineering challenges of the clean energy transition, comparing lithium-ion and lead-acid systems, addressing greenwashing, and examining India's progress in domestic cell manufacturing.*

1. How would you define “greenwashing” in the context of the backup power and energy storage industry specifically? What does it look like when a company does it?

Greenwashing in backup power and storage means marketing devices as “clean” or “green” while ignoring their real footprint, making sustainability claims backed by limited data. It shows up as sustainability reports built on partial information, inflated efficiency ratings, and vague recycling plans. At BPE, credibility means backing every claim with transparent, robust processes, from specification through to result.

2. Lead-acid still dominates India's backup power market largely on cost grounds. As an engineer who has tracked this space for decades, how much of that is genuine technological and infrastructural lag, and how much is simply that the market hasn't yet demanded the shift?

Under RoHS declarations, corporates are increasingly reviewing the use of lead-acid batteries and their end-of-life disposal. Key devices such as mobile phones, computers, laptops, tablets, and many medical monitoring instruments have already moved away from lead-acid batteries under competitive pressure.

The power-backup market is gradually reducing the space it allows for lead-acid batteries, too, and that shift is likely to accelerate until very little room remains for them. *RoHS (Restriction of Hazardous Substances) restricts the use of specific hazardous substances in electrical and electronic equipment sold in the European Union to protect environmental and public health.*

3. What, in your assessment, separates a power-solutions company that is “renewable-ready” in messaging from one that is renewable-ready in actual engineering and supply chain?

The difference shows up in the details, not the tagline. A company that is renewable-ready in messaging talks about solar and battery integration in its brochures but sells hardware built around grid or diesel assumptions. One that is renewable-ready in engineering designs for variable input, bidirectional inverters and battery chemistries that handle deep cycling, and backs it with suppliers vetted for

sourcing and capacity. At BPE, we test that readiness against real solar and off-grid conditions, not just against spec sheets.

4. From your engineering background, what is the real-world performance and lifecycle gap between lithium-ion and lead-acid systems, and does that gap justify the premium pricing that is often used to position lithium-ion as the “sustainable” choice?

From an engineering perspective, the gap between lithium-ion and lead-acid batteries is quite significant. A lead-acid battery typically takes around 8–10 hours to charge, whereas a lithium-ion battery can be charged in as little as 30 minutes to a few hours, depending on the application. In fact, the EV revolution would not have been possible without lithium-ion technology.

Yes, **lithium-ion batteries cost around 1.3 times more upfront**, but they also deliver much higher value. They offer up to **95% usable capacity, compared to around 60% for lead-acid batteries, and last 10–12 years instead of just 2–3 years.**

From a sustainability standpoint, lithium-ion also has a clear advantage. It avoids the challenges associated with hazardous lead disposal, requires far fewer replacements over its lifetime, and is over 20% more energy efficient. So, if you look beyond the initial purchase price and consider performance, lifecycle, and environmental impact, lithium-ion is not really a premium choice; it is the more sustainable and economical one in the long run.

5. To what extent is the “Made-in-India clean energy” claim realistic for Indian industry today, given persistent cost sensitivity in corporate procurement and the nascent state of domestic lithium-ion cell manufacturing? What would substantive, genuine domestic capability actually require in terms of manufacturing depth, supply chain maturity, and policy support?

“Made-in-India clean energy” is still more ambition than reality. Under the Advanced Chemistry Cell Production Linked Incentive (ACC PLI), India targeted 50 GWh of lithium cell-manufacturing capacity, but only about 3% of that (roughly 1.4 GWh) had been commissioned within the timeline, with land acquisition largely complete for the rest. Commercial cell production from most beneficiaries is likely to come on stream only over the next year or two. In the meantime, cost-sensitive buyers continue to favour cheaper imported cells while domestic capacity catches up.

Real domestic capability would need three things: deep manufacturing know-how, meaning not just battery-pack assembly but actual cell production at scale; a mature supply chain for critical minerals and cell components; and sustained policy support, including tariffs and a dedicated critical-minerals scheme to protect and enable local manufacturers while they scale. At BPE, we stay upfront about this. We use Indian-made components where they are genuinely ready, and we don’t label something “Made-in-India” just because it is assembled here.

6. Which industries are expected to be the biggest demand drivers of “green power” over the next decade?

Commercial and industrial (C&I) users are expected to be the biggest demand drivers, for several good reasons: reducing polluting components, optimising resources, conserving energy, cutting carbon, and meeting CSR commitments, all pointing toward a trillion-dollar market. Backup power will also support highways as a fuelling source for electric vehicles and serve as a source of energy in isolated and disaster-recovery situations.

7. Where do you see the backup power industry in five years on this question: closer to genuine lithium-ion and renewable-first solutions becoming the norm, or still managing the gap between sustainability marketing and ground reality?

Five years out, I'd bet we're closer to lithium-ion and renewable-first becoming standard for new installations, not just a marketing layer. Battery costs keep dropping, and supply chains are maturing fast enough that “green by default” starts to make commercial sense, not only PR sense.

But the gap won't fully close: diesel-heavy legacy fleets stick around, and some companies will still dress up old tech in new language. At BPE, we're not waiting for the industry to catch up; we're building toward that lithium-first standard now.

8. What is BPE's current roadmap for transitioning legacy product lines, particularly UPS and storage batteries, fully toward lithium-ion?

BPE is guided by the principle of adopting newer technology quickly and putting it into delivery. Currently, the majority of our installations use lithium batteries, unless a customer specifically asks for lead-acid batteries.





Justin McNeal

CEO, Dakota Biochar

Turning Forest Waste into Biochar: Building a Clean Energy Business

*Interview with **Justin McNeal, CEO of Dakota Biochar**, explores converting forest waste into biochar, renewable power, and carbon credits, with applications across agriculture, livestock, and oil-field cleanup. It also covers pyrolysis, decentralized facilities, expansion plans, and the challenges of scaling biochar operations.*

1. You've described biochar as a way of turning waste into a valuable product. What exactly is biochar, and how is it produced?

Biochar has existed since the beginning of time. Human beings have always burned biomass, and the ash and carbon left over from that process are essentially what we call biochar. The key difference is that **biochar is produced by heating biomass without oxygen**. Normally, when you burn something, oxygen enters the system and combustion turns much of the material into smoke or ash. With pyrolysis, biomass is heated without oxygen. It is essentially cooked down into a charcoal-like material called biochar.

I saw a huge waste stream here in South Dakota and started addressing it. Now we are looking at waste streams across the country and installing technology to upcycle that waste into a valuable product while also generating renewable power.



2. What are the primary applications for the biochar you produce?

Historically, biochar has been used for water and air filtration. In South Dakota, agriculture is the biggest industry, so that was the market I wanted to address. We use biochar for **soil remediation and soil improvement**. We are also using it as an animal-feed supplement. Because biochar acts like a sponge, it can absorb unwanted substances in an animal's digestive system. Livestock producers are seeing higher nutrient uptake from feed while using less feed, which can help offset the cost of the biochar.

In Texas, we also use biochar for **oil-field cleanup**. In the event of an oil spill, the biochar can be used to absorb the material.

3. Can biochar replace fertilizer, or does it reduce the amount of fertilizer farmers need over time?

Our proposition to farmers is that biochar can help decrease their input costs. Biochar can remain in the ground for more than 100 years. We activate our biochar based on what the farmer is trying to grow. If they are growing corn or soybeans, for example, they would normally use nitrogen, phosphorus and potassium. Instead of simply spraying those nutrients onto the crop or soil, we can put them into the biochar and then incorporate the biochar into the ground.

The biochar binds those nutrients and retains them in the soil until the plant needs them. As the fertilizer is depleted, the farmer can add more, and the biochar can continue to retain it. In South Dakota, **farmers may spend roughly \$150 per acre on fertilizer, and with our product we are seeing that cost reduced to around \$100 per acre.**

4. You also generate electricity through the biochar process. How does that work?

The pyrolysis process generates a significant amount of heat. We capture that heat and send it through a **heat recovery steam generator**, which produces steam. The steam turns a turbine, the turbine turns a shaft, and the shaft turns a generator to produce electricity.

We generally use that electricity for **on-site needs rather than selling it to utilities**. Depending on the size and scale of the facility, our **biochar reactors generate less than 10 MW of power**. That is not enough to operate as a conventional utility-scale power generator, but it can power our equipment, an on-site microgrid, or a farmer's equipment. The idea is to create greater resilience by generating power closer to where it is needed rather than transmitting electricity over long distances.

5. How does your feedstock collection model work with timber companies and other sources of forest residue?

We have a crew that goes out and collects material because we are currently at a scale where we need to continuously feed the reactors. We also have a drop-off site where people can bring material, and we charge a certain price per ton to receive it. We then process the feedstock into a size suitable for our reactors.

For larger sites, such as a 100-acre area that needs to be cleaned up or thinned, we use large equipment capable of processing hundreds of acres of land in roughly a week.



6. How do you calculate the carbon emissions avoided through the production of biochar, and how do carbon credits fit into the business?

We generate **carbon credits, or carbon-offset reduction credits**, but there is a detailed auditing process involved.

Auditors look at the type of feedstock being processed and what would happen to it if it were simply left to decay. They then conduct what is called a **lifecycle assessment**, looking at the emissions associated with our process and subtracting those from the baseline emissions.

For example, if one ton of material would produce four tons of CO₂ if left to decay, and our process results in a net reduction of 2.5 tons, the calculation would result in 2.5 carbon credits per ton of material processed. Those credits can then be sold at the prevailing market rate.

7. Who typically buys the carbon credits you generate?

A number of countries have introduced policies requiring companies to offset their emissions, although the United States does not have a carbon exchange in the same way. European energy producers, for example, have requirements related to offsetting carbon emissions. Companies such as **Microsoft and United Airlines** have also stated that they want to reduce or offset their carbon emissions.

These companies can purchase credits from businesses like Dakota Biochar that are sequestering or offsetting carbon emissions.

8. What are the different revenue streams in your business model?

We have **four main revenue streams**.

First, we receive a **tipping fee** for collecting or receiving waste material.

Second is the **sale of biochar**, which we have developed into several different markets.

Third is **carbon-credit revenue** from selling the carbon credits generated through our process.

Fourth is **power-generation revenue**. We provide electricity to customers with on-site power requirements.

There can also be an additional opportunity from **waste heat**. For example, at a sawmill, we could provide heat for drying incoming wood. Cement and asphalt plants also have significant heat requirements, so excess heat can become another revenue stream.

9. Which of these revenue streams is currently the largest for Dakota Biochar?

Currently, **biochar sales** are our largest revenue generator. Part of that is because we have priced the product appropriately and built a market for it. There are many people giving biochar away for free, but a lot of producers do not test their biochar, so they do not necessarily know what they are producing.

We provide a **certificate of analysis with every lot**. We look at three major characteristics: ash content, volatile matter, and fixed carbon. We aim for very high fixed carbon—around 90%—with low ash and volatile matter. High ash can indicate oxygen entering the system, while high volatile matter can indicate that the material has not been heated for long enough.

10. What energy source do you use to generate the heat required for pyrolysis?

We initially start the reaction by **burning wood**, which provides the initial heat source. As the wood heats the reactor, the incoming feedstock begins to release what is called **synthesis gas, or syngas**. We recycle that syngas back into the system and combust it to create additional heat. So the process works as a **circular-loop system**, where the syngas produced during the process becomes part of the heat source.

11. Your business combines soil improvement, wildfire prevention, carbon removal, electricity generation and multiple revenue streams. What are the potential downsides?

One major concern is starting a fire. We operate in forests, where conditions can be very dry. When we grind large piles of material, a piece of metal passing through the grinder could create a spark. We are very conscious of that risk. I own the largest fire truck in the state to help combat potential fires. Another issue is that biochar can be applied incorrectly.

The worst thing it can do in the ground is nothing. If you apply biochar to an application where it does not belong, it may provide no benefit. That is why we have spent significant resources making sure our product is appropriate for the applications we target.

12. What is your long-term vision for Dakota Biochar?

I want to take Dakota Biochar **across the country**. We have identified **10 sites across the United States** where we plan to build facilities. We are not trying to become a manufacturer of biochar equipment. Instead, we want to solve the waste-stream problem wherever it exists. We started in South Dakota, and our next 10 sites are spread across the country. I have also set a goal of building **50 sites within the next three years**.

13. What kind of partnerships are you looking for to support that expansion?

I am looking for **joint-venture partners** who have access to land and feedstock. We bring the technology, systems, markets for the biochar, carbon-credit revenue opportunities, and the business model for operating the facility. The local partner would provide access to the resources and site needed for the operation.

14. You ran for the U.S. Senate earlier this year and campaigned on fiscal responsibility and reducing government overreach. Now, as a business owner yourself, how does Dakota Biochar reconcile that position with its reliance, or lack thereof, on government support such as carbon-credit policies, renewable-energy incentives and grants?

I stand tall on that. We have **not received any government assistance** in our process. Our business case works without government support, and we are providing a service to the Forest Service without costing the government money. That does not mean we have never applied for grants. We have applied for grants, but we have not received any of them. A grant is also different from a subsidy, and we do not have government tax credits or similar support. From my perspective, the grant process can allow a private business to address a problem at a lower cost than it might otherwise cost the government directly.

15. What is the one mistake you would advise startups entering the biochar business in India to avoid? Have your technology figured out and start small.

I started with a **market demonstration unit**. At our first site, we processed around 8,000 tons of material a year. It was not a huge amount, but it was enough to get started and learn.

The capital expenditure was much lower at that demonstration scale, and we learned a lot by operating the reactors and understanding the technology. Eventually, we found that the technology we needed did not exist in the marketplace, so we had to engineer and build what was required for our specific application.

I would recommend the same approach in India: start on a smaller scale, identify the problems and technical challenges, prove the concept, and then scale up. You could spend \$100 million trying to solve a problem, but I would rather solve the **\$1 million problem first** and then scale that solution once it works.

A lot of large projects spend huge amounts of money before discovering that the technology does not work as expected. So I would say: **start small, prove the concept, and then scale up.**



Pradyumna Gupta

Founder and Chief Scientist of Infinita Lab and Infinita Materials

Thermal Runaway Is Not Just a Cell Problem: The Missing Link in BESS Safety Testing

The article is authored by Dr. Pradyumna Gupta, Founder and Chief Scientist of Infinita Lab and Infinita Materials. In this article, he explores the importance of bridging materials science, reliability engineering, and system-level safety to enable more resilient and sustainable next-generation technologies.

In April 2019, the commissioning test of a battery energy storage system in Surprise, AZ, caused a thermal runaway event within the battery at the substation. This event ultimately caused an explosion, which injured four firefighters and demolished the installation. Every cell in that system had passed their respective certification testing. Every module had been validated under its respective requirements. System-wide propagation behavior had never been characterized, despite it being the most critical scenario.

This system failure is not a standalone incident. There have been numerous grid-scale battery energy storage fires within the U.S., South Korea, UK and Australia over the last six years. Battery fire frequency has a positive correlation with total installed capacity. Nearly every one of the post-fire investigation results follow the same pattern: Current cell and module certifications existed; however, the behavior of the system under propagating thermal event conditions was never characterized.

This is not a manufacturing defect; it is a testing design failure.

What the Standards Actually Test

The main stationary battery storage certifications in place — IEC 62619, UL 1973, and IEC 62933 — were built on an intuitive engineering idea — that if the building block is qualified, then the system built with that block is also qualified. Cell-level abusive testing consists of overcharge, over-discharge, external short circuit, crush, and thermal testing, among others. Module level qualification includes many of these for multi-cell systems. **UL 9540A attempts to include propagation testing for the modules and the unit-level device.**

However, **UL 9540A, even when conducted to its highest severity level, tests the propagation of thermal runaway across the limits of a test specimen, not a complete installed system.** This standard was never designed to characterize the transport of heat, gas and pressure in a given rack arrangement, with a given thermal configuration, at a given state-of-charge distribution, and no standard today allows for that.

Meanwhile, the devices that are being deployed are increasing in energy density and scale. A utility-scale BESS today could be tens of thousands of cells over hundreds of racks in a single enclosure. **It is not an engineering conclusion that component-level safety data scales linearly to system behavior; it is the fact that this testing framework has been carried forward, not overcome.**

Three Variables That Cell Tests Cannot Predict

Three parameters at the system level dictate thermal runaway propagation, and simply cannot be measured with current, standalone module testing methodology:

1. **Pack Geometry:** The way the modules are arranged thermally couples neighboring modules. Whether or not an event triggered by one cell becomes an adjacent module fire or a local, one-module runaway depends on such things as module spacing, orientation in the rack, path of airflow through the enclosure, distances between modules, and so forth. These are a function of installation not component specification. There is little information a design engineer can glean about the propagation risk of the qualified module placed in the 12th position of a forty-rack enclosure with a common cooling plenum by testing it individually in a calorimetric chamber.
2. **Thermal Management Design:** A design that utilizes active liquid cooling, passive air cooling, phase change materials or a hybrid system architecture reacts to the thermal output of an event in one of three ways; it could accelerate propagation, it could retard propagation or it could redirect propagation. **How a system designed to cool under normal operating conditions responds to a propagating thermal event is a system-level phenomenon and not something that can be deduced from module-level tests.**
3. **State-of-charge Distribution at time of failure initiation:** This is arguably the least understood. Cells that are at a higher SOC carry a greater amount of energy with them, and are therefore at lower temperatures with respect to an exothermic reaction threshold. In a practical system, cells in a pack will never be at uniform SOC.

Why Propagation Is a Systems Problem

Thermal runaway in a lithium-ion cell generates heat, a flammable gas, and potentially ejected material. The rate at which the cells adjacent to a runaway event subsequently enter runaway is determined by the heat transfer coefficient between cells, the thermal mass of intermediate structures and the time-temperature history of the original event.

No test of individual cells, modules, or unit-level UL 9540A data can predict this combination. In every case investigated by fire authorities for significant BESS incidents, the path of the fire followed the geometry of the enclosure and the cooling system rather than the chemistry of the cell. **The cell chemistry dictated what can occur, while the system determined what occurred.**

What This Means for Procurement and Deployment

The downstream result of this divide is that asset owners, utilities, and project developers are making deployment decisions using certifications that don't describe the system they are installing's actual risk profile.

Without understanding how propagation behaves in a specific system configuration, it is impossible for an underwriter evaluating BESS facilities to accurately underwrite probable maximum loss. A fire department preparing a pre-incident plan will be ineffective if the only data points available are module datasheets.

Treating Safety Testing as a Systems Discipline

What should not be done is abandoning cell and module certification. That process has real, valuable uses. What should be done is institutionalizing system-level propagation characterization as a distinct and mandatory step in BESS qualification, with the same level of rigor used for component testing.

This means performing propagation testing at scale appropriate to system size using the rack geometry and thermal management configuration of the actual installation. It means characterizing initial-event scenarios across the range of operating SOC, not just at design conditions.

The most important shift, then, is conceptual: the safety of BESS must be viewed as a system property, not as a cell property. The same cells, configured within two different system designs, can have widely different risk profiles for thermal propagation.

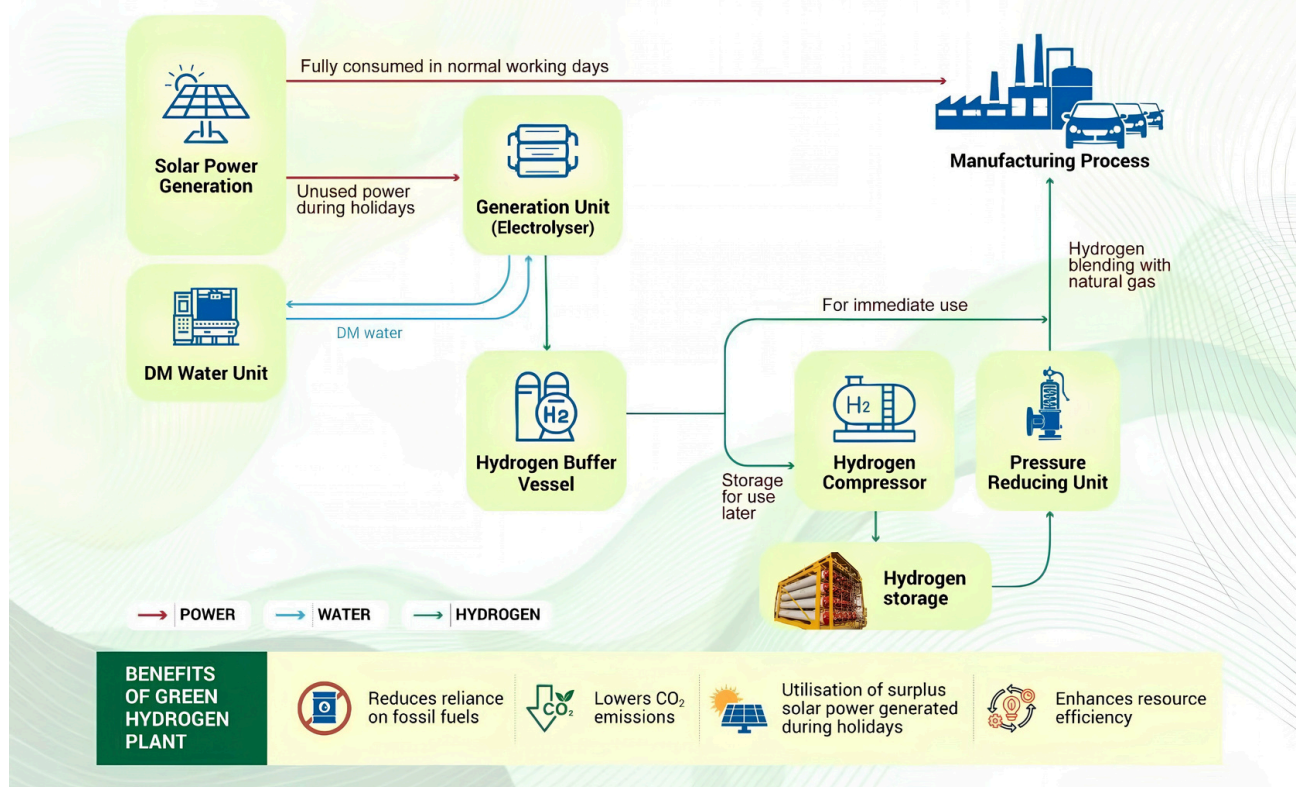
A runaway does not occur with the start of ignition. A runaway occurs when the test program failed to describe the system that was supposed to be tested.



Maruti Suzuki Commissions 300 kW Green Hydrogen Electrolyzer Plant at Manesar



Thematic diagram of Maruti Suzuki's Hydrogen Electrolyzer project



Maruti Suzuki India Limited has commissioned a **300 kW Green Hydrogen (GH₂)** electrolyzer plant at its **Manesar facility** as a pilot project to explore the use of green hydrogen in manufacturing operations. The initiative supports the company's efforts to integrate renewable energy into its production processes.

The green hydrogen produced will be blended with natural gas and used as process fuel in manufacturing operations. Solar energy generated at the Manesar facility during holidays will be used to produce and store hydrogen for subsequent use.

Based on the learnings from the pilot project, Maruti Suzuki plans to scale up green hydrogen adoption across its manufacturing facilities in Haryana and Gujarat, supporting the integration of cleaner energy sources into its manufacturing operations.

Investments & Project Financing

CleanMax has raised **₹2,500 crore** through green non-convertible debentures (NCDs) on a private placement basis.



The proceeds will be deployed toward renewable energy projects under its Green Bond Framework, with IFC, NABFID and IIFCL among the anchor investors.



AMPIN Energy Transition has secured an investment of up to **\$100 million** from Norfund under the Norwegian Climate Investment Fund. The funding will support C&I and utility-scale renewable projects, energy-transition businesses and manufacturing expansion.

Brookfield will invest up to **\$600 million** in ACME Cleantech Ventures to support the development and construction of green molecule projects. The investment will cover projects across India and the Middle East and marks Brookfield's entry into the regional green molecules sector.



Shakti Pumps has invested **₹11 crore** in its wholly owned subsidiary, Shakti Energy Solutions. The subsidiary is establishing a 2.20 GW solar DCR cell and PV module manufacturing plant in Pithampur, Madhya Pradesh.

SMBC Group has reached financial close on **JSW Energy's** 210 MW hybrid wind-solar project in Maharashtra. SMBC acted as Mandated Lead Arranger, Underwriter and Bookrunner, along with several other financing roles. The transaction is SMBC's first project finance deal with JSW Group's renewable energy platform.



Projects, Contracts & Tenders



Waaree Clean Energy Solutions is entering India's specialty gases business by setting up a plant at GIDC Saykha, Dahej, Gujarat. The facility will produce gases such as UHP ammonia, hydrogen, oxygen and phosphine/hydrogen mixtures for semiconductor and solar cell manufacturers.

KP Group has received a **₹2,025 crore** turnkey EPC work order from NACOF Orja for a 500 MW/550 MWp solar PV project in Bikaner, Rajasthan. The project forms part of NACOF's planned 5,000 MW solar PV power park and is scheduled for completion within 12 months.



Jakson Solar has secured a 75 MW solar module order from BluPine Energy.

The order will support the deployment of additional solar power capacity as part of India's renewable energy expansion.

Oswal Pumps has secured an order from TGREDCO for the design, supply, installation and commissioning of rooftop solar PV systems across 9,937 government schools in Telangana.

The **46.7 MW** project is valued at ₹273.19 crore, excluding GST, and includes five years of comprehensive maintenance.



Saatvik Solar has secured a **600 MWp** solar module supply order from SECI, valued at **₹1,041.63 crore**.

The scope covers manufacturing, testing, packing, supply and transportation of domestically manufactured solar PV modules using domestic solar cells.

Jain Irrigation Systems has received a Letter of Empanelment from MSEDCL for the supply and installation of 5,000 off-grid DC solar water pumping systems across Maharashtra.

The empanelment is valued at ₹117.96 crore, including GST, with project completion scheduled within 60 days.



h2e Power Systems has entered into a long-term partnership with YonderH2 to deploy IGBT rectifiers across green hydrogen and green molecule projects.

The partnership includes a purchase order for Power Grid's 1 MW green hydrogen micro-grid pilot project in Neemrana, Rajasthan.

Powertrac Group has signed an order agreement with Sunka Lead for a **10 GWh BESS** production line in Gujarat.

The facility will include automated container fabrication, robotic assembly, AGV-based material movement, inspection and testing systems.





GK Energy has received a Letter of Award from **MSEDCL** to set up **150 MW/300 MWh** of BESS capacity in Maharashtra.

The project will operate under a 15-year agreement at a tariff of ₹2.38 lakh per MW per month.

MoUs, Strategic Partnerships & PPAs

Adyant Renewables has signed a **50 MW** wind PPA with **SECI**, marking SECI's first C&I Power Purchase Agreement in India.

The agreement will support renewable energy procurement for commercial and industrial consumers.



CleanMax and **Nuvoco Vistas** have partnered for a **46.4 MW** wind-solar hybrid project in Bhikamkhore, Rajasthan.

The project includes 20 MW wind, 26.4 MWp solar and 2 MWh BESS under a group captive structure.

Fourth Partner Energy has partnered with Ghaziabad Precision Products to supply **2.33 million units** of solar power annually.

The renewable electricity will be supplied from FPEL's Babina solar plant in Uttar Pradesh to support GPP's manufacturing operations.



GREW Solar and **Caelux** have signed a **4 GW**, five-year commercialization partnership for Hybrid-Tandem solar modules.

The companies are targeting commercial production by 2028, combining Caelux's Energy Producing Glass with GREW Solar's N-Type TOPCon technology.

LR Energy has signed a PPA with Omega Bright Steel for a **6 MWp DC/5 MW AC** captive solar project in Haryana.

The project will supply renewable electricity to Omega Bright Steel's operations and reduce its reliance on conventional power.



Premier Energies and RCT India have signed a binding term sheet to establish a **12 GWh** BESS manufacturing facility in Telangana.

The first phase is planned at 6 GWh, with the facility targeting commercial, industrial and utility-scale energy storage markets.

Recyclekaro and **Uzbekistan's Technological Metals Complex** have agreed to establish a joint venture facility in Uzbekistan for e-waste and end-of-life lithium-ion battery recycling.



The facility will initially focus on critical mineral recovery, with plans to expand into e-waste and battery processing across Central Asia.



PETRONAS Lubricants India and **Tata Motors** have signed an MoU to establish a used automotive lubricant collection and recycling model.



The pilot will cover Maharashtra and Tamil Nadu, with recovered lubricants processed into re-refined base oil through registered recyclers.

Commissionings, Acquisitions & Milestones



Adani Green Energy has expanded its Khavda BESS capacity in Gujarat to 6.63 GWh, making it the world's largest single-location BESS installation. The capacity was achieved within 14 months of construction, with AGEL accounting for more than half of India's operational BESS capacity.

KP Group has signed a binding offer to acquire **100% equity** in ALFANAR Energy and Netra Wind at an enterprise value of approximately ₹2,410 crore. The companies own a combined 507.9 MW of operational wind projects in Gujarat, which sell power to SECI under 25-year PPAs.



UltraTech Cement's Kukurdih Cement Works in Chhattisgarh has met 100% of its electricity requirement through green energy every month since April 2026. The 3.3 MTPA facility uses renewable power and Waste Heat Recovery Systems to meet its electricity needs.

Servotech hosted Navaarambh 2026, bringing together more than 300 channel partners from across India.

The company launched three products: Sparkle Pro IP54 Hybrid Inverter, Sparkle Elite IP65 Hybrid Inverter and an Advanced Micro Grid Inverter.



Delta Renewable Energy Technologies has commissioned a 17.60 MW AC/24.64 MW DC solar power project in Tamil Nadu.

The company's total installed solar capacity has now reached 24.6 MW AC/34.44 MW DC, including its 7 MW AC plant commissioned in December 2025.

Premier Energies has commissioned its **7 GW** N-type TOPCon G12R solar cell facility at Naidupeta, Andhra Pradesh. The ₹3,293 crore facility takes the company's total solar cell capacity to 10.6 GW and incorporates digital and AI-based manufacturing technologies.



Torrent Power has commissioned **322 MWp** of decentralized solar projects across 50 locations in 14 talukas of Nashik district, Maharashtra. The projects will supply solar power to agricultural feeders under the MSKVY framework, supporting daytime electricity supply for farmers.

Sunkind Energy has commissioned a **42 MWp** solar park in Chhattisgarh, adding another renewable energy asset to its portfolio. The project will contribute to clean electricity generation and expand the company's renewable energy presence in India.



Juniper Green Energy has fully commissioned a **75 MW** wind-solar hybrid project, including the final 10 MW of wind capacity. Following the commissioning, the company and its subsidiaries have an aggregate operational capacity of approximately 2,604 MWp and 500 MWh of BESS.

Onix Renewable is conducting regular Toolbox Talk sessions at its **54 MW** wind project in Western Gujarat. The latest session covered lifting practices, snakebite awareness, biological hazards and manual handling to support safe project execution.



Hylenr Technologies has reported new experimental findings involving rare-earth signatures and unusual heat generation from its hydrogen-based reactor technology. The findings were presented at ICCF-27 and form part of the company's ongoing work on LENR-based decentralised power systems.

Torrent Power has commissioned **322 MWp** of ground-mounted decentralized solar projects across 50 locations in Nashik, Maharashtra. The projects are backed by 25-year PPAs with MSEDCL and will supply electricity to agricultural feeders under MSKVY 2.0.



SPML Infra has completed international safety, performance and transportation certification and testing for its proprietary 104.4 kWh battery pack. The system has completed requirements under multiple UL, IEC and UN standards at the battery-pack and system levels.

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