

Co-Processing Revenue Chains

Green-Energy Products and Critical Minerals — Millions of Tons per Year

Products

- *Biocoal* for baseline heat and power, all sustainable, low-cost green energy.
- *Biocoke* for green EAF steel, ferrosilicon refining, pig iron smelting.
- *Biochar* for soil amendments, improved crop yields, water and air filtration.
- *Bio-oil* for fuel, powering electrolyzers for green hydrogen, roadway slurry and asphalt.
- *Pyrolysis oil* for chemical feedstocks, SAF, DME, diesels, phenols and plastics.
- [GRC88®](#) marine fuel for ships, island power generation, data centers, and peak shaving.
- *Rare Earth Elements (REEs)* and critical minerals recovered in bulk from red mud through PIPE™ co-processing — magnetite (converted from hematite), titanium dioxide, residual alumina, copper, silica.

Feedstocks

Sustainable wood fiber from domestic and worldwide feedstocks, suitable for carbonizing with Permanente's patented and proprietary technologies.

- Forest silviculture thinning, whole trees, snags, off-spec species, logging residue (slash: tops, limbs, butts, root balls), sawmilling and panel-processing residuals (hog fuel) and waste outputs from processing of trees including bark, slabs, planer shavings, chips, sawdust, trim ends and edgings, sander dust.
- Fire- and bug-killed trees, standing or down, culled dead wood, future forest wildfire fuel, clearing of firebreaks, roadways, power-line rights-of-way, and large brush.
- Urban industrial and consumer wood waste including all types of construction wood residues, recycled wood from industrial fabrication, forming, crating, pallets, boxes, fences, cabinets, frames, millwork residues, solid wood trash.
- Urban green waste with sufficient solid wood from land clearing, removal of all tree types including palm trunks and fronds, pruning, large brush removal, ground or chipped.
- Industrial recycling of treated woods including railroad ties, crossarms, power and transmission poles, decks, dock piles, foundations, bridge timbers, cooling towers.
- Agribusiness by-products from orchard removal, trees, orchard trimmings, pruning, branches, limbs, trunks, ground or chipped including agribusiness waste biomass such as shells, pits, hulls, straw, stalks, stover, gin trash, bagasse and cultivated grasses.

More than four billion tons of red mud — the bauxite-refining residue — are stockpiled worldwide, with another 175 million tons added each year. PIPE™ reactor co-processing with cellulosic biomass neutralizes red mud's caustic alkalinity against the acidity of biomass pyrolysis — without added reagents — making rare-earth and critical-mineral extraction viable and simultaneously generating both energy and mineral revenue streams.