Biomass Power in Humboldt County

Brief Summary of Workshops, Consultations, and Research

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Key Points

1. Biomass is considered a climate change “bridge” solution, beneficial until other cleaner sources can fill the gap.
2. Biomass power emits air pollutants that are dangerous to human health where humans are exposed. Open burning emits more air pollutants and GHGs, but human exposure to air pollutants in the field is usually small.
3. Biomass provides local “baseline” power that is otherwise provided locally by the PG&E Natural Gas plant.
4. Biomass is often considered “carbon neutral” because wood products and mill residues are inside the natural carbon cycle. GHGs are emitted, and carbon neutrality is difficult to establish.
5. Biomass burning confers only small savings in GHG over open burning of mill residue or forest slash. The timing of emissions is modified but the totals emissions are similar.
6. Most alternatives for mill residue disposal produce higher levels of greenhouse gas warming than burning the residues for power.
7. Sequestering to carbon in mill residues over climate-meaningful timeframes is a local opportunity to contribute to climate change mitigation. Few alternatives exist at the required scale, but several are promising. Composting appears infeasible at the required scale. Additional manufactured products could be feasible, depending on investment, technology, and markets. Biochar production holds the most promise. A large-scale biochar pilot project using mill wastes is recommended to define the economic, the social, the logistical potentials of biochar production using mill wastes.

What is the global context for biomass power?

Since the human discovery of how to start a fire, biomass has been the primary human energy source. Even today, more than half the world’s people use biomass as their primary energy source. We have transitioned modern society to burning fossil fuels for energy, not realizing that the emissions would disrupt the climate worldwide, with immense and growing adverse consequences.

The UN IPCC has recently concluded that to avoid severe climate consequences, greenhouse gas emissions should be reduced as much as possible as soon as possible.

Now we face a critical question: How do we move from powering our world with fossil fuels to using only the sun, the wind, moving water, and the heat of the earth's crust?

We need bridge solutions, and biomass is considered a prime candidate worldwide. The potential to generate electricity and heat is obvious, but so are its drawbacks: air pollution, and carbon emissions, and the concern for forest and agricultural management needs and impacts.

At present, biomass fuels about two percent of global electricity production, more than any other renewable source. In some countries—Sweden, Finland, and Latvia among them—bioenergy is 20 to 30 percent of the national generation mix, almost entirely provided by trees. Biomass energy is on the rise in China, India, Japan, South Korea, and Brazil. (Hawken, et al. 2017.)

Is there a State of California context for biomass power?

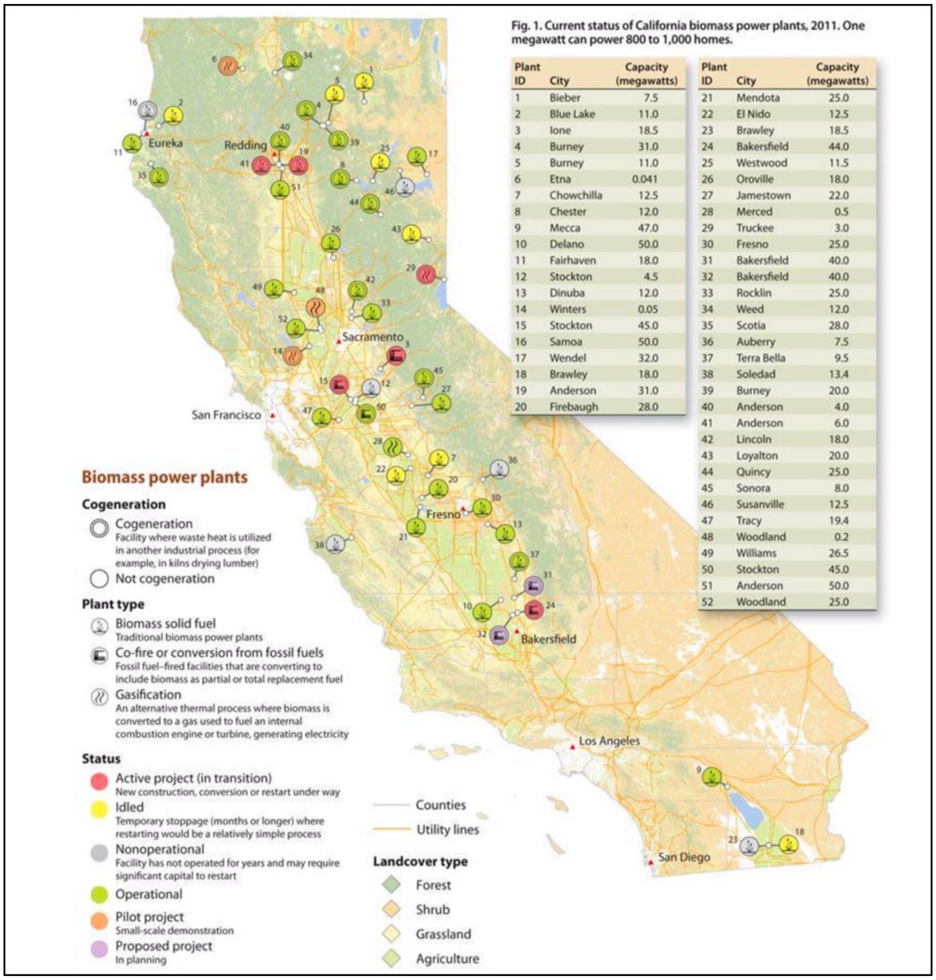
The California Department of Forestry and Fire Protection has published a California's Forest Carbon Plan (2018).

Among the findings of the report:

- Reducing carbon losses from forests, particularly the extensive carbon losses that occur during and after extreme wildfires in forests and through uncharacteristic tree mortality is essential to meeting the state's long-term climate goals. Fuel reduction in forests can increase the stability of the remaining and future stored carbon.
- The limited infrastructure capacity for forest management, wood processing, and biomass utilization, and the limited appropriately trained or licensed supporting workforce are significant impediments to forest restoration and ongoing forest management.

Near-term actions proposed by the State include:

- Expand wood products manufacturing in California and take actions to support market growth scaled to the longer-term projections of forest productivity and resource management needs.
- Continue public investment to build out the 50 megawatt (MW) of small scale (5MW or less sized facilities), wood-fired bioenergy facilities mandated through SB 1122 (Rubio, 2012).
- Maintain existing bioenergy capacity at a level necessary to utilize materials removed as part of forest restoration and to support long-lived storage of carbon in building materials.



Plant ID	City	Capacity (megawatts)
1	Bieber	7.5
2	Blue Lake	11.0
3	Ione	18.5
4	Burney	31.0
5	Burney	11.0
6	Etna	0.041
7	Chowchilla	12.5
8	Chester	12.0
9	Mecca	47.0
10	Delano	50.0
11	Fairhaven	18.0
12	Stockton	4.5
13	Dinuba	12.0
14	Winters	0.05
15	Stockton	45.0
16	Samoa	50.0
17	Wendel	32.0
18	Brawley	18.0
19	Anderson	31.0
20	Firebaugh	28.0

Plant ID	City	Capacity (megawatts)
21	Mendota	25.0
22	El Nido	12.5
23	Brawley	18.5
24	Bakersfield	44.0
25	Westwood	11.5
26	Oroville	18.0
27	Jamestown	22.0
28	Merced	0.5
29	Truckee	3.0
30	Fresno	25.0
31	Bakersfield	40.0
32	Bakersfield	40.0
33	Rocklin	25.0
34	Weed	12.0
35	Scotia	28.0
36	Auberry	7.5
37	Terra Bella	9.5
38	Soledad	13.4
39	Burney	20.0
40	Anderson	4.0
41	Anderson	6.0
42	Lincoln	18.0
43	Loyalton	20.0
44	Quincy	25.0
45	Sonora	8.0
46	Susanville	12.5
47	Tracy	19.4
48	Woodland	0.2
49	Williams	26.5
50	Stockton	45.0
51	Anderson	50.0
52	Woodland	25.0

Current status of biomass power facilities in California. Map source: UC Division of Agriculture and Natural Resources. As the wood products and bioenergy landscapes in California are quite dynamic, some of the 2012 data presented here may no longer be accurate. The University of California maintains an up-to-date wood facility database at: https://ucanr.edu/sites/WoodyBiomass/Project/California_Biomass_Power_Plants/

What is the Humboldt County Context for Biomass power?

Locally biomass is presently the only renewable energy source, with the minor exceptions of small solar installations and several small hydroelectric installations.

Humboldt County produces enough electricity for local consumption, using biomass and natural gas (RePower 2013). Additional generating capacity might increase soon if planned onshore and offshore wind power is installed and solar installations are built.

Biomass generates continuous power output to the grid, contributing to meeting variable electricity demand and complementing the power available from intermittent solar and wind.

In Humboldt County, biomass electricity, using chiefly mill residues, has been generating heat and electricity since the late 1980s. A local lumber manufacturing economy has been operating here for well over a century. Lumber mills generate remarkably large volumes of unusable wood materials, mostly sawdust, bark, and cutoffs. These have been disposed of in open burning, mostly in teepee burners until these were prohibited, and currently mainly in biomass generation plants.

Burning biomass produces carbon emissions. However, it is not adding fossil carbon that has been stored for eons far belowground, as is the case with fossil fuels. Biomass energy generation burns carbon that is in circulation, cycling from the atmosphere to plants and back again.

Does this carbon to the atmosphere count? Yes and no, depending on the time periods we consider and how we view the overall carbon balance and the continued extraction of fossil fuels.

Why is biomass power considered a climate solution? Is biomass power "carbon neutral"?

Climate change has primarily resulted from the extraction of fossil carbon from outside the natural carbon cycle and adding it to the atmosphere and oceans, resulting in a significant and consequential radiative forcing and the rapid climate warming that we now observe. There is a global consensus that we must limit the further additions of fossil carbon to the atmosphere and do so as quickly as possible.

Biomass burns carbon-containing materials and thus emits greenhouse gasses, but this carbon is "in the cycle" and does not contribute to increasing the total amount of carbon circulating on the earth system. That is, the carbon in biomass is already in circulation and, after being emitted, is typically sequestered again in years to decades.

Consideration and accounting for greenhouse gas emissions from biomass burning are nuanced.

The energy density of woody material is low relative to coal or natural gas. The CO2 emissions are thus higher than these other two sources. Approximately 320,000 tons of CO2 are emitted annually by the two plants.

The CO_2 emissions per unit of energy generation are:

Natural gas: 118 lb. CO_2/MMBtu

Bituminous coal: 205 lb. CO_2/MMBtu

Wood: 213 lb. CO_2/MMBtu (bone dry)

The authors of Repower Humboldt pointed out several key issues that would need to be addressed before any expansion of biomass infrastructure. One of these issues was the assumption that biomass is "carbon neutral":

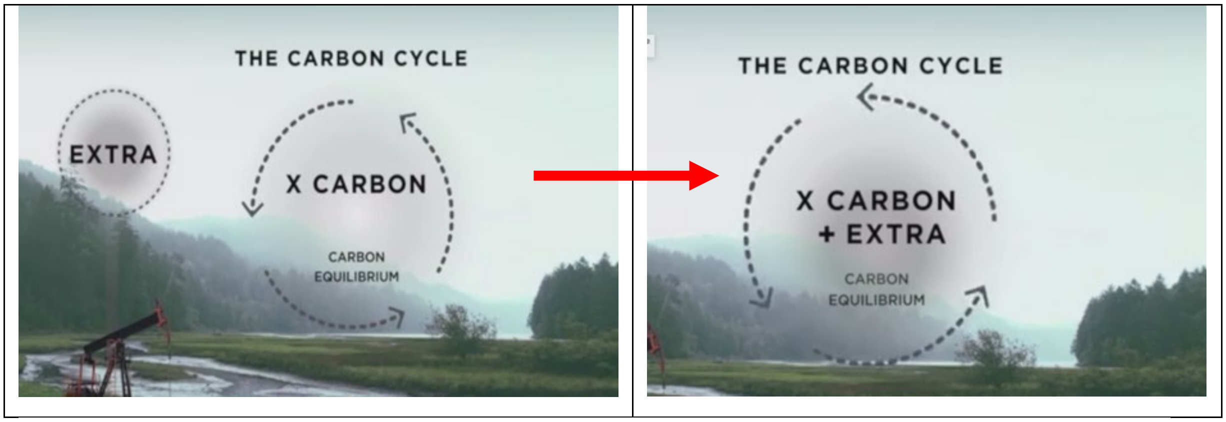
> *"In general, biomass has been treated as a carbon-neutral resource as long as the harvest rate does not exceed the rate of new growth. However, this premise is currently being scrutinized and regulatory treatment of biomass could change. (...) These emissions can be assessed in a life cycle analysis. This study treated biomass as a carbon-neutral resource. It is recommended that this assumption be further evaluated as a topic of future research."*

Biomass helps to move away from fossil fuels and helps balance the supply from intermittent power from solar and wind generation. When more flexible grid solutions come about and storage facilities are added, this will become less important.

Scientists tend to be split on whether biomass burning can be considered "carbon neutral." The carbon loading of any biomass generation facility depends on its context: fuel source, transportation and handling costs, the degree of substitution for fossil fuels, and other factors and differs from facility to facility.

Many scientists conclude that if trees grow back in a few decades and if harvest volume is equal to or greater than burned volume, the GHG inputs do not "count," as they are re-sequestered, just as the carbon cycle has been operating for millions of years. That is, if burning biomass that is inside the natural carbon cycle substitutes for fossil fuels, many contend that this amount can be "subtracted", creating a neutral or even carbon-negative result.

Others contend that a CO_2 molecule is the same and has the same radiative effect regardless of its source: and therefore, biomass burning does count as an adverse emission. In California and International carbon emissions accounting, some emissions from Land Use, Land-Use Change, and Forestry (LULUCF), which are inside the natural carbon cycle, is counted, while some are not, due to difficulties in measurement, such as for soil carbon.



The extraction of billions of tons per year of non-circulating fossil carbon has been added to the carbon cycle. This is the primary driver of human-caused climate change.

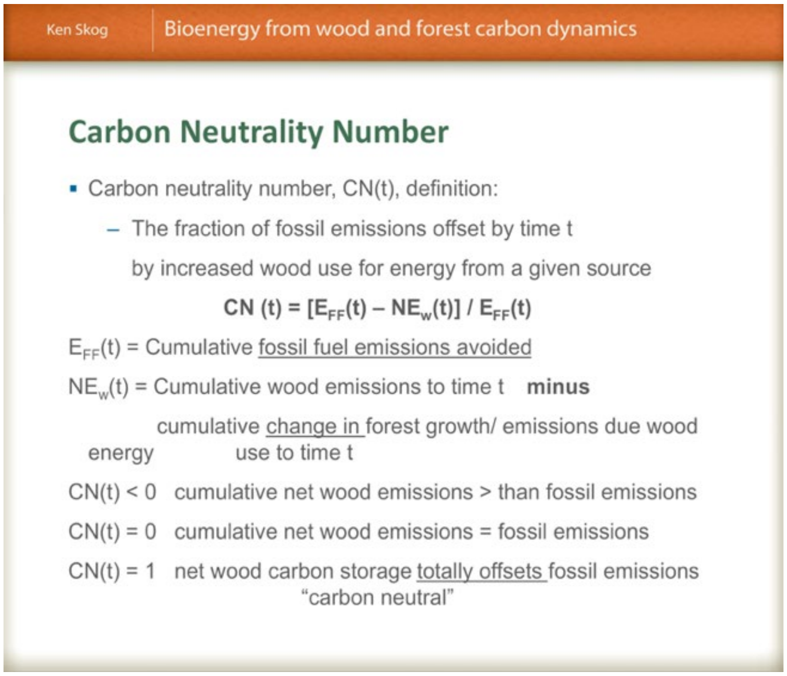
According to Morris, 2008,

> *" Carbon Neutral and Beyond: The greenhouse-gas emissions produced at biomass and biogas generating facilities comes from carbon that is already a part of the linked atmospheric – biospheric carbon cycle. This is in stark contrast to fossil fuel combustion, which removes carbon from permanent geologic storage, and adds it as net new carbon to the carbon already in the atmospheric – biospheric circulation system. Most people focus on this aspect of bioenergy production, and proclaim it to be "Carbon Neutral." .... Biomass energy production can change the timing and relative mix (oxidized vs. reduced) of carbon forms emitted into the atmosphere associated with the disposal or disposition of the biomass resources. As a greenhouse-gas, reduced carbon (CH4) is twenty-five times more potent than oxidized carbon (CO2) on an instantaneous, per-carbon basis."*

How the GHG emissions are regarded in emissions accounting depends on many factors: wildfire risk, frequency, extent, and severity; timing of emissions, the chemistry of environmental transformations; human interventions; applied logic and assumptions; assumed time periods of analysis; substitutions of biomass for fossil fuels; other avoided impacts, philosophy, and other factors.

The perplexities of the burning of biological carbon can be somewhat resolved by a thorough life-cycle analysis (LCA). Without a thorough life-cycle analysis, carbon neutrality cannot be claimed, quantified, or denied.

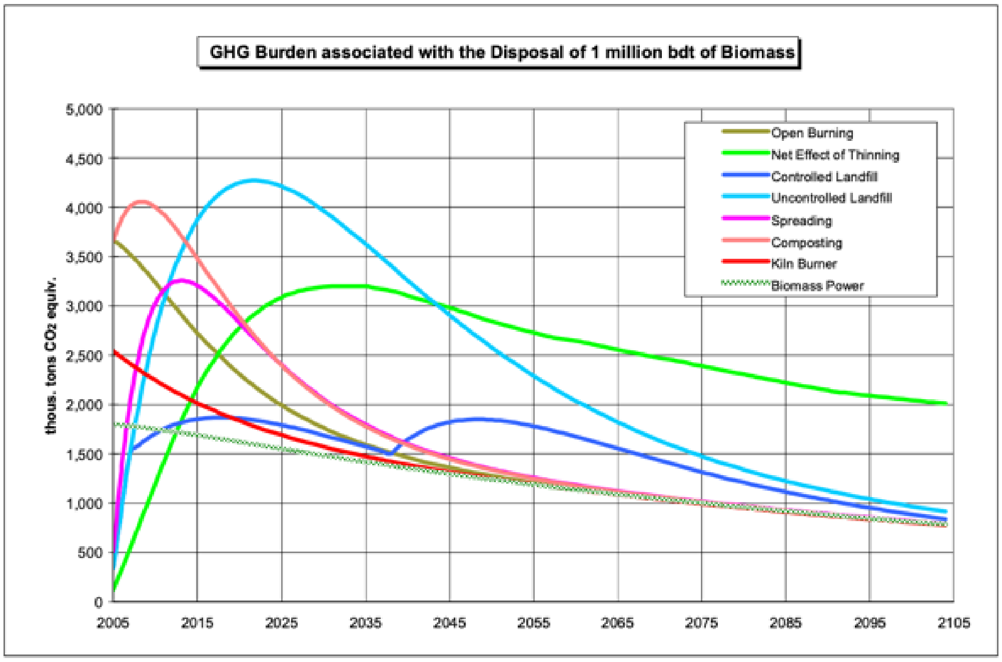
A formula used by US Forest Service economists is:



Forest Service economist Ken Skog. From: Swanston, Chris; Furniss, Michael J.; Schmitt, Kristen; Guntle, Jeffrey; Janowiak, Maria; Hines, Sarah, eds. 2012. Forest and grassland carbon in North America: A short course for land managers. Gen. Tech Rep. NRS- 93.

Considerable research effort is underway to more accurately assess the environmental and social impacts of biomass, including life cycle assessment modeling and tool development at the Schatz Energy Research Center at Humboldt State University. However, a detailed LCA of the local biomass plants is not planned at present.

As assessed in Morris 2008, biomass burning changes the timing of GHG emissions:



The curve for stack emissions from the biomass energy alternative is based on the immediate release of virtually all of the fuel-bound carbon as CO_2, followed by its gradual clearance from the atmosphere. The conversion of one million bdt of biomass leads to emissions of 1.75 million tons of biogenic CO_2 equivalents. Open burning and low-efficiency combustors (kiln boilers and fireplaces) also produce their emissions immediately, but their greenhouse-gas emissions are higher, in terms of tons of biogenic CO_2 equivalents, than those of the power alternative because of the release of black carbon and other products of incomplete combustion. (Morris, 2008).

Open burning of woody material from forest and milling operations emits substantially more air pollutants than the high-efficiency burning in a power plant, as the burning is less complete and less efficient. Black carbon (soot) and methane emissions from open burning are substantial and especially adverse to atmospheric warming but are short-lived.

What about the air pollution produced by the biomass plants?

Biomass power in RCEA's mix is generated by burning mill waste, comprised of woody material from lumber mills. Burning wood creates smoke. Smoke includes air pollutants that adversely affect human health to those exposed.

There is a growing worldwide recognition of the adverse health effects of smoke and other forms of air pollution, which can lead to a wide variety of serious human diseases and shorten life. Impacts can be especially severe for the young and infirmed. Smoke from wildfires, open burning, biomass production, campfires, even candles is not healthy to breathe. Recent large wildfires have exposed many city-dwellers to high levels of smoke and have sharpened awareness of this source of air pollution and its health consequences.

Smoke from burning wood emits several pollutants of concern, but by far the most serious is particulate matter – small particles that can pass through the lungs into the bloodstream. Small particles of 2.5 microns and below ($PM_{2.5}$) are of most significant impact and concern. There is no recognized No Effect Level (NOEL) for exposure to particulate matter.

Other pollutants in smoke include nitrogen oxides, carbon monoxide, volatile hydrocarbon compounds, and secondary production of ground-level ozone.

Pollutant	Description	Health Effects	Welfare Effects
Carbon Monoxide (CO)	Colorless, odorless gas	Headaches, reduced mental alertness, heart attack, cardiovascular diseases, impaired fetal development, death.	Contributes to the formation of smog.
Sulfur Dioxide (SO_2)	Colorless gas that dissolves in water vapor to form acid, and interact with other gases and particles in the air.	Eye irritation, wheezing, chest tightness, shortness of breath, lung damage.	Contribute to the formation of acid rain, visibility impairment, plant and water damage, aesthetic damage.
Nitrous Oxides (NO_2)	Reddish brown, highly reactive gas.	Susceptibility to respiratory infections, irritation of the lung and respiratory symptoms (e.g., cough, chest pain, difficulty breathing).	Contribute to the formation of smog, acid rain, water quality deterioration, climate warming, and visibility impairment.
Ozone (O_3)	Gaseous pollutant when it is formed in the lower atmosphere.	Eye and throat irritation, coughing, respiratory tract problems, asthma, lung damage.	Plant and ecosystem damage.
Lead (Pb)	Metallic element	Anemia, high blood pressure, brain and kidney damage, neurological disorders, cancer, lowered IQ.	Affects animals and plants, affects aquatic ecosystems.
Particulate Matter (PM)	Very small particles of soot, dust, or other matter, including tiny droplets of liquids.	Eye irritation, asthma, bronchitis, lung damage, cancer, heavy metal poisoning, brain damage, cardiovascular effects.	Visibility impairment, atmospheric deposition, aesthetic damage.

Health and welfare effects of common pollutants (from: Furniss 2017)

Health organizations that have publicly opposed biomass power include: the American Academy of Pediatrics, American Lung Association, American Public Health Association, Asthma and Allergy Foundation of America, National Association of County & City Health Officials, National Environmental Health Association, Trust for America's Health, Children's Environmental Health Network and Physicians. (Form letter of 2016)

Air quality and air ambient air monitoring

Air quality is continuously monitored in Eureka and is usually in the "good" category, considered "healthy" and "attaining" USEPA air quality standards, except sometimes for particulate matter. Humboldt County is a considered a "Non-Attainment" area for PM_{10} particulate air pollution.

No monitoring of ambient air quality is done in Fairhaven or Scotia, where exposure to biomass emissions would be expected to be the greatest.

Emissions by type of combustion in pounds emitted per ton of woody biomass consumed

	$PM_{2.5}$ (lb./ton)	NOx (lb./ton)	CO (lb./ton)	VOC (lb./ton)	CO_2 (lb./ton)
Industrial (dry fuel)	0.7-6.5	8.8	10.8	0.31	3120
Residential Stove	6-23	2-14	46-160	10-44	~2800
Prescribed Burn	12-34	6	167	19.0	~2700
Wildfire	~30	4	140	12-24	~2600

References: USEPA, AP12, Fifth Edition. McDonald et al. 2000, Environmental Science and Technology. USDA Forest Service, various reports

Average air quality impacts for boiler-spinner electricity generators

Air Emissions	Coal Fueled Boiler (lb./MMBtu)	Biomass Fueled Boiler (lb./MMBtu)	Natural Gas Boiler (lb./MMBtu)
CO	0.02-0.67	0.60	0.058
CO_2 fossil	178-231	0	117.6
CO_2 non-fossil	0	195.0	0
NOx	0.27-1.15	0.22-0.49	0.031-0.27
SOx	1.3	0.025	0.0005
VOC	0.002-0.048	0.017	0.005
Methane	0.002	0.021	0.002
Particulates	0.37-2.4	0.05-0.56	0.007

Note: Both contracted local plants use grid power for start-up and ongoing operation, much of which is fossil carbon.

Permitted air pollutant discharges

HRC Scotia permitted discharge of PM (all sizes) = 0.04 lbs./MMBtu

DGF permitted discharge of PM (all sizes) = 0.10 lbs./MMBtu

BL permitted discharge of PM (all sizes) = 0.04 lbs./MMBtu

Year	Facility	Total GHG	Non-Biomass GHG	Biomass CO2
2016	DG Fairhaven Power LLC	87,243	6,158	81,085
2016	Humboldt Sawmill Company	231,566	6,132	225,435
2016	PG&E Humboldt Bay Generating Station	171,847	171,847	0

Year	Facility	CO2	CH4	N2O	VOC	NOx
2016	DG Fairhaven Power LLC	85,532	27.75	3.64	8.9	74.8
2016	Humboldt Sawmill Company	226,819	76.95	10.1	36.9	174.8
2016	PG&E Humboldt Bay Generating Station	171,676	3.26	0.33	15.9	24.9

Year	Facility	SOx	PM10	PM2.5	Diesel PM	Formaldehyde	Hydrochloric Acid
2016	DG Fairhaven Power LLC	12.7	14.3	13.3	8.63	4,457	19,222
2016	Humboldt Sawmill Company	34.6	37.4	34.5	56.6	12,376	442
2016	PG&E Humboldt Bay Generating Station	1.2	5.2	5.2	129	1,933	

Reported greenhouse gas and air pollutant emissions for 2016. Data from California Environmental Protection Agency Air Resources CARB Pollution Mapping Tool. Accessed 11/18/2019

The current annual fine particle standard has been revised from the current level of 15.0 micrograms per cubic meter (μg/m3) to 12.0 μg/m^3. An area will meet the standard if the three-year average of its annual average PM2.5 concentration (at each monitoring site in the area) is less than or equal to 12.0 μg/m3[1]

[1] USEPA 2012 The National Ambient Air Quality Standards for Particle Pollution Revised Air Quality Standards for Particle Pollution and Updates To The Air Quality Index (AQI)

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Select 8 Summary

Monitoring Sites	PM2.5 State Annual Average 2014	2015	2016	2017	2018
Humboldt County					
Eureka-Humboldt Hill	7.4	4.7	*	*	*
Eureka-Jacobs	*	5.8	6.0	*	7.7

Air Basins	PM2.5 State Annual Average 2014	2015	2016	2017	2018
California					
North Coast Air Basin	7.4	7.9	6.4	9.4	11.3

Note: * There was insufficient (or no) data available to determine the value.

The annual standard is 12.0 µg/m³. Last five years: 5.8 – 7.7 µg/m³.

Table 3.12-1. Federal/State Ambient Air Quality Standards

Pollutant	Federal	State
Ozone	Unclassified/Attainment	Attainment
Sulfur Dioxide	Unclassified	Attainment
Nitrogen Dioxide	Unclassified/Attainment	Attainment
Particulate Matter 2.5 Microns or Smaller ($PM_{2.5}$)	Unclassified/Attainment	Attainment
Particulate Matter 10 Microns or Smaller (PM_{10})	Unclassified	Non-attainment
Sulfates	No Standard	Attainment
Lead	Unclassified/Attainment	Attainment
Hydrogen Sulfide	No Standard	Attainment
Vinyl Chloride	No Standard	Attainment
Carbon Monoxide	Unclassified/Attainment	Attainment

Source: ARB, 2016a

Federal and State ambient air quality standards

Table 3.12-2. Criteria Pollutant Concentrations in Humboldt County, 2011-2015.

Pollutant	State Std.[a]	National Std.[a]	Pollutant Concentration by Year[b] 2011	2012	2013	2014	2015
Ozone (ROG, NOx, CO)							
Highest 1-hour average (State), ppm	0.09	--	0.047	0.053	0.055	0.049	0.060
Days over State Std. [f]			0	0	0	0	0
Highest 8-hour average (State/national), ppm	0.07[c]	0.075	0.043/ 0.043	0.049/ 0.048	0.049/ 0.049	0.043/ 0.043	0.053/ 0.052
Days over State Std.			0	0	0	0	0
Days over National Std.			0	0	0	0	0
Respirable Particulate Matter (PM_{10})							
Highest 24-hour average (state national), µg/m³	50	150	**53.9/** 49.6	46.3/ 44.5	**66.7/** 64.3	ND[d]/ 104.7	ND[d]/ 54.9
Days over State Std.			6.1	0	11.8	ND[d]	ND[d]
Annual average (State), µg/m³	20[e]	--	19.1	16.8	19.3	ND[d]	ND[d]
Fine Particulate Matter ($PM_{2.5}$)							
Highest 24-hour average, µg/m³	--	35	24.8	22.3	28.1	21.2	18.6
Days over National Std.			ND[d]	0	0	0	0
Annual average (National), µg/m³	12	15	6.6	6.7	7.1	3.0	4.6

Notes:
Bold = in excess of standards
ppm = parts per million; µg/m3 = micrograms per cubic meter
[a] COE, 2008.
[b] ARB, 2016b (ozone data are from the Eureka-Humboldt Hill monitoring station while PM_{10} and $PM_{2.5}$ data are from the Eureka-Jacobs and monitoring station).
[c] In 2006, the State approved amendments to the regulations for the State Ambient Air Quality Standard for ozone establishing a new 8-hour average ozone standard of 0.070 parts per million (ppm).
[d] No data available.
[e] The national annual PM_{10} standard was revoked in December 2006 (ARB, 2008a).
[f] The national 1-hour ozone standard was revoked in June 2005 (ARB, 2008a).
Source: ARB, 2016b; compiled by ESA.

A sampling of criteria pollutant concentrations for Humboldt County

NCUAQMD has issued permits to the three biomass plants in Humboldt County. Emissions are monitored at the stack of the plants, but actual exposures of local populations in Eureka, Fairhaven, Scotia, and Blue Lake are not monitored.

Emission alone do not describe the public health hazard; Exposure of people to the emitted pollutants is necessary but is not currently available. The District has stated that it has done exposure modeling in formulating the permits, but this information is not publicly available, and ongoing exposure modeling and monitoring are not conducted.

In the absence of exposure modeling and monitoring, public health risks cannot be quantified or described. Scotia, Fairhaven, and Blue Lake plants are proximate to population centers. The DGF is across Humboldt Bay from the Eureka population but is proximate to the community of Fairhaven.

The emissions from biomass plants, where combustion is controlled to tight tolerances, efficiency is an objective and particulate control facilities are in place, are much less than from open burning, as occurs in burning piles of slash in the woods, in wildfires, in controlled burns, and in the teepee burners that were used for decades to dispose of mill wastes.

The emission controls at the two RCEA-contracted plants, based on the air quality permits, include:

DG Fairhaven

- Mechanical Multicyclone Collector
- Electrostatic Precipitator
- Forced Overfire Air System

HRC Scotia

- Particulate matter is controlled with multiple cyclones followed by an electrostatic precipitator manufactured by General Electric Co. The unit has three separate transformer/rectifier fields and a collection plate area of 42,120 sq.ft. Two of the fields are rated at 50 KVA and one at 35 KVA. A forced overtire air system is utilized to help control gaseous emissions.

Open burning of woody material from forest and milling operations emits substantially more air pollutants than the high-efficiency burning in a power plant, as the burning is less complete and less efficient. Black carbon (soot) emissions from open burning are particularly large and adverse to atmospheric warming.

What is the feed material and why does it matter to RCEA and the community?

The feed material for the two contracted plants is residues from local lumber mills that are not otherwise used for salable by-products of lumber manufacture. Small amounts of logs from arborists and sanitation of logs killed by Sudden Oak Death are also included. Small quantities of waste logs from forest thinning on public land have been burned at DG Fairhaven in the past.

Character

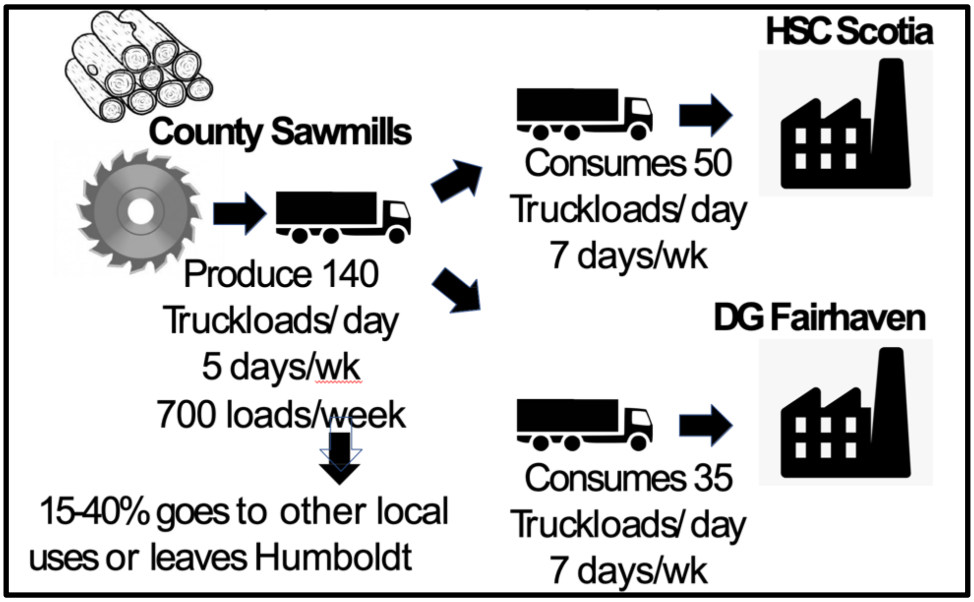
Lumber mills produce waste from lumber manufacture, including sawdust, bark, cutoffs, wings, and so on. Some of this material has economic value and is sold as chips for paper manufacture, mulch, fiberboard manufacture, burnable pellets, and so on. For these uses, the material must be of a particular quality, and there must be a current market demand, which can vary significantly over time.

What remains after these by-products are sold and transported away, is a low-quality material that has no current economic value, but can be burned to generate steam and electric power.

The primary factor that determines the quantity of mill residues used as fuel in California is the level of activity in the primary forest-products industry.

Unsaleable mill residues can look like this but vary in composition, sizes, and moisture content. A large component is in the form of sawdust.

Currently produced quantities of mill residue, based on queries to the mill operators are:



Note: Lumber mill operations have seen a steady decrease in the amount of waste per unit of lumber production via the use of computer analysis of logs for optimum lumber yield, low-kerf saws, and other technology.

What used to be done with this material?

History

Mill wastes that could not be sold as by-products have historically been burned in "teepee burners." During the height of timber harvest in the county, approximately 200 mills were operating, and each had a teepee burner that burned mill residues around the clock. A great deal of smoke was emitted. Many of these burners can still be seen today at old mill sites.

Teepee burners were common before stringent air pollution control regulations. Every mill had one, and they usually operated 24/7/365. The resulting air pollution was far worse than the relatively efficient burning conditions with pollution controls in a modern biomass plant.

What about forest health and sustainability?

Concerns about feed material and forest sustainability

The source material for biomass is a central issue in most biomass power elsewhere – that is, how this use and demand could induce unsustainable pressure to harvest forests and to use of agricultural land for other than food production.

This is not currently relevant here, as the feed is mill waste only, with very minor exceptions (the plants accept arborist waste and sanitation logs that must be burned, such as tanoak infected with Sudden Oak Death.)

While current biomass plant generation is fully satisfied by mill residues, additional capacity could be added, markets might divert more mill waste than currently, and forest management activities could become feed material for the plants,

Forestry officials in California hope to see extensive thinning and controlled burning in California forests to reduce wildfire hazards and improve forest health. Pre-commercial thinning is expected to increase markedly throughout California forests in the near future. Considerable funding is becoming available for this work. Large amounts of small logs and slash will be generated.

However, the economics of transport mostly keeps this material in the woods; it is simply not worth the transportation costs to bring it to the mills or the biomass plants. A haul of more than ~50 miles is cost-prohibitive. The small logs and slash must be treated in the woods to reduce fire hazards and enable regeneration.

There are several active research and development projects, including a local effort to evaluate various means of on-site processing of fuel treatment thinning and the associated large volumes of slash, including more efficient burning, wood-energy concentration for transportable fuel, and sequestration as biochar.

In terms of a concern that larger trees will be logged to feed biomass plants, this is not an issue -- sawlogs are always far more valuable for lumber manufacture than for burning in biomass plants.

Who is in favor and who is opposed to using biomass to generate electricity?

Public opposition is substantial. Vocal opponents come to CAC and Board meetings and express opposition and concern, primarily about air pollution, greenhouse gas emissions, and forest management.

Gaining the full support of the community is not likely or possible.

Local environmental groups that have addressed this include 350-Humboldt and EPIC are both are "neutral."

Four highly credible professional groups are notable:

1. Forestry and timber manufacturing professionals tend to be strongly in favor
2. Medical professionals, as represented by several professional medical societies, and two local physicians have strong concerns and opposition due to air pollution and greenhouse gas emissions.
3. Climate scientists and specialists are generally in favor of biomass as a bridge solution, but with caveats.
4. California Air Pollution Control Officers Association (CAPCOA) has issued a written statement in favor of biomass as a way to limit air pollution from other methods of waste incineration or landfills.

   Exceptions exist in all groups and are acknowledged.

Opponents frequently note that biomass cannot be considered "clean" because it emits both air pollutants and greenhouse gases. There is no broadly accepted definition of "clean" energy. In the context of energy and climate in California, "clean" means "non-fossil and non-nuclear" and not that there is no associated pollution.

What will happen to the mill residues if RCEA no longer buys the power from the plants?

As noted, a large volume of residue is generated at local mills. If biomass is not burned for electric generation, options for disposal include:

- Note: HRC uses biomass power for mill operations and heat from the plants for lumber drying, and so would continue to run at some level even if there were no electricity buyers.
- Transporting the material out of the county to other biomass plants or to landfills.
- Trucking the material to Anderson, CA for burning in the Wheelabrator biomass plant there (about 300 miles round trip) or other more distant plants.

- Open burning (this unlikely to be permitted locally due to air pollution regulations). The residue could be hauled to an acceptable open burning location.
- Plants sell electricity to other buyers, such as a community choice energy program serving a jurisdiction outside Humboldt County, as many municipalities have a mandate for renewable energy.
- Closing the mills and sending logs out of the County (likely to Oregon). Prices for local logs would decrease substantially. This would have the effect of making restoration forestry, road maintenance, and wildfire-resilience thinning less feasible and less practiced.

None of these options eliminates GHG emissions, and most would increase both air pollution and GHG emissions. Landfilling of mill waste could decrease air pollution but substantially increase GHG gas emissions, including methane, Current severe systemic societal waste disposal challenges would worsen. Landfills might not accept large quantities of organic wastes.

Two other options that could sequester the carbon include:

Developing or discovering additional products and markets for the residues.

Mill operators are always looking for new and reemerging by-product markets for mill residues. The potential depends on the existence of markets, levels of demand, manufacturing technologies and distance to markets. The quality of the unused material is often sub-standard for any commercial uses and sales: it is too variable in size, often has rock and dirt contamination, and has variable moisture content. Unless the provenance of the material in the piles is verifiably known, insect and pathogen non-presence cannot be assured.

Residues are currently sold as "by-products" for:

- Chips for paper manufacture, mostly to Asia, but also the PNW states. Paper manufacture requires large, clean chips, and there is currently a market for these over the Fairhaven loading dock.
- Burnable wood pellets are commonly produced and sold from Eastern USA forests for sale to the EU, Japan, and other places to substitute for coal burning, as climate mitigation. There might be a potential market for local burnable pellets, particularly for industrial use where feed material quality and produce polish is less important than for consumer-grade pellets.
- Small amounts of residues are sold for compost-making, landscaping, animal bedding, playground mulch, and so on.

A challenge to selling by-products is that interstate and international quarantines exist to prevent the introduction of pathogens. This is a barrier to export for some types of sales.

Emerging technologies include: gasification, torrefaction, biochar, and others are in active research and development locally and elsewhere.

Gasification converts woody materials into gasses by reacting the material at high temperatures (typically >700 °C), with little oxygen. The product is wood gas fuel that can be burned as fuel in furnaces, stoves, and vehicles in place of gasoline, diesel, or other fuels. Biochar is a byproduct.

Gasification is relatively expensive and is highly energy-intensive. The moisture content of the feedstock must be carefully controlled. Some of the sawmill residues could be diverted to a gasification plant, but it would require a significant capital investment and tight controls on the quality of the feedstock. The material would be burned with the associated carbon emissions. Gasification technology is not currently at a feasible scale to process the amount of available local sawmill residues.

Torrefaction is intended to increase the energy density of wood and involves the heating of biomass in the absence of oxygen to a temperature of typically 200 to 400°C. The weight loss is about 30%, but the energy loss is ~10%. The main product is the solid, torrefied biomass, either as torrefied wood material or briquettes. During the torrefaction process, combustible gas is produced that provides heat to drive the process. *(Biomass Technology Group. Accessed 11/11/19.)*

Torrefaction produces material to burn for heat, not for carbon sequestration.

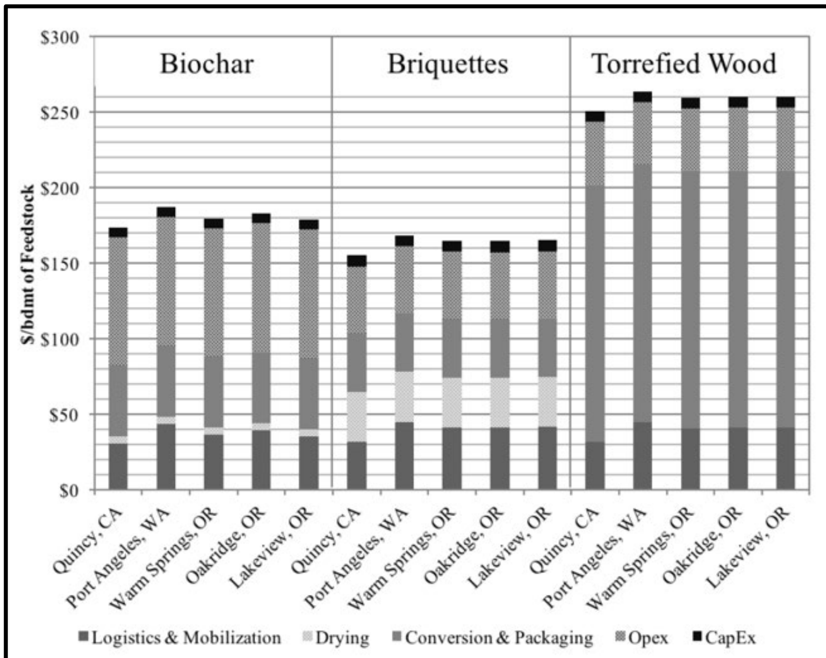


Figure 2. Production cost of product expressed as $/bdmt of feedstock.

Cost comparison for production of biochar, torrefied briquettes, and torrefied wood. From: Waste to Wisdom. 2018. Utilizing forest residues for the production of bioenergy and biobased products. (Waste to Wisdom, Final Report.

What are potential ways to achieve long-term sequestration of the carbon in local mill residues

A substantial opportunity exists for carbon sequestration of the embodied carbon in mill residues if a method to do this can be developed at the required scale and is economic against other options for disposal. To be meaningful for climate change, carbon must be sequestered for a century or more.

Manufactured products

Manufactured building materials can be an effective means of sequestering the carbon in mill residues, but at present, requires high-quality starting material. Sawdust, mill ends, and cutoffs are generally not suitable. That is, some mill waste can be manufactured into long-lived building materials, but a substantial residue of unsuited materials will always remain.

Composting

Composting of the non-salable residues is a common suggestion.

Sawdust is commonly added to biosolids (sewage sludge) to make compost, adding carbon-rich materials. Compost manufacture and biosolids disposal is the objective of these efforts, not mill residue disposal, and the operational scales are tiny when compared to the volume of local mill residue.

Advantages of composting

Compost can greatly improve soils, and increased soil fertility furthers soil carbon sequestration as well as plant growth.

Compost can substitute for synthetic nitrogen fertilizer, which is a significant source of NOx emissions. NOx is a powerful greenhouse gas and air pollutant and persists longer in the atmosphere than CO_2 or other GHGs.

Some small proportion of compost can form long-term soil humus, especially when lignin-rich wood is the source material.

Compost creation at the needed scale entails substantial challenges:

- Local mill waste comprises a large volume of material. The scale is significant and unprecedented.
- Composting would require substantial energy inputs to process and transport the resulting compost.
- Storing a large amount of chips presents fire hazards because the decomposition process generates and accumulates heat and compost fires are common. (The Burris wildfire incident in Lake County three weeks ago was ignited by a compost pile.)
- For composting to occur, N-rich material must be added to support decomposition. Sawdust is typically 325:1 carbon to nitrogen, while the rapid composting that is required to destroy pathogens and create high-quality compost needs a C:N of 25-30:1. Sewage and/or kitchen waste or green waste could provide the needed N, but concerns about sanitation, weeds, pathogens, and public nuisance would be present in any such operations.
- Most of the carbon in compost returns to the atmosphere in years or decades as compost decomposes. A small amount of compost might remain for climate-meaningful periods (100+ years), but the large majority does not remain for nearly that long.
- There are concerns about invasive plants and pathogens surviving the composting process and being introduced to fields where compost is applied. Most applications would require certified weed- and pathogen-free compost, and this can be difficult to achieve and ensure.

- The composting process releases methane, an especially powerful GHG.
- There is little or no local market. An existing local composting facility is currently producing more than the market demand. Non-local markets could likely be developed.

Bio-char

Biochar currently offers the most technically feasible option for sequestering the carbon in mill residues.

Biochar is a charcoal-type substance, similar to charcoal. It is produced by burning biomass material in a controlled process called pyrolysis. During pyrolysis, biomass is burned in a container with little or no oxygen. During the pyrolysis process, the organic material is converted into biochar and wood gas. Wood gas can be used as a fuel and can help to power the pyrolysis process.

Biochar a highly stable form of carbon that does not decompose or return carbon to the atmosphere. Biochar converts the carbon in biomass to a stable, long-term material. However, only half of the carbon in the feed material is sequestered. The pyrolysis process releases GHG and air pollutants, though less than biomass electricity generation.

Some air pollutants are released in making biochar, but far less than with burning.

Biochar is black, highly porous, lightweight, fine-grained, and has a vast surface area. Approximately 70 percent of its composition is carbon. The remaining material consists of nitrogen, oxygen and hydrogen and other elements. Biochar's chemical composition varies depending on the feedstocks used to make it and methods used in pyrolysis.

Biochar is a highly beneficial soil amendment, increasing water- and nutrient-holding capacity, enhancing soil biology, decreasing N_2O emissions from soils, and enhancing the sequestration of recalcitrant carbon in soil through increased soil fertility and plant growth. (Severy,et. al. 2018). Recent research points to electron channels in biochar that enhance soil microbial ecology (Sun et al. 2019)

Incorporating biochar into soils is a sound and tested method of storing carbon for long periods.

U.S. Forest Service research is demonstrating the benefits of making and using biochar. https://www.fs.fed.us/blogs/promise-biochar-forests-grasslands-and-farms

The potential to sequester carbon using biochar is well-recognized and the methodology and equipment are available. However, using the large quantities of local mill residue to make, market, and distribute biochar requires further research and development to establish the economic, sociologic, market, and logistic costs and benefits. A large-scale local pilot project to learn how this can be done makes good sense. A public-private partnership might be the best way to accomplish this.

Waste Option	**Potential GHG impacts**	**Time frame for sequestration**	**Other impacts/considerations**
Landfilling	Potential for substantial amounts of methane to be released, particularly if gases are not collected	Decades	California law may make it difficult to landfill organics. Methane production increases warming potential over alternatives. Less air pollutants.
Composting	5-20% of carbon sequestered but for short time periods; potential to release substantial amounts of methane	10-20 years	Expensive and complex at scale. Needs addition of N-rich material. Energy required for handling and processing. Benefits to soil. Potential multiplier effect as increased soil fertility increases plant growth and recalcitrant humus formation. Substitutes for N fertilizer reducing associate N_20 emissions.
Raw biomass incineration	Most carbon converted to CO_2	Essentially instantaneous	Human health impacts. Not permitted where human exposure to air pollutants is high. Higher GHG effects
Gasification	Similar GHG emissions as raw biomass incineration	Essentially instantaneous	Typically more efficient than raw biomass incineration; may have lower air quality impacts.
Biochar production	~50-80% of carbon sequestered	100-1000 years,	Expensive to scale; particulates and GHGs released during production. Benefits to soil. Multiplier effect increasing plant growth and recalcitrant humus formation.
Sale and reuse, durable products, including mass timber products	Most or all carbon in waste sequestered (theoretically). Can substitute for concrete and steel, with large avoided emissions	Potentially, 100+ years	Requires adequate base material, sawdust and end pieces are not suited for present technology. Potential environmental, health and climate impacts from glues.

A new report has just been published by the Sierra Club that examines the context and some of the details involved in alternatives to burning woody material from forestry operations. (Sierra Club, 2019)

Should RCEA use biomass power for the foreseeable future?

Planning to manage adaptively is always a sound strategy. Scenario-based planning can accommodate the uncertainties of future energy supplies, technology, climate policy, and economics.

Several considerations are paramount:

The future holds some crucial unknowns and unknowables: technology developments; availability and price of energy sources; electric grid upgrades; markets for various mill residues; climate policies for mitigation including sequestration incentives (such as offsets for sequestering mill residues), future air quality regulation, and so on.

Biomass power plants need some assurance of being able to sell power to justify upgrades to increase efficiency and reduce air pollution. These upgrades are expensive and often involve shutdowns for installation.

Scenarios can be created to evaluate potential futures and inform future decisions. For example, scenarios could be built for solar and wind power availability and prices into the future, increased grid flexibility for dispatchable power, and how these compare to a likely fixed price of biomass power. If prices, availability, and dispatchability cross a threshold, biomass power might be abandoned in one scenario and continued in another.

It is reasonable to expect that the cost to produce biomass power will not change much if at all in the next decade, while the costs of wind and solar are likely to continue to decline sharply. At what point is the differential determinative as to continuing to use biomass power? This could be specified.

Should RCEA use their purchasing leverage to incentivize better air pollution control technologies at the plants?

Ideally, the biomass plants would use the Best Available Control Technology (BACT) to limit air pollution effects. This is not currently the case. State-of-the-art control of air pollution is a reasonable goal for any power purchased by RCEA, as the emissions are directly connected to the purchases, and public health is an agency responsibility. RCEA could considering adding financial incentives and contract language to provide air quality protection beyond what the State requires, and be able to cancel contracts if emissions performance is substandard.

References

Furniss, M.J. 2017**. Methodologies for Determining Carrying Capacity of Environmental Elements in Viet Nam for the Environmental Planning Process: With a focus on air and water pollution.** Institute of Strategy and Policy on Natural Resources and Environment (ISPONRE) and Ministry of Natural Resources and Environment (MONRE). UNDP-Vietnam

Gurin, Fiske, and Gaiera. 2018. **Biomass Energy in Humboldt County**. 350 Humboldt

Han, Han-Sup; Jacobson, Arne; Bilek, E.M. (Ted); Sessions, John. 2018. **Waste to wisdom: utilizing forest residues for the production of bioenergy and biobased products**. Applied Engineering in Agriculture. 34(1): 5-10.

Hawken, P. (Ed.). (2017). **Drawdown: The most comprehensive plan ever proposed to reverse global warming**. Penguin.

RePower Humboldt. A Strategic Plan for Renewable Energy. Security and Prosperity. March 2013. RePower Humboldt.

Severy, M. A., Carter, D. J., Palmer, K. D., Eggink, A. J., Chamberlin, C. E., & Jacobson, A. E. (2018). **Performance and emissions control of commercial-scale biochar production unit.** Appl. Eng. Agric, 34(1), 73-84.

Sierra Club, 2019. **Moving beyond incineration: Putting residues from California forest management and restoration to good use**. 37 p.

Sun, T., Levin, B., Guzman, J. et al. **Rapid electron transfer by the carbon matrix in natural pyrogenic carbon.** Nat Commun 8, 14873 (2017) doi:10.1038/ncomms14873

Swanston, Chris; Furniss, Michael J.; Schmitt, Kristen; Guntle, Jeffrey; Janowiak, Maria; Hines, Sarah, eds. 2012**. Forest and grassland carbon in North America: A short course for land managers.** Gen. Tech Rep. NRS-93.

Gathered research materials (not an RCEA site): https://sites.google.com/view/biomass-info/home

Consultations and Expert Panelists

September 13 panel

Mark Andre, City of Arcata
Richard Engel, RCEA
Kevin Fingerman, HSU Environmental Science
Colin Fiske, 350 Humboldt
Carrise Geronimo, Schatz Energy Research Center
Katy Gurin, 350 Humboldt
Julia Levin, Bioenergy Association of California
Melanie McCavour, HSU
Timothy Metz, Restoration Forestry, Inc.
Bob Moreno, DG Fairhaven Power, LLC
Michael Richardson, Humboldt Sawmill Company
Wendy Ring, Independent physician
Adam Steinbuck, Humboldt Redwood Company
Andrea Tuttle, California Dept of Forestry and Fire Protection
Yana Valachovic, UYC Cooperative Extension
Michael Winkler, City Council of Arcata, RCEA Board Chair
Sheri Woo, HBMWD, RCEA Board member

October 18th panel

Richard Engel, RCEA
Kevin Fingerman, HSU
Angie Lottes, California Department of Forestry and Fire Protection
Wendy Ring, Freelance physician
Adam Steinbuck , HRC Scotia
Yana Valachovic, UC Extension
Jason Wilson, NCUAQMD
Michael Furniss, Consultant to RCEA - Moderator

Individual consultations

Jason Davis
Richard Engel
Kevin Fingerman
Jana Ganion
Larry Goldberg
Katy Gurin
Arne Jacobson

Angie Lottes
Matthew Marshall
Melanie McCavour
Bob Moreno
Wendy Ring
Gary Rynearson
Adam Steinbuck
Nancy Stephenson
Andrea Tuttle
Yana Valachovic
Tom Wheeler
Brian Wilson
Michael Winkler
Sheri Woo