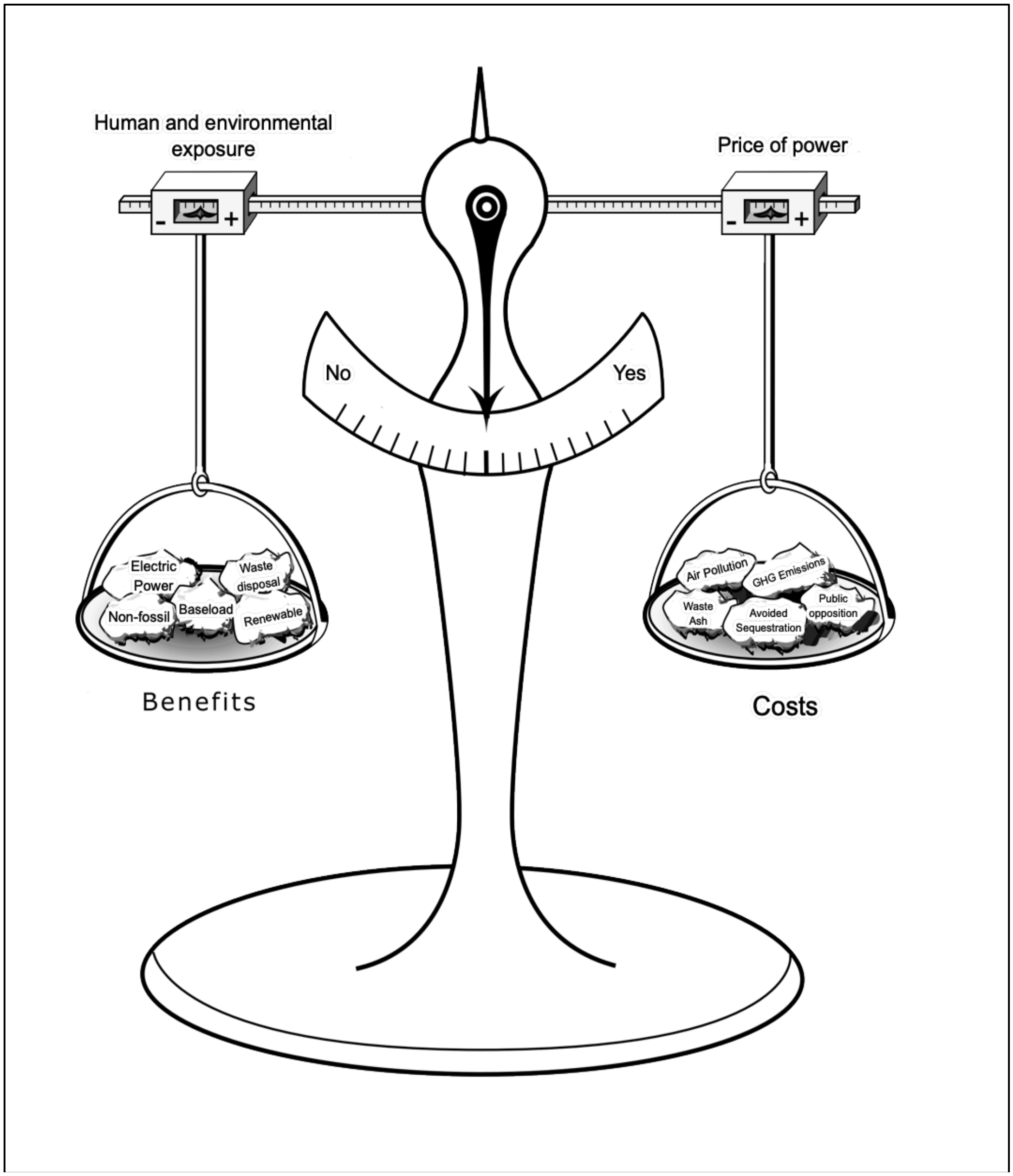
BIOMASS POWER IN HUMBOLDT COUNTY

SUMMARY OF WORKSHOPS CONSULTATIONS, AND RESEARCH



Prepared by:
Michael J. Furniss
Climate and Forests Consultant to Redwood Coast Energy Authority
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Contents

Purpose

Mr. Furniss's work for RCEA, including this report, was performed in fulfillment of several of the bioenergy strategies included in RCEA's 2019 RePower Humboldt strategic plan update.

The report is intended to explain the social and environmental context of biomass electric power generation for the benefit of the RCEA Board of Directors and the public to assist in informing decisions about power acquisition for Humboldt County.

Summary

1. As a source of electric power, biomass can replace fossil fuels and balance the intermittent supply of solar and wind power. As flexible grid solutions and storage facilities are added, this will become less important. Biomass power is widely regarded as a climate change "bridge solution."

2. For Humboldt County, biomass power is currently the only source of renewable utility-scale electricity.

3. The local electric power provided by biomass plants would otherwise come from the PG&E natural gas plant in King Salmon until additional local renewable generation is built and brought online.

4. It has long been customary to burn non-commercial forest harvesting and sawmill residues, although some in-forest material is chipped or lopped and left on-site, and small amounts of sawdust are used for animal bedding, compost helper, and other uses.

5. Because forests and the materials that come from them to become wood products and mill residues are part of nature's carbon cycle, biomass energy is often considered "carbon neutral." Because greenhouse gases (GHGs) are produced when creating biomass electricity, carbon neutrality is not always clear and depends mainly on the alternative fate of the residues if not used for power generation.

6. Biomass power can be considered roughly carbon neutral or carbon negative if: 1) the feedstock would be burned anyway, and 2) the resulting power replaces fossil fuel burning. A comprehensive life-cycle analysis is needed to firmly establish the emissions consequences of biomass power.

7. Biomass power emits air pollutants that are dangerous to human health when and where humans are exposed.

8. Burning biomass in a facility designed for power production involves efficient combustion as well as pollutant filtration systems, though the degree of efficiency varies with the age and maintenance of the plant. Most combustion alternatives for mill residue disposal, such as open pile burning, produce higher levels of GHG emissions, black carbon (soot), and air pollutants than burning in a power-generating biomass plant.

9. Substantial opportunities exist for the sequestration of the carbon in local sawmill residues on the order of several hundred thousand tons of carbon per year.

10. Biochar, nanocellulose crystal products, composting, or some combination of these could provide the most effective carbon sequestration. Cost and market considerations are not yet ideal to drive development of carbon-sequestering products in Humboldt County. Currently, incentives and subsidies would drive the development of these products based on their capability to reduce emissions and sequester carbon over climate-meaningful time periods.

Biomass Power in RCEA's Current Strategic Plan

From: RePower Humboldt 2019 Update[1]

4.1.11 Power Resources: Bioenergy

4.1.11.1 Support Biomass Fuels Reduction and Utilization. Develop strategies and technologies for improved biomass utilization in ways that effectively support restoration objectives and fire management priorities. Coordinate with local agencies, communities, and landowners to develop biomass energy plans that are consistent with sustainable forest management, hazardous fuels reduction, fire safety, and restoration needs.

4.1.11.2 Procure Local Biomass Energy. Contract with local biomass facilities as a means of providing locally-generated renewable power and managing wood waste from mills and, when feasible and appropriate, from forest management and restoration activities. Require and support a high standard of environmental performance from RCEA's biomass suppliers. Support the deployment of the best-available emissions control technologies, recognizing that power producers' ability to implement such technologies is affected by the price they are paid for their power and term length of contracts.

4.1.11.3 Investigate the Impacts of Biomass Emissions. Support research and quantification of the gross and net emissions of greenhouse gases and criteria pollutants associated with local biomass energy production, and the potential emissions reductions associated with disposing of biomass feedstocks by other means. Support development of a locally-specific model to estimate human exposure to criteria pollutants from biomass power plants under different operating scenarios. Adjust RCEA's biomass power procurement strategy as appropriate based on these findings and power producers' progress in limiting emissions and in keeping with achieving RCEA's power mix goals for 2025 and 2030. Consider power producers' historic emissions performance in making procurement decisions.

4.1.11.4 Establish a Biomass Technical Advisory Committee. Create a technical advisory committee made up of local government representatives; state and federal natural resource agencies; and subject matter experts on biomass energy, public health, the local forest products industry, and environmental impacts associated with biomass energy. The committee shall meet periodically and provide a quarterly report to the RCEA Board of Directors on technical feasibility and financial, environmental, and health implications of biomass use alternatives.

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[1] Redwood Coast Energy Authority, *RePower Humboldt 2019 Update,* pp. 17-19. https://redwoodenergy.org/wp-content/uploads/2020/06/RePower-2019-Update-FINAL-.pdf. Note that this agency strategic plan is a different document from the California Energy Commission-funded 2013 "RePower Humboldt: A Strategic Plan for Renewable Energy, Security and Prosperity" study cited elsewhere in this report.

4.1.11.5 Promote Small-Scale Biomass Generation Sites. Monitor feasibility of smaller and/or mobile biomass electric generators fed with wood waste and very small diameter logs (e.g., from thinning for fire safety and timber harvest slash). If/when technology proves feasible and cost-effective, promote its use in county areas where appropriate.

The Global Context for Biomass Power

Ever since humans developed the ability to start fires, biomass has been their primary source of energy. For more than half of the world's population, the principal energy source remains biomass. The modern industrialized world has switched from using raw materials for energy to burning fossil fuels, and until recently was unaware that industrialized nations' GHG emissions are seriously warming the climate.

The United Nations Intergovernmental Panel on Climate Change (UN IPCC) has recently concluded that to avoid severe climate consequences, GHG emissions must be reduced dramatically as soon as possible. National, state, and local governments and corporations have begun to adopt policies to achieve this reduction.

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" in moving to new and necessary technologies, and biomass is considered a prime candidate worldwide. The potential to generate electricity and heat is obvious, but so are the drawbacks of air pollution, carbon emissions, and the concern for forest and agricultural management and impacts.

Lumber mills produce abundant residue from product manufacturing, including sawdust, bark, cutoffs, wings, and other remnants. Some of this leftover material has economic value and is sold as chips for paper production, mulch, fiberboard manufacture, burnable pellets, and so on. To be utilized in these ways, the waste material must be of high and uniform quality. There must also be a current market demand, which can vary significantly over time.

What remains after these higher quality byproducts are sold and transported away is a lower-quality material, woody biomass that has no current economic value. For decades, this material was disposed of by open burning. Along with CO_2 emissions, black carbon (soot) and methane emissions from open burning are substantial and especially adverse to atmospheric warming and climate change.

However, the same biomass can be burned to make steam that drives turbines, generating electric power with substantially fewer emissions. Biomass energy plants must meet strict regulatory requirements, including high-efficiency burning and particulate filters on smokestacks.

While the use of biomass helps to move us away from fossil fuels and helps provide continuity to the intermittent power from solar and wind generation, it has drawbacks. As technologies improve with more flexible grid solutions and as storage facilities are added, the need for biomass generation to bridge these gaps will diminish.

At present, biomass energy fuels about 2% of global electricity production, more than any other renewable source. In some countries—Sweden, Finland, and Latvia among them—bioenergy is 20 to 30% of the national generation mix, almost entirely provided by trees. Biomass use for electrical generation is also on the rise in China, India, Japan, South Korea, and Brazil (Hawken et al., *Drawdown,* n.p.).

Is Biomass Power a "Carbon Neutral" Climate Solution?

Forests and mill residues in Humboldt County can be roughly classified as carbon neutral or carbon negative if these two conditions are met:

1. If the woody material would be burned for disposal, as has traditionally occurred with woody material that cannot be otherwise sold, and;

2. The biomass power generated from these sources substitutes for fossil fuel-based generation.

These conditions are normally met in Humboldt County.

However, to determine if carbon emissions are positive, negative, or neutral, ton-for-ton, requires a full "life-cycle analysis" to define all emissions related to the fuel and generation processes involved, and even then assumptions are required to conduct these analyses, leaving uncertainties. For example, in the use of natural gas, the energy required to develop and transport the gas, associated methane emissions, plant construction- and maintenance-related emissions, and so on would be part of a full accounting.

Climate change has primarily resulted from fossil carbon extraction from outside the natural carbon cycle, adding it to the atmosphere and oceans, resulting in significant and consequential radiative forcing[2] and the rapid climate warming that we now observe everywhere. 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 plants burn carbon-containing materials and thus emit GHGs. This carbon is considered to be "in the cycle" and does not contribute to increasing the total amount of carbon circulating within the earth's biosphere. That is, the carbon in biomass would naturally be emitted as the plants die and decay, and after being emitted, is typically sequestered again through new biomass growth within years to decades. The time-value of emissions and avoided emissions can be considerable and depends on the time that the emissions occur or duration of the avoided emission.

[2] *"Radiative forcing is what happens when the amount of energy that enters the Earth's atmosphere is different from the amount of energy that leaves it. Energy travels in the form of radiation: solar radiation entering the atmosphere from the sun, and infrared radiation exiting as heat. If more radiation is entering Earth than leaving—as is happening today—then the atmosphere will warm up. This is called radiative forcing because the difference in energy can force changes in the Earth's climate." MIT Climate Portal Explainer, "Radiative Forcing," accessed on November 30, 2021, https://climate.mit.edu/explainers/radiative-forcing.*

The energy density of woody material is low relative to coal or natural gas. Thus, the CO_2 emissions per unit of useful energy are higher for woody biomass than from fossil energy sources.

The CO_2 emissions per unit of fuel combusted are:

Natural gas:	118 lb. CO_2/MMBtu[3]
Bituminous coal:	205 lb. CO_2/MMBtu
Wood:	213 lb. CO_2/MMBtu (bone dry)

An approximate average of 320,000 tons of CO_2 have been emitted annually by the two local biomass plants recently in operation, DG Fairhaven and Humboldt Sawmill Company (HSC) Scotia.

Burning biomass produces carbon emissions. However, it is not adding fossil carbon that has been stored for eons far below ground, 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 addition to the atmosphere "count"? Yes and no, depending on the timing of emissions and how we view the overall carbon balance, the continued extraction of fossil fuels, and what would be done with the residues if not used for power production.

The authors of *RePower Humboldt* (Schatz Energy Research Center 2013, 22) pointed out several key issues that should 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 of 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, the fate of the material if not burned for power generation, and other factors that differ from facility to facility. Even fuel moisture content can impact the carbon intensity of biomass fuel, as wet fuel requires

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[3] *MMBtu = millions of British Thermal Units. The United States Energy Information Agency's Form EIA-923 provides publicly available data on fuel use and energy production at individual power plants. https://www.eia.gov/electricity/data/eia923/*

more of the fuel's energy content be directed to driving off this moisture before combustion can occur. In Humboldt County's moist coastal climate, biomass fuels tend to have a high moisture content.

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 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, are counted while some are not due to difficulties in measurement, such as for soil carbon.

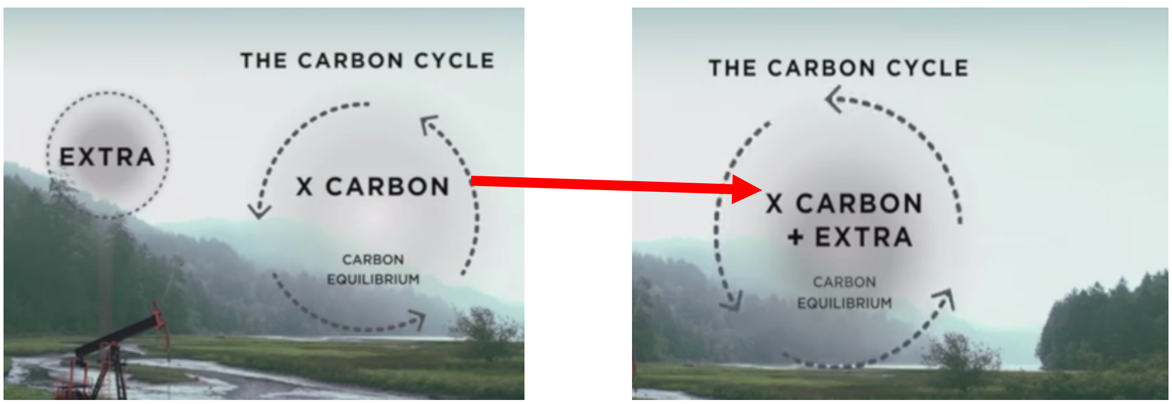

Figure 1: Billions of tons per year of non-circulating fossil carbon have been added to the carbon cycle. This is the primary driver of human-caused climate change.

According to Gregory Morris (2008, under "Carbon Neutral and Beyond"):

> *"The greenhouse-gas emissions produced at biomass and biogas generating facilities come 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 biomass resources' disposal or disposition. As a greenhouse-gas, reduced carbon (CH_4) is twenty-five times more potent than oxidized carbon (CO_2) on an instantaneous, per-carbon basis."*

How the GHG emissions are regarded in emissions accounting depends on many factors: changes in 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; and 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 comprehensive life-cycle analysis, carbon neutrality cannot be claimed, quantified, or denied.

A formula used by US Forest Service economists for carbon neutrality is:

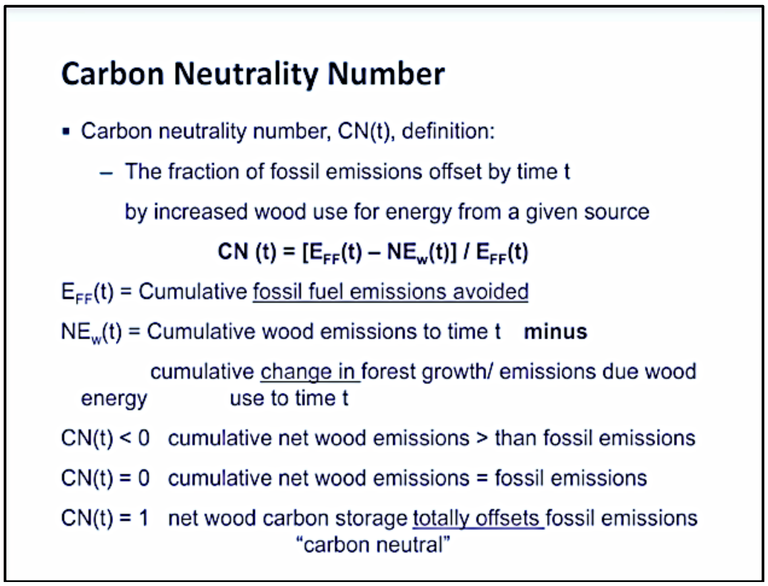

Figure 2: How the US Forest Service calculates a "carbon neutrality number." By US Forest Service Economist Ken Skog. (Swanston, et al., 2012.)

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. As assessed in Morris 2008, biomass burning changes the timing of GHG emissions as shown in Figure 3.

At a time when society is challenged to dramatically reduce all GHG emissions within the coming decade to avert extreme climate change scenarios, the distinction between emitting carbon today from biomass generation or allowing the same carbon to be released over decades through natural processes on the landscape is an important one. However, the risk of increasing areas of wildfire releasing large amounts of carbon sequestered on the landscape even faster makes it still more difficult to find an optimal solution that minimizes climate risk.

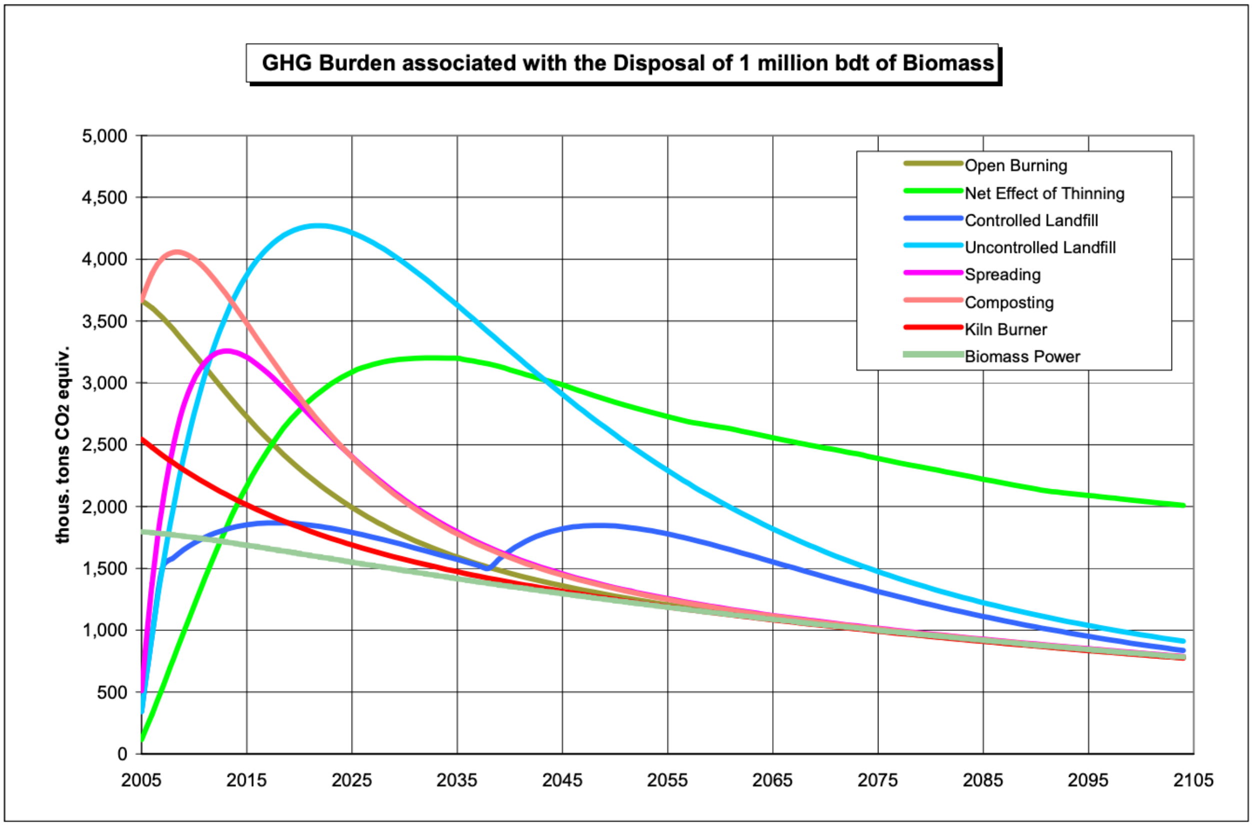

Figure 3: The curve for stack emissions from the biomass energy alternative is based on the immediate release of virtually all of the fuel-bound carbon as CO2, followed by its gradual clearance from the atmosphere. The conversion of one million bone-dry-tons of biomass leads to emissions of 1.75 million tons of biogenic CO2 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 CO2 equivalents, than those of the power alternative because of the release of black carbon and other products of incomplete combustion (Morris, 2008).

Air Quality Issues and Concerns

There is growing worldwide recognition of the adverse health effects of smoke and other forms of air pollution that lead to a wide variety of serious human diseases and can shorten lifespans. Impacts can be especially severe for the young and infirm. Smoke from wildfires, open burning, biomass production, campfires, indoor cooking, and even candle burning can negatively impact human health. 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 fine 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 the most significant impact and concern. There is no safe level (No Effect Level or NOEL) recognized for exposure to small particulate matter. Other pollutants in smoke include nitrogen oxides, carbon monoxide, volatile hydrocarbon compounds, and secondary production of ground-level ozone.

The California Context for Biomass Power

In 2018, the California Department of Forestry and Fire Protection published California's Forest Carbon Plan.

- 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 megawatts (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.

The current status of biomass power facilities in California is shown in Figure 4.

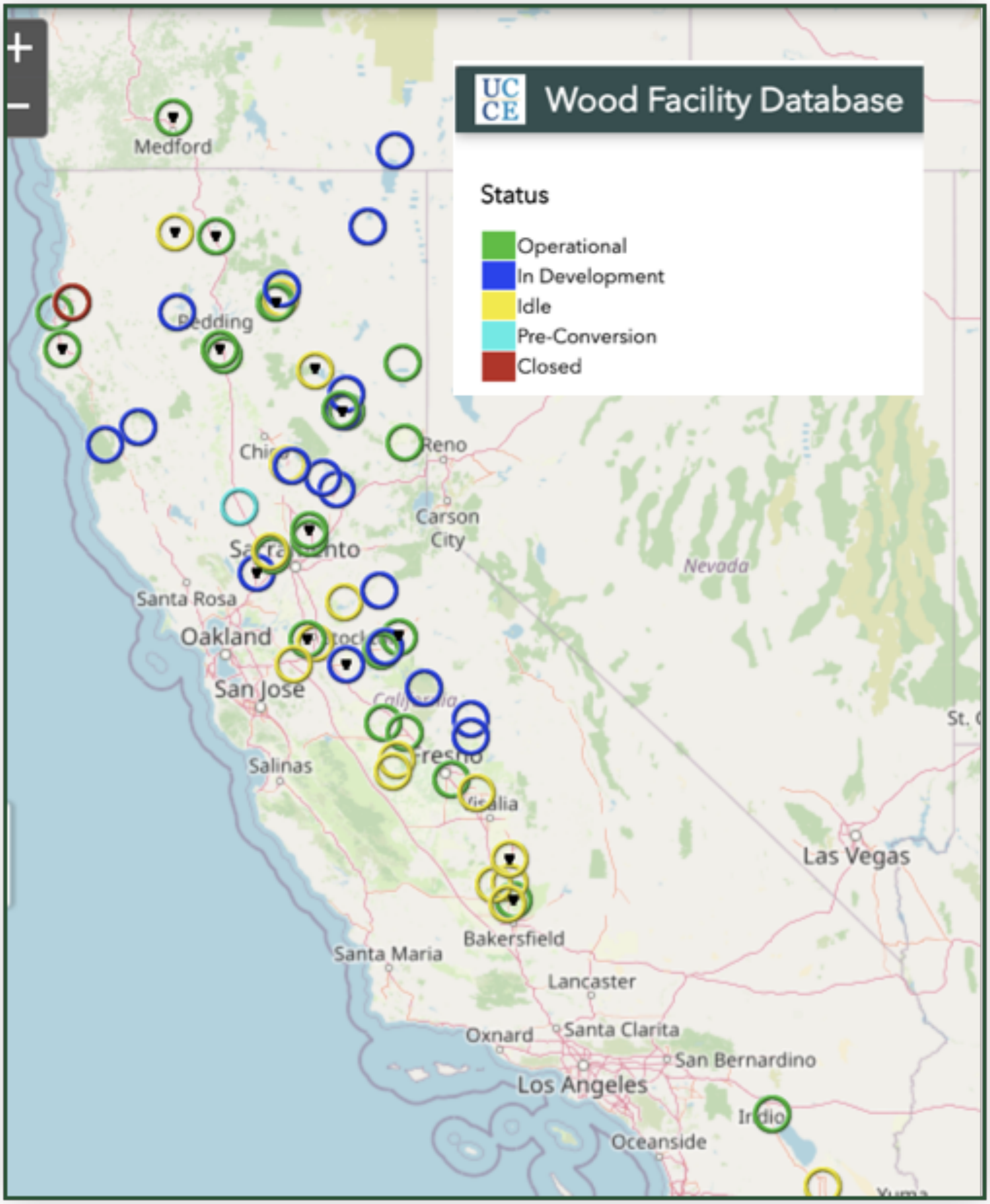

Figure 4: Biomass power facilities in California. The classification of the local DG Fairhaven plant needs to be updated as it is currently "idle." Source: University of California Woody Biomass Utilization Group. The University of California maintains an up-to-date wood facility database at: https://ucanr.edu/sites/WoodyBiomass/Project/California_Biomass_Power_Plants/

The Humboldt County Context for Biomass Power

Humboldt County has three biomass power plants. Only one of these is currently running and under an RCEA Power Purchase Agreement (PPA). A timeline of operation of these three plants is below.

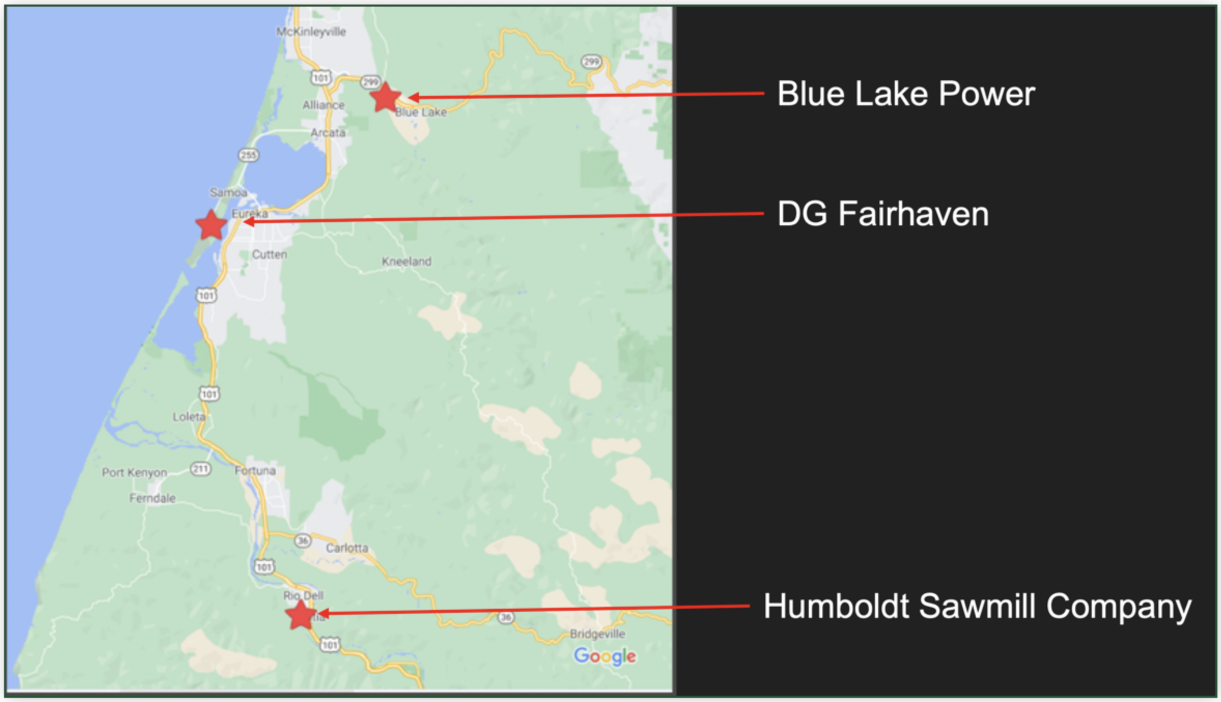

Figure 5. Locations of biomass plants in Humboldt County

HSC Scotia

DG Fairhaven

Blue Lake Power

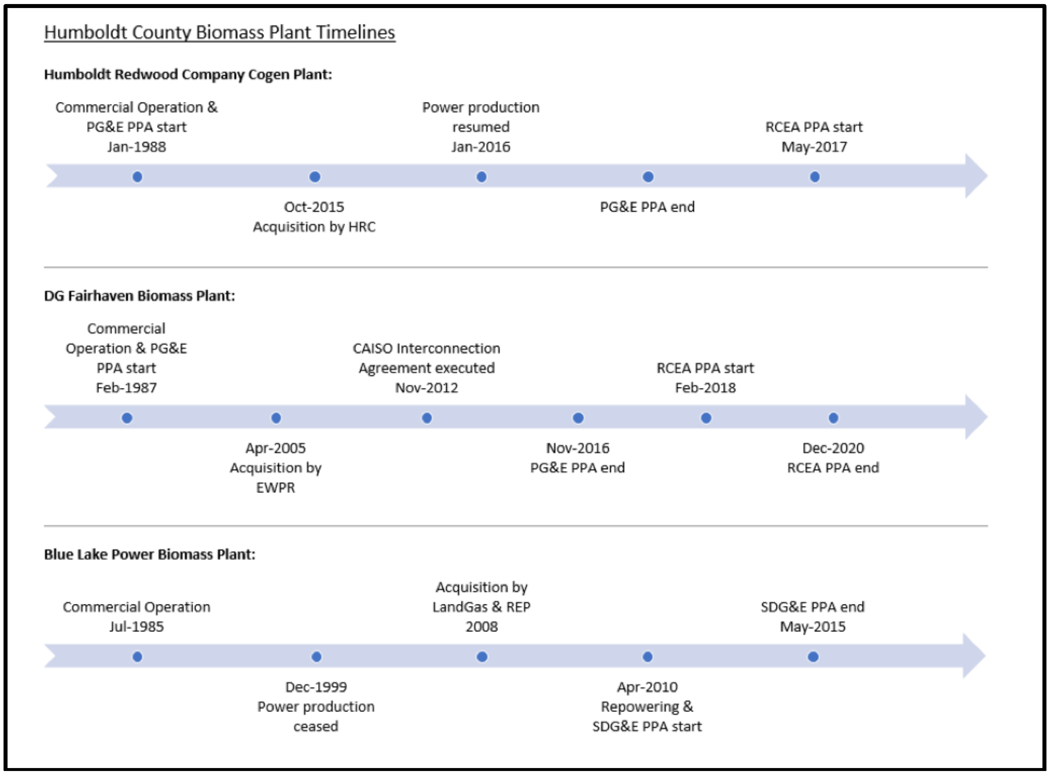

Figure 6. Timelines of operation, ownership, and Power Purchase Agreements (PPAs) for the three biomass power plants in Humboldt County. Graphic by Jocelyn Gwynn, RCEA.

Biomass is presently the only local renewable energy source in use in Humboldt County, with the exceptions of small solar, wind and hydroelectric installations.

Humboldt County produces enough electricity for local consumption, using biomass and natural gas (RePower 2013). Additional renewable generating capacity might increase soon if planned offshore wind power is installed and utility-scale solar installations are built. Biomass can generate continuous power output to the grid, contributing to meeting variable electricity demand and complementing the power available from intermittent sources like solar and wind.

In Humboldt County, biomass electricity, primarily using 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, with very roughly half of the harvested volume of wood becoming residues. These have been disposed of in open burning until this practice was prohibited, and currently are mainly burned in the county’s one remaining operating biomass generation plant.

Feed Material for the Biomass Plants

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

Figure 7: Unsaleable mill residues can look like this but vary in composition, sizes, and moisture content. A large proportion of this residue is in the form of sawdust. Historically, mill waste that could not be sold as byproducts was burned in "tipi burners." During the height of timber harvest in Humboldt County, approximately 200 mills were operating – and each had a "tipi burner" that burned mill residues around the clock. During this era, a great deal of unfiltered smoke was emitted. Many of these burners can still be seen today at old mill sites.

Figure 8: "Tipi burners" were common prior to 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 comparatively efficient burning conditions with pollution controls in modern biomass plants.

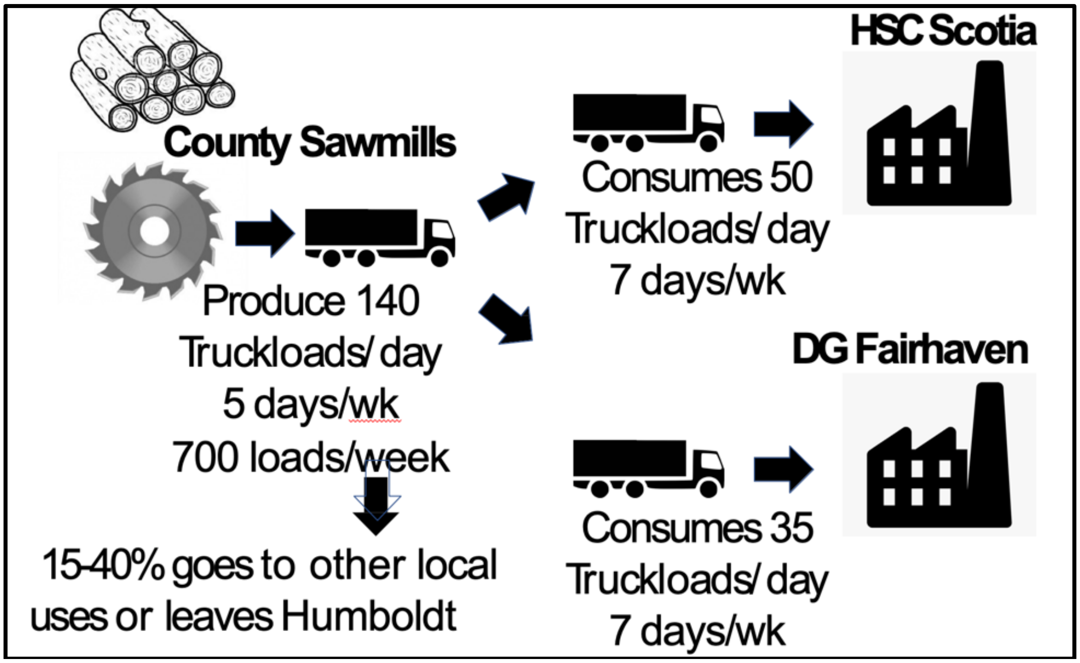

Figure 8: Typical currently-produced quantities of mill residue, based on queries to mill operators, via Yana Valochovic (personal communication). The feed material for the two contracted plants is residues from local lumber mills that are not otherwise used for salable byproducts of lumber manufacture. 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. Graphic by RCEA.

Table 1. Estimated volume of biomass used for power generation at the Humboldt Sawmill Company plant in 2020. Source: The Energy Authority. Accessed on July 24, 2021, http://www3.teainc.org/.

Month	Bone Dry Tons
20-Jan	8,979
20-Feb	7,520
20-Mar	10,377
20-Apr	1,230
20-May	8,655
20-Jun	9,650
20-Jul	8,523
20-Aug	10,751
20-Sep	9,332
20-Oct	9,972
20-Nov	11,255
20-Dec	11,283
Total	**107,527**

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 technologies. As a general rule, roughly half of the woody material and embodied carbon leaving the forest is converted to lumber. Roughly half is non-lumber products and residues (wastes) (Professor Mark Harmon, Oregon State University, personal communication with author).

Air Pollution Produced by Local Biomass Plants

Biomass power in Redwood Coast Energy Authority's (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.

	$PM_{2.5}$ (lb./ton)	NOx (lb./ton)	CO (lb./ton)	VOCs (lb./ton)	CO_2 (lb./ton)
Biomass Generation (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

Table 2: Emissions by type of combustion in pounds emitted per ton of woody biomass consumed. References: USEPA, AP12, Fifth Edition. McDonald et al., Environmental Science and Technology, 2000. USDA Forest Service, various reports.

Air Emissions	Coal Fueled Boiler (lb./MMBtu)	Biomass Fueled Boiler (lb./MMBtu)	Natural Gas Recip. Engine (lb./MMBtu)
CO	0.02-0.67	0.60	0.51
CO_2 fossil	178-231	0	120
CO_2 non-fossil	0	195.0	0
NOx	0.27-1.15	0.22-0.49	0.32
SOx	1.3	0.025	0.0005
VOCs	0.002-0.048	0.017	0.32
Methane	0.002	0.021	0.002
Particulates	0.37-2.4	0.05-0.56	0.007

Table 3: Approximate average air quality impacts for electricity generators. Note: Both contracted local plants use grid power for start-up and ongoing operation, much of which is from fossil carbon (natural gas). Source: Technology Characterization – Reciprocating Internal Combustion Engines U.S. Environmental Protection Agency Combined Heat and Power Partnership, 2015.

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.

Table 4: Health and welfare effects of common pollutants (from: Furniss 2017)

Permitted Air Pollutant Discharges

HSC Scotia permitted discharge of PM (all sizes) = 0.04 lbs./MMBtu
DG Fairhaven permitted discharge of PM (all sizes) = 0.10 lbs./MMBtu
Blue Lake 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	

Table 5: Reported greenhouse gas and air pollutant emissions for 2016. All units in tons. Data from California Environmental Protection Agency Air Resources CARB Pollution Mapping Tool. Accessed on November 18, 2019.

The current annual fine particle ($PM_{2.5}$) standard has been revised from the current 15.0 micrograms per cubic meter ($\mu g/m^3$) to 12.0 $\mu g/m^3$. An area will meet the standard if the three-year average of its annual average $PM_{2.5}$ concentration (at each monitoring site in the area) is less than or equal to 12.0 $\mu g/m^3$.

Air Resources Board

iADAM

FAQs

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.

Table 6. Comparison of Eureka-Humboldt $PM_{2.5}$ averages for 2014 to 2018.

During a recent five-year period, the annual average $PM_{2.5}$ concentration for two monitoring sites in Humboldt County ranged from 5.8 – 7.7 $\mu g/m^3$.

Air Quality and Ambient Air Monitoring in Humboldt

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 considered a "Non-Attainment" area for PM_{10} particulate air pollution.

The North Coast Unified Air Quality Management District (NCUAQMD) has issued permits to the three biomass plants in Humboldt County. Emissions are monitored at the stack of the one operating plant. However, no official monitoring of ambient air quality is done in Eureka, Fairhaven, Scotia, or Blue Lake, where exposure to biomass emissions would be expected to be the greatest. Exposure to particulate matter pollution, usually expressed as PM_{10} and $PM_{2.5}$ is the most significant threat to human health from the burning of woody materials, as these abundant small particles produced can lodge in the lungs and pass through the lungs into the human circulatory system. (See Table 7.)

Site emissions alone do not accurately describe the public health hazard; measured human exposure to emitted pollutants is necessary to understand public health impacts. Unfortunately, this analysis is not currently available. The Air Quality Management District has stated that it has conducted exposure modeling in formulating the permits but that this information is not publicly available. Currently, ongoing exposure modeling and monitoring are not being conducted.
In the absence of exposure modeling and monitoring, public health risks cannot be quantified or described. Scotia, DG Fairhaven, and Blue Lake plants are proximate to population centers. The DG Fairhaven plant is across a typically windy Humboldt Bay from the Eureka population but is proximate to the community of Fairhaven. The Humboldt Sawmill Company plant is in a narrow river valley that is not prone to stagnant air or long-term windless inversions, so the accumulation of smoke and related pollutants is likely quite low.

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.

Table 7. A sampling of criteria pollutant concentrations for Humboldt County and state and national standards. Source: US Environmental Protection Agency, The National Ambient Air Quality Standards for Particle Pollution Revised Air Quality Standards for Particle Pollution and Updates to The Air Quality Index (AQI), 2012.

Biomass Plant Air Quality Controls

The emission control tools utilized at the two RCEA currently- and previously-contracted plants include (from their permits):
DG Fairhaven

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

HSC 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 overfire air system is utilized to help control gaseous emissions.

Concerns About Forest Health and Sustainability

Biomass power in Humboldt County has come from three plants; Blue Lake Power, DG Fairhaven, and Humboldt Sawmill Company (Scotia). Only Humboldt Sawmill Company is currently producing power and under a power purchase agreement with RCEA.

Power generated by these three plants has used and is currently using mill residues as feed material (sawdust, cutoffs, end pieces, etc.). The use of these residues generates salable electricity but also functions as a primary method for disposal of mill residues, for which there are few other options for disposal, none of which generate revenue. A small amount of arborist waste and sudden oak death-killed hardwood trees removed for sanitizing have been added to the feed material at DG Fairhaven from time to time.

The amount of sawmill residue is driven by the volume of sawtimber manufactured into lumber products. This volume varies over time and is driven primarily by the softwood lumber market conditions and log inventories. Lumber from softwood harvesting is far more valuable in the market than using trees for biomass electricity generation, so generating electricity from biomass does not drive or incentivize timber harvest.

As with sawtimber, markets for biomass power are unpredictable and variable.

Timber harvest and associated concerns for forest management are not currently relevant for Humboldt County biomass electrical generation. This is in contrast to most other forest biomass projects that do use trees as feed material, and the forest management concerns are often paramount.

However, thinning of overstocked forest stands and the removal of non-commercial hardwoods for forest health and fuel reduction is widely acknowledged to be needed. Significant funding is becoming available statewide for these treatments, which yield large quantities of woody residues (slash). Proper disposal of thinning and fuel treatment slash is a highly significant challenge and is receiving abundant attention as quantities are anticipated to spike upward greatly. A set of field trials were conducted by HSU/Schatz Energy Research Center and others several years ago to define the feasibility of various options for field disposal of thinning slash, including the manufacture of biochar and charcoal, as well as torrefaction and briquetting to increase energy density for more efficient transport of woody fuel materials. *(Han et al., 2018.)*

From the executive summary of this study:

> *"Forest residues, including unmerchantable and small-diameter trees, tops, and limbs, produced during thinning and timber harvest operations can be used to produce renewable bioenergy and bioproducts. The more efficient utilization of forest residues could also help offset the high costs of forest restoration activities, fire hazard treatments, post-harvest activities and forest management in general. Forest residues have long been underutilized and treated as waste materials because of their high collection and transportation costs as well as their low market value. While open burning is often employed to dispose of forest residues, this practice generally results in substantial negative economic and environmental impacts, including increased forest management costs and reduced local air quality.*
>
> *At present, the greatest obstacle to more effectively utilizing forest residues is high transportation cost. The integration of biomass conversion technologies (BCTs) with new in-forest biomass operations could provide a cost-effective alternative to the long-distance transport of high moisture and low energy density forest residues. However, innovative new biomass feedstock technologies that produce high-quality feedstock materials from low-quality forest residues are needed to meet feedstock specifications for BCTs, including particle size and minimal contamination. BCTs can effectively convert comminuted forest residues into high-value fuels with desirable market characteristics (i.e., low moisture content and high energy density) and soil amendment products (i.e., biochar) in the woods, resulting in significantly-increased transportation efficiencies. Using a process that is either in-woods or near-the-forests would also provide substantial environmental benefits by displacing fossil fuels, improving forest health, reducing catastrophic wildfires, and reducing greenhouse gas emissions."*

The incentive to use trees and forest slash for biomass power generation in Humboldt County could become important under several foreseeable future scenarios:

> Off-site transport of slash is deemed to be the best option for disposal of slash and is hauled to biomass plants as feed material.
>
> Alternative uses of biomass are implemented (such as biochar, nanocellulose, compost, and so on) that create a larger economic demand for the product than the available supply of sawmill residues.
>
> Close-in fuel management thinnings are financially viable to transport to biomass plant(s).
>
> Biomass generating plants are built and operated in small towns in or near Humboldt County such as Hoopa, Willow Creek, and Hayfork (Trinity County).

If forest harvesting/thinning/fuel management is done to provide biomass electricity generation, the following guidelines and advice should be considered and incorporated.

- Forest harvesting should be sustainable.
- Best Management Practices should be implemented to ensure that forest operations are fully protective of soil and water resources.
- Woody forest residues function as food and energy for soil microbiota and are necessary for soil health and long-term site productivity. Sufficient woody residue should be left in place to feed the soil. Chipping and lopping of slash can reduce associated fuel hazards and promote incorporation into the soil system and long-term carbon sequestration.

Disposal of forest residues offers an opportunity for significant carbon sequestration and should be considered as an important climate solution measure. Sequestering activities include:

- Forest residues can be incorporated as long-term soil carbon stocks when chipped or lopped and scattered in ecologically appropriate quantities
- Biochar can be manufactured on-site or applied locally to forest soils. Biochar pyrolysis equipment may be used, or the local burning of piles or burnt areas may be extinguished before full combustion.
- Nanocellulose crystals can be produced that can be manufactured in a wide variety of useful products, such as concrete additives, plastic substitutes and packaging, biomedical products and many others.
- Composting the material for addition to soils to enhance fertility and increase soil carbon content.

Biochar, nanocellulose, and composting are discussed in greater detail below.

Expressed Community Support for and Opposition to Biomass-Generated Electricity

Support:

Some groups have publicly supported this technology, including forestry and timber manufacturing professionals, primarily because it supports their industry. Climate scientists and specialists are also generally in favor of biomass as a bridge solution, but with caveats. California Air Pollution Control Officers Association (CAPCOA) has also issued a written statement in favor of biomass as a way to limit air pollution from other methods of waste incineration or to avoid adding it to landfills.

Opposition:

Currently, public opposition to biomass burning is substantial. Vocal opponents come to the RCEA Community Advisory Committee, Board of Directors, and California Air Resources Board meetings and express opposition and concerns primarily about air pollution, GHG emissions, and forest management.

Many medical professionals, as represented by several professional medical societies and at least two local physicians have expressed strong concerns and opposition due to particulate air pollution and GHG emissions. For a summary of particulate pollution and health, see https://www.epa.gov/sites/production/files/2014-05/documents/huff-particle.pdf.

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

Nationally, 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 for Social Responsibility.

Local environmental organizations that have weighed in on these issues include 350-Humboldt and the Environmental Protection Information Center (EPIC). Both are "neutral" at the time of writing.

Exceptions exist within each of these groups and gaining the full support of the community for biomass power is not likely.

What Is the Likely Fate of Mill Residues if RCEA No Longer Buys Power from the Plants?

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

- HSC Scotia uses biomass power for mill operations and heat from the plant for lumber drying and so would continue to run at some level even if there were no electricity buyers.
- Material could be transported out of the county to other biomass plants or to landfills. For example, the material could be transported to Anderson, California (or other more distant plants) for burning in the Wheelabrator biomass plant there, which is about 300 miles round trip.
- Because open burning is unlikely to be permitted locally due to air pollution regulations, the residue could be hauled to an acceptable open burning location.
- Plants keep operating but sell electricity to other buyers, such as a community choice energy program serving jurisdictions outside of Humboldt County, as many municipalities have a mandate for renewable energy and biomass power "counts" as a renewable source.
- A final option would be closing the mills and sending logs out of the county for milling, likely to Oregon. Prices for local logs would decrease substantially. This would have the unfortunate effect of making restoration forestry, road maintenance, and wildfire-resilience thinning, all of which are expensive, less feasible and less likely to be practiced.

None of these options eliminates GHG emissions, and most would increase both air pollution and climate-warming emissions. Landfilling of mill waste could decrease air pollution but substantially increase GHG emissions including methane. However, current severe systemic societal waste disposal challenges would worsen and landfills might not accept such large quantities of organic wastes. As discussed below, an alternative pathway is to find ways to divert the material to other marketable uses.

Options for Mill Residue Disposal

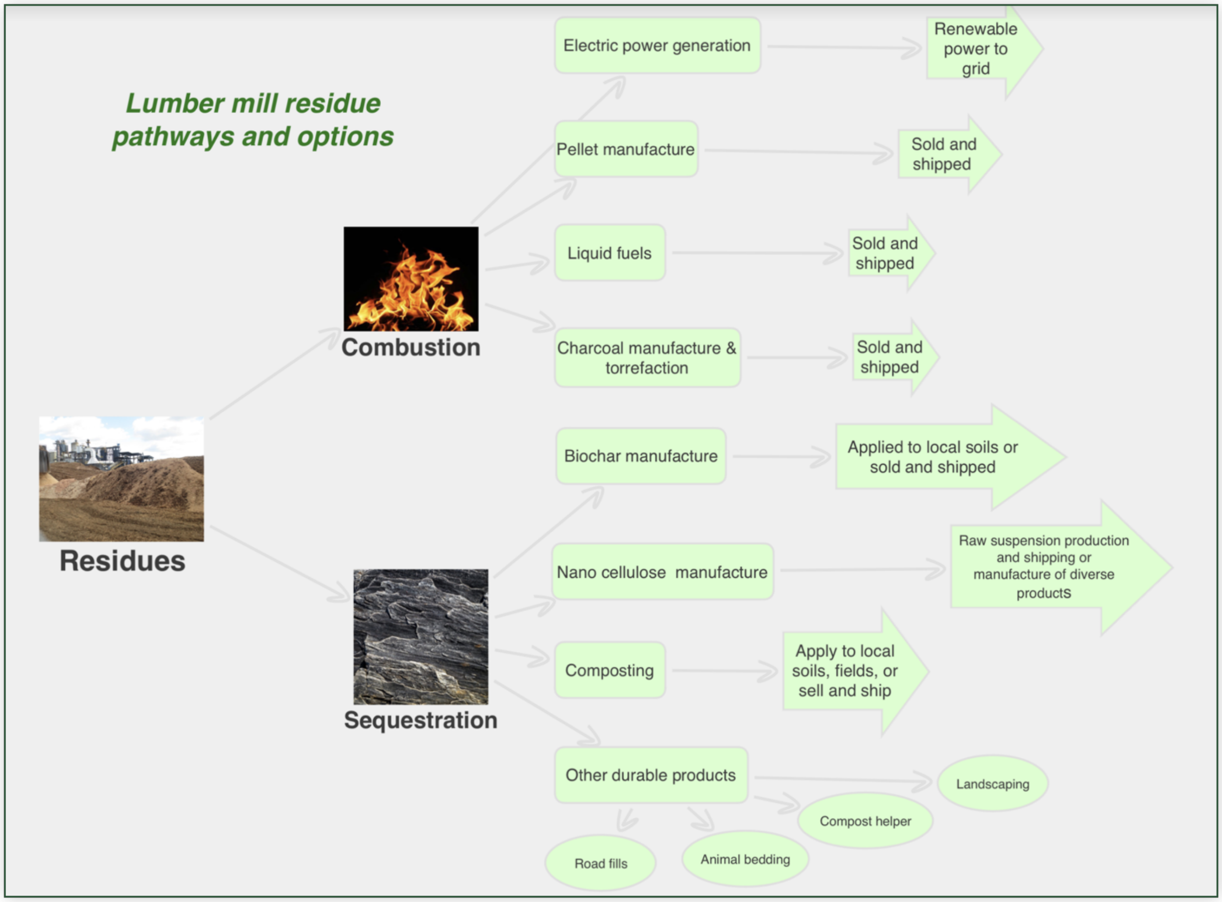

Figure 9. Illustration of options for mill residue disposal. There are two main categories: Combustion and sequestration.

Discovering or Developing Additional Products and Markets for Residues

Mill operators are always looking for new and re-emerging byproduct 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 substandard 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 and potentially sold as "byproducts" for the following:

- Chips for paper manufacture, mostly to Asia but also to the Pacific Northwest. Paper manufacture requires large, clean chips, and there is currently a market for these over the Fairhaven Loading Dock.

- Small amounts of residues are sold for compost-making, fertilizer mixes, landscaping, animal bedding, playground mulch, and so on.
- 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 polish are less critical than for consumer-grade pellets.

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

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

Gasification converts woody materials into gases 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 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, but potentially lower criteria pollutant emissions than in the direct combustion used in conventional biomass plants. Gasification technology is not currently at a feasible scale to process the amount of available local sawmill residues.
Torrefaction increases 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 on November 11, 2019.)* Torrefaction produces material to burn for heat or electrical generation, not for carbon sequestration.

A discussion of biochar may be found below.

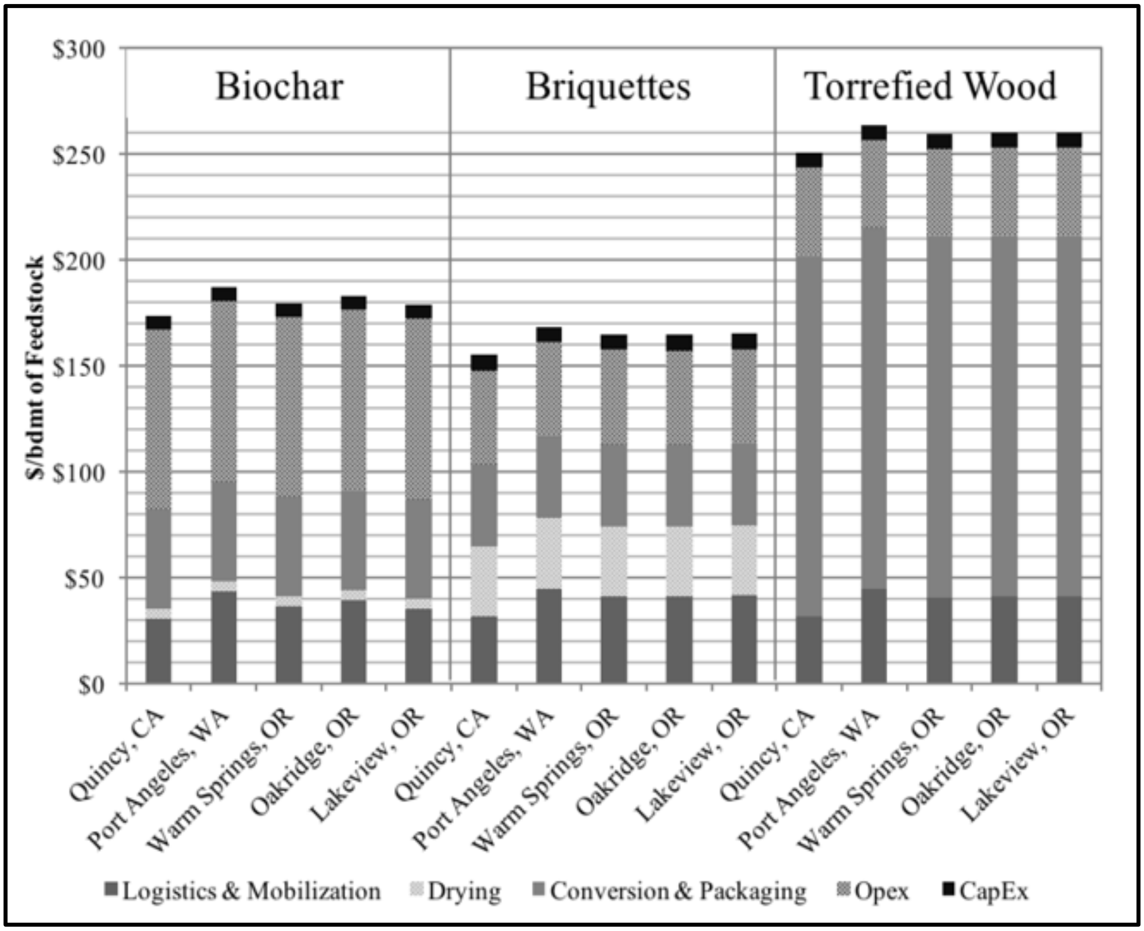

Figure 10: Cost comparison for production of biochar, torrefied briquettes, and torrefied wood, expressed as US$/bdmt (Bone Dry Metric Ton). From: Han, et al., Waste to Wisdom, 2018.

Potential Ways to Achieve Long-Term Carbon Sequestration 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 economically feasible compared with other disposal options. To be meaningful for climate change, carbon must be sequestered for decades to 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. Some mill waste can be manufactured into long-lived building materials, but a substantial residue of unsuited materials will always remain.

Biochar Manufacture as a Means to Sequester Carbon in Woody Residues

What Is Biochar?

Biochar is a charcoal-like substance that is intended to be applied to soil and/or used to sequester carbon long-term. It is distinguished from charcoal which is intended to be used as fuel.

Figure 11. Biochar is black, highly porous, lightweight, fine-grained and has a vast surface area. Approximately 70% of its composition is carbon. The remaining material consists of nitrogen, oxygen, hydrogen and other elements. Biochar's chemical composition varies depending on the feedstocks used to make it and methods used in pyrolysis.

Is Biochar the Same as "Activated Charcoal"?

The carbon-rich source materials used to make charcoal or biochar can be 'activated' through a set of processing techniques that increase the porosity of these materials, such as soaking in a strong base like Potasium Hydroxide. All 'activation' processes remove carbon atoms from the carbon-rich material, creating very small crevices and nooks that act as adsorption and absorption sites. Activated carbon is optimized for specific adsorption applications (water, vapor, certain adsorbates, and so on.) Unactivated biochars also have very large surface area and excellent absorption capacities, which is largely responsible for their soil-enhancing properties. The surface area of activated products is even greater, useful in a wide variety of specialty applications, including bioremediation of toxic waste sites, poison control, air and water filtration, and products like toothpaste and skin conditioners.

How is Biochar Made?

Biochar is made by burning biomass such as wood or crop residues with limited or no oxygen present, a process called pyrolysis. This results in much of the carbon in the wood remaining while other components are volatilized. The pyrolysis process produces flammable gases that are typically used to power the pyrolysis process. So after startup, the process is largely self-powered and can produce excess gas as a fuel product. Biochar can be manufactured in many ways from simply extinguishing fires prior to full consumption to relatively complex industrial-scale pyrolysis plants.

Are All Biochar Products the Same?

No. Biochar products vary significantly depending on the material used, the temperature of pyrolysis, and the specific process used. The presence of lignin in forest and mill residues has some advantages over crop residues as a starting material.

Biochars can have a terroir (a description of the unique character of the place of origin), based on the factors that make them unique, especially the starting material. Biochars thus have a specific “character.” Biochar made from redwood would be different than biochar from Douglas-fir, and both would be quite different from crop residue biochar.

How Does Biochar Contribute to Climate Change Solutions?

Biochar is largely carbon. Wherever the carbon content of a substance is ≥70%, microbial decomposition does not occur. Thus the substance will last indefinitely, at least for a few centuries. By converting readily decomposed organic material such as wood into biochar or charcoal much of the carbon content is sequestered for climate-meaningful time periods. Roughly 50% of the carbon in woody biomass is converted to biochar with pyrolysis, with the other 50% producing biogas, CO_2 and other gases. The converted proportion depends on the feed material and the pyrolysis process used.

What Are the Uses and Benefits of Biochar?

When applied to soil, biochar can:

- Improve soil physical properties, especially water-holding capacity, aeration, soil tilth, increased porosity, decreased density and increased infiltration capacity
- Increase the nutrient-holding capacity of soil
- Increase the microbiological diversity and activity in soils, improving nutrient retention and cycling, enzyme activity and overall soil health
- Increase the pH of acidic soils
- Convert simple fertilizer salts into slow-release fertilizer, increasing fertilizer delivery to plants and decreasing groundwater pollution. Soils that are poor in plant nutrients will usually benefit the most. For example, sandy acidic soils and nutrient-poor tropical soils would generally see the most benefits from biochar amendments. Fertile, productive soils may see little benefit but are a good place to store biochar simply to sequester it for a century or more.
- Adsorb and absorb soil pollutants, immobilizing them and remediating soil pollution, assist in toxic waste clean up
- Enhance soil microbial ecology through biochar’s electron channels (Sun et al., 2017)

Can Biochar and Compost Be Used Together?

Yes, there is strong evidence that adding biochar to compost improves the properties of compost as a soil amendment.

Is There a Commercial Market for Biochar?

Yes, but it is somewhat nascent and many conclude that the market demand could increase greatly in the near future once the soil benefits of biochar and its utility for carbon sequestration are further appreciated and biochars become available at scale. The local Redwood Forest Foundation project has a goal of biochar market definition and enhancement. Results should become available in the coming year.

Is Biochar a Way to Treat Excess Fuels in Forests?

Yes. This has been studied locally in detail and is undergoing further field testing and market research now. At a minimum, piles that are commonly burned in the forest can be extinguished or smothered to (inefficiently) produce biochar that can simply be left in the forest.

Is the Humboldt Bay Area Suitable for Biochar and Other Biomass Materials Production, Such as Nanocellulose Crystals?

Yes, in many ways, including:

- Abundant biomass resources in mill residue and extensive forests that are almost universally in need of thinning to reduce wildfire hazards. There is a great abundance of wood in our area.

- Good industrial space on the Samoa Peninsula that has fresh water supply, power supply, wastewater facilities and is already thoroughly disturbed (no new ecosystems would be lost in development). A deep-water port is available for ocean shipments.

- Strong Polytechnic University to gather knowledge and do research and development on these nascent technologies.

What *Could* RCEA Do to Promote the Production and Use of Biochar from Mill Residues?

***NC** means this measure also applies to promotion of nanocellulose from mill residues in Humboldt County*

- Keep discussion and innovation going with forums, information exchange and knowledge management. *NC (See https://sites.google.com/view/biomass-info/alternatives-to-combustion/biochar.)
- Create a clearinghouse for biomass, including all compostable waste/biosolids in the County, which is a local marketplace for all, including those who may make charcoal, and other fuel products. *NC
- The CA Climate Action Reserve (CAR) is currently developing a carbon-offset protocol for biochar. Offer CAR to be a development site for biochar credits. Get a plan and biochar system set up as soon as possible. Find out if the DG Fairhaven site has some biochar on hand.

- Acquire some biochar from the Redwood Forest Foundation effort in Branscomb to trial on local soils. (Obtaining a biochar sample for the Board when physical meetings resume may help them to get a tangible sense of the product.)
- There would be high interest in designing field trials in the HSU-Polytechnic Forestry and Wildland Resources Department soils group. Doing this work now would demonstrate a capacity for practical research and participation in the upgrading of HSU to a State Polytechnic University where the emphasis is on natural systems and the environment.
- Consider a program of contributed purchase of local sequestration to finance production and spreading as biochar might be unlikely to finance itself without grants. This could help jurisdictions meet their CAP goals, which is tenuous for some of the cities now. The County might be able to focus this effort. *NC
- Form a working group comprised of practitioners (those with a financial and operational stake, including mill owners, instead of mainly experts). *NC
- Investigate whether biochar can be used to treat wastewater from fish plants. Encourage a demonstration project in conjunction with soil/site remediation. Contact Nordic Aquaculture regarding this effort.
- Conduct a soil restoration project on the Humboldt Bay Harbor District's old L-P mill site. The site's disturbed soils would benefit greatly from the addition of biochar, compost and sawdust. Biochar works well in sandy, droughty, salty and acidic soils.
- Offer the HSU Environmental Resources Engineering Department a field site for composting and other sequestration experiments. The Harbor District could assist with this effort. *NC
- Enlist farmers, dairypersons and nurserypersons to conduct trials for soil enhancement.
- Work up the case for redwood and "Humboldt Biochar" as a specialty product. Biochar products vary with the feed material and the development of biochar terroirs/appellations has been advanced as a good marketing idea.
- Develop a biochar development proposal for Humboldt County that highlights its site suitability, biomass resources, potential plant sites with existing infrastructure and local amenities.

Can Biochar Be Used to Dispose of In-Woods Slash from Thinning?

Yes. The HSU Forestry and Wildland Resources Department and Schatz Energy Research Center, along with others, evaluated in-woods residue disposal options. The results are available in the "Waste to Wisdom" reports found here.

Local Biochar Production Business Development Considerations

Currently, markets for biochar may be inadequate to support the production costs of biochar, even when low-cost or free feed material are available close to production facilities.

Production cost of biochar and other soil amendments differ depending on many factors such as: 1) cost of starting material, 2) collection and transport cost of starting material, 3) quality requirements of the finished product (pH, bulk density, weeds and pathogens, carbon-to-nitrogen ratio, and so on), 4) production facility capitalization and maintenance, and 5) permitting and monitoring.

Documented biochar production cost plus profit and risk average about $200/ton produced. This is relatively expensive as a soil amendment and does not compete favorably with compost at an average price of $50/ton. In most or all cases, compost or inorganic fertilizers and other soil amendments will be less expensive to farmers than biochar at this time. However, biochar does have significant climate mitigation benefits and if these can be monetized, the cost calculus for biochar becomes more favorable. Marketing, packaging, and transportation costs and profit and risk must be added to this to arrive at the price at the point of use.

There is a likelihood that biochar will be added in the near future as a "carbon offset" in California's Cap and Trade system, providing additional value and revenue for biochar production where soil application can be quantified and documented. The current price for forest carbon offsets is about $15/ton. The price is driven by allowance trading and can be volatile. While this improves the outlook for the business viability of biochar production, offset credits would likely only defray a relatively small proportion of production costs.

Biochar also has promise for use in wastewater treatment if it is activated. A recent study by the CA Association of Sanitation Agencies (report in preparation) did not produce favorable results, but further research and development of this potential use is expected. Currently, wastewater treatment uses large quantities of granulated activated charcoal that is imported from Asia and is derived from coal.

A 2011 study of biochar feasibility recently summarized some of the challenges in commercializing biochar production. (Baranick, M. et. al., 2011).

> *Despite using a technology that has been around for more than 2000 years, the nascent biochar sector is faced with some challenges, including:*
>
> > *1) High start-up costs associated with biochar production, particularly compared to the composting sector.*
> > *2) Lack of consensus among the scientific community on how biochar achieves its range of benefits, especially over the long-run. This is critical to convincing the possible market sectors of biochar's benefits.*
> > *3) With so few operations up and running, it is hard to test the benefits on a commercialized scale. For now, industry pioneers rely on the research community to prove the benefits. This makes it hard for potential investors – especially risk-averse investors – without which a large-scale biochar business is unlikely.*
> > *4) In the long-run, if biochar becomes a profitable industry it runs the risk of over competition for feedstock sources, which could lead to land misuse, thus reversing the benefits of the process. These obstacles create a high barrier to entry for biochar companies. However, there are many biochar organizations working around the world to move the industry forward. For this reason, it is important to understand the competition within the biochar industry, which*

includes both commercialized biochar businesses and not-for-profit or university-related organizations.

An archive of references and other materials on biochar may be found here: https://sites.google.com/view/biomass-info/alternatives-to-combustion/biochar

A new report has 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, "Moving Beyond Incineration," 2019).

Composting

Composting of the non-salable residues is a commonly suggested method for disposing of mill waste and creating a valuable product.

Sawdust is commonly added to biosolids (sewage sludge, kitchen waste, or both) in making compost to add carbon-rich materials. Compost manufacture and biosolids disposal are the objectives of these efforts, not mill residue disposal, and the operational scales are tiny when compared to the volume of local mill residues. Demand for compost that contains biosolids (sewage and food waste) is limited by societal acceptance and regulations.

Advantages of Composting

Compost improves soil fertility and increased soil fertility furthers soil carbon sequestration and supports plant growth.

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

A 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

- 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.
- Local mill waste comprises a large volume of material. The scale is significant and composting this amount of wood waste is unprecedented.
- Composting would require substantial energy inputs to process and transport the resulting compost.
- For composting to occur, nitrogen-rich material must be added to support decomposition. Sawdust is typically 325:1 carbon to nitrogen (C:N), while the rapid composting that is required to destroy pathogens and create high-quality compost needs a C:N ratio of 25-30:1. Sewage, kitchen waste or green waste could provide the

needed N, but concerns about transport, mixing, sanitation, weeds, pathogens, costs, and public nuisance would be present in any such operations.

- Processing and storing a large amount of compost presents fire hazards because the decomposition process generates and accumulates significant heat.
- 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 and N_2O, especially powerful GHGs.
- Local markets are limited. An existing local green waste composting facility is currently producing more than the market demand. Non-local markets could likely be developed.

An archive of references and other materials on composting may be found here:
https://sites.google.com/view/biomass-info/alternatives-to-combustion/composting

Nanocellulose Crystals

Nanocellulose is a relatively new set of materials technologies that have enormous potential to be used in a broad variety of applications. Nanocellulose is made from cellulose-rich materials like wood waste or cotton, broken down into extremely small particles of cellulose and then repolymerized into a wide variety of materials.

These materials are environmentally benign and have remarkable properties. They are light and strong, have very large surface-to-volume ratios, are extremely strong in the longitudinal direction, have very low thermal expansion and excellent moisture and gas exclusion properties. Thin composites of nanocellulose crystals are transparent and good electrical conductors. One especially promising application is to increase the strength and flexibility of concrete and reduce the GHG emissions in making Portland cement. Nanocellulose products can substitute for most plastics and already have many biomedical and electronic technology applications.

These technologies are largely in the demonstration and pilot phase as this new technology is worked out and capitalized. We can expect rapid growth and adoption of this remarkable range of useful materials.

Mill resides are suitable for manufacture of nanocellulose crystals.

An archive of references and other materials on nanocellulose crystals may be found here:
https://sites.google.com/view/biomass-info/alternatives-to-combustion/nano-cellulose

Method	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 periods; potential to release substantial amounts of methane	10-20 years	Benefits to the soil. Needs addition of N-rich material. Energy required for handling and processing. Potential multiplier effect with increased soil fertility. Substitutes for N fertilizer reducing associated N_2O 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 are released during production. Benefits to the soil. Long-term sequestration and significant reduction in soil N_2O emissions. Multiplier effect increasing plant growth and recalcitrant humus formation.
Nanocellulose	100% of carbon sequestered. Lowers the GHG emission for cement manufacture	Variable depending on product	Can produce biodegradable substitutes for plastics, make stronger concrete, wide variety of new products.

Method	Potential GHG Impacts	Time Frame for Sequestration	Other Impacts/Considerations
Production of charcoal or wood pellets for fuel	Similar GHG production as raw biomass generation. Depends on burning technology and transportation costs	No sequestration	There is some demand for wood pellets and charcoal products to substitute for the use coal in electricity production in Asia.
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.

Table 8: Options for mill residue disposal. Adapted and modified from Gurin et al., 2018.

Making Decisions about Biomass Power Acquisition

Because biomass power has significant environmental costs, such as emission of air pollutants, as well as relatively high costs to produce, decisions for a public agency about acquisition of biomass electric power are complex, nuanced and require a balancing of the pluses and minuses.

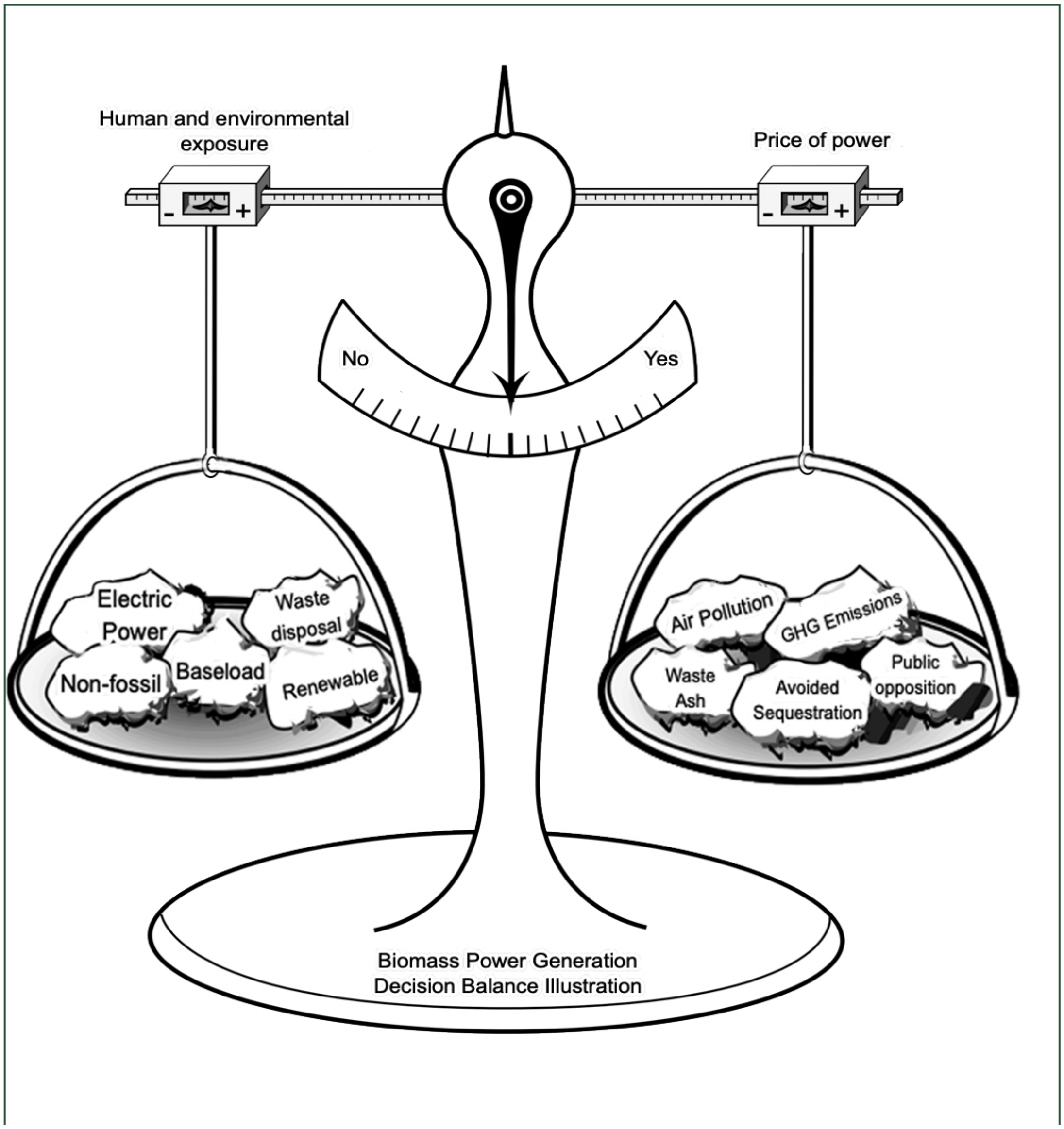

Figure 12. Biomass power acquisition decision considerations. Adapted from USDA-Forest Service 1999. (https://www.fs.fed.us/eng/road_mgt/DOCSroad-analysis.shtml). Concept by MJ Furniss.

The Future of RCEA's Use of Biomass Power

Adaptive management planning 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, innovations, business considerations, electric grid upgrades, markets for various mill residues, climate policies for mitigation including sequestration incentives (such as offsets for sequestering mill residues) and future air quality regulations, to name a few.
- Biomass power plants need some assurance of being able to sell power to justify upgrades to increase efficiency and reduce air pollutants. 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 fluctuate with fossil fuel prices but not otherwise change much 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? Future decisions to use biomass for power might turn on economics and the need for baseline power.

Leveraging Incentives for Better Air Pollution Control Technologies

Ideally, the biomass plants would use the Best Available Control Technology (BACT) to limit air pollution effects. This is not currently the case as the plants were built and permitted long ago. Implementing 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.

Results from biomass questionnaires from three local biomass plants in December 2016:

https://redwoodenergy.org/wp-content/uploads/2017/08/BLP_RCEA_2016_Biomass_RFO_Questionnaire.pdf

https://redwoodenergy.org/wp-content/uploads/2017/08/DGF_RCEA_2016_Biomass_RFO_Questionnaire.pdf

https://redwoodenergy.org/wp-content/uploads/2017/08/HRC_RCEA_2016_Biomass_RFO_Questionnaire.pdf

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

Consultations and Expert Panelists

Expert Panel: September 13, 2019

Mark Andre, City of Arcata

Richard Engel, Redwood Coast Energy Authority

Kevin Fingerman, Humboldt State University Dept. of Environmental Science & Management

Colin Fiske, 350 Humboldt

Carrise Geronimo, Schatz Energy Research Center

Katy Gurin, 350 Humboldt

Julia Levin, Bioenergy Association of California

Melanie McCavour, Humboldt State University Dept. of Environmental Science & Management, Humboldt County Planning Commission

Matthew Marshall, RCEA

Timothy Metz, Restoration Forestry, Inc.

Bob Marino, DG Fairhaven Power, LLC

Michael Richardson, Humboldt Sawmill Company

Wendy Ring, Independent physician

Adam Steinbuck, Mendocino Forest Products Company, LLC (Humboldt Redwood Company)

Andrea Tuttle, Freelance forest carbon expert

Yana Valachovic, University of California Cooperative Extension

Michael Winkler, City Council of Arcata, RCEA Board of Directors

Sheri Woo, Humboldt Bay Municipal Water District , RCEA Board of Directors

October 18, 2019, panel

Richard Engel, RCEA

Kevin Fingerman, HSU

Angie Lottes, California Department of Forestry and Fire Protection

Wendy Ring, Independent physician

Adam Steinbuck, Humboldt Redwood Company

Yana Valachovic, UC Extension

Jason Wilson, North Coast Unified Air Quality Management District

Michael Furniss, Consultant to RCEA - Moderator

Individual Consultations

Juliette Bohn, Clean Energy, and Waste Utilization Strategist, Juliette P. Bohn Consulting

Jason Davis, Deputy Air Pollution Control Officer, North Coast Unified Air Quality Management District

Richard Engel, Director, Power Resources, Redwood Coast Energy Authority

Kevin Fingerman, Assistant Professor, Energy & the Environment, HSU

Jana Ganion, Director of Sustainability and Government Affairs, Blue Lake Rancheria

Larry Goldberg, Vice Chair RCEA Community Advisory Committee, 350 Humboldt Steering Committee

Katy Gurin, Hydraulic Engineer, AECOM

Arne Jacobson. Schatz Energy Research Center Director, Humboldt State University Professor of Environmental Resources Engineering

Angie Lottes, Assistant Deputy Director for Climate & Energy, California Department of Forestry and Fire Protection

Matthew Marshall, Executive Director, RCEA

Melanie McCavour, Humboldt State University Dept. of Environmental Science & Management, Humboldt County Planning Commissioner

Bob Marino, Manager, DG Fairhaven Power, LLC

Wendy Ring, Physician, Climate/Health activist, Cool Solutions Radio Show producer

Gary Rynearson, Manager, Forest Policy and Sustainability. Green Diamond Resource Company

Adam Steinbuck, Director, Fiber and Freight, Humboldt Redwoods Company, LLC

Nancy Stephenson, Community Strategies Manager, RCEA

Andrea Tuttle, former Director of the California Dept. of Forestry and Fire Protection (CDF). Freelance forest carbon expert

Yana Valachovic, County Director and Forest Advisor, Humboldt County UC Extension

Tom Wheeler, Executive Director, Environmental Protection Information Center

Brian Wilson, Air Pollution Control Officer, North Coast Unified Air Quality Management District

Michael Winkler, Mayor, City of Arcata, RCEA Board of Directors

Sheri Woo, Environmental Engineer, SHN Consulting Engineers and Geologists. Humboldt Municipal Water District Board of Directors, RCEA Board of Directors