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To: Board of Redwood Coast Energy Authority (RCEA)
Date: October 14th, 2019
From:
Daniel L. Sanchez, PhD., Cooperative Extension Specialist; Department of Environmental Science, Policy, and Management, University of California Berkeley
Yana Valachovic, University of California Cooperative Extension County Director and Forest Advisor; Humboldt and Del Norte Counties

Dear RCEA Board,

As Specialists and Advisors with University of California Cooperative Extension, we wish to highlight the importance of continued use of local biomass as an energy source for Redwood Coast Energy Authority's (RCEA) renewable portfolio. Biomass power produces benefits for our local community, economy, *and* the environment.

Our support for bioenergy production in Humboldt County arises from its numerous benefits: clean energy, improved forest health, ambitious climate change mitigation, and rural job creation. We recognize that no energy source is perfect, but on the balance, locally produced and utilized biomass provides numerous public trust, environmental, and economic benefits. More information about the benefits of woody biomass and bioenergy is included in an appendix to this letter.

In the future, we expect innovation to create new wood utilization opportunities with the potential for enhanced economic and environmental benefits. However, focusing on new technologies ignores the role that current biomass power plants play in creating benefits at scale. Existing biomass power plants provide a backbone to accommodate the diversity of feedstocks that are available as California develops and deploys emerging technologies.

We urge RCEA to sustain their commitments to bioenergy produced electricity and to Humboldt County for both the near-term and long-term benefits.

Sincerely,

Daniel L Sanchez, Ph.D.

Yana Valachovic, RPF #2740

FAQs about Forest Biomass Energy in Humboldt

What are the benefits of energy made from forest biomass?

Forest-based biomass for this set of FAQs is defined as organic matter (materials from fuels reduction projects or the chips and bark from sawmill operations) that can be utilized to produce heat and power in emissions-controlled power plants that can provide clean energy, improved forest health, ambitious climate change mitigation, and rural job creation. **No energy source is perfect, but on the balance, locally produced and utilized biomass energy provides numerous public trust, environmental, and economic benefits** such as:

- ✓ Delivers distributed, flexible baseload generation. Biomass energy production provides a continuous 24-hour and reliable power source, unlike solar or wind that have a variation in daily and seasonal power production. Additionally, biomass power plants can be ramped up and down to meet the needs of the grid.
- ✓ An essential tool in the promotion of healthy forests and defensible communities through fuel reduction strategies for diseased and over-crowded forests that contribute to large and high intensity wildfires.
- ✓ Reduces emissions from wildfires or burn piles. Biomass power plants include effective air quality emissions technologies. Biomass emissions are substantially lower than wood stoves, wildfires, or burn piles[1].
- ✓ Reduces greenhouse gas emissions. Bioenergy production using materials from sustainably managed forests reduces long-term climate impacts by replacing fossil fuel energy sources.
- ✓ Utilizes a local product. The ability for forest landowners to sell logs to local sawmills provides an economic incentive to steward and sustainably manage local forests. Furthermore, farmers use the ash produced as an organic soil amendment.
- ✓ It's renewable. Unlike coal, oil and natural gas, which are fossil fuels that bring "new" carbon into the earth's atmosphere, biomass is an abundant and renewable source of fuel. The burning of biomass and the growth of trees creates a closed-loop system and does not contribute additional long-term atmospheric carbon. In Humboldt County biomass operations turn wood waste into electricity without compromising the essential cultural and habitat values that forests provide.

Is biomass clean energy?

There is no universally accepted definition of clean energy. Definitions can incorporate life cycle analysis, social justice, and other externalities. Nevertheless, the vast majority of scientists and governments classify biomass as both a clean energy and renewable (i.e. non-fossil fuel) source. The State of California defines biomass as a renewable energy resource along with solar, wind, geothermal, small hydro, renewable methane, ocean wave, ocean thermal, or fuel cells[2].

When bioenergy is made from locally grown small diameter trees and shrubs or the byproducts of sawmill operations it is a clean energy source. Not only do trees convert solar energy into fixed carbon, they store energy organically with far lower environmental impact than fossil fuels or batteries. This naturally fixed carbon and energy may then be managed as habitat in the forest, harvested for use as a building material, or

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[1] Springsteen B, Christofk T, York R, Mason T, Baker S, Lincoln E, Hartsough B, Yoshioka T. 2015. Forest biomass diversion in the Sierra Nevada: Energy, economics and emissions. Calif Agr 69(3):142-149. https://doi.org/10.3733/ca.v069n03p142.

[2] https://focus.senate.ca.gov/sb100/faqs

utilized as energy in a biomass power plant. Burning biomass for bioenergy production is importantly distinguished from burning fossil fuels in that *biomass is part of the actively cycled carbon in the atmosphere and was sequestered within the past 40-100 years, while fossil fuels reintroduce carbon into the atmosphere that were sequestered 60-200 million years ago and now are being reintroduced into the atmospheric carbon cycle*.

All clean energy sources have an important role to play in fighting climate change and producing renewable energy. In this regard, biomass energy provides many advantages beyond its renewable electrons, especially when fuel is sourced from the local area. From producing long-lived building materials that sequester carbon, to generating renewable heating, cooling, and power in local communities, strategic biomass utilization can support the interrelated goals of forest health, forest carbon sequestration, water and air quality, creating and maintaining local jobs, as well as keeping forests healthy for everyone's enjoyment and recreation.

How does biomass support forest health?

The fire seasons of 2017 and 2018 in California[3] have been a reality check for many, forcing a collective understanding that forest management plays a key role in wildfire risk reduction. In California alone, at least 129 million trees have died since 2010, due to a combination of fire suppression leading to overstocked and dense forests[4], drought, and pests. Managing the large number of dead trees is a difficult challenge, particularly within the context of protecting rural California residents. In January 2019 the Governor charged CAL FIRE and the Natural Resources Agency with the task of reducing fuels to protect our most vulnerable communities. CAL FIRE estimates that 15 million acres need forest restoration[5] and recognizes that "while it is not possible to eliminate wildfire risks in California; focused and deliberate action can protect communities and improve forest and fuels conditions to enable a more moderate and healthier wildfire cycle that can coexist with Californians". These challenges are not limited to the Sierra Nevada and are common throughout California including the North Coast.

The North Coast is blessed and burdened with highly productive forest and plant growth. However, all living vegetation is part of the natural carbon cycle and its fate is eventual carbon release either through decomposition or wildfire. The question is when and how? Management of this growth in the form of forest fuels reduction and the reduction of stand densities are important steps to creating more fire resilient forests and reducing uncontrolled emissions of greenhouse gasses and Short-Lived Climate Pollutants, including black carbon, during wildfires. Over the coming decade California will see an enhanced level of fuel reduction through mechanical and prescribed fire techniques and a broader level of incentives to manage fuel backlogs and improve forest health. Bioenergy utilization with emission-control technologies is an important part of the solution and provides an alternative to open-pile burning[6] of forest fuels and prescribed fire.

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[3] Governor's Executive Order N-05-19 https://www.gov.ca.gov/wp-content/uploads/2019/01/1.8.19-EO-N-05-19.pdf and the state emergency declaration http://www.fire.ca.gov/general/downloads/45-DayReportPlans/3.22.19-Wildfire-State-of-Emergency.pdf

[4] Parsons and DeBenittie (1979) Impact of fire suppression on a mixed-conifer forest. Forest Ecology and Management 21: 21–33.

[5] CAL FIRE 45 Day Report. http://www.fire.ca.gov/downloads/45-Day%20Report-FINAL.pdf

[6] Springsteen B, Christofk T, York R, Mason T, Baker S, Lincoln E, Hartsough B, Yoshioka T. 2015. Forest biomass diversion in the Sierra Nevada: Energy, economics and emissions. Calif Agr 69(3):142-149. https://doi.org/10.3733/ca.v069n03p142. http://calag.ucanr.edu/Archive/?article=ca.v069n03p142

How does forest biomass utilization support climate change mitigation?

Biomass utilization produces important climate change mitigation benefits, both by sequestering carbon and displacing carbon-intensive products. Executive Order B-55-18 'To Achieve Carbon Neutrality', issued by Governor Brown on September 10, 2018, places California on a path to net-neutral economywide emissions by 2045[7]. Carbon sequestration from forest biomass will be essential to achieving this goal, as carbon stored in living trees or wood-based lumber products can help with long-term sequestration and to offset emissions from hard-to-decarbonize sectors such as aviation, long-distance trucking, and agriculture. Further, biomass power plants support removal of hazardous forest fuels that are otherwise placing these carbon stores at risk.

Furthermore, forest biomass has an important role to play in carbon sequestration. In the near-term, maintenance of bioenergy markets will help to make reducing forest fuels economically feasible thereby helping California's forests become more resilient to wildfire or other disturbances. In the future, RCEA and other energy consumers may be able to procure net carbon-negative electricity from biomass, which permanently removes CO_2 from the atmosphere. For instance, numerous scientists and policymakers recognize that biomass utilization combined with carbon sequestration (commonly referred to as BECCS—Bio-Energy with Carbon Capture and Storage) will be necessary if we are to keep global warming significantly below 2 degrees Celsius. Supporting biomass energy through power purchase agreements and other procurement mechanisms can help drive the deployment of BECCS technologies in California as they become commercially viable.

Finally, many recognize that a "portfolio" approach to fighting climate change produces large economic benefits in comparison to those that rely solely on a limited number of energy sources[8,9]. Biomass, alongside other complimentary renewable energy sources, can play an important role in achieving cost-effective climate change mitigation.

How does the State of California view biomass and forest carbon?

California's Forest Carbon Plan, released in 2018, embraces biomass utilization as a key driver of sustainable forest management[10]. Key findings include:

- 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 major impediments to forest restoration and ongoing forest management.

Near-term actions proposed by the State include:

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[7] https://www.gov.ca.gov/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf

[8] D.L. Sanchez, J.H. Nelson, J. Johnston, A. Mileva, D. Kammen. "Biomass enables the transition to a carbon-negative power system across western North America." *Nature Climate Change*, 5, 230–234 (2015).

[9] S.J. Davis *et al.* (with over 30 authors) "Net-zero emissions energy systems" *Science* (2018). http://science.sciencemag.org/node/711939.full

[10] Forest Climate Action Team. 2018. California Forest Carbon Plan: Managing Our Forest Landscapes in a Changing Climate. Sacramento, CA.

- 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.

What role does biomass have in rural job creation?

Biomass utilization creates economic opportunities locally[11]. Forest management and restoration activities cannot be outsourced and produce many living wage jobs in our local communities. These jobs include forest management, forest operations, trucking, processing, and other value-added operations. The many steps involved in bioenergy production require that workers be employed to operate each link of the supply chain. By having an integrated infrastructure rural development persists providing both near- and long-term economic benefits.

Does biomass utilization emit greenhouse gasses?

Yes, combustion of woody materials emits CO_2, however, these gases are already in the atmospheric carbon pool as opposed to releasing stored carbon from the fossil fuel pool (e.g. utilizing coal or natural gas for energy production). In short, utilization of organic sources of carbon for building materials or sources of energy is a part of a closed loop carbon cycle. When trees emit carbon from decomposition or through combustion in a wildfire, carbon is made available as CO_2 and can be sequestered from the atmosphere through photosynthesis into new organic forms.

Is biomass power the best means of handling the waste stream generated by our local forest products industry?

Yes, at present, power produced from the utilization of feedstocks from sawmill operations is the best means to utilize this material because:

- The utilization of chips, bark, sawdust, and other smaller pieces of wood to produce heat and power in emission-controlled power plants allows for utilization of a **diversely-sized feedstock** with a range of moisture contents. Other utilization options are not as flexible in their size or moisture variation.
- This material is abundant in our **local** region and does not require the importation of other feedstocks.
- Biomass energy complements other **higher value markets**, including using chips to produce pulp and paper, using bark and chips for landscape mulch, using sawdust for compost manufacturing, and using shavings for animal bedding. Bioenergy is part of a broad solution for the sustainable and renewable use of locally available woody materials. When no other higher value markets exist, the remaining residuals are used for energy production.

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[11] Henderson, James E.; Standiford, Richard B.; Evans, Samuel G. 2017. Economic contribution of timber harvesting and manufacturing to north coast redwood region counties. In: Standiford, Richard B.; Valachovic, Yana, tech cords. Coast redwood science symposium—2016: Past successes and future direction. Proceedings of a workshop. Gen. Tech. Rep. PSW-GTR-258. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: 371-381.

- Looking for new and creative technologies and markets is encouraged and over time, these markets may include composting, gasification, or other uses (see discussion below). However, at present these markets do not exist at scale in Humboldt or within reasonable transportation distances.

In the medium- to long-term, new, innovative wood products could provide enhanced climate benefits and enhanced revenues from forest products. To this end, California has founded the Joint Institute on Wood Products Innovation[12] to serve as a center for analysis, testing, and outreach to support industry retention and development in California for new wood products. The work of the Institute will support long-term ecological and economic sustainability, increase forest resilience, long-term carbon storage, and local economies.

Should we be looking to emerging technologies such as gasification to keep using biomass as a power source?

Gasification is a process that converts organic materials into carbon monoxide, hydrogen and carbon dioxide. This is achieved by reacting the material at high temperatures (typically >700 °C), without combustion, with a controlled amount of oxygen and/or steam. Wood gas is a syngas fuel which can be used as a fuel for furnaces, stoves and vehicles in place of gasoline, diesel or other fuels. Biochar is a coproduct.

It is always valuable to look for higher value options and to test emerging technologies. However, gasification technology has not been deployed at scale yet to process the amount of available sawmill residues and requires a uniform feedstock free of soil and rocks. Moisture management of the feedstock is also critical. Some of the sawmill residue could be diverted to a gasification plant, but it would require a significant capital investment and tight controls on the feedstock quality.

An additional question is what is the lifespan of a biomass power plant and what modifications and improvements can be reasonably expected or are feasible? Furthermore, do these plants really age out or can they be upgraded when new emission control technologies become available? At present both DG Fairhaven and Scotia have invested significant capital into emission control technology upgrades and are operating within their existing air quality permits requirements.

Should we be continuing with the existing centralized power plant approach or looking to more decentralized emerging technologies?

Yes, we should explore emerging technologies and yes, we should recognize the value that the existing power plants provide as a backbone to accommodate the diversity of feedstocks that are available. There are challenges to financing and permitting new facilities that also need to be evaluated and it is important to recognize that innovation takes time. A recent example was the proposed development of a BioRAM eligible 5 MW biomass plant in Arcata that was derailed when PG&E required the developer to fund an additional $6 million upgrade of the PG&E substation. It could be viewed from a “bird in the hand is worth two in the bush” perspective where we are certain in what we have and there is no guarantee that future technologies will perform adequately or at scale. Permitting and capital investments for building new

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[12] https://bof.fire.ca.gov/board-committees/joint-institute-for-wood-products-innovation/

infrastructure will likely continue to be a large barrier to deployment of emerging bioenergy technologies across the State and in the North Coast.

What can be expected if the existing power plants close?

- An immediate logistical challenge to divert the ~100-120 truckloads a day to Wheelabrator Shasta (in Anderson, CA), the closest biomass facility, and assuming they would take the material. This is a 300+ mile round trip haul. There are not enough trucks available to move this material.
- In the longer term, forest landowners, managers, and product manufacturers would be affected as these sectors shrink. Specific Humboldt groups include:
  - Manufacturing: Humboldt Redwood Company, Green Diamond, Mad River Lumber, North Fork Lumber, Schmidbauer Eureka, Pacific Clears, CW Wood, Arcata Lumber Products
  - Landowners of all sizes, including all small forested landowners, Bureau of Land Management, State and National Parks, USDA Forest Service, conservation organizations, etc.
  - Municipal compost facilities such as Arcata, Humboldt Waste Management Authority, Recology, etc.
  - Many licensed timber operators and trucking companies
  - And any further development of the forest products manufacturing sector. It is reasonable to assume there would be a contraction of this sector if the biomass power plants closed.

Could the sawmill residues be utilized for compost?

While compost is a promising option for wood waste, the industry faces a number of barriers to reaching scale. As a result, only smaller amounts of biomass can be utilized for compost. With the county's daily production of ~100-120 truckloads of biomass a day, there is no existing option available at scale. HRC alone produces 70-100 chip vans per day (5 days/week) of this material. It would take 2.65 days to fill a football field (120 x 53 x 5 yards) to a height of 15 feet with the volume of material that HRC generates. Storing large amount of chips present fire hazards because the decomposition process releases heat and fires are common. An additional challenge is that the local compost industry is currently experiencing a contraction. Finally, some portion of the compost will decompose and emit CO_2 and methane over time and the carbon will not be permanently sequestered.

Is biomass energy more expensive than other renewables?

Community-scale biomass facilities in California are currently receiving 12.7 to 19.7 cents per kilowatt (kWh) hour of power; RCEA is currently paying 6.5 cents per kWh for power from DG Fairhaven and Scotia. In contrast, distributed solar is typically 6 to 7 cents and large scale solar is 3-4 cents per kWh[13]. Biomass provides 24-hour base-load generation unlike wind and solar. If power needs were calculated on a 24-hour framework, wind and solar need other complementary sources to meet daily power demands. This is why biomass is an important Resource Adequacy tool for load serving entities. Right now, half of California's electricity comes from natural gas - so storage is not a problem because the gas provides both storage (gas can be stored) and generation- but as we phase out fossil fuels, solar and wind will increasingly require energy storage to meet demand.

[13] Julia Levin Per. Comm., Bioenergy Association of California

The energy storage needed to fill in around solar costs 25 to 50 cents per kWh. When the cost of battery storage is added to the costs of solar, then biomass has a competitive advantage. Furthermore, battery technology is still in development and their longevity and life cycle needs to be included in our analyses. As California fully decarbonizes its economy and phases out fossil fuels, bioenergy will become increasingly cost competitive. This is due to both its flexibility, and its ability to sequester carbon from the atmosphere.

Is RCEA providing a "subsidy" to the timber industry by purchasing power from biomass from the two power plants?

It could be viewed from that perspective; however, biomass produces numerous local benefits to offset its perceived higher cost. Biomass is the primary locally available and renewable power source, a key consideration for RCEA and meets Resource Adequacy standards. Minimal trucking and processing is required to utilize this source and new infrastructure does not need to be built. **Biomass utilization is providing many community benefits including: an ability to steward and improve the resiliency of our forestlands, job creation; tightly controlled emissions of low-value forest residues; disposal of urban organic wastes; and a reliable source of 24-hour power that meets local energy demands.**

To: Redwood Coast Energy Authority Community Advisory Committee

From: Daniel Chandler, Ph.D.

Subject: Getting empirical about biomass greenhouse gas emissions

On October 24th I presented the Redwood Coast Energy Authority Board two facts and two suggested actions. Today I would like to discuss the idea of carbon neutrality, a different so-called "fact," but the suggested actions will be the same as proposed to the Board but with added detail.

Current California law assumes that burning biomass for electric power is carbon neutral. The law exempts biomass from cap and trade restrictions. And it incentivizes burning dead and dying trees from high hazard fire zones. In the face of a climate crisis, is assuming biomass to be carbon neutral reasonable? And should RCEA's projections be based on this assumption?

From a theoretical perspective it is true that unlike fossil fuels, which add carbon to the atmosphere that was previously buried, using forest products for energy maintains a steady state, or as UC Extension's Yana Valachovich would say, a "closed system" as long as the forest is managed for sustainability. However, in the past few years misuses of these ideas have gotten so common that scientists have started calling them "myths."[1] Instead scientists are reframing the goal and method as investigating the "net climate change effects of bioenergy, assessed in the specific context where bioenergy policies are developed and bioenergy is produced."[2]

The idea of "carbon neutrality" is dependent on at least two questionable assumptions.

Look first at the assumption that forests will be managed for sustainability.

a. In the midst of the climate crisis, we are losing forests and their capacity to sequester CO_2. World Bank data show world forest cover as a percent of all land decreased from 31.6% in 1990 to 30.7% in 2015. https://data.worldbank.org/indicator/AG.LND.FRST.ZS[3] Thus there is approximately 3% less forest cover than 35 years ago.
b. Also, we don't know that California forests will be sustainable long term in the face of fire.[4]

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[1] Ter-Mikaelian, Michael T., Stephen J. Colombo, and Jiaxin Chen. "The Burning Question: Does Forest Bioenergy Reduce Carbon Emissions? A Review of Common Misconceptions about Forest Carbon Accounting." Journal of Forestry 113, no. 1 (2015): 57–68. https://doi.org/10.5849/jof.14-016.

[2] Göran Berndes, Bob Abt, Antti Asikainen, Annette Cowie, Virginia Dale, Gustaf Egnell, Marcus Lindner, Luisa Marelli, David Paré, Kim Pingoud and Sonia Yeh. 2016. Forest biomass, carbon neutrality and climate change mitigation. From Science to Policy 3. European Forest Institute. "Forest carbon neutrality is an ambiguous concept and its debate distracts from the broader and much more important question: how European forests and the associated industries can contribute to climate change mitigation while serving many other functions. Rather than debating the carbon neutrality of bioenergy, we should be concerned with the net climate change effects of bioenergy, assessed in the specific context where bioenergy policies are developed and bioenergy is produced."

[3] The November 5th report by over 11,238 scientists lists loss of tree cover world-wide as the third largest effect of human activity. (WJ Ripple, et al., World Scientists' Warning of a Climate Emergency, Bioscience, 2019.) During 2018 it amounted to a global tree cover loss of 24.8 million hectares, or 61.3 million acres. Contained in the data supplement from https://academic.oup.com/journals/pages/open_access/funder_policies/chorus/standard_publication_model

[4] Op cit, Berndes. "Events such as storms, insect infestations and fires can cause forest damage and losses of some of the carbon that was sequestered into forests as compensation for GHG emissions, which can further hamper the fulfillment of longer-term objectives." https://www.efi.int/sites/default/files/files/publication-

Second, the carbon neutrality assumption *presumes* the current land use of logging for wood products with electricity from mill waste as a byproduct. But compared to the year 1800, we have already lost an immense amount of forest capacity to store carbon. Compared, to the "baseline" alternative use of growing forests as a carbon sink, lumber plus burned mill waste hastens rather than slows global warming.[5]

Current power plants burn mill waste, but there is nothing in the RCEA draft CAPE plan that requires bioenergy to come from "waste." Other options are even less likely to be anything close to neutral.

1) There is currently a good deal of debate among foresters and biologists about the role of dead and dying trees in fire prevention and doubt about the value of logging them. But there are no agreed upon standards for when going beyond utilizing mill waste could become a racket, as it has in Europe and in US southern states.[6]

2) If whole trees, "thinnings" for example, are burned the "payback" period for carbon sequestration is 100 to 200 years in some models.[7] So we put carbon into the air immediately and wait until 2120 or later to have sequestered it again.

3) Even the immediate burning of "forest residues" for energy, instead of gradual decomposition if left in the forest, can have a large greenhouse gas effect.[8]

Considering these "biomass" alternatives, the CAPE plan should specify mill waste, not "biomass."

The UN and Project Drawdown, among others, assume that bioenergy will be a transitional source of power. At this point, in Humboldt it seems likely that wind power will make it possible to drop or greatly minimize biomass power in a few years. Continuing with biomass electricity when wind or solar is possible would be counter-productive. *The CAPE plan should make it explicit that if and when Humboldt County's local power generation needs can be met by solar and wind power biomass will be phased out.*

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bank/2018/efi_fstp_3_2016.pdf; The WJ Ripple report in footnote 3 states that between 1985 and 2015 loss of forest to fires increased on average by 44.1% each decade in the United States.

[5] "The basic error in the carbon neutrality of biomass assumption is the failure to count the production and use of biomass that land would generate if not used for bioenergy (the counterfactual)." Helmut Haberl, et al., Correcting a fundamental error in greenhouse gas accounting related to bioenergy, Energy Policy. 2012 Jun; 45-222(5): 18–23. And forest used for conservation sequesters much more carbon than forest used for wood products: Keith H, Lindenmayer D, Macintosh A, Mackey B (2015) Under What Circumstances Do Wood Products from Native Forests Benefit Climate Change Mitigation? PLoS ONE 10(10): e0139640. doi:10.1371/journal.pone.0139640

[6] In Britain and Europe a flaw in the UN carbon accounting has permitted coal plants to substitute wood chips, altogether dirtier than coal, and claim *no* emissions.

[7] Zanchi, G. , Pena, N. and Bird, N. (2012), Is woody bioenergy carbon neutral? A comparative assessment of emissions from consumption of woody bioenergy and fossil fuel. Glob. Change Biol. Bioenergy, 4: 761-772. doi:10.1111/j.1757-1707.2011.01149.x

8 Anna Repo, Mikko Tuomiand Jari Liski, Indirect carbon dioxide emissions from producing bioenergy from forest harvest residues. GCB Bioenergy (2011)3, 107–115, doi: 10.1111/j.1757-1707.2010.01065.x

ORAL COMMENTS (IN BOLD)

Most biologists now recognize that "The extent to which the CO2 emitted from bioenergy use is balanced by CO2 uptake is an empirical question."[9] The method used to answer this question in any given situation is Life Cycle Assessment, which accounts for all carbon in a set of alternatives "cradle to grave."

a. **LCA can compare alternative uses of mill waste (or other biomass used for electrical power)[10] in terms of greenhouse gas emissions and other results (like health). What reduces greenhouse gas emissions most? Burning, recycling, composting, etc? We need to know and move in that direction.**
b. **LCA also looks at different time frames for calculating payback, including the all-important next ten to 30 years. If payback occurs after 2050 it will not help with keeping global temperatures within a 1.5 to 2.0 degrees centigrade increase[11]**
c. An LCA study can look at different analytic boundaries, ranging from two biopower plants in Humboldt to the over 25 plants in California
d. And **LCA analysis can take into account efficiency.** Even with some recent updates, equipment used in the power plants in Humboldt emit both more greenhouse gases and more dangerous particulates (less than 2.5microns) than if more modern equipment were used. **Efficiency of biomass power plants has been shown to be a major controllable determinant of greenhouse gas emissions.**[12]

In short, RCEA policy for the future should not be based on the over-simplified biological assumption that biomass energy is carbon neutral. In the midst of a climate crisis, we should not presume what we can actually discover. Urge the RCEA Board to fund a Life Cycle Assessment of biomass power and its alternatives. And advocate that in the meantime we hold off on commitments for biomass beyond 2025.

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[9]Opinion: Reconsidering bioenergy given the urgency of climate protection, John M. DeCicco and William H. Schlesinger, PNAS September 25, 2018 115 (39) 9642-9645 "The assumption that bioenergy is inherently carbon-neutral, which is based on static forms of carbon accounting, is a major error. Viewed objectively, it is quite a sweeping assumption: It asserts that a carbon flow into the atmosphere at one place and time (from bioenergy combustion) is automatically and fully offset by carbon uptake at another place and time (on ecologically productive land). Scientifically speaking, there is neither a sound basis nor a need to make this assumption."

[10]A 2017 British study summarizes the range of options if one looks at alternative uses: "[This] report suggests only biomass energy with the shortest carbon payback periods should be eligible for financial and regulatory support. The feedstocks which are most likely to reduce net carbon emissions would be primarily mill residues and post-consumer waste... Overall, while some instances of biomass energy use may result in lower life-cycle emissions than fossil fuels, in most circumstances, comparing technologies of similar ages, the use of woody biomass for energy will release higher levels of emissions than coal and considerably higher levels than gas. *However, even for waste feedstocks, it is still important to consider whether they could have been used for other, lower carbon purposes. For instance, mill residues can also be used for wood products, which would keep the carbon trapped in materials, such as particleboard, for several decades more than if it is released into the atmosphere through burning it."* https://www.carbonbrief.org/biomass-subsidies-not-fit-for-purpose-chatham-house

[11] DeCicco, J. and Schlesinger, W., Reconsidering bioenergy given the urgency of climate protection, Proceedings of the National Academy of Sciences, September 25, 2018, vol. 115 ,no. 39, 9642–9645 . "All currently commercial forms of bioenergy require land and risk carbon debts that last decades into the future. Given the urgency of the climate problem, it is puzzling why some parties find these excess near-term CO2 emissions acceptable."

[12] "The thermal efficiency of the plant has the greatest influence on LCA [estimates of GHG] results at the plant..." is the conclusion from a meta-analysis of generating power from forest refuse including sawmill waste by Electric Power Research Institute, Literature Review and Sensitivity Analysis of Biopower Life-Cycle Assessments and Greenhouse Gas Emission, 2013, Palo Alto. Also see F. Sebastián, J. Royo, M. Gómez,Cofiring versus biomass-fired power plants: GHG (Greenhouse Gases) emissions savings comparison by means of LCA (Life Cycle Assessment) methodology, Energy,Volume 36, Issue 4,2011,Pages 2029-2037, ISSN 0360-5442,https://doi.org/10.1016/j.energy.2010.06.003

And as noted earlier: ***the CAPE plan should specify mill waste, not "biomass." And it should make explicit that if and when Humboldt County's local electrical power generation needs can be met by solar and wind power and conservation, biomass will be phased out.***

Note: Copies of all articles cited are available from Daniel Chandler at [redacted]

November 12, 2019

Matty Tittman, RCEA CAC Chair and Members of RCEA CAC

RE: RePower Humboldt (CAPE 2019 Update)

As a RCEA CCE ratepayer, I attended two CAPE 2019 workshops held in Eureka. At the first workshop the overwhelming majority of attendees were against biomass energy, as am I. The CAPE 2019 written following this workshop contains even more reliance on biomass. I strongly urge the RCEA CAC to reject continuing and increasing use of biomass for the following reasons:

1. Biomass is not clean; it is more polluting than coal or natural gas;
2. It is much more expensive than other clean, renewable energy sources (solar, wind, geothermal, small hydro);
3. The Scotia and Fairhaven biomass plants are old and more polluting than newer plants and the for-profit corporate owners will not spend the money to clean the combustion output;
4. The Scotia plant is close to an elementary school and children are more susceptible to air pollution;
5. Our ratepayer money is a welfare check to Humboldt Sawmill Corporation (Humboldt Redwood Corporation) and EWP Renewable Corporation (parent company based in South Korea); mill waste and timber harvest slash can be disposed of in ways that slow the release of carbon into the atmosphere compared to burning 24/7;
6. The extra ratepayer money that goes to biomass could go toward developing more energy storage and solar micro-grids which we sorely need to reduce impacts of PG&E's PSPS practice.

As a REA CCE ratepayer, I want to be able to choose an energy mix that does not contain biomass – but I'm stuck with 23% or 12% biomass. The state-wide power mix is only 2% biomass. I don't want to give more money to PG&E, but this for-profit corporation does offer a 100% solar choice. The down side to this choice is money leaves our area into the pockets of investors and the CEO. I am also a CCE ratepayer for MCE based in Marin County and I have 3 choices: 100% local solar or 50% wind + 50% solar or a mix that contains only 4% biomass. Why doesn't RCEA offer a 0% biomass choice? Fear of displeasing power players in the local timber industry?

Thank you for considering my comments.

Diane Ryerson
[redacted]
Arcata, CA 95521

From:	Information
To:	Dwight Winegar; Information
Cc:	Lori Taketa
Subject:	RE: Comments to the RCEA-COC and Organization
Date:	Monday, November 18, 2019 11:21:35 AM

Hello Dwight,

We will include your comments, our apologies for the delay in responding. We have been talking about the issues you brought up, so stayed tuned for updates to these ideas.

Also, the easiest link to RePower is from the front page "Quick Links" section, the first line. https://redwoodenergy.org/

Thank you for your contribution,

Nancy

Nancy Stephenson

Community Strategies Manager | Redwood Coast Energy Authority

(707)269.1700 x 352 | www.RedwoodEnergy.org

From: Dwight Winegar [redacted]

Sent: Tuesday, November 12, 2019 3:28 PM

To: Information <info@redwoodenergy.org>

Subject: Comments to the RCEA-COC and Organization

Since I'm just getting ready to leave for work doing swing shift this evening, I will not be able to attend tonight's big meeting, otherwise I'd love to be there and present input comments and questions in person.

Therefore I'm sending you those thoughts now at this time by way of eMail.

1) I want to know about why we could not (or if CAN - "how?") become a rate-payer "Energy Co-op", like Coos-Curry Electric Coop serving those two counties north of us. 2) If the discussion is for a county-wide "micro-grid" what then about "sub-micro-grids" such as City of Arcata (like Sebastopol) through the same infrastructure as their Water/Sewer? 3) IF WE become our own "micro-grid" how would we interface with the regional grid for being "supplementary" in backup receiving or giving? 4) What does the CPUC have to say about all of this? Yeah, I know - BIG questions.

And just today after reading the item on Lost Coast Outpost, but not finding the link for "RePower Humboldt" on the RCEA Website, I'd also like to know where we are with an update of that whole study, recommendations and comment period - so end of 2019 Follow-Up for that idea of a Sustainable (need we say "Resilient") "Strategic Plan for Renewable Energy Security and Prosperity."

Dwight Winegar

[redacted]

Nov 12, 2019

RCEA CAC

Re: CAPE 2019

I'm opposed to any contract extensions with the 2 biomass plants. The energy is too expensive. The US Energy Information Agency shows an NP15 (NorCal) wholesale hub price of between$ $ 4O to $50 in August.

I requested The Energy Authority price for non-biomass energy from RCEA and I was denied the information because of contracting issues. That is the reason for a summary total.

HSC will receive 3 Percent increased next year followed by cost of living increases. After 10 years with normal inflation the fee could be around 75.00 per MWh. When I compare past payments to net energy generated it appears that at least in several months RCEA is taking all the energy output.

I don't think that this leads to competitive bidding . Who contracts for 30 year old machines at a premium price. There is a claim of spending millions in upgrades. Actually the rate payer is paying for that. Let the Energy market decide.

Long terms contracts should follow the lowest price, most efficient or truly cleanest. These contracts are anything but that. We would loose the opportunity cost for a greater financial reserve, or for aiding the truly needy or adding new technology when you spent too much.

The rates are the same for both plants. How can that be ; the distance from the Scotia mill to the plant is a few hundred yards but Fairhaven is miles from the nearest sawmill.

These plants are an inefficient source of power; however, they are a great source of revenue while forcing rate payers to supplement [redacted] the revenue of a privately heard company in one case. The other plants' parent company is EWP a South Korea energy conglomerate whose US holding includes EWP Renewable Corp..It owned 3 power plants in Ca. They are Fairhaven 16 MW and 2 Natural Gas plants totally 98MW.

PG&E 's 100% solar is looking good!

Walt Paniak
Arcata

From:	EnergyPlan2019@RedwoodEnergy.org
To:	"Lee, Christopher@CALFIRE"; EnergyPlan2019@RedwoodEnergy.org
Cc:	Lori Taketa
Subject:	RE: Biomass power in Humboldt County
Date:	Tuesday, November 19, 2019 9:42:00 AM

Thank you for your comments, Chris. We'll add to them to the public comments. Thanks also for attending the October 18 meeting.

Best,
Nancy

Nancy Stephenson
Community Strategies Manager | Redwood Coast Energy Authority
(707)269.1700 [redacted] | www.RedwoodEnergy org

From: Lee, Christopher@CALFIRE [redacted]
Sent: Monday, November 18, 2019 9:21 PM
To: EnergyPlan2019@RedwoodEnergy.org
Subject: Biomass power in Humboldt County

Dear RCEA Board Members:

At the community meeting on October 18, I presented a comment during the public comment segment of the meeting, but I also wanted to take this opportunity to reiterate my support for continuing to include biomass energy generation in RCEA's power procurement portfolio for the foreseeable future.

My support for biomass energy generation comes from a deep concern for forest health. Biomass power plants are an essential component of the wood utilization infrastructure that we need to develop (re-develop, really) in California for healthier forests. Such augmented infrastructure is required if we are to increase the quantity and quality of forest management activities required to make our forests resilient to drought, insect and pathogen attack, and catastrophic wildfire.

As part of witnessing recent large-scale tree mortality events in California, including megafires and bark beetle-related mortality, it has been inspiring to see people respond wholeheartedly to try to improve forest health and resilience. It has been equally frustrating to watch this process so often stymied by the lack of facilities to deal with the woody byproducts of their efforts. Native insects, wildfires, and severe droughts are all linked to climate change. Responses to these climate change events don't happen without economically viable management projects. In turn, economically viable management projects don't happen unless wood utilization facilities such as biomass power plants are widely distributed enough around the state to be near any particular project. We are fortunate in Humboldt to have these facilities, even though their continued existence seems perennially precarious.

Obviously, burning the woody byproducts of management activities in the woods is for the most part less controlled and more dangerous in California than burning them for biomass power, and many projects, and therefore effective control of many forest tree attackers, won't happen if this is the only means of disposal.

I am also concerned from another forest-health angle. Non-native insects and tree-attacking pathogens are on the rise and have been for many years, largely because of globalization and increasing movement of these pests around the world. Like our responses to native pests and wildfires, forest management to slow the spread of non-natives also depends on the presence of sufficient wood utilization capacity to help management projects break even. In recent years, I have seen one large-scale, local effort to slow the spread of sudden oak death (caused by a non-native pathogen) break down because the Blue Lake biomass plant was shuttered. I have also seen other vegetation management efforts within the sudden oak death quarantine zone, in places with no local biomass facilities, forced to truck their woody byproducts far out of the zone in order to get them burned, thus putting the non-quarantine areas through which they pass at hazard of being infested. I have observed the same for other non-native tree-killers such as the pathogen that causes pitch canker of pines.

On a visit to Napa County this week, I saw a new non-native pest that has the potential to put an entire beloved California native tree species at risk of elimination (the information will become public once UC Davis scientists finish confirming its identity). This new pest will likely be easily spread if its woody host material is moved long distances around the state. For non-native tree pests, local management is essential, and that is only possible if local biomass energy facilities and other woody byproduct utilization facilities exist relatively nearby. This is as true for Humboldt County as it is for any other county: although our redwoods and Douglas-firs are tough, they are not invulnerable, and an insect or pathogen from another part of the globe could appear at any time to cause major problems for them. Keeping biomass capacity in Humboldt County thus fulfills responsibilities to our local area as well as to the rest of the state.

I appreciate the efforts that RCEA has made to bring the entirety of Humboldt County into this discussion and to educate the public so that we can contribute to the Board's decision. The meeting on October 18 was well-run and well-attended, and I learned a lot. Obviously, this issue is not simple, and I understand that there are many angles you must consider. After all the explanation of how not only improvement of California forest health, but also the very existence of some of our California tree species, could depend on the continued existence of biomass facilities, it was dismaying to hear some community members continue to reduce the issue to "but we shouldn't be pumping any carbon into the atmosphere." While I applaud your consideration of all the well-argued points of view brought out at that meeting, I do hope you will disregard that kind of oversimplification.

Thanks so much for your time, attention, and hard work on this issue.

Best regards,

Chris Lee

Forest Health Specialist

Chair, California Oak Mortality Task Force

RPF #2885

California Department of Forestry and Fire Protection

118 S Fortuna Blvd

Fortuna, CA 95540

office phone: 707.726.1254

cell phone: [redacted]

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cell phone: [redacted]
email: christopher.lee@fire.ca.gov

From: Richard Engel
To: Sierra Huffman; Matthew Marshall; Dana Boudreau; Lori Biondini; Jocelyn Gwynn; Patricia Terry; Ben Mattio; Nancy Stephenson
Subject: RePower input from Mark Hilovsky in SoHum
Date: Monday, November 18, 2019 11:03:00 AM

Hi All,

I got a call from Mark Hilovsky, one of the few community members who showed up at our Redway CAPE meeting. He asked about a few subjects related to CAPE, but his main concern is addressing red (off-road) diesel. He's concerned about what he believes is a recent spike up in use of this fuel driven by increased enforcement of cannabis regulations driving growers back toward clandestine indoor grows instead of greenhouses. He says even many grid-connected growers are using generators because their electric service isn't sized big enough for their load.

Perhaps we should add a strategy specifically about addressing energy use in the cannabis sector – though it would be challenging for us as a non-enforcement public agency to tackle the energy impacts Mark's concerned with, that are outside the segment of the industry that's operating with permits.

Any thoughts on whether/how to address this in RePower?

Richard

From:	Walter Paniak
To:	EnergyPlan2019@RedwoodEnergy.org
Subject:	CAPE Comment
Date:	Tuesday, November 19, 2019 9:03:52 AM
Attachments:	IMG_0566.jpg

I have four areas of concern regarding continuing Biomass contracts.
Cost: The current rate of $ 65.00 per MWh (Megawatt hour)is too high compared to other power sources. The average wholesale price for Northern California per the EIA Energy Information Agency for Aug 2019 was between 40 and 50 dollars. The RCEA 2018 Integrated Resource Plan page 13 figure 6 shows an energy price assumptions for average wholesale price of 41.78 MWh for 2018 and 40.53 MWh for 2022. The Humboldt Sawmill Company contract is $65 increasing to $67.00 in 2022. Humboldt Sawmill Company had a price reduction from $83 to $65 effective March 2019; however, it appears that the cash shortfall was cushioned by increasing contracted output . The average Humboldt Sawmill Company output for Jan, Feb and Mar 2019 was 9300 MWh and increased to an average of 13000 MWh for June , July and August.(See the screen shot of report below)

Air quality: The 2 biomass plants are the only significant county point sources of NOX at 319 tons annually in 2018 and small particulates PM2.5 at 61 tons annually for 2018 per an RCEA report. The increase output noted above will further increase these pollutants.

Green House Gas: The IPPC scientists and even Michael Furniss from HSU and consultant to RCEA concluded that CO2 is CO2 regardless of the sources at a recent CAC meeting. Biomass energy produces much more CO2 per MWh of energy. To insure the adequacy of sequestration will take multiple decades. Today’s burning will take 50 years approximately assuming proper forest management for resequestration and next year’s burning will take another 50 years and the same goes for each new burn cycle.

Wild fire: Burning mill waste has no direct connection to wild fire reduction. When you harvest merchantable trees you lower the crown height and increase the chances of a crown fire. Removal of small trees that allow ground fires to reach the crown are more important. It is very problematic to figure what areas need thinning when over 80% of wild fires are human caused.

Walt Paniak
Arcata

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Walt Paniak

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EIA 923 ytd Humboldt Sawmill Company MWh report 2 boilers

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November 19, 2019

RCEA Board Chair and Members:

RE: RePower Humboldt (CAPE 2019 Update) Comments

As a RCEA CCE ratepayer, I do not support specific parts of the Energy Generation section, namely Biomass and On-shore Wind.

If RCEA CCE continues to offer only REpower with 23% biomass and REpower+ with 12% biomass, I will opt out and switch to PG&E's solar choice, even if this costs me more money. I realize that the Scotia and Fairhaven biomass plants will continue to operate, but if enough Humboldt County residents opt out, and certainly if RCEA does not renew the contacts, these plants will close. Globally, we have a decade to reduce carbon emissions to avoid an increasing rate of global warming. Burning biomass emits carbon 24/7 and seedlings planted to replace harvested trees do not grow fast enough to sequester the amount of carbon emitted by biomass burning, especially within the decade we have to reduce carbon emissions and because we continue to harvest the biggest trees, those that have the most photosynthetic surface area to sequester the most carbon. This is like continually harvesting the biggest fish, those that have reached reproductive age, and wondering why the fish population is decreasing.

Biomass burning emits fine particulates that lodge in our lungs and enter our blood stream, increasing risk of asthma, heart attacks, cancer and early death. Why are we consciously subjecting ourselves to this risk?

Biomass is more expensive than solar, wind, and battery storage, and dirtier as well as more expensive than natural gas, a better transition fuel than biomass. The ratepayer money given to Humboldt Sawmill Corporation and EWP Corporation could be used to build leverage funds to develop solar micro-grids, battery storage, off-shore wind, wave energy converter buoys and making Humboldt County energy independent.

As a person who has invested in roof top solar, I was angered and dismayed to hear a RCEA Board member and a Schatz Lab employee downplay the value of roof top solar, not address the possibilities of a network of solar micro-grids and battery storage, and speak of off-shore wind as far off and maybe not possible when they extolled the benefits of on-shore wind at the Humboldt County Planning Commission meetings I attended. Off-shore winds are stronger and more consistent than on-shore winds. The ocean area set aside for wind turbines can also provide space for wave energy converter buoy power stations (Oregon is already testing OE 35 buoys, made in Portland, OR, off the coast of Newport, OR). Off-shore wind and waves can produce much more energy than on-shore wind; this will provide more benefits for both Humboldt County and California. Off-shore wind is described as being at least 5 years away from fruition; on-shore wind is expected to be completed in 18 months. The sovereign Wiyot nation has not reached agreement with Humboldt County on the on-shore project and the EIR process and product are likely to initiate law suits; these aspects may extend the completion time line and increase the costs.

Off-shore wind infrastructure will provide new surface area habitat for ocean critters that need to attach themselves to a substrate; these organism are lower in ecosystem food chains and will provide more food for fish, and the area set aside for wind turbines may serve as a marine sanctuary and enhance fish populations.

An off-shore wind project will not alter/violate Wiyot cultural and sacred sites; will not cover land based habitat with concrete pads; will not require stream crossings and wetland disturbance; will not require permanent access roads that eliminate vegetation and habitat; will not require removal of trees for new transmission lines; will not create visual blight – the wind turbines and flashing lights for planes will not be visible on land 20 miles away; Hoary bats do not have a mating hot spot over the ocean; carbon sequestration in ocean water will not be reduced compared to the reduction caused by the on-shore project; thirty years of land lease costs will be avoided; construction and maintenance will not cause highway traffic flow problems. For these reasons I strongly support rapid development of off-shore wind energy and reject on-shore wind energy development in Humboldt County.

Thank you for considering my comments.

Diane Ryerson
[redacted]
Arcata, CA 95521

November 9, 2019

Redwood Coast Energy Authority Board Members
633 3rd Street
Eureka, CA 95501

Dear Board Members,

First of all, thank you for serving on this board, and therefore serving your community. With the recent power outage debacle, our local energy production is on the minds of many more of our local citizens. I know I have recently had many discussions about our sources of energy, and how we should proceed in the future.

I believe that the State of California should support each county, both monetarily and intellectually, in developing its own power sources and micro-grids. The brightest minds in renewable energy development should be hired to help develop these systems, individualizing each system to fit the resources, needs, and climate of each county.

Here in Humboldt County, I think we need to develop more solar micro-grids, such as the one at the airport. I do NOT support the Terra Gen Wind Project, as I feel the costs to our county both environmentally AND culturally far outweigh the benefits. Terra Gen is a for-profit company that has NO real interest in Humboldt County, other than plunder. I think we need to research offshore wind projects, such as those that are being used in the North Sea, and if that seems like a good fit, then we should pursue that technology.

I also wonder about the possibility of installing solar panels on awnings in existing parking lots (private/public partnerships). I have seen several examples of that recently, both at a junior college in Bakersfield, and at the Medford Airport in Oregon. This seems to be a win-win situation, as valuable land is not used up for the panels, and cars parked under the awnings benefit from the shade.

I also do NOT support creating energy from biomass, and I strongly urge the RCEA to abandon its support of this form of energy. Several years ago, I attended a local talk about biomass energy production throughout our country, and though I cannot remember the details (sad, but true) I remember leaving the talk feeling like biomass fuel and its byproducts are a major source of air and water pollution. We CANNOT add to our ever-increasing carbon production!

I realize that, as a board, you have an extremely challenging task. As a community, we all need to be involved in the difficult decisions you are trying to make. Thank you for letting me share my thoughts.

Sincerely,

Lisa Bethune

Lisa Bethune
[redacted]
Arcata, CA 95521

[redacted]

From:	Wendy Ring
To:	Lori Taketa
Subject:	Correction to health impacts of biomass: It"s worse than we thought
Date:	Friday, November 29, 2019 2:02:11 PM

Lori,

Can you please make sure this gets to board members. What I told them about the health impacts of biomass turns out to be an understatement. Two studies just published in highly reputable medical journals found more hospitalizations and deaths from low level particulate exposure than what I presented.

Study of 4.5 million US veterans found increased deaths from 9 causes at levels below US air quality standard
Study of Medicare recipients found increased hospitalizations from expanded list of conditions at levels below US air quality standard

Please note:
The most recent version of the CAPE still commits to expanding biomass generation, increasing particulate pollution and health impacts. It's not as bad as the 2nd draft, but it's still more pollution. In 10 years there will be so many more options for local clean energy and mill waste that the aspirational goal should be to eliminate combustion energy, not increase it.

The Best Available Control Technology in the current language does not mean updating pollution controls. The language for that is **Best Available Retrofit Control Technology,** a procedure defined by the state but not required up here because they are prioritizing places with worse air pollution. The CAPE language should require it as a condition for any new contracts. Still not a panacea: judging from what the EPA required of Blue Lake Power and expected in terms of emissions reduction.

Wendy Ring MD, MPH

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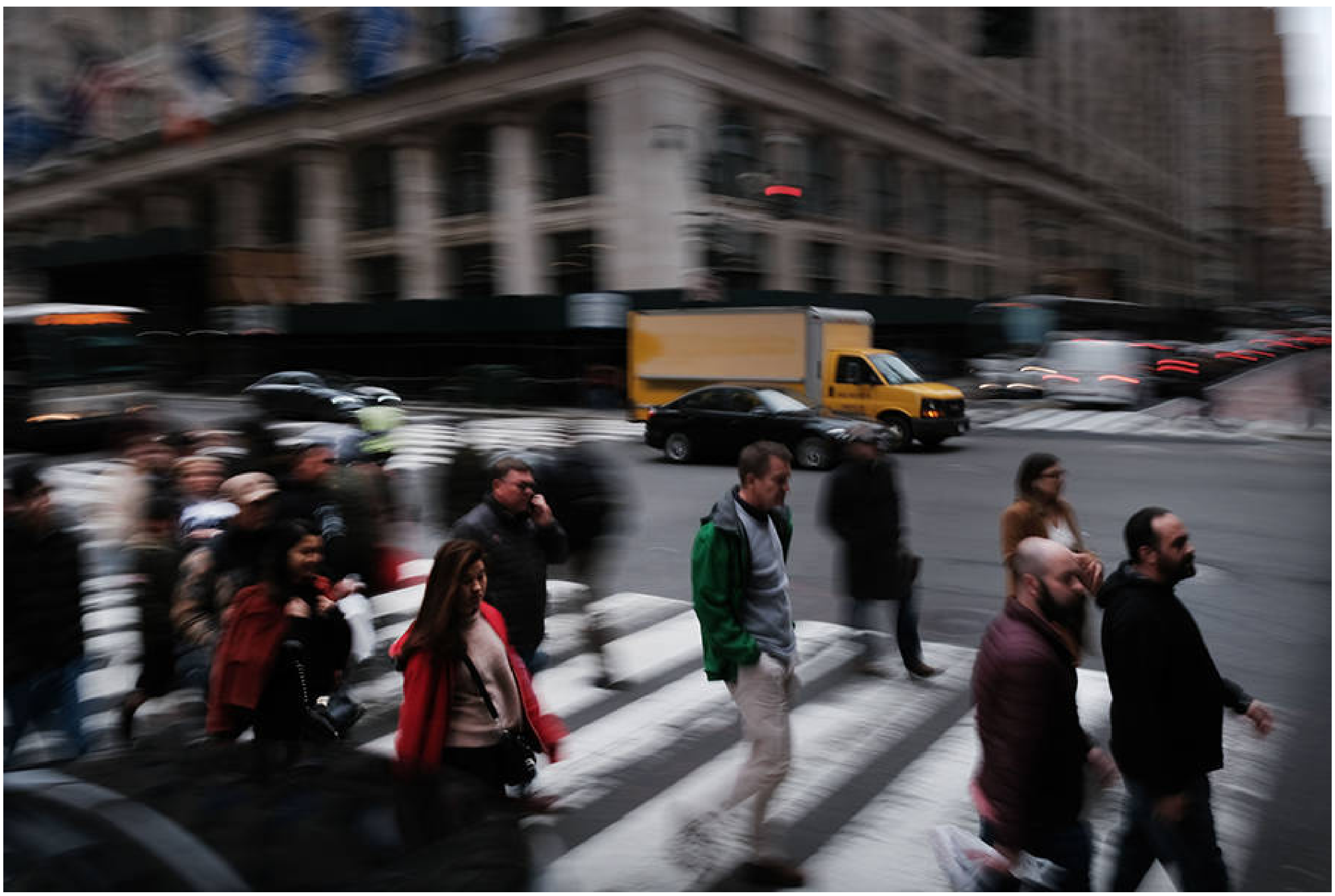
Study Links Short-Term Air Pollution Exposure to Hospitalizations for Growing List of Health Problems

The Harvard researchers focused on a tiny, troublesome air pollutant that comes primarily from vehicles, power plants and wildfires.

Neela Banerjee

By Neela Banerjee

Follow @neelaeast
Nov 27, 2019



“The study shows that the health dangers and economic impacts of air pollution are significantly larger than previously understood,” said the study's author Yaguang Wei. Credit: Spencer Platt/Getty Images

A new Harvard University study for the first time links hospitalizations for common blood, skin and kidney ailments to short-term exposure to fine particulate matter from fossil fuel combustion and wildfires.

The findings widen the population of older Americans considered especially vulnerable to threats from the air pollutant even when exposed to it over short periods.

Led by researchers at Harvard University's T.H. Chan School of Public Health, the study published Wednesday in the British medical journal BMJ [1] found that short-term exposure to fine particulate matter led to higher levels of hospitalization for people with illnesses such as septicemia, or blood poisoning, kidney failure, urinary tract infections, skin and other tissue infections and electrolyte disorders often brought on by loss of fluids from vomiting or diarrhea.

Researchers defined "short-term" as exposure on the day of hospitalization and compared the pollution levels to the day before. The population studied was Americans over the age of 65, through a vast analysis of Medicare records for the 48 continental states.

As the amount of PM 2.5 increased between the days analyzed, so did the hospital admission rate connected to those disease groups. Further, the link between exposure to fine particulate matter and hospitalizations was still evident even when the daily air pollution levels were lower than current World Health Organization guidelines and the less-stringent U.S. regulatory standards.

The researchers studied a microscopic pollutant known as PM 2.5, which is generated by fossil fuel combustion in power plants and vehicles and by wildfires.

The tiny particles infiltrate the lungs, contributing to heart disease and worsening respiratory conditions such as asthma over the long-term, studies have shown. A 2015 study [3] by the World Health Organization estimated that regular exposure to outdoor PM 2.5 pollution caused 3.7 million premature deaths worldwide each year. Previous studies showed that exposure to PM 2.5 heightened the risk of hospitalization largely for cardiovascular and respiratory illnesses, diabetes and Parkinson's disease.

The new study indicates that people with diseases other than those with a clear link to heart or lung problems are also harmed by even short-term exposure to PM 2.5.

"The study shows that the health dangers and economic impacts of air pollution are significantly larger than previously understood," said Yaguang Wei, the study's lead author and a doctoral student at the Chan School.

Trump EPA Moves to Suppress Science on PM 2.5

The study's focus on a broader public vulnerability to PM 2.5 comes as the Trump administration prepares to adopt a regulation [4]that would severely curtail the use of scientific research to support public health standards, a major step in its efforts to undo pollution rules.

Environmental Protection Agency Administrator Andrew Wheeler, a former coal industry lobbyist, has described the proposed rule as an effort to improve "transparency." But it has been widely criticized as an attempt to protect polluters by preventing policymakers from considering decades of well-established scientific research that connects air pollution to premature death.

The draft rule would prevent the use of studies based on confidential health data, which is often necessary to get a wide swath of participants and sensitive details. If it is also applied retroactively, that could lead to the regulator's rejection of a seminal 1993 Harvard study [5] that showed the threat that air pollution, including PM 2.5, poses to human health.

That has triggered a backlash in the medical and scientific communities, which say the result would be increased harm to human health. On Tuesday, the executive editors of some of the world's most prestigious scientific journals, including *Nature*, *Science* and *The Lancet*, published a rare joint statement [6] condemning the proposed rule. Scientists and health experts have been fighting it for over a year, raising alarms that it could be used to suppress scientific evidence critical for health regulations by preventing the use of studies useful for drug development or understanding asthma and pollution impacts. If such scientific evidence is dismissed by EPA under the new rule, "that would be a catastrophe," they wrote.

Francesca Dominici, a professor of biostatistics at the Chan school and the new study's principal investigator, described the proposed rule as "clearly an attack against science."

Understanding the Connections

The new Harvard PM 2.5 study has transparency built into its design—it used government data from Medicare which is accessible to others who might want to replicate or build off the research.

The study was partly funded by the EPA and arrives as the agency should start a process to review and finalize the National Ambient Air Quality standards, including on fine particulates, by the end of 2020. EPA staff have reached a preliminary conclusion [7] that the current PM 2.5 standard is too weak, but the agency's Trump administration-appointed science advisers disagreed. The final decision will be Wheeler's.

For the study, researchers analyzed hospital admissions data from 2000 to 2012 for 95 million inpatient claims on Medicare.

They classified the illnesses that landed people in the hospital into 214 groups, based on codes Medicare uses. To estimate the daily PM 2.5 levels over the same period, the researchers relied on satellite-based pollution measurements and a computer model of air pollution. Then they matched the PM 2.5 estimates with the zip codes of those people hospitalized.

The study did not seek to determine how PM 2.5 worsens the illnesses for which people were hospitalized. Wei, the lead author, said that many studies have shown that exposure to fine particulate matter can induce inflammation. But for some of the diseases found to be aggravated by PM 2.5, the underlying mechanism of how exposure worsens illness wasn't clear and warranted further research.

"Now that we have reported on these new sets of diseases, it will allow others to look into the physiology of the diseases," Dominici said. "It will open up a better understanding of how this is happening and that will allow us to prevent these hospitalizations."

InsideClimate News reporter Marianne Lavelle contributed to this story.

Source URL: https://insideclimatenews.org/news/27112019/fossil-fuel-air-pollution-hospital-increase-underlying-kidney-skin-blood-illness

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Burden of Cause-Specific Mortality Associated With $PM_{2.5}$ Air Pollution in the United States

Benjamin Bowe, MPH; Yan Xie, MPH; Yan Yan, MD, PhD; Ziyad Al-Aly, MD

Abstract

IMPORTANCE Ambient fine particulate matter ($PM_{2.5}$) air pollution is associated with increased risk of several causes of death. However, epidemiologic evidence suggests that current knowledge does not comprehensively capture all causes of death associated with $PM_{2.5}$ exposure.

OBJECTIVE To systematically identify causes of death associated with $PM_{2.5}$ pollution and estimate the burden of death for each cause in the United States.

DESIGN, SETTING, AND PARTICIPANTS In a cohort study of US veterans followed up between 2006 and 2016, ensemble modeling was used to identify and characterize morphology of the association between $PM_{2.5}$ and causes of death. Burden of death associated with $PM_{2.5}$ exposure in the contiguous United States and for each state was then estimated by application of estimated risk functions to county-level $PM_{2.5}$ estimates from the US Environmental Protection Agency and cause-specific death rate data from the Centers for Disease Control and Prevention.

MAIN OUTCOMES AND MEASURES Nonlinear exposure-response functions of the association between $PM_{2.5}$ and causes of death and burden of death associated with $PM_{2.5}$.

EXPOSURES Annual mean $PM_{2.5}$ levels.

RESULTS A cohort of 4 522 160 US veterans (4 243 462 [93.8%] male; median [interquartile range] age, 64.1 [55.7-75.5] years; 3 702 942 [82.0%] white, 667 550 [14.8%] black, and 145 593 [3.2%] other race) was followed up for a median (interquartile range) of 10.0 (6.8-10.2) years. In the contiguous United States, $PM_{2.5}$ exposure was associated with excess burden of death due to cardiovascular disease (56 070.1 deaths [95% uncertainty interval {UI}, 51 940.2-60 318.3 deaths]), cerebrovascular disease (40 466.1 deaths [95% UI, 21 770.1-46 487.9 deaths]), chronic kidney disease (7175.2 deaths [95% UI, 5910.2-8371.9 deaths]), chronic obstructive pulmonary disease (645.7 deaths [95% UI, 300.2-2490.9 deaths]), dementia (19 851.5 deaths [95% UI, 14 420.6-31 621.4 deaths]), type 2 diabetes (501.3 deaths [95% UI, 447.5-561.1 deaths]), hypertension (30 696.9 deaths [95% UI, 27 518.1-33 881.9 deaths]), lung cancer (17 545.3 deaths [95% UI, 15 055.3-20 464.5 deaths]), and pneumonia (8854.9 deaths [95% UI, 7696.2-10 710.6 deaths]). Burden exhibited substantial geographic variation. Estimated burden of death due to nonaccidental causes was 197 905.1 deaths (95% UI, 183 463.3-213 644.9 deaths); mean age-standardized death rates (per 100 000) due to nonaccidental causes were higher among black individuals (55.2 [95% UI, 50.5-60.6]) than nonblack individuals (51.0 [95% UI, 46.4-56.1]) and higher among those living in counties with high (65.3 [95% UI, 56.2-75.4]) vs low (46.1 [95% UI, 42.3-50.4]) socioeconomic deprivation; 99.0% of the burden of death due to nonaccidental causes was associated with $PM_{2.5}$ levels below standards set by the US Environmental Protection Agency.

(continued)

Key Points

Question What are the causes of death associated with fine particulate matter ($PM_{2.5}$) air pollution?

Findings In this cohort study of more than 4.5 million US veterans, 9 causes of death were associated with $PM_{2.5}$ air pollution: cardiovascular disease, cerebrovascular disease, chronic kidney disease, chronic obstructive pulmonary disease, dementia, type 2 diabetes, hypertension, lung cancer, and pneumonia. The attributable burden of death associated with $PM_{2.5}$ was disproportionally borne by black individuals and socioeconomically disadvantaged communities; 99% of the burden was associated with $PM_{2.5}$ levels below standards set by the US Environmental Protection Agency.

Meaning This study adds to known causes of death associated with $PM_{2.5}$ by identifying 3 new causes (death due to chronic kidney disease, hypertension, and dementia); racial and socioeconomic disparities in the burden were also evident.

+ Supplemental content

Author affiliations and article information are listed at the end of this article.

Abstract (continued)

CONCLUSIONS AND RELEVANCE In this study, 9 causes of death were associated with $PM_{2.5}$ exposure. The burden of death associated with $PM_{2.5}$ was disproportionally borne by black individuals and socioeconomically disadvantaged communities. Effort toward cleaner air might reduce the burden of $PM_{2.5}$-associated deaths.

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Introduction

The association between ambient fine particulate matter air pollution ($PM_{2.5}$) and risk of all-cause mortality has been well characterized.[1-7] Multiple studies have outlined several specific causes of death attributable to $PM_{2.5}$ exposure.[7] However, a growing body of evidence (from both experimental research and human studies) suggests that the adverse health effects (including conditions associated with death) of $PM_{2.5}$ may extend beyond those currently recognized causes of death associated with $PM_{2.5}$ exposure.[7,8] Evidence developed by Burnett and colleagues[8] estimated that approximately 43% of the burden of death due to noncommunicable diseases and lower respiratory tract infections attributable to $PM_{2.5}$ in the United States and Canada relates to causes of death that had not yet been characterized. A knowledge gap exists in that no prior study, to our knowledge, systematically examined causes of death associated with $PM_{2.5}$ exposure, characterized their $PM_{2.5}$ exposure-risk function, and provided estimates of their burden. In this study, we built a longitudinal cohort of 4 522 160 US veterans and studied them for 10 years; guided by evidence on the health outcomes associated with $PM_{2.5}$, we used a systematic approach to identify causes of death associated with $PM_{2.5}$ exposure, characterized the morphology of the association between $PM_{2.5}$ and each cause of death, and provided estimates of the national and state-level burden of these causes.

Methods

Data Sources

Data on participants were obtained from United States Veterans Health Administration (VA) databases, which consist of information collected during routine care.[9-17] National Death Index data contained date of death and underlying cause of death information. Modeled $PM_{2.5}$ data for the contiguous United States were obtained from the US Environmental Protection Agency (EPA) Community Multiscale Air Quality Modeling System.[18,19] The 2013 Area Deprivation Index (ADI), which allows for rankings of geographic locations by socioeconomic status disadvantage and is composed of education, employment, housing quality, and poverty measures, was used as a measure of a county's socioeconomic deprivation.[20,21] We used data from the County Health Rankings data set, a curated set of county-level determinants of health.[22] Number of deaths due to underlying causes, defined by *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10)* codes, were obtained from the Centers for Disease Control and Prevention WONDER online database at the state and county level in 2017.[23] Additional information is provided in the eMethods in the Supplement. This study was reviewed and approved by the institutional review board of the VA Saint Louis Health Care System, and the requirement for informed consent was waived because risk to participants was intangible. Study reporting followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

Cohort

Participants were selected if they had at least 1 record of receipt of care in the VA from January 1, 2006, to December 31, 2006, with a corresponding record of location of residence (n = 4 667 242);

the last date in this time period was designated T_0 (baseline). Participants were restricted to those who could be linked at baseline with a $PM_{2.5}$ exposure and who had data on ADI, population density, and County Health Rankings, yielding a final cohort of 4 522 160 who were followed up until December 31, 2016.

Exposures and Outcomes

Exposure to $PM_{2.5}$ in 2006 was linked with a veteran's county of residence at baseline as contained in inpatient and outpatient records of care.

Outcomes included time until death due to nonaccidental causes and noncommunicable diseases (NCDs). We further investigated associations with specific causes of death where prior literature suggested an association; for example, there is evidence that increased $PM_{2.5}$ exposure level is associated with increased risk of chronic kidney disease, which itself is associated with increased risk of death.[10,24,25] We analyzed death due to cardiovascular disease, cerebrovascular disease, chronic kidney disease, chronic obstructive pulmonary disease (COPD), dementia, type 2 diabetes, hypertension, lung cancer, and pneumonia.[4,10,11,26-28] Cause of death was determined by the recorded *ICD-10* code for underlying cause of death. eTable 1 in the Supplement includes *ICD-10* death codes used for assignment.

Covariates

Covariates were selected based on prior evidence of potential confounding of the association between $PM_{2.5}$ and death.[29,30] We adjusted for age, race, sex, smoking status, and regional characteristics of population density, ADI, percentage of population living in a rural area, percentage with limited access to healthy food, percentage with adequate access to exercise opportunities, and percentage of adults reporting excessive drinking.[31,32] Further details are included in the eMethods in the Supplement.

Statistical Analysis

Demographic and regional characteristics in the overall cohort and by $PM_{2.5}$ quartile at baseline are presented as frequencies (percentage) and medians (interquartile range). Incident rates of death outcomes, standardized for age, race, sex, and smoking status, are reported for all investigated causes of death. A Kaplan-Meier curve for all-cause mortality was constructed, as well as a plot of cumulative incidence of the specific causes of death. Missing regional covariate data were imputed. Further details are included in the eMethods in the Supplement.

Positive and Negative Controls

Negative controls served as a means for identifying whether latent biases may be driving observed results.[33] There is no evidence that ambient air sodium levels are associated with adverse health outcomes; here we assessed the association between ambient air sodium levels and nonaccidental causes, NCDs, cardiovascular, lung cancer, and COPD deaths (outcomes with well-established associations with $PM_{2.5}$) using Cox proportional hazards models. We also tested a negative outcome control, accidental poisoning by exposure to noxious substance, and a positive outcome control, all-cause mortality.[3,34,35]

Nonlinear Exposure-Response Models

Nonlinear exposure-response models for monotonic relations were constructed.[36] Cox proportional hazards models were estimated using linear or log-linear functions of $PM_{2.5}$ concentration times a logistic weighting function. Multiple combinations of functions and parameters were assessed, and an optimal model (best model fit) and ensembled model are described; ensembled models were selected as primary results. Models were adjusted for all covariates. Median and 95% uncertainty intervals (UI) were obtained from 1000 bootstraps. Further information is included in the eMethods in the Supplement.

Sensitivity Analyses

To test robustness of study results, we built Cox models to perform the following sensitivity analyses. We (1) defined exposure by a 3-year mean of $PM_{2.5}$ prior to baseline to broaden the time window of capturing exposure; (2) developed time-updated analyses (where exposure and outcome status were updated every quarter of a year) by defining $PM_{2.5}$ exposure as the year prior's mean at each point (for each time *t* during follow-up, this covers exposure from $t - 1$ year to *t*) to capture changes in $PM_{2.5}$ over time and as participants moved from one location to another[31] and, alternatively, building time-updated cumulative exposure analyses where we defined $PM_{2.5}$ exposure as the cumulative mean of exposure starting from 3 years prior to baseline up to each point (for each time *t* during follow-up, this covers t_0 − 3 years up to *t*)[37]; (3) varied the spatial resolution of exposure definition by assigning exposure on the basis of the nearest air monitoring within 30 and 10 miles of the participants' residence at baseline; (4) additionally adjusted for latitude and longitude, and their interaction, as a means of accounting for geospatial correlation; and (5) additionally adjusted for ozone.[4] Further details are provided in the eMethods in the Supplement.

Attributable Burden of Death Associated With $PM_{2.5}$

Using results from the nonlinear exposure-response models, we estimated deaths associated with $PM_{2.5}$ for each state in the contiguous United States. Owing to data availability, estimates at the county level were only done for deaths due to nonaccidental causes and NCDs. A theoretical minimum risk exposure level of 2.4 μg/m^3 was used.[8] For state and contiguous US burden estimates, within each state, a population-weighted risk was estimated by applying risk functions to county-level $PM_{2.5}$ values to calculate a population-attributable fraction, which was multiplied by state-level cause-specific death values. We estimated cause-specific mortality numbers, rates per 100 000 persons, and age-standardized rates per 100 000 persons, along with 95% UIs for each value; 95% UIs were obtained from 1000 realizations of the burden. To enhance generalizability of our results, we calibrated estimates by applying an adjustment factor of the ratio of the nonaccidental cause burden estimated here to estimates calculated based on the Global Exposure Mortality Model of Burnett et al[8] for the contiguous US.[38] Burden was additionally estimated for deaths due to nonaccidental causes and NCD using the EPA National Ambient Air Quality Standard of 12 μg/m^3 as the theoretical minimum risk exposure level.

Disparities in Burden

We estimated differences in burden by race/ethnicity category for deaths due to nonaccidental causes and NCDs. Race/ethnicity distributions were applied to the county-level estimates to estimate the attributable burden of death associated with $PM_{2.5}$ in each race/ethnicity category. Estimates were summed across counties where data were available. Differences in burden were also estimated by ADI quartile. We analyzed the county-level age-standardized rates of death due to nonaccidental causes and NCDs associated with $PM_{2.5}$ exposure to estimate the percentage associated with racial (percentage black or African American) and socioeconomic (ADI) disparities.[39] We additionally conducted effect modification analyses in the nonlinear exposure-response models for deaths due to nonaccidental causes and NCDs for ADI quartile and black vs nonblack race with $PM_{2.5}$. Results, including *P* values and the change in Akaike information criteria, are reported from the optimal model. Results were considered statistically significant at 2-tailed $P < .05$. Further information is provided in the eMethods in the Supplement. All analyses were performed in SAS Enterprise Guide statistical software version 7.1 (SAS Institute). Maps were generated using Tableau version 10.5 (Tableau Software).

Results

There were 4 522 160 participants (4 243 462 [93.8%] male; median [interquartile range] age, 64.1 [55.7-75.5] years; 3 702 942 [82.0%] white, 667 550 [14.8%] black, and 145 593 [3.2%] other race) in the overall cohort who were followed up for a median (interquartile range) duration of 10.0 (6.8-10.2) years. The demographic characteristics of the overall cohort and by $PM_{2.5}$ quartile are presented in **Table 1**. The highest quartile of $PM_{2.5}$ exposure had the highest percentage of participants with black race, greatest proportion of current smokers, oldest median age, and greatest population density. During the course of follow-up, there were a total of 1 647 071 deaths (36.4%) (eFigure 1 in the Supplement).

Positive and Negative Controls

Ambient air sodium concentrations (a negative exposure control) exhibited a weak or nonsignificant association with death due to nonaccidental causes, NCDs, cardiovascular disease, COPD, and lung cancer (eTable 2 in the Supplement). Exposure to $PM_{2.5}$ was not associated with death due to accidental poisoning by exposure to noxious substances (negative outcome control) (eFigure 2 in the Supplement). Higher levels of $PM_{2.5}$ exposure were associated with increased risk of all-cause mortality (positive outcome control) (eFigure 2 in the Supplement).

Causes of Death Associated With $PM_{2.5}$ Exposure

Broad Causes

Total number of deaths and standardized incidence rates (per 1000 person-years) in the overall cohort and by $PM_{2.5}$ quartile are provided in eTable 3 in the Supplement. Increased $PM_{2.5}$ concentration was associated with both risk of death due to nonaccidental causes and death due to NCDs (**Figure 1**). Results from the optimal model were consistent with those generated from an ensemble model for exposure-response hazard functions.

Table 1. Demographic Characteristics of the Overall Cohort and by Baseline $PM_{2.5}$ Quartile

	No. (%)				
		$PM_{2.5}$ Quartile, μg/m^3			
Characteristic	Overall Cohort	1 (4.8-10.0)	2 (10.1-11.8)	3 (11.9-13.8)	4 (13.9-20.1)
No.	4 522 160	1 167 675 (25.82)	1 122 188 (24.82)	1 134 457 (25.09)	1 097 840 (24.28)
Age, median (IQR), y	64.1 (55.7-75.5)	64.8 (56.6-75.6)	65.0 (56.5-75.7)	63.8 (55.3-75.4)	62.8 (54.0-75.0)
Male	4 243 462 (93.8)	1 097 043 (94.0)	1 054 961 (94.0)	1 064 543 (93.8)	1 026 915 (93.5)
Race					
White	3 702 942 (82.0)	1 044 988 (89.7)	971 509 (86.7)	903 470 (79.7)	782 975 (71.4)
Black	667 550 (14.8)	65 903 (5.7)	113 802 (10.2)	210 167 (18.5)	277 678 (25.3)
Other	145 593 (3.2)	54 493 (4.7)	34 993 (3.1)	20 101 (1.8)	36 006 (3.3)
Smoking status					
Current	1 130 280 (25.0)	275 293 (23.6)	266 693 (23.8)	293 062 (25.8)	295 232 (26.9)
Former	960 549 (21.2)	238 706 (20.4)	248 896 (22.2)	244 773 (21.6)	228 174 (20.8)
Never	2 431 331 (53.8)	653 676 (56.0)	606 599 (54.1)	596 622 (52.6)	574 434 (52.3)
Area Deprivation Index, median (IQR)[a]	54.7 (42.8-64.3)	54.0 (46.9-63.2)	56.1 (43.1-64.7)	57.7 (43.4-68.8)	53.6 (39.8-61.2)
Rural residence, median (IQR), %	14.5 (3.3-41.2)	20.5 (5.1-46.6)	16.8 (4.5-43.2)	23.8 (5.6-52.2)	4.6 (0.6-21.3)
Population density, median (IQR), No./square mile	284.5 (83.4-975.0)	91.8 (30.4-417.4)	247.1 (84.6-821.1)	261 (88.7-910.0)	670.0 (254.9-2344.2)
Limited access to healthy food, median (IQR), %	5.9 (3.7-8.5)	6.2 (4.3-9.6)	6.3 (4.2-8.6)	5.2 (3.2-7.9)	5.8 (2.7-7.5)
Adequate access to exercise opportunities, median (IQR), %	75.6 (57.1-90.3)	71.9 (56.3-85.7)	74.9 (53.2-87.5)	68.8 (51.9-88.4)	85.6 (69.2-95.2)
Adults reporting excessive drinking, median (IQR), %	16.5 (14.2-18.7)	16.9 (15.0-19.2)	16.9 (14.7-19.2)	14.9 (12.0-18.4)	16.5 (14.5-17.8)
Follow-up, median (IQR), y	10.0 (6.8-10.2)	10.0 (7.0-10.2)	10.0 (6.8-10.2)	10.0 (6.7-10.2)	10.0 (6.8-10.2)

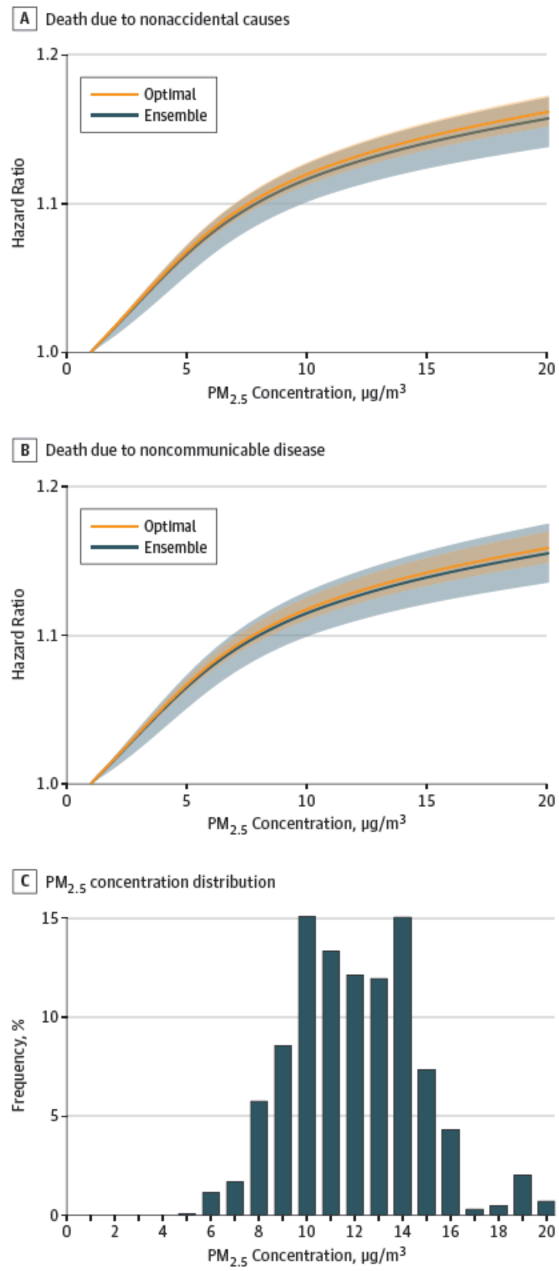
Abbreviations: IQR, interquartile range; $PM_{2.5}$, ambient fine particulate matter.

[a] The Area Deprivation Index ranges from 0 to 100 and is a measure of socioeconomic deprivation, where higher values indicate higher levels of deprivation.

Specific Causes

We investigated specific causes of death due to disease states that are known to be in the causal pathway to death for which strong evidence exists of an association between $PM_{2.5}$ exposure and the disease state.[7] Total number of deaths and standardized incidence rates (per 1000 person-years) of these specific causes of death in the overall cohort and by $PM_{2.5}$ quartile are provided in eTable 3 in the Supplement, and a cumulative incidence plot is furnished in eFigure 3 in the Supplement. There were associations between $PM_{2.5}$ exposure and risk of death due to cardiovascular disease, cerebrovascular disease, chronic kidney disease, COPD, dementia, type 2 diabetes, hypertension, lung cancer, and pneumonia (6 causes are presented in **Figure 2**; the remaining 3, in eFigure 4 in the

Figure 1. Nonlinear Exposure-Response Hazard Functions for Death Due to Nonaccidental Causes and Noncommunicable Diseases



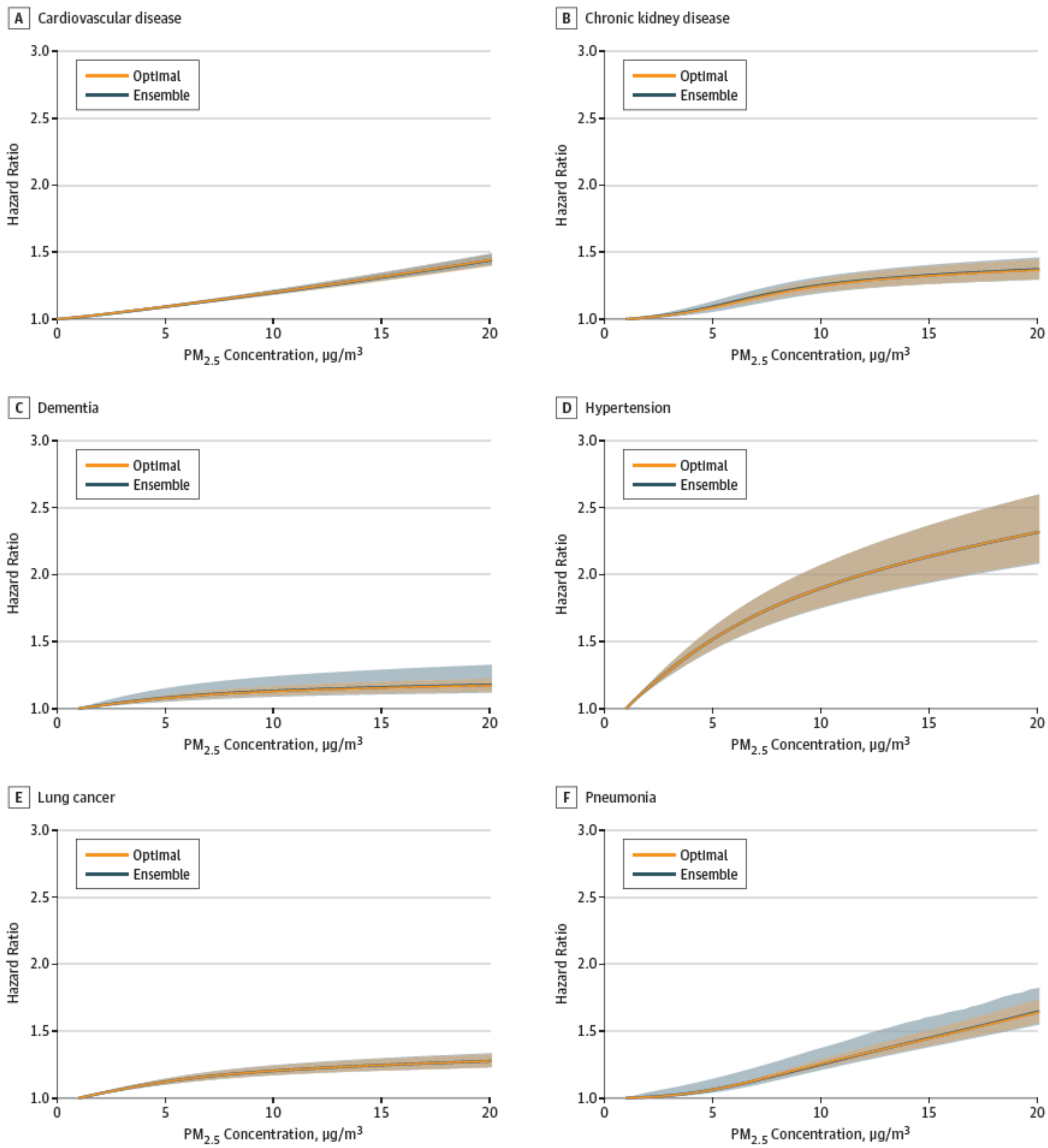
A and B, Plots are presented for both the optimal and ensembled model for nonaccidental causes (A) and noncommunicable diseases (B). The 95% uncertainty intervals are presented as bands. C, Histogram of ambient fine particulate matter ($PM_{2.5}$) distribution.

Supplement). Results of the optimal model were concordant with those obtained from an ensemble model for exposure-response hazard functions.

Sensitivity Analyses

To test robustness of study results, we conducted several sensitivity analyses (eTable 4 in the Supplement) in which we (1) used a 3-year mean $PM_{2.5}$ exposure definition to broaden the time window to capture exposure; (2) built models with time-updated exposure (where exposure and outcome were updated every quarter year) that first accounted for changes in $PM_{2.5}$ over time and changes in $PM_{2.5}$ exposure levels as participants moved over the years and, alternatively, used a measure of the cumulative mean exposure to $PM_{2.5}$ starting from 3 years before cohort entry until

Figure 2. Nonlinear Exposure-Response Hazard Functions for Cause-Specific Mortality



Plots are presented for both the optimal and ensembled model. The 95% uncertainty intervals are presented as bands. $PM_{2.5}$ indicates ambient fine particulate matter.

each point of analysis during follow-up; (3) varied the spatial resolution of exposure assignment to within 30 miles and 10 miles from the nearest air monitoring station; (4) built models additionally controlling for latitude and longitude to account for geospatial correlations; and (5) built models additionally adjusting for ozone levels. The results of the sensitivity analyses were robust to these challenges and were consistent with those in the primary analyses in that a significant association was observed between $PM_{2.5}$ and each examined cause of death (eTable 4 in the Supplement).

Burden of $PM_{2.5}$-Associated Death

Uncalibrated burden estimates of death due to nonaccidental causes associated with $PM_{2.5}$ from ensembled models for the contiguous United States were 208 500.1 deaths (95% UI, 193 285.2-225 082.6 deaths), 5.4% higher than the Global Exposure Mortality Model–based estimate. Following calibration, burden of death due to nonaccidental causes and NCDs was 197 905.1 deaths (95% UI, 183 463.3-213 644 9 deaths) and 188 540.3 deaths (95% UI, 173 883.7-209 786.3 deaths), respectively. Estimated age-standardized rates of death per 100 000 persons were 51.4 (95% UI, 47.7-55.5) and 48.4 (95% UI, 45.1-54.3) due to nonaccidental causes and NCDs, respectively (**Table 2**). Age-standardized death rates due to nonaccidental causes and NCDs exhibited substantial geographic variation and appeared to cluster in swaths of the Midwest, Appalachia, and the South (eFigure 5 and eFigure 6 in the Supplement).

Burden of Death Associated With $PM_{2.5}$ Exposure by ADI and Race

Evaluation of burden of death due to nonaccidental causes and death due to NCDs suggests that age-standardized death rates were highest among non-Hispanic black or African American individuals. Analyses by ADI quartile suggested that age-standardized death rates due to nonaccidental causes and due to NCDs increased with increasing ADI (Table 2; eFigure 7 in the Supplement).

We developed analyses to estimate the relative amount of burden associated with socioeconomic status disadvantage (expressed by ADI) and race. In models that account for both race and ADI, we estimated that in a counterfactual scenario in which racial disparities were eliminated, the age-standardized rate of death due to nonaccidental causes and death due to NCDs may be reduced by 10.6% and 10.2%, respectively; in a counterfactual scenario in which disparities related to ADI were eliminated, the age-standardized rate of death due to nonaccidental causes and death due to NCDs may be reduced by 34.5% and 34.2%, respectively.

Given the observed disparities across ADI categories and racial groups of age-standardized death rates associated with $PM_{2.5}$, we conducted formal interaction analyses for nonlinear exposure-response models. The results suggest that the risk associated with $PM_{2.5}$ exhibited a graded increase by increasing ADI quartile at all levels of $PM_{2.5}$ exposure for both risk of death due to nonaccidental causes and NCDs ($P < .001$ for interaction) (eFigure 8 in the Supplement). Effect modification by race was also observed in that risk associated with $PM_{2.5}$ increased for black individuals compared with nonblack individuals across the spectrum of $PM_{2.5}$ exposure levels for both risk of death due to nonaccidental causes and NCDs (eFigure 8 in the Supplement).

Burden of Death Associated With $PM_{2.5}$ Levels Below the Current EPA Guidelines

The EPA recommends that annual average $PM_{2.5}$ levels not exceed 12 μg/m^3. We estimated the burden of death associated with $PM_{2.5}$ concentrations below the current EPA standards; the results suggest that 99.0% of the burden of death due to nonaccidental causes (195 868.0 deaths; 95% UI, 181 588.6-211 444.2 deaths) and 99.0% of the burden of death due NCDs (186 597.2 deaths; 95% UI, 172 105.3-207 614.7 deaths) were associated with $PM_{2.5}$ levels below the current EPA guidelines (eFigure 9 in the Supplement).

Burden of Cause-Specific Death Associated With $PM_{2.5}$

Population-attributable fraction, total cause-specific death, burden of cause-specific death (per 100 000), and age-standardized burden of cause-specific death associated with $PM_{2.5}$ are presented in Table 2. The estimated burden of cause-specific death associated with $PM_{2.5}$ exposure was 56 070.1 deaths (95% UI, 51 940.2-60 318.3 deaths) due to cardiovascular disease, 40 466.1 deaths (95% UI, 21 770.1-46 487.9 deaths) due to cerebrovascular disease, 7175.2 deaths (95% UI, 5910.2-8371.9 deaths) due to chronic kidney disease, 645.7 deaths (95% UI, 300.2-2490.9 deaths) due to COPD, 19 851.5 deaths (95% UI, 14 420.6-31 621.4 deaths) due to dementia, 501.3 deaths (95% UI, 447.5-561.1 deaths) due to type 2 diabetes, 30 696.9 deaths (95% UI, 27 518.1-33 881.9 deaths) due to hypertension, 17 545.3 deaths (95% UI, 15 055.3-20 464.5 deaths) due to lung cancer, and 8854.9 deaths (95% UI, 7696.2-10 710.6 deaths) due to pneumonia (Table 2). Burden of cause-specific death varied by state (eTable 5 in the Supplement). Maps of 6 causes are presented in **Figure 3**; the remaining 3 are shown in eFigure 10 in the Supplement.

Table 2. Burden of Death Associated With Ambient Fine Particulate Matter

Population	PAF, % (95% UI)	Total Deaths, No. (95% UI)	Rate, No. per 100 000 (95% UI)	Mean Age-Standardized Rate, No. per 100 000 (95% UI)
Nonaccidental cause of death				
Overall	7.76 (7.19-8.37)	197 905.1 (183 463.3-213 644.9)	61.2 (56.7-66.0)	51.4 (47.7-55.5)
Non-Hispanic black or African American	7.97 (7.41-8.60)	24 853.9 (22 728.0-27 276.1)	62.5 (57.2-68.6)	55.2 (50.5-60.6)
All other races and ethnicities				
Overall	7.73 (7.17-8.34)	172 089.7 (156 372.6-189 649.8)	60.9 (55.3-67.1)	51.0 (46.4-56.1)
Hispanic or Latino	7.89 (7.32-8.52)	30 535.7 (28 009.3-33 337.3)	53.3 (48.9-58.2)	48.9 (44.9-53.4)
White or others	7.69 (7.13-8.30)	141 553.9 (128 363.3-156 312.5)	62.8 (56.9-69.3)	51.5 (46.7-56.8)
ADI quartile[a]				
1 (2.9-53.0)	7.70 (7.13-8.31)	97 471.6 (89 406.1-106 424.4)	53.2 (48.8-58.1)	46.1 (42.3-50.4)
2 (53.1-65.5)	7.90 (7.33-8.52)	61 758.9 (56 373.5-67 823.6)	66.0 (60.3-72.5)	56.3 (51.5-61.8)
3 (65.6-75.2)	7.77 (7.21-8.38)	26 147.9 (23 359.9-29 322.2)	80.4 (71.8-90.2)	61.7 (55.1-69.2)
4 (75.3-95.9)	7.63 (7.08-8.23)	11 565.1 (9961.1-13 355.8)	84.9 (73.1-98.1)	65.3 (56.2-75.4)
Noncommunicable disease cause of death				
Overall	7.66 (7.06-8.53)	188 540.3 (173 883.7-209 786.3)	58.3 (53.7-64.8)	48.4 (45.1-54.3)
Non-Hispanic black or African American	7.88 (7.28-8.76)	23 451.7 (21 415.8- 26 769.6)	59.2 (53.9- 67.4)	52.1 (47.5-59.3)
All other races and ethnicities				
Overall	7.64 (7.04-8.50)	164 058.6 (148 247.7-187 544.2)	58.0 (52.4-66.3)	48.4 (43.8-55.3)
Hispanic or Latino	7.79 (7.19-8.68)	29 048.1 (26 502.7-32 824.8)	50.8 (46.3-57.4)	46.5 (42.4-52.5)
White or others	7.60 (7.00-8.45)	135 010.5 (121 744.9-154 719.4)	59.9 (53.9-68.6)	49.0 (44.2-56.1)
ADI quartile[a]				
1 (2.9-53.0)	7.61 (7.01-8.46)	93 066.1 (84 885.2-105 151.9)	50.8 (46.3-57.4)	43.9 (40.1-49.6)
2 (53.1-65.5)	7.80 (7.20-8.68)	58 630.1 (53 238.8-66 786.3)	62.7 (56.9-71.4)	53.3 (48.5-60.7)
3 (65.6-75.2)	7.67 (7.08-8.54)	24 907.2 (22 118.7-29 117.3)	76.6 (68.0-89.6)	58.5 (51.9-68.4)
4 (75.3-95.9)	7.54 (6.95-8.39)	10 996.9 (9420.7-13 258.3)	80.8 (69.19-97.4)	61.8 (52.9-74.6)
Cardiovascular disease	12.6 (11.7-13.5)	56 070.1 (51 940.2-60 318.3)	17.3 (16.1-18.6)	14.4 (13.3-15.5)
Cerebrovascular disease	28.4 (15.0-31.9)	40 466.1 (21 770.1-46 487.9)	12.5 (6.7-14.4)	10.6 (5.7-12.1)
Chronic kidney disease	17.1 (14.0-19.9)	7175.2 (5910.2-8371.9)	2.2 (1.8-2.6)	1.9 (1.5-2.2)
Chronic obstructive pulmonary disease	0.4 (0.2-1.6)	645.7 (300.2-2490.9)	0.2 (0.1-0.8)	0.2 (0.1-0.6)
Dementia	8.2 (6.0-13.1)	19 851.5 (14 420.6-31 621.4)	6.1 (4.5-9.8)	5.1 (3.7-8.2)
Diabetes (type 2)	1.4 (1.2-1.5)	501.3 (447.5-561.1)	0.2 (0.1-0.2)	0.1 (0.1-0.2)
Hypertension	34.1 (30.6-37.6)	30 696.9 (27 518.1-33 881.9)	9.5 (8.5-10.5)	8.0 (7.2-8.8)
Lung cancer	12.1 (10.4-14.1)	17 545.3 (15 055.3-20 464.5)	5.4 (4.7-6.3)	4.4 (3.8-5.1)
Pneumonia	18.0 (15.7-21.9)	8854.9 (7696.2-10 710.6)	2.7 (2.4-3.3)	2.3 (2.0-2.2)

Abbreviations: ADI, Area Deprivation Index; PAF, population-attributable fraction; UI, uncertainty interval.

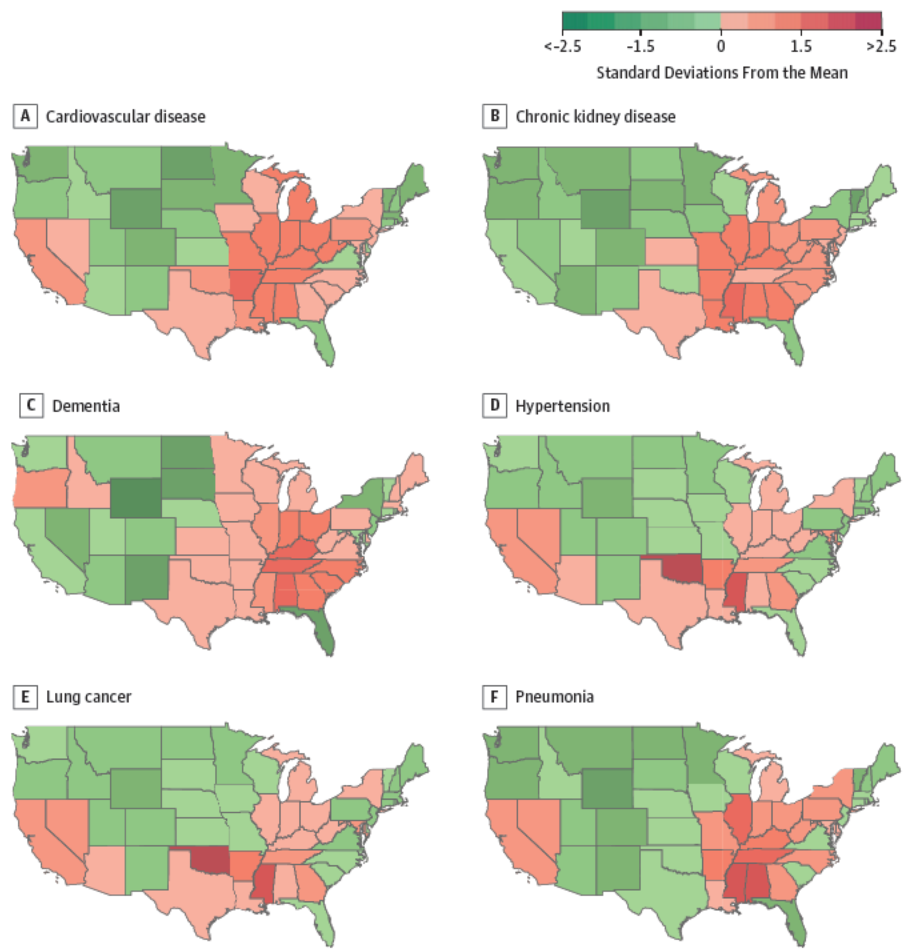
[a] The ADI is a measure of a county's level of socioeconomic deprivation and ranges from 0 to 100, where 0 is low deprivation and 100 is high deprivation.

Discussion

In this study, we systematically evaluated the association between $PM_{2.5}$ exposure and cause-specific mortality. Exposure to $PM_{2.5}$ has a known association with death due to cardiovascular disease, cerebrovascular disease, COPD, type 2 diabetes, lung cancer, and pneumonia. Our study expands the list of known causes of death associated with $PM_{2.5}$ exposure to include chronic kidney disease, hypertension, and dementia. We characterized the shape of $PM_{2.5}$ exposure-risk relationship for all causes, and the resulting estimates of cause-specific age-standardized death rates exhibited geographic variation across states in the contiguous United States. Burdens of $PM_{2.5}$-associated death due to nonaccidental causes and NCDs were more heavily borne by non-Hispanic black and African American individuals and those living in areas with high socioeconomic deprivation; most of the burden of death due to nonaccidental causes (99%) and death due to NCDs (99%) were associated with $PM_{2.5}$ levels below the current EPA standards.

Prior reports by the Global Burden of Disease Study[40] and others[5] that estimated the causes of death attributable to $PM_{2.5}$ were limited to estimation of all-cause mortality and mortality due to ischemic heart disease, stroke, COPD, lung cancer, and lower respiratory infections; this list was most recently expanded to include diabetes. Burnett and colleagues[41] developed an advanced Global Exposure Mortality Model that uses risk information restricted to cohort studies (41 cohorts from 16 countries) of outdoor $PM_{2.5}$ air pollution (whereas prior work used proxy measures of $PM_{2.5}$ exposure, including secondhand and active smoking). Their results suggested that the Global Burden

Figure 3. Maps of the Age-Standardized Death Rates Due to Specific Causes Associated With Ambient Fine Particulate Matter in the Contiguous United States by State



Color indicates a state's number of standard deviations from the mean for each cause of death.

of Disease study estimates vastly underestimate the burden of all-cause and cause-specific mortality, and that $PM_{2.5}$ exposure may be related to additional causes of death other than those currently considered by the Global Burden of Disease study.[8] In our study, we leveraged the enhanced understanding provided by Burnett et al[41] and systematically evaluated specific causes of death where there is evidence of an association between $PM_{2.5}$ and the underlying disease state. Our findings identified additional causes including death due to chronic kidney disease, dementia, and hypertension and provide updated estimates for all 9 causes for the contiguous United States. Evidence from Burnett et al[41] suggests a 43% gap between the estimated burden of all-cause mortality and burden estimates of currently recognized specific causes of death associated with $PM_{2.5}$ exposure; this gap has since been narrowed with the recent inclusion of diabetes.[40,41] The work presented here suggests that the recognition of 3 additional causes of death associated with $PM_{2.5}$ exposure further shrinks this gap to 8%, representing an overall improvement but also suggesting that a smaller gap remains a likely indication that burden of some causes may be underestimated or that there are yet-to-be identified causes that are not accounted for in our analyses.

Evidence from this work suggests that burden of death associated with $PM_{2.5}$ exposure concentrates geographically in the Midwest, Appalachia, and the South and is disproportionally borne by non-Hispanic black and African American individuals and those living in counties with a high index of socioeconomic deprivation. Our analyses of counterfactual scenarios suggest that both race and ADI contribute measurably and independently to burden of death associated with $PM_{2.5}$ exposure. The findings suggest that the underlying socioeconomic conditions (independent of race) in which people live and disparities based on race (independent of ADI) are both important factors in the burden of death associated with $PM_{2.5}$. Disparities in $PM_{2.5}$-associated age-standardized death rates reflect the influence of not only differences in $PM_{2.5}$ exposure and underlying mortality rates, but also sensitivity to exposure. Profound racial and socioeconomic disparities in $PM_{2.5}$ exposure are well documented; our formal interaction analyses provide evidence suggesting that for the same level of $PM_{2.5}$ exposure, black individuals and those living in disadvantaged communities (areas of high ADI) are more vulnerable (exhibit higher risk) to the adverse health outcomes associated with $PM_{2.5}$ exposure,[3,42] further compounding their risk. Greater attention is needed to address and alleviate the burden borne by racial monitories and those living in disadvantaged communities who might also be least equipped to deal with the adverse health consequences of air pollution.[43-46]

There is a considerable national discussion about the current EPA standards for air pollutants and whether further reduction might yield improved health outcomes.[3,47,48] An extensive body of scientific evidence suggests substantial health gains realized by cleaner air, and that further reduction in $PM_{2.5}$ might lead to even greater reduction in burden of disease.[49] Our results further inform this national discussion in that the shape of the exposure-risk function for most causes of death suggests increased risk across the full $PM_{2.5}$ range between the theoretical minimum risk exposure level and 12 μg/m^3 (the current EPA standard). We estimated the number of deaths associated with $PM_{2.5}$ for the entire spectrum of exposure levels experienced by people living in the United States. Our analyses suggest that substantial burden of death due to nonaccidental causes (99%) and death due to NCDs (99%) are associated with $PM_{2.5}$ levels below the current EPA standard of 12 μg/m^3 (eFigure 9 in the Supplement). This result reflects a near total elimination of death burden associated with $PM_{2.5}$ concentrations above 12 μg/m^3, a testament to the remarkable progress in cleaning the air and meeting the current EPA standards, but also indicates that further reduction in $PM_{2.5}$ concentrations below the current EPA standards may yield additional public health benefit.

Limitations and Strengths

This study has several limitations. We present burden estimates derived from a cohort of US veterans in which the majority of participants were older white men, which may limit generalizability of study results; although we used estimates from a state-of-the-art multistudy integrative metaregression to calibrate our nonaccidental burden estimate, estimates of other causes (which applied the same calibration factor) may have had different proportions of error. Although we accounted for several individual-level and county-level health characteristics, our analyses do not account for individual-level differences in socioeconomic status, physical activity, and indoor exposure to air pollution; however, the successful application of negative exposure controls, a negative outcome control, and a positive outcome control lessens the concern about residual confounding. Underlying cause of death codes from the National Death Index may contain some misclassification,[50] and our analytic approach did not consider multiple causes of death simultaneously; however, our estimates of death due to nonaccidental causes were calibrated against those of Burnett and colleagues.[8] Our analyses did not consider the source or the chemical composition and toxic content of $PM_{2.5}$, which might vary geographically; however, studies have shown that estimates using nonspecific $PM_{2.5}$ biomass alone will underestimate the burden of disease attributable to $PM_{2.5}$ pollution.[5] Although we developed strategies to account for cumulative exposure (averaging exposure values starting from 3 years prior to cohort up to each point of analysis during follow-up), our data did not account for complete lifetime history of exposure. Our study focused on evaluating causes of death associated with $PM_{2.5}$ exposure; however, evaluation of causes of death associated with exposure to other pollutants should be undertaken in future research.

Our study also has several strengths. Guided by evidence in the literature on health effects of $PM_{2.5}$, we systematically evaluated the morphology of the relationship between $PM_{2.5}$ and specific causes of death in a national cohort of more than 4.5 million people followed for a median duration of 10 years, which provides power to detect associations that may not be feasible in smaller cohorts. We also developed and tested negative exposure, negative outcome, and positive outcome controls to investigate concerns about spurious associations. We used state-of-the-art methods to estimate health burden and provided estimates of burden at the county level for deaths due to nonaccidental causes and NCDs and state level for specific causes of death. We provided estimates of uncertainty that incorporate not only the standard error of parameter estimates, but uncertainty due to model construction and standard error in National Death Index death rate estimates.[29,30]

Conclusions

In conclusion, we provide evidence of an association between $PM_{2.5}$ air pollution and 9 causes of death—expanding by 3 the list of specific causes of death associated with ambient particulate matter air pollution. We characterize the shape of the association and provide measures of burden for each specific cause at the national and state level. Our results provide further evidence that racial disparities and nonracial socioeconomic disparities contribute measurably and independently to the burden of death associated with $PM_{2.5}$ exposure. Finally, we provide estimates that nearly all deaths attributable to air pollution in the contiguous United States are associated with ambient air pollution concentrations below the current EPA standards, a finding that both reflects past success and suggests that more stringent $PM_{2.5}$ air quality standards may further reduce the national death toll associated with air pollution.

ARTICLE INFORMATION

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SUPPLEMENT.
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From:	Walter Paniak
To:	Lori Taketa
Subject:	CAPE rePower comment
Date:	Monday, December 9, 2019 11:34:05 AM
Attachments:	PFPI-biomass-carbon-accounting-overview-April.pdf

The attached article from the Partnership for a Policy Integrity provides information about the timing of carbon sequestration. In the model that is used the results show a continuous carbon debt for the sequestration of carbon because the cutting and burning continues. Each additional year of cutting and burning moves the point of balance out several decades. See page 11.

Walt Paniak
Arcata

PFPI
driven by data

Carbon emissions from burning biomass for energy

Is biomass “Worse than coal”? Yes, if you’re interested in reducing carbon dioxide emissions anytime in the next 40 years.

Biomass burning: a major carbon polluter

It’s often claimed that biomass is a “low carbon” or “carbon neutral” fuel, meaning that carbon emitted by biomass burning won’t contribute to climate change. But in fact, biomass burning power plants emit **150% the CO_2 of coal, and 300 – 400% the CO_2 of natural gas, per unit energy produced.**

These facts are not controversial and are borne out by actual air permit numbers. The air permit for the We Energies biomass facility (link) at the Domtar paper mill in Rothschild, WI, provides an example of how biomass and fossil fuel carbon emissions compare. The mill has proposed to install a new natural gas boiler alongside a new biomass boiler, and presented carbon emission numbers for both. The relevant sections of the permit are shown below.[1] They reveal that the biomass boiler would emit 6 times more carbon (at 3,120 lb/MWh) than the adjacent natural gas turbine (at 510 lb/MWh).

The Domtar plant was required to show its greenhouse gas emissions from biomass by EPA rules. Although the EPA has proposed a three-year deferral of greenhouse gas permitting for “biogenic” emissions under the “tailoring rule” of the Clean Air Act, this waiver will not go into effect until July 2011. Until then, the EPA is requiring facilities with biogenic emissions to report and try to mitigate their greenhouse gas pollution (using Best Available Control Technology, or BACT) if they are also major emitters of other air pollutants. There is no realistic means to reduce CO_2 emissions, however, other than improving plant efficiency.

Burning biomass emits more CO_2 than fossil fuels per megawatt energy generated:

1. Wood inherently emits more carbon per Btu than other fuels
   - Natural gas: 117.8 lb CO_2/mmbtu
   - Bituminous coal: 205.3 lb CO_2/mmbtu
   - Wood: 213 lb CO_2/mmbtu (bone dry)

2. Wood is often wet and dirty, which degrades heating value
   Typical moisture content of wood is 45 – 50%, which means its btu content per pound is about half that of bone dry wood. Before “useful” energy can be derived from burning wood, some of the wood’s btu’s are required to evaporate all that water.

3. Biomass boilers operate less efficiently than fossil fuel boilers (data from air plant permit reviews and the Energy Information Administration)
   - Utility-scale biomass boiler: 24%
   - Average efficiency US coal fleet: 33%
   - Average gas plant: 43%

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A. Boiler B02 – 350 MMBTU/hour natural gas. This boiler is subject to NSPS (Part 60, Subparts D and Db).

8. Greenhouse Gases
a. Limitations: BACT. (1) Greenhouse gas emissions may not exceed 190 lb CO_2e per 1,000 pounds of steam produced, or 510 lb CO_2e per MWh of steam produced per month, averaged over any consecutive 12-month period. (s. NR 405.08, Wis. Adm. Code and 10-SDD-058)

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B. Boiler B01 – Biomass and natural gas fired boiler with a capacity not to exceed 800 MMBTU/hour. The boiler is subject to NSPS (Part 60, Subparts D and Db).

11. Greenhouse Gases
(a) Limitations: BACT. (1) Greenhouse gas emissions may not exceed 3,120 pounds of CO_2e per MWh of gross output, averaged over any consecutive 12-month period. *Gross output* means the gross useful work performed by the steam generated. When the unit is generating only electricity, the gross useful work performed is the gross electrical output from the turbine/generator set. For cogeneration, the gross useful work performed is the gross electrical output plus 75 percent of the useful thermal output measured relative to ISO conditions that is not used to generate additional electrical output (i.e., steam delivered to an industrial process). . **(s. NR 405.08, Wis. Adm. Code)**

If burning biomass emits carbon dioxide, how can it be "carbon neutral"?

CO_2 is CO_2, whether it comes from burning coal or burning trees. So why do some people argue that biomass power generation is "carbon neutral"?

There are two main arguments, the "waste" argument and the "resequestration" argument:

The "waste" argument part 1: "It would have decomposed anyway"
Biomass fuel is often portrayed as being derived from "waste" materials, particularly the tree branches and other material left over after commercial timber harvesting ("forestry residues, slash"), as well as sawdust and chips generated at sawmills ("mill residues"). Because these materials are expected to decay eventually, emitting carbon dioxide in the process, it is argued that burning them to generate energy will emit the same amount of carbon as if they were left to decompose.

This claim only works if the time element is ignored, and if there is actually enough waste to power the proposed facilities.

It takes years and even decades for trees tops and branches to decompose on the forest floor, and during that process, a portion of that decomposing carbon is incorporated into new soil carbon. In contrast, burning pumps the carbon stored in this wood into the atmosphere instantaneously. There is a difference of many years, and even decades, between the immediate emissions from burning residues, and the slow evolution of carbon from natural decomposition. So one question is, how can a form of energy that dramatically *accelerates* the release of CO_2 into the atmosphere be considered carbon neutral? The answer is that it can't be, unless critical factors like time are ignored.

Another important question is, how much of these "forestry residues" are really available, compared to the amount of fuel required by a growing biomass industry? We explore that question in detail elsewhere; here, it's sufficient to state that forestry residues are extremely limited, relative to fuel demand, and that many facilities already harvest whole trees for fuel.

Waste argument, part 2: the "Methane Myth"
Some people claim that it's better to collect logging residues for biomass fuel, rather than leaving them in the forest, because allowing these materials to decompose naturally can emit not just carbon dioxide (CO_2), but also methane (CH_4). Because methane has a greater global warming potential than carbon dioxide, proponents of biomass power argue it is better from a greenhouse gas perspective to burn this material, and emit the carbon as carbon dioxide, rather than let it decompose in the forest, where some of it may be emitted as methane.

There are notable problems with this argument.

- Methane is not produced in upland areas where well-aerated logging residues are decomposing. Instead, it is chiefly produced in wet, low-oxygen environments like wetland soils. Forest soils contain bacteria that produce methane, but also bacteria that consume methane, so the net emissions are small. (EPA's information on methane puts different sources into perspective).
- Landfills can be sources of methane, but according to a study on landfilled wood, "the resistance of most forest products to anaerobic decomposition in landfills is significant"… and that only about 3% of land-filled wood is emitted as methane or carbon dioxide.
- Notably,biomass proponents never mention something that *is* very likely to be a source of methane emissions: the football field-sized, 30 – 70 foot tall, wet, steaming, and poorly aerated piles of chipped wood fuel at many biomass plants. (One study found temperatures in a wood chip pile rose to 230F less than two months after pile completion; temperatures above 180F are considered to produce a high probability of spontaneous combustion. Off-gassing from relatively dry wood fuels can produce, in addition to CO_2, carbon monoxide, methane, butane, ethylene, and other toxic gases. The buildup of gases in the holds of ships transporting wood pellets has caused accidents and fatalities. Spontaneous combustion in wood chip piles is not uncommon.)

The "resequestration" argument.
The other main argument used to justify the idea that biomass energy is carbon neutral is that re-growing plants recapture, or "resequester" an amount of carbon equivalent to that released to the atmosphere by burning biomass fuels, and therefore net carbon emissions are zero.

When trees are used for fuel, it is obviously not possible for the system to be "carbon neutral" in a timeframe meaningful to addressing climate change. A 50 megawatt biomass power plant burns more than a ton of wood a minute. It takes seconds to burn a tree, and many decades to grow it back.

But proponents have devised deceptive arguments to obscure this logic. Some claim that as long as forests in a region are are growing more wood than is being cut, then carbon emissions from biomass burning are neutralized by this growth. This argument seems to persuade some people, but it is wrong. It sidesteps that fact that growing forests are taking up carbon *now* – and that cutting and burning them for fuel dramatically increases carbon emissions from energy compared to the fossil fuels you're replacing (see a letter about how the Washington State Department of Natural Resources made this very mistake, **here**; and see the Manomet team's takedown of a similar argument. We explain the Manomet study in more detail below).

A similar argument states that as long as forests are growing and sequestering carbon in one place, this makes up for the carbon that's emitted by harvesting and burning trees in another place. But those trees "somewhere else" were already sequestering carbon - and cutting and burning trees over *here* does nothing to increase carbon sequestration over *there*. Not to mention that the trees that you burn over *here* are no longer sequestering any carbon at all, but instead are floating around in the air as CO_2. It makes as much sense to discount biomass carbon emissions using this logic, as it does to discount fossil fuel emissions "because trees are taking up carbon somewhere".

Over long enough time periods, forests cut for biomass fuel can ultimately regrow and recapture the carbon released by burning. But the inescapable conclusion of doing carbon accounting correctly is that burning biomass instead of fossil fuels always represents an extra burst in carbon emissions over some multi-year or multi-decadal period, and in some cases more than a century. It can't be any other way. When you cut a forest for fuel, you're *increasing* carbon emissions produced per unit energy by switching to wood, and at the same time, *decreasing* the total amount of forest available to take carbon out of the air and sequester it into growing trees (think of the forest as a scaffolding, upon which more carbon is hung each year. A forest cut for biomass doesn't have the "infrastructure" to accumulate carbon quickly).

Industry data show that the overwhelming majority of biomass burners are now and will continue to be fueled by wood. Net carbon emissions from burning trees are enormous in part because trees are such long-lived organisms, so it takes decades to centuries to re-grow them after they're burned.

But what about using crops for fuel, or other plants that have a shorter lifecycle than trees? Plants with a yearly lifecycle – like the perennial grass switchgrass – have lower net carbon emissions over time, because net carbon emitted by harvesting and burning can be re-grown in a shorter period. However, it is important to make sure that using energy crops as fuel doesn't cause an increase in carbon emissions somewhere else. For instance, cutting down forests and planting switchgrass would represent a massive loss of carbon to the atmosphere from harvesting the trees, as well as the decomposition of roots and soil carbon following harvest. This pulse of carbon would outweigh any benefit of replacing fossil fuels with energy crops for a long time.

And, to replace even a small percentage of fossil fuels with switchgrass or a similar energy crop would take a huge amount of land. Supplying a single 50 MW biomass plant with switchgrass would require harvesting around 65,000 acres a year (assuming 7 tons of switchgrass harvested per acre). To replace any significant amount of the approximately 969,440 MW of fossil-fueled capacity in the U.S. (2009 data), would require tens of millions of acres of land that are currently growing food or feed, not to mention the 30 million acres of corn that are currently devoted to ethanol production, with notable impacts on commodity prices worldwide.

Science-based accounting for biomass energy carbon emissions: the Manomet Study

When citizen scientists and activists discovered that two to four utility-scale biomass electricity generating plants were planned in Massachusetts, they organized. Some basic math quickly revealed that the hundreds of thousands of tons of wood required to fuel these plants would far exceed not only the amount of "forestry residues" generated in the state, but also the state's total annual commercial sawtimber harvest. Clearly, these plants would be big carbon polluters, but as "renewable energy" they would not have to report or count their emissions under state regulations, which treat all renwables as carbon neutral.

Responding to citizen activism, the state issued a request for proposals for a group to study the forest cutting impacts and net carbon emissions from biomass power. The group that was awarded the contract was headed by the Manomet Study for Conservation Sciences, and included representatives from the Biomass Energy Resource Center, the Forest Guild, and others. Several of the group's members were already on the record claiming that burning biomass was carbon neutral.

Nonetheless, when the final "Biomass Sustainability and Carbon Policy Study" (aka the "Manomet Report") was issued, the results surprised even the researchers. The study concluded that net carbon emissions from burning biomass in utility-scale facilities emitted more carbon than even coal, and that it would take decades to pay off the "carbon debt" created by harvesting forests for fuel. Small burners (i.e. thermal and combined-heat-and-power facilities) with higher efficiencies were found to have shorter payoff periods for their carbon debt, but even their emissions exceeded those from fossil fuels for several years.

The study assumed that the carbon debt from "logging residues" used for fuel – that is, the wood left over from sawtimber harvesting, which would decompose and emit carbon anyway – was basically paid off within a few years. But because there is relatively little of this material available in Massachusetts, the main fuel supply for biomass facilities would have to be trees that would not otherwise have been cut. And "trees that would not otherwise have been cut" turned out to have a really large carbon footprint when harvested and burned for fuel.

Upon release of the Manomet Study, the State issued a directive that new rules should be drafted to restrict the eligibility of biomass power for renewable energy credits to those facilities that could demonstrate lifecycle emissions no more than 50% those of a natural gas plant, over a 20 year period. New restrictions were also proposed that restricted the amount of wood that could be taken from a logging site and used for fuel. As of March, 2011, the final version of the rules has not been released, but as drafted, the regulations stood as the sole example of a science-based policy on biomass power anywhere in the U.S, or the world.

The Manomet Study approach to carbon accounting, or, "Carbon accounting ain't for sissies".

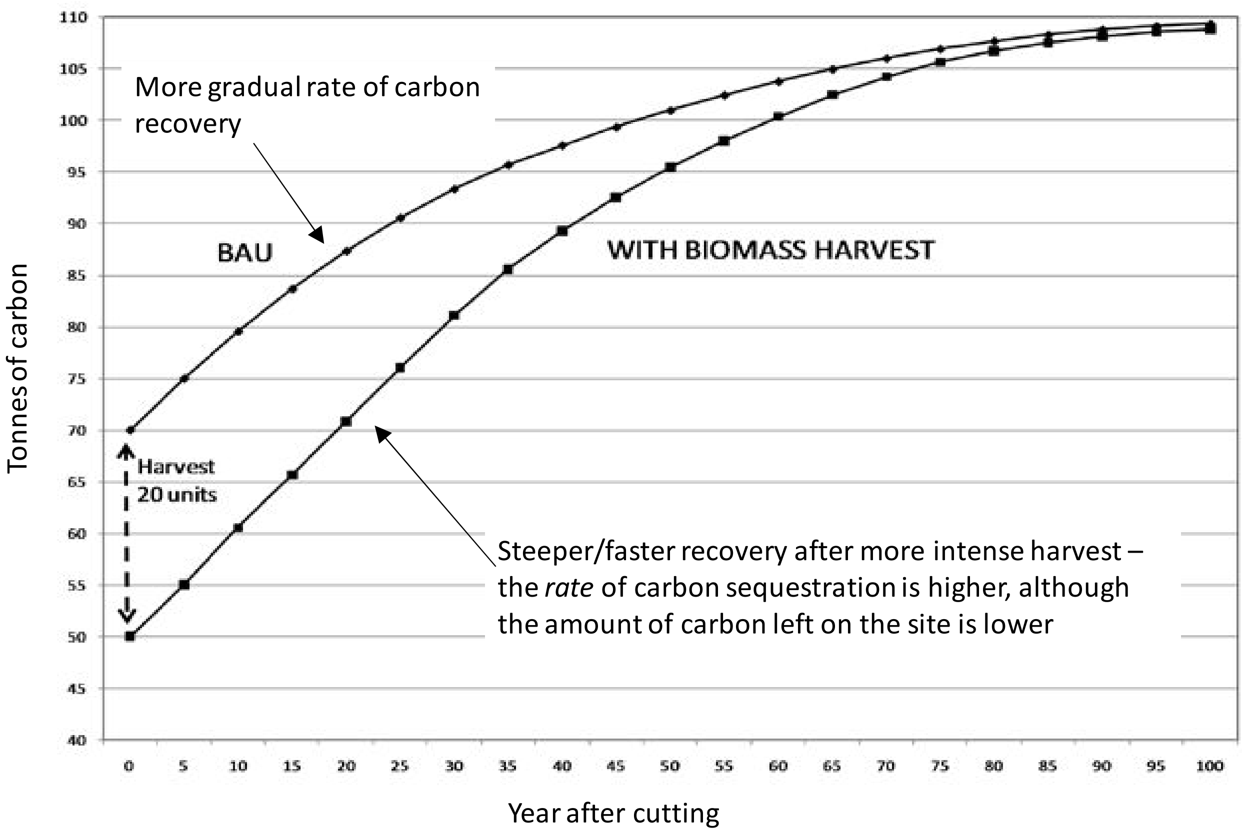
The Manomet team used a computer model of forest growth, the Forest Vegetation Simulator (FVS) to estimate net carbon emissions from biomass power. The FVS uses data collected on forest biomass and growth from the region of interest (in this case, Massachusetts forests) to run the simulations of forest regrowth after harvest.

The strength of the Manomet approach is that it acknowledges that forests *already* represent significant "sinks" for our emissions of carbon dioxide – that is, they convert atmospheric carbon dioxide into wood that takes the carbon out of circulation and thus reduces global warming potential. Forests do this whether the carbon is emitted by burning fossil fuels, or biomass.
The Manomet modeling approach compares carbon release and forest carbon sequestration under two basic scenarios:

1. The "business as usual" (BAU) scenario, where energy is generated from fossil fuels, and forests are cut for commercial timber, but not biomass fuel. Under the BAU scenario, the standing carbon in the forest is reduced down to 70 tonnes/hectare by commercial timber harvesting.

2. Under the "biomass" scenario, forests are still harvested for commercial timber down to 70 tonnes of standing carbon per hectare, but then a further 20 tonnes of forest carbon is harvested for biomass fuel, reducing the standing carbon to 50 tonnes/hectare (these assumptions and scenarios are particular to the model but do not turn out to be very important for the results, because the results largely depend on the magnitude of the *difference* between the two harvest intensities, and not the absolute magnitudes of the harvest intensities themselves).

Manomet's graphic (from page 98 of the report) shows the regrowth of forest plots cut under the BAU scenario and the biomass scenario. We reproduce it and annotate it below. Notice that the model estimates a higher rate of regrowth (steeper curve) under the heavier harvest of the biomass scenario. This occurs because the model simulates greater penetration of light and greater water and nutrient availability in the more heavily cut forest, which allows the trees remaining on the site and the new trees geminating after harvest to grow faster. The graphic shows how initially, there is a difference of 20 tonnes of carbon between the two scenarios. After a couple of decades of regrowth, the faster rate of carbon sequestration on the more heavily harvested plot starts to narrow the gap between the two curves.



The next step is to add the emissions from energy generation into the model. Manomet estimated the amount of energy that could be generated from the 20 tonnes of biomass per hectare removed in the biomass scenario, then calculated what the carbon emissions would be if the same amount of energy were generated using fossil fuels in the BAU scenario (fossil fuel carbon emissions are a weighted average from power generators in Massachusetts, so are not representative of a 100% coal or a 100% gas scenario, but lie somewhere in-between). For this scenario, Manomet concludes that generating a given amount of energy using biomass would emit 20 tonnes of carbon, and generating the same amount of energy from fossil fuels would emit only 11 tonnes of carbon.

Biomass as fuel emits more carbon per unit energy than using fossil fuels. This creates a “carbon debt”, the carbon emitted to the atmosphere that was formerly held in trees or other plants that must be paid back. When trees are harvested and burned as fuel, repaying the debt requires a higher rate of carbon sequestration than in the BAU scenario, where forests were cut for commercial timber but not fuel. If the growth rates were the same, the initial difference of 20 tonnes of carbon following harvest would persist indefinitely.

The growth curves above shows how this carbon debt is repaid. For the carbon held in the biomass scenario to catch up to the BAU scenario requires accelerated growth, and indeed, the FVS model simulates a higher growth rate in the forests cut heavily for both commercial timber and biomass fuel, compared to the forests that are cut just for commercial timber. The higher growth rate allows carbon to accumulate faster in the biomass scenario, eventually closing the gap and catching up to the carbon accumulated in the BAU scenario.

This outcome is heavily dependent on the FVS model assumption of a higher growth rate in the forest cut more heavily for fuel. If this turns out to be not true for any reason – for instance, if cutting forests for biomass actually lets in *too much* sun, overheating and drying the site and interfering with seedling regeneration, then resequestration of the extra carbon emitted by burning biomass may be postponed indefinitely. The model’s conclusions will not be sustainted unless the growth rate on the more heavily cut biomass plot eventually exceed the growth rate on the BAU plot.

Further, for these conclusions to hold it is also essential that the forest plot not be cut again, prior to the full resequestration of carbon. To achieve that goal following harvesting for biomass, forests have to be left alone for decades.

For a review of these and other assumptions that likely mean that the Manomet Study painted *too rosy* a picture of the carbon impacts of biomass energy, click here.

Manomet's modeling – a closer look

Getting deeper into the modeling behind the Manomet study requires defining some terms. We try here to present the Manomet approach from a couple of different angles.

First, we look back at the previous graphic, and see that immediately following harvest, there is more standing carbon in the BAU system than the biomass system:

- C_{BAU}: Standing carbon per hectare in the BAU forest, which has been cut for sawtimber = 70 tonnes
- C_{BIO} : Standing carbon in the forest cut for biomass fuel and sawtimber = 50 tonnes

Following harvest, 20 additional tonnes of carbon have been removed as fuel from the biomass system. This is subtracted from the standing carbon (as shown in the term above) and shows up as energy emissions:

- E_{BIO} : Emissions from biomass fuel = -20 tonnes (expressed as a negative number to represent carbon that's been taken out of "solid" form and entered the atmosphere as CO_2.)

In the BAU system, energy was produced by burning fossil fuels instead of biomass, which emitted 11 tonnes of carbon:

- E_F : Emissions from fossil fuels = -11 tonnes

Below are the first 75 years of data that describe the carbon recovery (in tonnes) of single plots harvested under the BAU and biomass scenarios from the graphic above (these values are estimated off Manomet's graphics, so may not match the data used in the model precisely).

year	C_{BAU}	C_{BIO}	$E_F + C_{BAU}$
0	70	50	59
5	75	55	64
10	79.75	60.5	68.75
15	83.75	65.75	72.75
20	87.5	71	76.5
25	90.5	76.25	79.5
30	93.4	81.4	82.4
32	94.25	82.75	83.25
35	95.5	85.5	84.5
40	97.5	89.5	86.5
45	99.4	92.5	88.4
50	101	95.4	90
55	102.5	98	91.5
60	103.75	100.4	92.75
65	105	102.5	94
70	106	104.4	95
75	107	105.5	96

Remembering that in the BAU scenario, energy emissions from fossil fuel combustion were 11 tonnes of carbon, and in the biomass system were 20 tonnes from the material harvested and burned for fuel, we can see that the BAU system as a whole contains 9 tonnes more standing carbon than the biomass system.

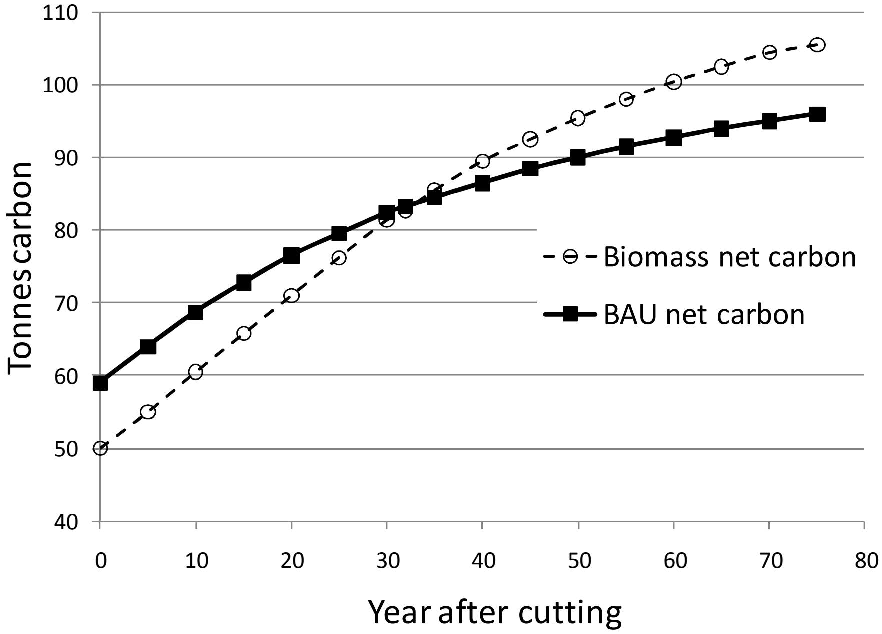
The question thus is, How many years will it take until the gap is closed and $E_F + C_{BAU} = C_{BIO}$?

Five years after harvest:
BAU system: $E_F + C_{BAU} = -11 + 75 = 64$
Biomass system: $C_{BIO} = 55$
So there are still 9 tonnes more carbon held in the BAU system than the biomass system.

At year 25, the growth rate for the biomass scenario is higher than for the BAU scenario, so the gap is narrowing and there is now only 3.25 tonnes more carbon held in the BAU system:
BAU system: $E_F + C_{BAU} = -11 + 90.5 = 79.5$
Biomass system: $C_{BIO} = 76.25$

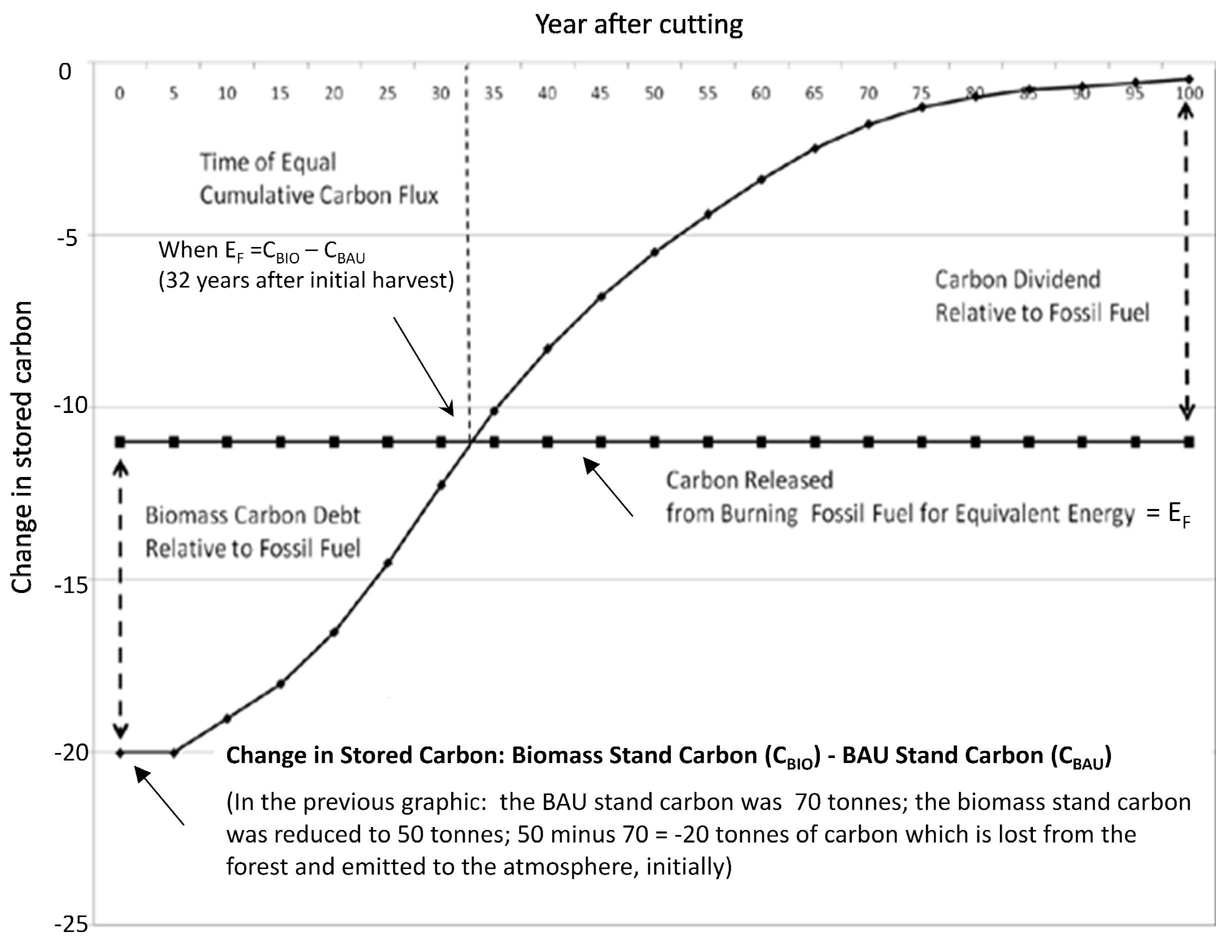
The Manomet model estimates that the gap closes completely at year 32. That is when net carbon held in the two terrestrial systems is equivalent, and net emissions from biomass power equal net carbon emissions from fossil fueled power.

Graphically, Net Carbon looks like this:



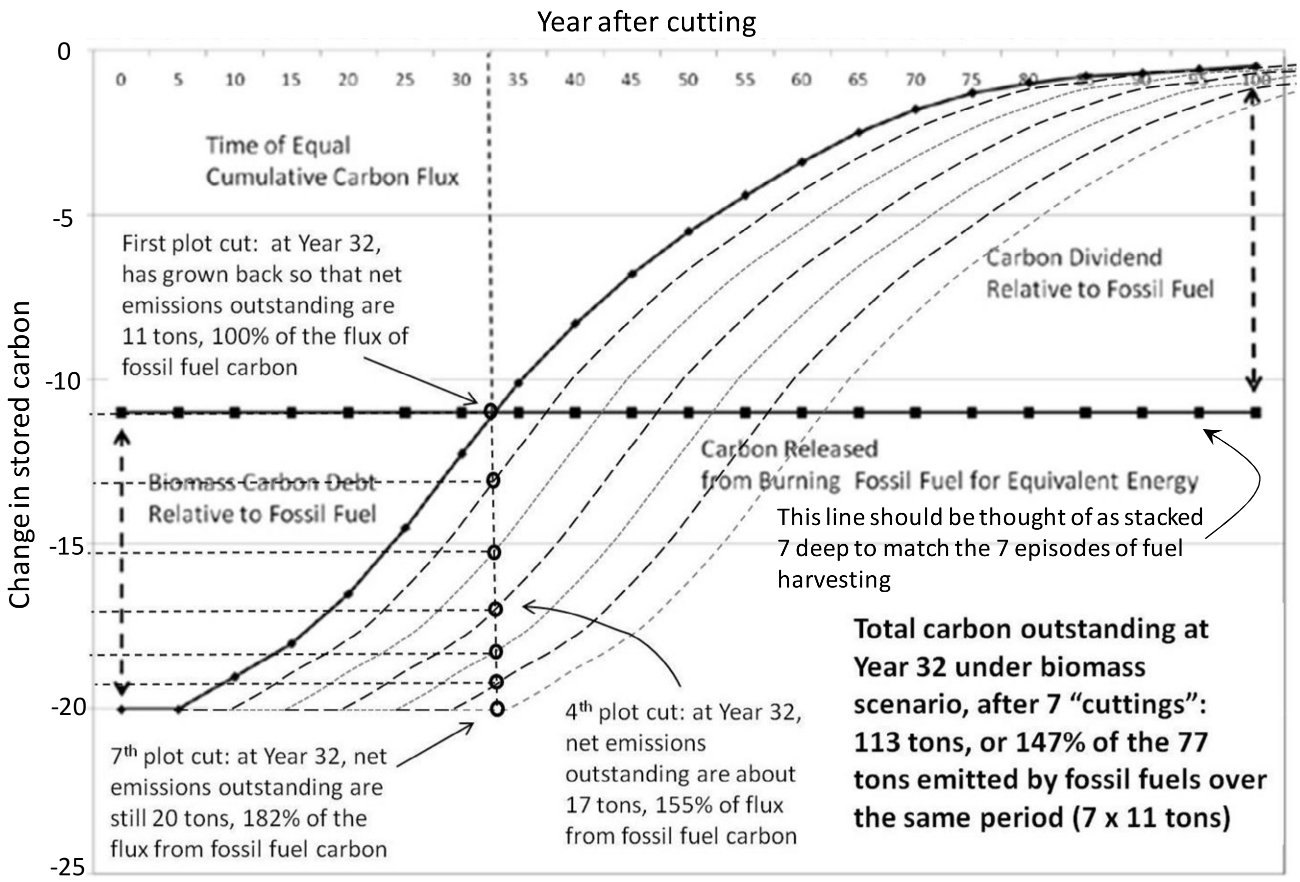
Manomet demonstrates the relationship between the two systems in a way that can be a little difficult to explain. One way to think about it is by rearranging the initial equation. Instead of asking as we did above, At what year does $E_F + C_{BAU} = C_{BIO}$, we rearrange the equation and instead ask, At what year does $E_F = C_{BIO} - C_{BAU}$?

When this is graphed against time, it looks like the following, which appears in the Manomet report on page 98:



The two previous graphics both show that following a single year's worth of fuel harvesting, it takes 32 years to repay the carbon debt and sequester enough carbon so that net emissions from biomass are the *same* as if the energy had been produced from burning fossil fuels. It is especially important to remember that up to this point, we have only been talking about the net carbon emissions through time and the carbon recovery occurring on the plots cut in a single year that have been cut once to yield biomass fuel.

Biomass plants are big investments, and no one builds one to operate for just a single year. To see what a facility's total carbon footprint looks like through time, we replicated the single plot graph to show multiple years of fuel harvesting (as with the former graphics, we have added to and adapted Manomet's charts). The horizontal line describing emissions from fossil fuels should be assumed to be duplicated as well – think of lines stacked on top of each other - since each year's use of biomass for fuel is compared against a year's use of fossil fuels in the BAU scenario.



As in the earlier graphic, net carbon emissions from the initial harvest of biomass achieve 100% parity with fossil fuel emissions at year 32 since the beginning of facility operation. However, at year 32, carbon from the next round of harvesting hasn't achieved 100% parity – it still has a carbon debt of about -13 tonnes. The third round of harvesting has a carbon debt slightly south of -15 tonnes at year 32 since the beginning of operation, and by the fourth round of cutting, the carbon outstanding is -17 tons. Summed over the 7 harvests shown here, the total biomass emissions are still greater than the total fossil fuel emissions, which are 77 tons (11 tons, replicated 7 times).

This is just an example – for visual clarity, the "harvests" have been staggered every five years, instead of occurring every year as they would for a biomass facility in continuous operation – but for this scenario, after 7 rounds of harvests, the net emissions under the biomass scenario are still 147% those in the BAU scenario.

The bottom line: unlike other renewable energy technologies like wind and solar, biomass is a perpetual emitter, meaning that every year's fuel supply requires creating a new "carbon debt".

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[1] The biomass boiler can also burn gas but the emission figures are for biomass, only. Greenhouse gas emissions are expressed as CO_2 equivalents per unit output – i.e., per megawatt-hour – as opposed to being on a per unit heat input basis, as is typical for conventional pollutants. This allows the differences in the boiler efficiencies to be reflected in the final output numbers.

From:	Walter Paniak
To:	Lori Taketa
Subject:	CAPE RePower “mastication of forest residues in place”
Date:	Monday, December 9, 2019 9:35:34 AM
Attachments:	What is Forest Mastication Diversified Resources.pdf

The attachment provides an alternative to pile burning and for the transport of small trees and forest residue to biomass plants.
The article explains Forest mastication and how the reduction of “ladder” material encourages growth of merchantable trees while reducing surface fuels that can cause torching to create crown fires. There is also a benefit to the soil by adding back organic matter that retain micronutrients. The downside: this technique is more costly then pile burning . Pile burning is the least costly way to clear the recently cut forest for replanting.

Transporting forest residue to a biomass plant is a way to gain revenue from rate payers versus billing forest health cost into the cost of lumber. (The attachment is from Diversified Resources a Chester Ca timber services company.)
Walt Paniak
Arcata
--
Walt Paniak

We are often asked, What do you do in the forest? To which we respond, we are forest health improvement specialists. We utilize mastication techniques in the forest to improve forest health, reduce wildfire and provide healthy habitats for wildlife. After a puzzled look, the next question we get is what is mastication? Well, Webster's defines it as to chew or grind food. So think of it in terms of forestry and we "chew" or "grind" woody vegetation with machinery.

UNDERSTANDING MASTICATION AND ITS AFFECTS FOREST HEALTH

Mastication is a fuel reduction treatment method used in forestry management to reduce wildfire risk, to reduce fuel loadings by returning the forest to natural conditions. Masticating fuels , or mulching the forest, involves the reduction of vegetation into small chunks and is one of the many ways overstocked forest stands are thinned. The benefits include opening the canopy and forest floor which provides the remaining trees access to more nutrients, sunlight and water. When trees are crowded together, they are in competition for sunlight and water. As a result they tend to be less healthy. Mastication can assist in removing some trees in the early stages, to allow the remaining trees to grow faster, stronger and larger. Over the past decade, Forest mastication methods have dramatically reduced wildfire hazards and greatly improved forest health.

MASTICATION AS A FUEL REDUCTION METHOD

A wide variety of manual and mechanical methods are used to reduce hazardous fuels on forest property. Chipping, mechanical piling, crushing and mastication are frequently used forest treatment methods. Mastication treatment utilizes several different types of equipment to grind, chip, or break apart fuels such as brush, small trees and slash into small pieces. By masticating fuels we reduce the potential for catastrophic wildfires by reducing ladder fuels and creating a gap between surfa ce fuels and crown fuels. Mastication may be used as a stand-alone treatment or an alternative treatment prior to prescribed burning.

WHAT EQUIPMENT IS USED IN FOREST MASTICATION OR MULCHING?

A masticator is similar to a wood chipper, it is mounted on an excavator type tractor, which moves through the forest to grind or chip trees and brush, leaving the chips behind. The masticator head, often termed the cutting head, is usually mounted horizontally, as is the case with our equipment.

Masticated material is processed based on specifications by the forest landowner. The small chunks of woody debris left on the forest floor can be relatively light or dense depending on the specifications for treatment. Treated areas are generally not at risk of beetle infestation due to the small size of woody debris. We specialize in taking overgrown forests and return them to a natural state.

Our machines can get the job done fast, efficient and with low impact on the landscape. We operate our equipment in an environmentally effective manner. Our equipment is maintained to the highest standards.

The following depicts the historical state of our forests, versus what a typical forest looks like today.

WHAT IS THE IMPACT DOES MASTICATION HAVE ON FOREST HEALTH ?

For the past 100 years, natural fire cycles have been altered, changing the character of many fire-adapted ecosystems and increasing wildland fire risk. The use of prescribed fire is the least expensive option to managing fire adapted forests, there are many areas where prescribed fire cannot be used. High fuel loads, air quality restrictions, weather conditions and risk of escaped fire are all factors that limit the use of prescribed fire.

A century of fire suppression and declines in timber harvests on federal land over the past 20 years have left many forests over-stocked with small trees competing for water. Add drought to the mix and the trees become even more vulnerable to insect outbreak. Forests of stressed trees surrounded by heavy fuel loads are vulnerable to wildfires that are hotter and larger than would have burned historically.

Given current conditions in many forests, it's generally thought that mechanical fuel reduction treatments, like forest mastication, is needed to help restore beneficial fire to the ecosystem. Without intervention, current fuel loads leave many areas at increased risk of catastrophic fire.

ALTERNATIVES TO BIOMASS REMOVAL NOW THAT BIOMASS POWER PLANT FACILITIES ARE CLOSING IN CALIFORNIA

Biomass removal is one method for thinning overcrowded and unhealthy forests. The trees are chipped and trucked to cogeneration plants for use in energy production. For California, many cogeneration plants are closing, thus limiting the amount of biomass removal. This will only further complicate the already overstocked forests, possibly contributing to more catastrophic wildfire and insect infestation. Landowners are faced with forests of higher density and high incidence of insect and stress related tree die-off. Which leads to increased fire potential and disease transmissibility.

Mastication, as an alternative to biomass removal, has relatively low environmental impacts and provides an effective method to achieve forest and watershed health goals. Correct use of mastication services can vastly increase the health of the vegetation. Allowing space between trees and shrubs allows for proper drainage, soil stabilization, and sunlight.

Mastication treatment creates a mosaic of open wooded conditions that are capable of maintaining wildlife habitats, increased tree size and reducing the risk of severe wildfire. Mastication provides an effective, affordable, low risk alternative fuel reduction treatment method for forests today.

DIVERSIFIED RESOURCES INC.

We are fully insured and bonded licensed timber operator and licensed California tree service contractor. We take pride in our quality of work and are always good stewards of the land. We put safety and quality of work above production.

ASSOCIATIONS AND LICENSES

California Contractors License: 966089
California Timber Operators License – A-10959
Associated California Loggers – Certified ProLogger

FEDERAL AND STATE CERTIFICATIONS

California Small Business - 1529463
HubZone
Supplier Clearinghouse – Women Business Enterprise – 12010092
California Dept of Industrial Relations Public Works Contractor - 1000024066

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Dec 10, 2019

The biomass paragraph dealing with transitioning away from biomass was most encouraging. It should have a time frame target and a responsible subcommittee. My intuition tells me that soil amendments will be a premium items as land it lost to rising seas and weather pattern change the location of agriculture land.
However, if appears that we are kicking the can down the road in terms utilizing both plants full capacity. The staff report to the board September 2017 Para 7.1 stated that there was approximate 20 to 25 MW from mill waste. The new wording appears to say that fuels from forest thinning will be added to the mix. Have the goal posts been moved? Single aged forest land require one or two thinning to encourage more rapid growth of merchantable trees. Reducing surface fuel is an ancillary benefit. Pile burning is the least costly way clear land for replanting. Now it appears that the rate payer will cover the cost of industrial waste removal and pay for the bad forest management practices of the past. Paying higher prices for biomass with yearly cost of living adjustment versus the wind and solar contracts where there are constant rates over the life of the contract is problematic.
Thinning should be built into the cost of lumber and not your electric bill. Saving can be applied to other beneficial uses
Matthew Marshall stated at a CAPE meeting words to the effect that RCEA does not pay for anything it was the rate payer who pays.
When equipment is upgraded the rate payer paid for that equipment and then the the plant owner use the cost of that equipment as an investment tax credit or as depreciation cost to lower payable taxes.

Walt Paniak

Dec 10

I would like to provide some additional data for review .

The source of this data is the Energy Information Agency form 923Generation and Fuel consumption report The top report is the 2018 Final showing the fuel used and net energy output for the year. Fairhaven cogenerates with NG. (Discuss 2018 Natural Gas for U Months 45,318 mcf and Humboldt Sawmill use 51,996 gal. of diesel oil. The middle report shows interim totals for Jan thru Sept 2019 for HSC only (30,996 gals used). The backside of the report taken from a OSU Dept of Forestry paper showing Dept of Energy measuring pounds of CO2 per MWh comparing biomass to fossil fuel.

Biomass energy averaged 3450 lbs of CO2 per MWh versus 1915 lbs for petroleum and 1314 lbs for Natural Gas.

The use of these supplemental fuels should be noted in the board's definition of clean energy or not so clean.

The RCEA 2018 Integrated Resource plan figure 10 lists :NOX 319 tons per year and 61 tons per year PM 2.5.

Nitrous oxide is 264 times more powerful as a GHG than CO2 per IPPC.

I would request that the committee directs the staff to provide updated information for these pollutants because the biomass output has increased.

Walt Paniak

Arcata

/alter Paniak <[redacted]
o: Walter Paniak <[redacted]

Sat, Dec 7, 10:15 AM

Department of Energy, The Energy Information Administration (EIA)
-923 Monthly Generation and Fuel Consumption Time Series File, 2018 Final Revision
rces: EIA-923 and EIA-860 Reports

t Id	Plant Name	Reported Fuel Type Code	Physical Unit Label	Year-To-Date Total Fuel Consumption Quantity	Year-To-Date Net Generation (Megawatthours)	YEAR
10052	Fairhaven Power	NG	mcf	45,318	2,054	2018
10052	Fairhaven Power	WDS	short tons	100,690	37,565	2018
50049	Humboldt Sawmill Company	DFO	barrels	1,238	271	2018
50049	Humboldt Sawmill Company	WDS	short tons	209,140	109,866	2018

Text

Fairhaven final NG total 2018 45318 mcf
HSC used 51,996 gals of diesel for cogeneration

U.S. Department of Energy, The Energy Information Administration (EIA)
EIA-923 Monthly Boiler Fuel Consumption and Emissions Time Series File, 2019 September
Sources: EIA-923 and EIA-860 Reports

Plant Id	Plant Name	Physical Unit Label	Year-To-Date Total Fuel Consumption Quantity	YEAR
50049	Humboldt Sawmill Company	barrels	497	2019
50049	Humboldt Sawmill Company	short tons	72,696	2019
50049	Humboldt Sawmill Company	barrels	241	2019
50049	Humboldt Sawmill Company	short tons	76,259	2019
50049	Humboldt Sawmill Company	barrels	0	2019
50049	Humboldt Sawmill Company	short tons	0	2019

Fairhaven is not required to report 2019 until Fed 2020
HSC con-generates with Diesel using 2 boilers: total diesel used in gals
497+241=738x42 gal=30,996

Figure 10: Estimates of annual emissions of nitrogen oxides and particulate matter

	2018	2022	2026	2030
Biomass MWh	177,828	48,018	0	0
Nox (tons)	319	120	0	0
PM2.5 (tons)	61	24	0	0

2018 IRP

RCEA's long-term

between forest biomass and fossil fuels, forest biomass has a higher CO_2 production per energy unit produced. This analysis applies only to boiler output, and does not include alternatives or other emissions for each energy source.

Data from OSU
Chair endowed by forest industry

Table 4. CO2 output ratios of fossil fuels compared to wood biomass. (fossil fuel estimates from U.S. Dept. of Energy 2000). For example, natural gas releases 38% of CO2 per MW-hour of electricity or 54% of CO2 per MM BTU as compared to the wood biomass.

Stand-alone Electric Plant			
Assumptions:	45% MC (Wet Basis)		
	25 MW plant		
	Uptime: 20 hrs/day		
	33% from boiler converted to electricity		
Calculations	0.94	bone dry tons per MW-hr	
Biomass	0.47	tons Carbon per MW-hr	
	940	lbs Carbon per MW-hr	
	3450	lbs CO2 per MW-hr	
Compare to Biomass			**Percentage of Biomass**
Coal	2117	lbs CO2 per MW-hr	61%
Petroleum	1915	lbs CO2 per MW-hr	56%
Natural Gas	1314	lbs CO2 per MW-hr	38%

Combined Heat and Power			
Assumptions	80% from boiler recovered for heat		
Calculations	4800000	BTU recoverable for heating per green ton	
	0.94	bone dry tons per 4800000 BTU	
	3450	lbs CO2 per 4800000 BTU	
	719	lbs CO2 per MM Btu	
Compare to Biomass			**Percentage of Biomass**
Coal	620	lbs CO2 per MM Btu	86%
Petroleum	561	lbs CO2 per MM Btu	78%
Natural Gas	385	lbs CO2 per MM Btu	54%

CAPE Comment

December 10, 2019

Matty Tittman, RCEA CAC Chair and Members of RCEA CAC

RE: RePower Humboldt (CAPE 2019 Update)

As a RCEA CCE ratepayer, I oppose biomass as an energy source because it is not clean and it is not renewable.

Examples of clean energy sources are solar, wind, geothermal, small hydro. These sources do not emit carbon dioxide, carbon monoxide, N0x, or particulates, and do not have waste products that are toxic and/or radioactive; the raw input comes from natural physical processes that are consistently available and do not have to be mined, or result from large scale ecosystem disruption e.g., industrial logging.

Examples of renewable energy sources are solar, wind, geothermal, small hydro. These sources come from natural physical processes that occur daily or intermittently within a short time scale compatible with electricity demands and energy storage.

Burning mill and timber waste 24/7 emits more carbon into the atmosphere than can be sequestered by the remaining forest within the time we have left to reduce atmospheric carbon and stay within 1.5 degrees Celsius global temperature increase. At the current global carbon emission rate, we have 8 years of the carbon budget left, the point at which we will surpass 1.5 degrees of global warming. Burning woody biomass 24/7 is not renewable or carbon neutral within a decade because: 1) trees sequester carbon only in daylight; they respire and emit C02 at night and when wind or water/temperature stressed; 2) newly planted trees don't grow fast enough to even approach the photosynthetic capacity of older trees; 3) clear cuts disturb the soil and change it from a carbon sink into a carbon emitter; 4) internal combustion engines used in logging and biomass plants emit carbon. The physical process of global warming operates without regard for the carbon source.

Humboldt Redwood and Humboldt Sawmill corporations put short term profit over people and planet. They could choose to work with RCEA to transition to a solar micro-grid system with batteries and backup generators; they have the space and assets. This would be a better investment and asset than a biomass plant. They want, and RCEA is forcing, ratepayers to pay to upgrade the biomass plant to coal plant standards and pay to thin their plantation forests. This is disgusting!

Thank you for considering my comments.

Diane Ryerson
[redacted]
Arcata, CA 95521

December 10, 2019

RCEA Board Members & Staff
Redwood Coast Energy Authority
633 3rd Street
Eureka, CA 95501

Dear RCEA board members and staff,

Thank you very much—to staff, CAC members, and board members—for all the work you have put in to updating RCEA's strategic plan. I appreciate how so many of you have worked to both listen to and educate community members, myself included.

I applaud the recommendation to adopt the bold goals to "achieve net-zero greenhouse gas emissions countywide by 2030" and "...maintain a trajectory to reduce emission from natural g 90% by 2050." All the goals and strategies in the plan seem on course to help address the climate crisis now and ahead.

My request is that you consider reorganizing the language in the plan so that conservation is always listed first. At public meetings, RCEA staff have told me that conservation is the most cost-effective strategy. I also gather and/or assume that conserving energy:
>> is in most cases the most affordable strategy for users to reduce GHG emissions;
>> is required if Humboldt County is ever to get near 100% renewable energy supply;
>> is an excellent way to build meaningful, working relationships with community members and colleagues at partner agencies;
>> is an effective way to keep marketing RCEA, which leads to public outreach and education; and
>> must have the least environmentally adverse impacts, compared to other strategies, virtually every time.

Here are examples of where I would like to see "conservation" (or education) get first billing:

a) Make the first strategy be **Energy Efficiency & Conservation**.

b) Regional Energy Planning & Coordination: Pull the whole Education section to the front, before Economic Development. Also place "education" before economic development in this sentence: RCEA will take a leadership role to develop and advance strategic regional energy goals through economic development, funding, planning efforts, and education.

c) **Support Countywide Strategic Energy Planning.** Coordinate an effective energy strategy based on self-sufficiency, development of renewable energy resources, energy conservation, and electrification...

d) Add the word to: **Encourage Adoption of Energy Elements.** Encourage and assist with the adoption of energy elements by other local and regional jurisdictions. Periodically review local energy elements and recommend updates, as necessary, to reflect changing technologies for the conservation, generation, transmission, and efficient use of energy.

e) Add under Education: "**Develop Public Displays.** Encourage and assist development of educational displays for exemplary energy conservation, renewable energy and distributed energy systems installed throughout Humboldt County."

f) Add under Education: "**Provide Energy Professional Education and Training.** Provide and encourage training for local contractors and energy professionals on energy-related topics such as: conservation, energy code, energy

g) First goal for Integrated Demand Side Management: **Make energy efficiency and conservation services available to every household and business in the county by 2030.**

h) INTEGRATED DEMAND-SIDE MANAGEMENT: Move up the whole section "Energy Efficiency & Conservation" to list all the strategies in that category first.

i) "**Perform Energy Assessments.** Advise building owners on the life cycle costs and benefits of energy efficiency, conservation, demand response, generation, electrification and storage opportunities through assessments…"

j) ENERGY EFFICIENCY & CONSERVATION: Move up this strategy to be first or second: **Develop and Support Behavioral, Retro-Commissioning and Operations Programs.**

k) DEMAND RESPONSE: "**Enable Automated Demand Response.** Install communicable controls with conservation, electrification, efficiency, and storage technologies that automatically reduce energy use during demand response events."

l) **Low-carbon Transportation:** List the first goal as "**Work with other local public entities to reduce vehicle miles traveled in Humboldt County by at least 25% by 2030.**"

Other revisions, humbly suggested:

- ☐ (page 8) "Support Climate Change Adaption" – In one or both places, I would rather see the neutral "climate change" be identified as "climate crisis."
- ☐ (page 8) "Support Renewable Energy Permitting. Support the County…" -- Is RCEA able to support incorporated cities, too? How about tribes/rancherias?
- ☐ (page 9) To be consistent with "Encourage Adoption of Energy Elements," revise the following strategy to say:

  "**Encourage Energy Policies and Plans**. Encourage other jurisdictions and entities, including the cities in Humboldt County, to adopt and implement sound energy plans and policies, to include energy policies and/or energy elements ~~and/or energy policies~~ in their general plans…"
- ☐ (page 9) Add "transportation" -- **Develop Programs that Foster Social Equity.** Identify, fund, and establish new programs that address the energy and transportation needs of the least advantaged and underserved members of our community.
- ☐ (page 14) REDUCE VEHICLE MILES TRAVELED, **Encourage Transportation-efficient Land Use Planning.** *Please seriously consider supporting land use planning that calls for efficient and financially sustainable parking supply, and that avoids the over-supply of publicly subsidized (free to user) storage of private cars on public streets, which is known to induce people to drive even for short trips.*

Thank you for your time and efforts.

Best regards,

Oona Smith
(Arcata resident)