Permanente's Newly Patented Densification Technologies

Applications and Benefits of US Patent 12,595,340 B1

Permanente Corporation ("Permanente"), the Houston-based developer of the patented PIPE™ reactor platform, is pleased to announce the issuance of U.S. Patent No. 12,595,340 B1 on April 7, 2026,[1] covering Permanente's novel and revolutionary technology for value-adding waste cellulosic biomass through ammonia treatment and densification. Invented by the father-and-son team of the Seidner family of inventors, this mobile, modular, and scalable technology has broad national and global application, and it materially extends the reach of Permanente's existing patent portfolio.

How the Process Works

A Permanente 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.[2]

Why It Matters — Applications and Benefits

Permanente's densification technology unlocks immediate, measurable value across four major application areas:

- **Resolving the Wildfire and Forest-Health Crisis** — Logging slash leaves waste fiber on the forest floor, where it endangers forest health and feeds catastrophic wildfires. Diseased and dead trees are left standing because they have no economic value. 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.[3] All of this fiber should

[1]U.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/. This patent further extends the Permanente patent portfolio, which also includes U.S. Patent Nos. 9,758,738 B2, 10,961,459, 11,345,860, and 11,674,086, together with foreign and pending counterparts.

[2]U.S. Patent No. 9,758,738 B2, *Green Renewable Liquid Fuel*, assigned to Permanente Corporation. Available at: https://patents.google.com/patent/US9758738B2/en.

[3]California'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 (lower bound 26.2 million BDT). Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6978512/. See also Net Zero California, Addressing California's Wood Waste Crisis, noting that "hundreds of millions of dead and dying trees litter the Sierra Nevada and North Coast alongside millions of tons of residues that have already been piled and left to decay."

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be reconfigured into building products, sustainable carbon-neutral green energy, and CO_2 sequestered as biochar — turning today's fire-and-life-safety burden into financially beneficial products for energy and utility.

- **Obsoleting Conventional Wood Pellets** — North America produces and exports over twelve million metric tons of conventional wood pellets per year.[4] Wood pellets are low-energy-density (approximately 7,800 BTU/lb) and require specialized dry-bulk handling. They are obsolete. Permanente's densified, reshaped, and carbonized fiber briquettes and cubes deliver approximately 12,500 BTU/lb — roughly 60% greater energy density than conventional wood pellets —[5] while reducing shipping costs, increasing power-plant efficiency, requiring no special handling, and burning cleanly. They are lower in cost to process and to distribute, and they substitute seamlessly into existing infrastructure.
- **Turning Forest-Management Costs Into Revenue** — Value-adding waste fiber through Permanente's technology overcomes the historical economic barriers to removing and managing forest waste. What has long been a public-safety expense — borne by landowners, utilities, and taxpayers — becomes, for the first time, a revenue stream of energy and utility products produced at industrial scale.
- **Structural Lumber and Green Energy from Juvenile Fiber** — Engineered wood products are at demand capacity, and pulp-and-paper mills are closing. Millions of tons of juvenile fast-growth trees are left without a market each year, jeopardizing the economics of future cultivation. Permanente's treatment of juvenile fiber creates utility as structural lumber, while the processing by-product becomes green-energy fuel. This is a winning proposition for the sustainable forest cultivator and for the green-energy user alike — a path along which sustainable carbon reduction and environmentally protective economic practices can flourish together.

[4]U.S. Energy Information Administration, Monthly Densified Biomass Fuel Report, reporting U.S. wood-pellet production of approximately 10.7 million metric tons in 2024 and exports of 10+ million metric tons in 2024 and 2025. Combined U.S. and Canadian North American wood-pellet exports exceeded 12 million metric tons in 2024; see also USDA Foreign Agricultural Service data via Biomass Magazine, USDA: US Wood Pellet Exports Top 10 Million Metric Tons in 2024.

[5]Wood-pellet heating value is conventionally reported in the range of 7,600 to 8,900 BTU/lb depending on grade and species, with the lower-grade utility-export pellets that dominate North American export volume falling toward the lower end of that band. See U.S. Forest Products Laboratory, Fuel Value Calculator, and Pellet fuel (Wikipedia summary of industry sources). Permanente densified, reshaped, and carbonized fiber briquettes at approximately 12,500 BTU/lb are supported by Permanente Corporation internal product testing.

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