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FACT SHEET: California's Wood-Based Bioeconomy

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What is a Wood-Based Bioeconomy?

California's bioeconomy includes renewable products made from a variety of biomass sources — forest, agricultural, and urban wood. Agricultural sources include processing byproducts such as fruit pits, nut shells, and hulls, while urban sources include tree trimmings and construction wood waste.

This fact sheet focuses specifically on forest-derived woody biomass, which comes from:

- ***Forest residues***: branches, treetops, and other non-merchantable logs left after logging or forest thinning.
- ***Sawmill byproducts:*** wood chips, sawdust, and bark produced during lumber manufacturing.
- ***Small-diameter understory trees:*** often removed to reduce wildfire risk and improve forest health.

These forest-derived resources can be converted into renewable fuels, engineered wood products (e.g., mass timber and panel products, such as particle board and veneer for plywood), biochemicals, and soil amendments like biochar, helping to offset fossil-based products across energy, construction, agriculture, and manufacturing sectors. In doing so, reliance on fossil fuels is reduced, forests can become healthier, wildfire risks are diminished, and rural economies are strengthened.

Wood Bioeconomy Products

Bioenergy and Biofuels

Woody biomass can be converted into various forms of biofuels such as wood pellets (solid), renewable natural gas and hydrogen (gas), and oil (liquid). These fuels and products provide heat, electricity, and transportation energy while reducing fossil fuel use.

Engineered Wood Products

Mass timber is one example of a large, engineered wood component created by bonding multiple layers of solid wood together for strength and stability. Other engineered wood products include mass plywood, laminated veneer lumber (LVL), cross-laminated timber (CLT), glued laminated timber (GLT or glulam), and dowel laminated timber (DLT). Engineered fiberboard products, which play important roles in the construction industry, include medium-density fiberboard (MDF), oriented strand board (OSB), parallel strand lumber (Parallam or PSL), and laminated strand lumber (Timberstrand or LSL). These products promote eco-friendly, fire-resilient, and earthquake-resistant building solutions as well as serve as long-term carbon sinks by storing carbon for decades or centuries.

Biochemicals

Wood can be broken down into various constituents that are further refined into valuable products. Examples include phenol for resins, lignin for biopolymers and carbon fiber, plant-based plastics for containers, and cellulose for textiles and medical products.

Soil Amendment

Soil amendments are materials added to improve soil health and boost plant growth. Wood can be converted into carbon-rich biochar through pyrolysis. Biochar improves soil fertility, aeration, and water retention, creating a better environment for roots. Its porous structure supports beneficial microbes, makes nutrients available to plants, neutralizes acidic soils, and boosts crop yields.

Key Terms and Definitions

Bioenergy and Biofuels: *Energy or fuels made from woody biomass.*
Bioproducts and Biochemicals: *All non-fuel materials made from woody biomass, including wood products and chemicals.*
Pyrolysis: *A method of heating biomass at 400°C–700°C with no oxygen, used primarily to produce biochar.*
Gasification: *A method of heating biomass at 700°C–1,000°C with limited oxygen, used primarily to produce syngas for energy.*
Biochar: *A charcoal-like product created by heating woody biomass through pyrolysis.*
Syngas: *A "synthesis gas" mixture; a combustible fuel produced during high-temperature biomass conversion processes like pyrolysis and gasification.*

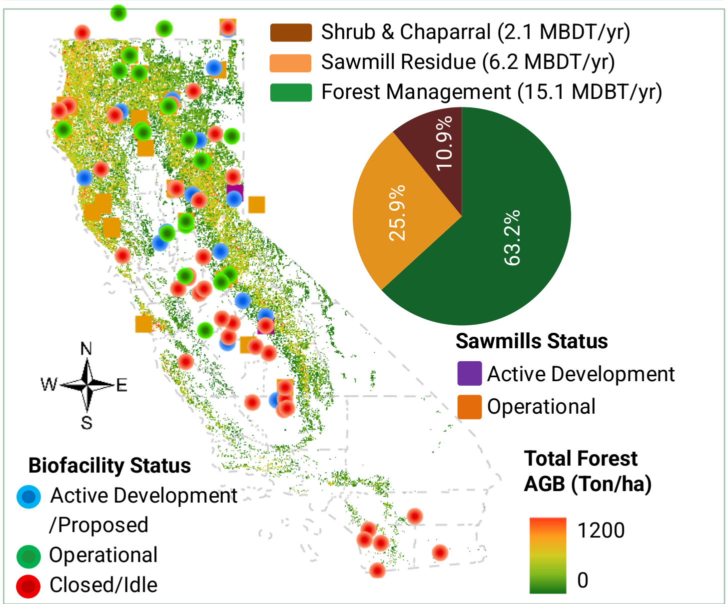

FIG. 1. Estimated available above-ground forest biomass in California[1,2,3]

California's Bioeconomy: A Future of Sustainable Growth

California's bioeconomy draws on abundant resources from forestry, agriculture, and urban wood, totalling ~47 million bone dry tons (BDT) of biomass annually[4]. California has already committed significant investments to develop a growing network of facilities that convert these resources into renewable energy, biofuels, and bio-based materials, supporting rural jobs and reducing wildfire risk.

Current efforts focus on scaling up carbon removal technologies like biomass with carbon removal and storage (BiCRS), while also expanding markets for emerging low-carbon fuels such as biohydrogen and renewable natural gas (RNG). These advances in new wood product manufacturing aim to strengthen California's clean energy leadership, promote sustainable forest management, and help meet state climate goals.

1. Fessenden, M. (2015). A Map of All the Trees in California, Smithsonian magazine. 2. Simmons et al. (2021) Scale-Up of Advanced Deconstruction and Conversion Technologies for Producing Biofuels from Woody Biomass. CA Energy Commission. 3. UCCE (2025), California Primary Wood Processing Facilities, University of California Woody Biomass Utilization Group. 4. California Energy Commission (2025). Biomass Energy in California, Sacramento, CA 95814.

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FIG. 2. Examples of value-added products from forest biomass

Biohydrogen Sector in California

California is exploring innovative ways to enhance its bioenergy sector, including biohydrogen — a clean fuel that can power fuel cell vehicles, generate electricity, support chemical industries, and provide heat. Biohydrogen is produced from woody biomass through gasification, a thermochemical process that converts organic material into hydrogen-rich syngas. When sustainably sourced, this pathway offers the potential to reduce atmospheric carbon via carbon capture and storage (CCS), while decreasing reliance on fossil fuels.

Currently, most hydrogen in California is produced from natural gas, with only a few demonstration projects using woody biomass. Key challenges for biohydrogen include high production costs, limited commercial-scale facilities, and underdeveloped supply chains, which restrict its widespread adoption. Overcoming these barriers will require investment in production infrastructure, feedstock logistics, and technology development. Despite these challenges, biohydrogen offers a renewable, low-carbon alternative that can support clean energy goals, reduce reliance on fossil fuels, and integrate with California's broader decarbonization strategies.

Research and development efforts in California are focused on evaluating the cost effectiveness of biohydrogen production from woody biomass, ensuring a reliable long-term feedstock supply, and developing necessary infrastructure. The integration of carbon capture technologies is critical to making this renewable fuel more competitive with conventional hydrogen derived from fossil fuels. Furthermore, incorporating biohydrogen into existing energy systems and expanding supply chains will be essential for broader adoption. With continued investment and supportive policies, biohydrogen has the potential to play a significant role in California's clean energy transition and to help achieve the state's ambitious climate goals.

Biohydrogen: Economic Snapshot

The levelized cost of biohydrogen from biomass gasification is estimated at \$1.48–\$3.00/kg (\$3.15–\$3.60/kg with carbon capture and storage). Although currently more expensive than conventional hydrogen produced from natural gas **(\$1.03–\$2.16/kg),** declining technology costs, carbon credit markets, and incentives from California's Low Carbon Fuel Standard (LCFS) improve its economic viability. As infrastructure expands and carbon policies strengthen, biohydrogen could achieve cost parity with conventional hydrogen in the near term**.**

Biochar Sector in California

Biochar is a rich, charcoal-like material produced by heating organic biomass (e.g., forest residues, agricultural byproducts, urban wood waste) in low oxygen environments. It has diverse applications such as soil enhancement, water retention and purification, livestock feed, concrete additives, battery electrodes, and energy production.

Biochar is primarily produced through pyrolysis, which yields carbon-rich biochar, bio-oil, and syngas, with a focus on carbon sequestration for soil enhancement and climate mitigation. Gasification, on the other hand, produces syngas as the main product (and smaller amounts of biochar) and, while primarily used for energy production, both methods help to reduce carbon emissions.

California's potential annual biochar production capacity is up to 4.7 million BDTs if 20% of accessible biomass is converted via pyrolysis. Each ton of biochar (70% carbon content) can store about 3 tons of CO_2-equivalent, meaning that producing 2 million tons of biochar per year could sequester roughly 6 million tons of CO_2 annually (~1.5% of California's total emissions). Additional benefits include reducing nitrous oxide emissions by ~20%, improving water retention in soils (up to 19% less agricultural water use), diverting biomass from open burning to reduce fine particulate ($PM_{2.5}$) pollution, and lowering methane emissions by ~20% when added to 1% of cattle feed[2].

Biochar: Economic Snapshot

Biochar is becoming popular for more than just improving soil. It is also now used to clean water, strengthen building materials, and it is used as animal bedding and feed additive.

In the western USA, producing biochar from low-value forest wood could be worth over \$20 billion and has the potential to create ~70 million carbon credits annually.[3]

Currently, biochar production is still limited. Challenges such as limited funding, unclear benefits, lack of awareness, and limited market research and promotion are holding the market back. Addressing these obstacles could unlock greater opportunities for biochar adoption to help people and the planet in many ways.

1. Gilani, H. & Sanchez, D (2020). Introduction to the Hydrogen Market in California. Joint Institute for Wood Products Innovation. 2. Thengane et al. (2021). Market prospects for biochar production and application in California, Biofuels, Bioproducts and Biorefining, 15:1802–1819. 3. Elias et al. (2024). Market analysis of coupled biochar and carbon credit production from wildfire fuel reduction projects in the western USA. Biofuels, Bioproducts and Biorefining, 8(5):1226-37.