

A Sustainable Green-Energy Platform for Industrial Scale

Patented Technologies for Converting Cellulosic Biomass and Red Mud into Competitive, Carbon-Neutral Fuels and Critical Minerals

1. Executive Summary

Permanente Corporation (“Permanente”), based in Houston, has built a patented and proprietary processing platform that converts abundant, low-cost waste cellulosic biomass — and, in co-processing configurations, bauxite-process red mud — into a family of competitive, sustainable, carbon-neutral green-energy products and into commercially recoverable quantities of rare-earth elements and other critical minerals. At the heart of the platform is the patented PIPE™ reactor, which obsoletes every other carbonizing technology in use today and enables output volumes measured in millions of tons per year. Permanente’s products compete with conventional petroleum hydrocarbons and fossil fuels on a pure cost basis, *without subsidy* of any kind — while also qualifying, where applicable, for federal carbon-removal incentives including the Section 45Q Carbon Oxide Sequestration Credit.¹

The platform’s sustainability profile is not an afterthought or a marketing veneer; it is structural. Permanente’s solid and liquid fuels are carbon-neutral in combustion and carbon-negative in manufacture. Its soil-amendment biochar sequesters approximately 2.8 tons of CO₂ per ton applied, effectively forever. Its co-processing of cellulosic biomass with red mud simultaneously solves the alumina industry’s largest legacy waste problem and unlocks a domestic revenue stream of rare-earth elements that national-security and critical-supply-chain policy has designated as strategically essential. And all of this is fed by an abundant resource — U.S. waste cellulosic biomass — that the U.S. Department of Energy has determined can sustainably provide 1.1 to 1.5 billion tons per year under mature-market conditions.²

Three generations of visionary, global, entrepreneurial, value-added forest-products expertise stand behind the Permanente platform, carried forward by the Seidner family of inventors in the form of the PIPE™ reactor, the GRC88® family of green-energy products, and a patent portfolio of issued U.S., Canadian, and European patents, with additional patents pending.³

¹Internal Revenue Code § 45Q (Credit for Carbon Oxide Sequestration). See [26 U.S.C. § 45Q \(Cornell Legal Information Institute\)](#), and IRS Form 8933 instructions, [Carbon Oxide Sequestration Credit](#).

²U.S. Department of Energy, Bioenergy Technologies Office, *2023 Billion-Ton Report: An Assessment of U.S. Renewable Carbon Resources* (March 2024), finding that the United States could sustainably produce 1.1–1.5 billion tons of biomass annually in a mature market. Available at <https://www.energy.gov/articles/doe-releases-report-outlining-how-america-can-sustainably-produce-more-one-billion-tons>.

³The PIPE™ reactor platform and related processing methods are protected under the Permanente Corporation patent portfolio, which includes U.S. Patent No. 9,758,738 B2, *Green Renewable Liquid Fuel* (Google Patents), U.S. Patent Nos. 10,961,459, 11,345,860, 11,674,086, and 12,595,340 B1; Canadian Patent No. 309645 and Canadian application 3,280,527 (pending); and European Patent EP3841184, *Method for Production of a Renewable Liquid Fuel* (EPO Register at register.epo.org), together with additional U.S. and foreign patents pending.

2. The Technology Platform — The PIPE™ Reactor

The patented PIPE™ reactor operates as a horizontal version of a refinery cracking tower, configured as a pipe-in-pipe radiator that gives cellulosic feedstock the extended process path and dwell time required for clean, complete conversion. Recycling heat-transfer fluids propel, torrefy, and pyrolyze biomass at controlled temperatures ranging from 350°C to 850°C.⁴ With very few moving parts, the reactor enables continuous, precisely controlled time, temperature, and feedstock flow, drawing its process heat from perpetually self-generating syngas produced inside the reactor itself. The result is industrial-scale, sustainable throughput — measured in millions of tons per year — from a platform that obsoletes every legacy carbonization technology against which it competes.

Torrefaction by Permanente

Torrefaction by Permanente is a ten- to twenty-minute, lower-temperature (approximately 300°C to 350°C) pre-pyrolysis process that “cooks” cellulosic biomass in the PIPE™ reactor under controlled time and temperature to yield high-energy-dense biocoal, biocoke, biochar, wood vinegar, and biocarbon — all through a continuous process in an oxygen-free environment. The reactor’s serpentine horizontal radiator configuration accepts a wide range of cellulosic feedstocks and delivers industrial volumes that can exceed 400,000 tons per year per reactor.

Pyrolysis by Permanente

Pyrolysis by Permanente is the gasification of cellulosic biomass and torrefied biocarbon in the PIPE™’s second-stage oxygen-free environment at higher temperatures (approximately 500°C to 850°C) under controlled time and temperature. The process produces syngas, biochar, and a pyrolysis bio-oil condensed from a major portion of the syngas. A portion of the syngas is used as a self-generating recycled heating fuel to perpetuate both torrefaction and pyrolysis, so that once the process begins, no other fuels are required. Excess heat can be used to generate further heat and power; excess syngas and condensed bio-oil feed the liquid-fuel side of the platform.

3. The GRC88® Product Family — Sustainable Solids and Liquids

From a single PIPE™ platform, Permanente produces a coordinated family of green-energy and carbon-negative products branded under the GRC88® name. Each product is engineered to substitute directly into existing industrial infrastructure — power plants, blast furnaces, marine engines, soil programs — without requiring special-purpose machinery, equipment, or capital-intensive conversions by the customer.

GRC88® Biocoal — Lower in Cost Than Fossil Alternatives

Permanente biocoal is a clean, drop-in solid fuel that blends or burns seamlessly with coal. It is hydrophobic, low-moisture, and low-ash, with a heating value of approximately 12,500 BTU/lb — delivering roughly 33% to 62% greater energy density than Powder River Basin (PRB) coal

⁴Conventional torrefaction is conducted at 200°C to 300°C and conventional pyrolysis at 500°C to 850°C. See Ohio State University Extension, *Torrefaction: Upgrading Biomass to “Green Coal”*, available at <https://ohioline.osu.edu/factsheet/fabe-6603>. Permanente’s PIPE™ reactor operates torrefaction at approximately 300°C to 350°C in a ten- to twenty-minute cycle and pyrolysis at 500°C to 850°C in a second stage, with per-reactor throughput exceeding 400,000 tons per year.

across its published range,⁵ yet containing no sulfur, no heavy metals, and no toxics. It competes dollar-for-dollar with coal on an energy basis, requires no special-purpose machinery or equipment, and provides a sustainable, carbon-neutral energy solution for existing power and industrial boilers.

GRC88® Biocoke — A Green Alternative to Metallurgical Coal

Produced through a newly patented process that first highly densifies woody biomass and then carbonizes it, Permanente biocoke yields a strong, high-fixed-carbon, low-ash shaped fuel that substitutes directly for, or blends with, coked fossil metallurgical coal in blast furnaces for pig-iron smelting and supports electric-arc-furnace (EAF) production of green steel.

GRC88® Biochar — Soil Amendment and Carbon Sink

Refined from a soil-amendment tradition more than a thousand years old, Permanente biochar is a rich, low-cost amendment that enhances nutrient and moisture retention, rebuilds depleted soils, and increases crop yields by as much as 20%.⁶ Each ton of biochar applied to the soil sequesters approximately 2.8 tons of CO₂ — effectively forever.⁷ Fresh from the PIPE™ reactor, pristine biochar additionally provides modest direct-air-capture sorption of CO₂ — approximately 6% of its mass under typical conditions — contributing further to its negative-emissions profile prior to soil application.⁸ Conventional biochar has historically been too scarce and too expensive to realize its potential; Permanente's PIPE™ reactor makes biochar available in massive bulk quantities at sharply reduced cost, with sustainability benefits that compound for the life of the soil into which it is placed.

GRC88® Bio-oil and Marine Fuel — A Drop-In for a 330-Million-Ton Market

Slow-pyrolysis catalyzed syngas from the PIPE™ reactor is condensed into bio-oil suitable for further refinement into higher-grade liquid green fuels and chemical feedstocks. Bio-oil is the primary ingredient of GRC88® marine fuel: a carbon-neutral, drop-in viscous colloidal suspension of bio-oil, pyrolysis oil, and nano-particle-sized energy-rich biocarbon — a formulation that is the patented technical basis of GRC88®'s energy density and commercial economics. GRC88® contains no sulfur, no heavy metals, and no toxics; it is engineered for use in heat-and-power boilers and in low-speed two-cycle marine diesels, and it delivers energy density on par with No. 6 Residual Fuel Oil and Bunker C.⁹ GRC88® blends with heavy marine

⁵Wyoming State Geological Survey, *Wyoming's Coal Geology*, reporting Powder River Basin (PRB) subbituminous coals ranging from 7,710 BTU/lb to 9,410 BTU/lb, averaging 8,580 BTU/lb. <https://main.wsgs.wyo.gov/energy/coal/coal-geology>. Permanente biocoal at approximately 12,500 BTU/lb is supported by Permanente Corporation internal product testing. Applied across the published PRB range, Permanente biocoal delivers approximately 33% greater energy density than PRB coal at its high end (9,410 BTU/lb), and approximately 62% greater than PRB coal at its low end (7,710 BTU/lb).

⁶S. Jeffery et al., meta-analyses of global biochar field trials report average crop-yield increases of approximately 13–25%, with higher responses in acidic and tropical soils. See K. Schmidt et al., *Biochar in Agriculture — A Systematic Review of 26 Global Meta-Analyses*, GCB Bioenergy (2021), available at <https://onlinelibrary.wiley.com/doi/10.1111/gcbb.12889>.

⁷International Biochar Initiative, [Why Biochar](#). The IPCC AR6 (2022) recognizes biochar as a carbon-dioxide-removal pathway with global potential of approximately 2.6 GtCO₂ per year. Industry consensus places carbon sequestration at approximately 2–3 tons CO₂ per ton of biochar applied.

⁸Pristine biochar exhibits measurable CO₂ adsorption attributable to its high surface area and microporous structure. Reported pristine-biochar CO₂ uptake is on the order of 68 mg CO₂ per gram of biochar (≈ 6% by mass) under controlled conditions. See [“Biochar-based materials in environmental pollutant elimination, H₂ production and CO₂ capture applications.” Biochar \(Springer, 2023\).](#)

⁹Energy density of No. 6 Residual Fuel Oil (Bunker C) is approximately 17,400 BTU/lb (lower heating value) and approximately 124,000–150,000 BTU per gallon. See U.S. Forest Products Laboratory, [Fuel Value Calculator](#).

fuels at approximately 30% less cost on a BTU-for-BTU basis and meets or exceeds the no-sulfur, non-polluting marine-fuel regulations of the International Maritime Organization.

4. **Densification — The Newly Patented Force Multiplier**

On April 7, 2026, the United States Patent and Trademark Office issued U.S. Patent No. 12,595,340 B1, covering Permanente's novel technology for value-adding waste cellulosic biomass through ammonia treatment and densification.¹⁰ Invented by the father-and-son team of the Seidner family of inventors, this mobile, modular, and scalable technology materially extends the reach of the Permanente patent portfolio and multiplies what the PIPE™ platform can economically do with every ton of cellulosic biomass it processes.

A PIPE™ reactor configured for densification operates as a closed-loop system for liquid anhydrous ammonia penetration treatment with full recovery and recycling of ammonia gas. Inside the reactor, the process reconfigures the molecular, chemical, and mechanical structures of cellulosic biomass: the hydrogen bonds of lignin — the natural binder of all cellulose fiber — are broken, plasticized, and reformed, producing a mechanically compressed cell structure of the desired shape, permanently reformed with no spring-back memory. The reformed fiber emerges with markedly improved strength, hardness, durability, dimensional stability, fire retardancy, and cosmetic appearance.

The density of most wood fiber can be more than doubled, with a proportionate increase in strength and a reduction in cubic volume. From there, the densified fiber may be torrefied with higher efficiency through a second PIPE™ reactor stage into biocoke, biocoal, or biochar, or pyrolyzed into syngas and condensed into bio-oil for production of GRC88® marine fuel.

Application Benefits

Permanente's densification technology unlocks four immediate, measurable application areas. First, it addresses the wildfire and forest-health crisis: California alone holds hundreds of millions of tons of dead and dying standing fiber and waste forest residues across the Sierra Nevada and North Coast,¹¹ all of which can be reconfigured into sustainable building products, carbon-neutral green energy, and CO₂ sequestered as biochar — converting a public-safety burden into financially beneficial products for energy and utility. Second, it obsoletes conventional wood pellets: North America produces and exports over twelve million metric tons of conventional wood pellets per year at approximately 7,800 BTU/lb, while Permanente's densified, reshaped, and carbonized fiber briquettes and cubes deliver approximately 12,500 BTU/lb — roughly 60% greater energy density —¹² with lower shipping costs, higher power-plant efficiency, no special handling, and cleaner combustion. Third, it turns forest-management costs into revenue by making waste-fiber valorization economically attractive at industrial scale.

¹⁰U.S. Patent No. 12,595,340 B1, issued April 7, 2026; full record available via USPTO Patent Public Search at <https://ppubs.uspto.gov/pubwebapp/>.

¹¹California's wood-waste crisis is well documented. Krieger et al., *Characterization of the woody biomass feedstock potential resulting from California's drought*, Scientific Data (2020), report approximately 95.1 million bone-dry tons of standing-dead biomass from 2012–2017 California tree mortality alone. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6978512/>. See also Net Zero California, [Addressing California's Wood Waste Crisis](#).

¹²U.S. Energy Information Administration, [Monthly Densified Biomass Fuel Report](#). Combined U.S. and Canadian North American wood-pellet exports exceeded 12 million metric tons in 2024; see USDA Foreign Agricultural Service data via [Biomass Magazine](#). Wood-pellet heating value is conventionally reported in the range of 7,600–8,900 BTU/lb; Permanente densified carbonized briquettes and cubes at approximately 12,500 BTU/lb therefore deliver roughly 60% greater energy density.

And fourth, it creates structural lumber and green-energy fuel from juvenile fast-growth fiber that today has no market — a winning proposition for the sustainable forest cultivator and for the green-energy user alike.

5. Co-Processing for the Valuable Extraction of Rare-Earth Elements

Permanente has filed patents covering a uniquely important application of the PIPE™ platform: the simultaneous, industrial-scale co-processing of waste cellulosic biomass with the highly alkaline bauxite residue known as red mud. This single technology step advances two sustainability agendas at once. It solves the alumina industry's largest legacy waste problem — and it unlocks, for the first time at commercial scale, the cost-effective extraction of the rare-earth elements, magnetite, titanium dioxide, and residual alumina that red mud has always contained but has stubbornly failed to yield.

Red mud is the waste residue of bauxite processing into alumina by the Bayer process, through which virtually all of the world's aluminum is produced. Over decades, more than four billion tons of red mud have accumulated globally, the vast majority sitting in containment ponds and impoundments, with only a small fraction reclaimed or valorized. Red mud is extremely alkaline (pH 10–13) and environmentally hazardous when mismanaged; mismanaged red mud has caused fatal industrial accidents and long-term environmental damage. Buried inside this global waste stream is a strategic opportunity: red mud typically contains up to 40% to 50% iron oxide — principally hematite — alongside meaningful quantities of titanium dioxide, residual alumina, copper, and rare-earth elements including scandium and yttrium.¹³

With rare-earth elements now designated as critical minerals in the United States and prioritized under national-security and critical-supply-chain policy, attention has turned decisively to red mud as a potential domestic source.¹⁴ Yet despite decades of research and multi-year, multi-million-dollar European and U.S. programs, red mud's valuable mineral content has remained too costly to extract at scale — until now.

Inside the closed-loop, oxygen-free torrefaction and pyrolysis environment of the PIPE™ reactor, carbonizing biomass is initially acidic. When biomass and red mud are introduced together, that acidity offsets red mud's alkalinity, and both extremes are neutralized within the process itself. Simultaneously, under engineered time and temperature exposure, an oxygen molecule migrates from the carbonizing biomass to the hematite in the red mud, converting it to magnetite. Magnetite, unlike hematite, can be quickly and cost-effectively removed from the red mud matrix by magnetic separation — creating an immediate revenue stream and, crucially, leaving behind a dramatically cleaner substrate from which titanium dioxide, residual alumina, copper, and rare-earth elements can be extracted by conventional means. Alternative methods of creating magnetite from hematite in red mud are costly, chemically hazardous, high-

¹³Multiple authoritative sources place global accumulated red mud in excess of four billion tonnes. See *Green steel from red mud through climate-neutral hydrogen plasma reduction*, Nature (2024), <https://www.nature.com/articles/s41586-023-06901-z>, and Rio Tinto, [Rehabilitating Red Mud](#). On average, approximately 1 to 1.5 tonnes of red mud are produced per tonne of alumina refined. Iron content in red mud typically runs up to 40–50% by weight, with meaningful quantities of titanium dioxide, residual alumina, and rare-earth elements (including scandium and yttrium).

¹⁴U.S. Geological Survey, [2022 List of Critical Minerals](#). See also the European Commission's multi-year RemovAL and ReActiv programs targeting rare-earth-element recovery from bauxite residue via [Horizon Magazine \(European Commission\)](#).

temperature in operation, and largely ineffective at commercial scale. Permanente's approach obsoletes them.¹⁵

The economic result is a double revenue stream that extends well beyond the conversion of low-value waste cellulosic biomass into valuable green-energy fuels and sustainable decarbonization activity. On the biomass side, the economic uplift from waste cellulosic feedstock to finished green-energy product is projected at more than 10X processing cost. On the red mud side, what has historically been a perpetual, uncapped waste-management expense for alumina refiners becomes instead a vital and valuable perpetual revenue stream projected at not less than 10X, and as much as 20X, the ongoing waste-management cost. For the aluminum industry, red mud converts from liability to asset. For the United States and its allies, a strategic stockpile of critical minerals — long considered economically inaccessible — becomes economically accessible at last.

6. GRC88® Marine Fuel — The Sustainable Drop-In

Global marine petroleum-hydrocarbon fuel consumption is approximately 330 million metric tons per year and increasing, burned by approximately 100,000 commercial vessels worldwide.¹⁶ The proposed marine-sector alternatives — methanol, ammonia, and LNG — are not energy-dense by volume and typically require newbuild vessels, allowing shipowners to defer meaningful emissions action. No cost-competitive marine biofuels exist today at scale: global marine biofuel production from vegetable oils amounts to less than 0.3% of the marine sector's total energy use, and there will never be enough vegetable oil to provide the needed green-fuel feedstock.

GRC88® liquid green-energy fuel from cellulosic biomass can be made and distributed at approximately 30% less than the cost of conventional marine fuels — *without subsidy of any kind* — and it meets or exceeds the no-sulfur, non-polluting marine-fuel regulations of the IMO 2020 sulfur cap and the EU FuelEU Maritime framework.¹⁷ Its combustion is carbon-neutral; its manufacture is both carbon-neutral and carbon-negative. GRC88® is a drop-in, not a newbuild — which means it can decarbonize the global bunker market at its existing scale, immediately, at lower cost than the fuel it displaces.

¹⁵Competing processes for producing magnetite from red mud typically require high-temperature pyrometallurgical treatment (above 600°C) or pure-grade precursor materials, at high operating and capital cost. See NSF Industry-University Cooperative Research Center achievement summary, [An Economically Viable Process to Recover High-Value Products from Red Mud](#), reporting approximately 46% lower operational costs and approximately 52% lower capital costs than competing magnetite-recovery processes, with substantial additional upside from the recovery of scandium, yttrium, aluminum, and titanium. Value-multiple projections (approximately 10X on biomass feedstock cost and 10X to 20X on ongoing red mud waste-management cost) are drawn from Permanente Corporation internal economic analysis and process modeling.

¹⁶U.S. Department of Transportation Maritime Administration (MARAD), [Techno-Economic Analysis and Life Cycle Assessment](#), reporting annual global marine fuel consumption of approximately 330 million metric tons and increasing with rising maritime trade volumes.

¹⁷IMO Resolution MEPC.305(73) (2018) established the IMO 2020 sulfur cap, limiting marine fuel sulfur content to 0.50% m/m outside Emission Control Areas (0.10% inside ECAs). The EU FuelEU Maritime regulation (Regulation (EU) 2023/1805) took effect January 1, 2025, establishing declining GHG-intensity limits for energy used on board ships and phasing shipping into the EU Emissions Trading System. See [Ship Universe, Marine Diesel and Alt Fuel Prices](#). Marine fuel pricing benchmarks: High Sulfur Fuel Oil (modern successor to Bunker C for scrubber-equipped vessels) averaged approximately \$450–\$550 per metric ton in 2024–2025; Very Low Sulfur Fuel Oil averaged approximately \$535–\$665 per metric ton; vegetable-oil-based marine biofuel blends have historically priced at \$900 per metric ton and above.

7. Why the Opportunity Has Been Open

The legacy U.S. forest-products industry and its international counterparts have operated for decades under narrow margins, high capital and operating costs, and cyclical demand dependent on lumber, pulp, and paper markets. Interest rates and financing cycles have repeatedly stymied the creative vision that would otherwise redirect waste forest feedstocks toward higher-value energy applications. Juvenile fiber, logging slash, and waste agribusiness by-products have gone unused at industrial scale because the technology to convert them economically did not exist — and because the organizations best positioned to change that chose not to. Permanente created GRC88® because the forest-products industry lacked vision and could not, and the legacy bunker-fuel industry lacked motivation and would not.

8. A Foundation of Three Generations

Three generations of global, entrepreneurial, value-added forest-products expertise stand behind Permanente's technology platform. That heritage — carried forward by the Seidner family of inventors — enabled the vision, engineering discipline, and persistence required to invent, validate, and commercialize a sustainable, low-carbon alternative to fossil fuels and conventional carbonization, and to extend the same platform into critical-minerals recovery. The result is a family of bioenergy products and a co-processing methodology produced from abundant, low-cost, waste woody biomass, waste agribusiness by-products, and industrial waste residues — secured by multiple U.S. and foreign patents and ready for industrial deployment today. Permanente's ambition is not incremental: it is to make sustainable carbon reduction and environmentally protective economic practices flourish together, at the scale at which both are actually needed.