Can torrefaction make biomass reliable, energy-dense fuel?

14 August 2026 | Interviews

In an exclusive AgroSpectrum interview, Sampath Subramaniam, Director, PYROGREEN Energy Pvt Ltd, explains why feedstock aggregation, logistics, heat recovery, contracted offtake and ash valorisation will determine whether torrefaction can move from technology promise to commercial scale

In this **exclusive AgroSpectrum interview, Sampath Subramaniam, Director, PYROGREEN Energy Pvt Ltd**, examines why India's torrefaction opportunity must be viewed beyond the reactor and through the lens of biomass logistics, fuel standardisation and commercial offtake. He argues that torrefaction can convert dispersed agricultural residues into a denser, more consistent and transportable energy commodity, but technology alone cannot overcome weak feedstock aggregation or uncertain markets. The discussion takes a sharp look at the economics of biomass, emphasising delivered energy cost in Rs/GJ, plant availability, energy yield and long-term offtake rather than headline capacity or simple Rs/tonne comparisons. It also explores whether torrefaction gases and process heat can be integrated to reduce external energy requirements and improve project economics. A significant part of the conversation focuses on ash valorisation, challenging the industry to treat ash not automatically as waste but as a potentially valuable input for construction materials, soil amendments and selective mineral recovery, subject to rigorous characterisation.

Subramaniam also stresses that contamination control must begin at the feedstock level, with segregation and analytical testing determining whether ash can enter higher-value applications. The interview ultimately makes a compelling case for an integrated biomass model—combining aggregation, torrefaction, heat recovery, standardised fuel production and ash valorisation—as the pathway for converting India's vast but fragmented biomass resource into a commercially bankable and resource-efficient energy platform.

Can torrefaction transform biomass from a low-density, heterogeneous fuel into a consistent, coal-like energy commodity, and is the economics strong enough to support large-scale adoption?

Yes, with an important qualification. Torrefaction can transform biomass into a substantially more consistent, hydrophobic and energy-dense solid fuel, but the economics depend heavily on feedstock cost, logistics and the value of the final product. Raw agricultural biomass has several disadvantages: high moisture, low bulk density, poor grindability, biological degradation during storage and significant variation in composition. Torrefaction removes moisture and a fraction of low-energy volatile components, increasing the relative fixed-carbon and energy content. The resulting material is easier to store, transport, grind and co-fire. It would not describe torrefied biomass simply as 'coal replacement'. It is better considered an engineered solid biofuel whose properties can be designed around the end user's requirements.

The economics become attractive when three conditions occur together: low-cost locally available biomass, efficient recovery/use of torrefaction gases for process heat, and a premium market with reliable demand such as power-plant co-firing, industrial boilers, cement plants or selected metallurgical applications. India's current biomass co-firing policy also creates an important demand-side driver. The Ministry of Power's November 2025 policy provides for biomass pellet co-firing and, in specified circumstances, MSW-derived torrefied charcoal in coal-based thermal power plants. Large-scale adoption is possible, but not through torrefaction technology alone. It requires an integrated biomass supply chain and a contracted offtake market.

What is the real bottleneck for commercialising torrefaction in India: feedstock aggregation, technology efficiency, energy consumption, product quality, or the absence of a reliable market for torrefied biomass?

It would be ranked the bottlenecks approximately as: feedstock aggregation and logistics, reliable product offtake and pricing, process energy efficiency, product consistency, and only then reactor technology. India does not fundamentally lack biomass. The challenge is that biomass is geographically dispersed, seasonal and often contaminated with soil or other materials. A large theoretical surplus does not automatically translate into an economically recoverable feedstock supply. Transportation of low-density raw biomass can quickly destroy project economics. Torrefaction has an important logistical advantage because it upgrades and densifies the material before longer-distance transport.

The second major issue is the buyer. A plant should not be built first and then ask who will buy the torrefied product. Product specification and plant design should start with customer requirements for calorific value, moisture, ash, sulfur, chlorine, particle size, bulk density, grindability and ash behaviour. Therefore, it is visualized as the strongest Indian model as distributed biomass aggregation, regional torrefaction hubs and standardized fuel supplied to large, contracted consumers. The biggest bottleneck is not 'torrefaction technology'; it is building a reliable biomass-to-market supply chain.

Ash is often treated as a waste liability, but could systematic ash valorisation turn it into a revenue stream through soil amendments, cementitious materials, or nutrient recovery and which applications are commercially closest to scale?

Absolutely. Ash should not automatically be treated as waste. The key is to stop treating 'biomass ash' as one generic material. Rice-husk ash, bagasse ash, wood ash, coconut-shell ash and other agricultural-residue ashes can have very different chemistry and therefore very different value propositions. The closest commercial opportunity is generally construction materials, especially where a consistent, mineral-rich ash can be qualified as a supplementary material or silica-rich feedstock. This route benefits from the enormous scale of the construction-materials market.

Second is soil amendment and nutrient recovery. Clean biomass ash can contain useful calcium, potassium, magnesium and phosphorus. However, agricultural use requires stronger contaminant control and product qualification than many construction applications.

Third is higher-value mineral recovery such as silica, potassium, phosphorus, calcium or magnesium compounds. This can be attractive for selected ashes, but the economics depend on recovery yield, reagent consumption, purification requirements and the value of the recovered product.

A practical commercial ranking is therefore: construction materials first, soil amendment/nutrient products second, and specialized mineral recovery third, with the ranking changing according to ash chemistry. Ash becomes a product only after chemistry, consistency and end-use specifications are matched. The first step is ash characterisation, not processing.

How can operators control contaminants, alkali metals and heavy metals in biomass ash to ensure that valorised ash is both technically useful and environmentally safe?

The cheapest way to control ash contamination is upstream: prevent unsuitable feedstock from entering the plant. Feedstock quality control is therefore more important than downstream treatment alone. It would require establishing a feedstock acceptance protocol covering source, moisture, ash, chlorine, sulfur, major alkali metals, heavy metals, soil contamination, plastics/PVC contamination and treated-wood contamination. Feedstocks should also be segregated. Clean woody biomass can follow a high-value ash route; rice husk can be directed toward silica-oriented applications; and contaminated or mixed waste-derived material should follow a separate pathway.

Each commercial ash stream should be periodically tested for major elements such as Si, Al, Fe, Ca, Mg, Na, K, P, S and Cl, and trace metals such as As, Cd, Cr, Pb, Hg, Ni, Cu and Zn. Depending on the end use, pH, electrical conductivity, leachable metals, particle size, mineral phases and ash-fusion behaviour may also be required. Processing: screening, magnetic separation, washing/leaching, drying, grinding/classification or stabilization should be selected only after the final product specification is known. Washing, for example, should not be automatic if it destroys the economics of an otherwise suitable construction-grade ash. Control contamination through feedstock segregation first, analytical verification second, and targeted ash treatment third.

Could an integrated model combining torrefaction, heat recovery and ash valorisation significantly improve the overall carbon and economic performance of biomass plants, and what metrics should investors use to judge such projects?

Yes. An integrated model is more compelling than a stand-alone torrefaction plant. The plant should be designed around the entire material and energy balance: biomass enters, useful heat is recovered from drying and torrefaction gases, a standardized solid fuel is produced, and the ash is characterized and directed toward an appropriate value-added route. Instead of a one-product model, biomass to torrefied fuel with waste ash, the objective should be a multi-output model: engineered solid fuel plus recovered process heat plus potentially valuable ash products.

The investor should examine not only tonnes of product but also energy yield, delivered energy cost, logistics savings and plant reliability. The most useful commercial comparison is often Rs./GJ delivered to the customer rather than Rs./ton alone. Carbon performance should likewise be measured on a system basis: fossil fuel displaced, process energy consumed, transport emissions, avoided residue burning where demonstrable, and the net greenhouse-gas benefit of the final product pathway. The project should be evaluated as an integrated biomass resource platform, not merely as a torrefaction reactor.

Investor Metrics: What Should Be Measured?

Metric	Why It Matters	Recommended Focus
Raw biomass delivered cost (**Rs** /t)	Determines the basic feedstock economics	Secure supply contracts and realistic collection/transport costs

Torrefied product selling price (**Rs** /t)	Defines the primary revenue stream	Prefer contracted offtake with specification-linked pricing
Net process energy consumption	Shows whether external fuel/electricity is eroding margins	Maximise internal use of torrefaction gases and recovered heat
Mass yield and energy yield (%)	Shows how much material and original energy remain in the product	Optimise for the customer's required fuel quality, not maximum mass yield alone
Delivered energy cost (**Rs** /GJ)	Allows fair comparison with coal and other fuels	Use customer-site delivered cost, not only factory-gate Rs /t
Bulk density and grindability	Directly affect logistics, handling and co-firing	Measure against the target customer's handling system
Ash content and ash quality	Influences fuel acceptance and creates either a disposal cost or secondary revenue	Characterize each feedstock/ash stream separately
Ash valorisation revenue (**Rs** /t ash)	Can convert a disposal liability into a second revenue stream	Match ash chemistry to the highest-value practical application
Plant availability (%)	Determines actual annual production and revenue	Evaluate demonstrated continuous operating performance
CAPEX per annual tonne	Shows capital efficiency	Compare plants on actual annual output, not nameplate capacity
EBITDA per tonne	Captures the real operating margin	Include feedstock, energy, labour, maintenance and disposal costs.
Net COâ??e avoided per tonne	Measures climate performance and supports ESG/carbon-value assessment	Use a transparent system boundary and independently verifiable assumptions
Payback / IRR	Summarizes investment attractiveness.	Stress-test feedstock price, product price, yield and plant availability

The recommended integrated business model starts with biomass aggregation close to the source, supported by strict feedstock acceptance and segregation protocols. Pre-processing and drying should be designed around the actual seasonal moisture profile, followed by continuous torrefaction with high internal heat recovery and controlled residence time. Torrefaction gases should be combusted or recycled to minimise external process-fuel requirements. The torrefied product should then be standardised according to customer-specific fuel specifications, rather than being designed around a generic “coal-like” target.

Ash streams should be kept separate based on feedstock and chemistry, with analytical qualification determining their suitability for construction materials, soil and nutrient applications, or mineral recovery. Long-term offtake agreements should be secured before commissioning large-scale capacity, reducing market risk and aligning plant design with customer requirements. Finally, project economics should be evaluated using delivered Rs/GJ, energy yield, plant availability and net COâ??e benefit, alongside conventional Rs/tonne metrics, to assess the true commercial and environmental performance of *the integrated model.*

--- Suchetana Choudhury (suchetana.choudhuri@agrospectrumindia.com)