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Subject: Review of Biomass Power Valuation

Date: May 27, 2016

What follows is a review of the document titled "*Biomass Proposed Response to Governor's Emergency Proclamation*" and supplementary documents detailing the calculations used to arrive at a value of biomass power delivered to California's electricity grid of $84.22/MWh.

1 Key Findings

The review panel supports the position that existing biomass power plants are **vitally important** in the near and long term in mitigating emissions of criteria air pollutants, short lived climate pollutants, and greenhouse gases from likely alternative fates of residual biomass. Action should be taken to ensure that substantial capacity is not lost from the existing fleet of biomass power plants. Generally, the panel agrees with the request's implication that a range of ecosystem services and other societal benefits provided by the biomass power industry are likely not fully monetized under the current renewable electricity market clearing price.

The analysis presented makes useful first steps in the direction of quantifying the value of some of these benefits derived from agriculture, urban and forestry residuals used for biopower. However, several assumptions and methods used to determine the price adders result in an incomplete analysis that provides a partial estimate of the range of benefits and costs. The panel finds that there is substantial uncertainty around the estimated valuation and recommends that a more complete analysis be conducted prior to final determination of a state level of support.

Uncertainties in the analysis are associated with the following assumptions:

Criteria Pollutant Emissions Valuation The analysis uses values from emissions transactions in two air districts to establish a statewide value of criteria pollutant emissions yet many of the power plants and much of the alternative fate occurs in air districts with lower value transactions. An emissions-weighted average by air district would more accurately reflect a statewide value.

Alternative fates of forest and agricultural biomass residuals The approach to ascribing value to urban residuals uses a different basis compared to the other feedstocks. The analysis assumes landfill as the alternative fate and applies an estimated value of 50% of the average landfill self-haul disposal (tipping) fee as the value of the use of urban wood in biomass power. The approach is admittedly speculative and a more detailed methodology should be employed to reduce the uncertainty of the estimate. Assessment and valuation of emissions from alternative fates vs emissions from the use of urban derived feedstock in the biomass power sector should be used instead.

Alternative fate and value of urban wood waste The approach to ascribing value to urban residuals uses a different basis compared to the other feedstocks. The analysis assumes landfill as the alternative fate and applies an estimated value of 50% of the average landfill self-haul disposal (tipping) fee as the value of the use of urban wood in biomass power. The approach is admittedly speculative and a more detailed methodology should be employed to reduce the uncertainty of the estimate. Assessment and valuation of emissions from alternative fates vs emissions from the use of urban derived feedstock in the biomass power sector should be used instead.

Accounting for Short Lived Climate Pollutants (SLCP) and Greenhouse Gasses (GHG) Black carbon (GWP 3200) emissions are substantially reduced in biomass power compared to open burning. This analysis does not attribute avoided SLCP emissions to biomass used in power generation and only partially accounts for GHG offsets. Including a SLCP benefit would increase the value of biomass power plants.

Accounting for externalities Though the report mentions meaningful benefits that accrue to hydrologic systems, wildfire emissions reductions,and other ecosystem services, economic values were not associated these benefits but should be included in such a calculation.

Over the longer term, performance-based incentive structures targeting performance enhancement (e.g. efficiency improvement) and emissions reduction would likely provide more consistent methodology for assigning state support to the industry. In the more immediate term, some of the current assumptions could be refined based on other existing resource and life-cycle assessments and methodology for the urban feedstock estimate could be improved to provide greater insight into the full range of impacts and benefits attributable to the industry.

2 Review panel

Dr. Peter Tittmann (*UC Berkeley*) Dr. Tittmann was asked to conduct an unbiased review of the documents by the California Biomass Energy Alliance on behalf of the California Governors Office. Dr. Tittmann manages the Woody Biomass Utilization Group within the Center for Forestry at UC Berkeley.

Dr. Bryan Jenkins (*UC Davis*) Prof. Jenkins is Professor and Chair of Biological and Agricultural Engineering at the University of California, Davis. Dr. Jenkins has more than thirty years of experience working in the area of biomass thermochemical conversion including combustion, gasification, and pyrolysis.

Dr. Alissa Kendall (*UC Davis*) Prof. Kendall is an Associate Professor, Department of Civil and Environmental Engineering, University of California, Davis. Her research advances life cycle assessment and other environmental assessment methods and applies them to transportation and energy systems.

Robert Williams, P.E. (*UC Davis*) Mr. Williams is a Research Engineer at UC Davis and supports the work of the California Biomass Collaborative. He has more than twenty years of experience working in thermochemical conversion systems, bioenergy technology evaluation, biomass fuel properties, and bioenergy system analysis.

3 Summary document

Filename: `Summary of Biomass Response 2-15-16.pdf`

Many of the assumptions in the model are not referenced eg. "based on a publicly available scientific study [sic]". Therefore, reviewers had trouble verifying some document claims because of a lack of citation for sources of information and the lack of clear labels/titles to describe reported results. The review panel acknowledges the existing biomass power plants are vitally important in the near term in mitigating emissions of criteria air pollutants, short lived climate pollutants, and greenhouse gases from likely alternative fates of residual biomass. However, in the mid-term, innovation in the biomass energy sector should be stimulated through performance standards and market price signals. For example, biomass might play a larger role in load balancing with an ever-increasing proportion of variable renewable power on the grid. Most of the existing plants are not dispatchable to meet this need and more advanced technologies might be required. Basing benefits on amount of fuel consumed does not incent more efficient plants. Longer term support should shift to an improved efficiency, emissions performance or energy output basis, rather than on material consumption, while still providing means for the industry to economically contribute to major environmental challenges facing the state.

This effort is at best a rough approximation of the value that biomass power production in the state in terms of GHG emissions reduction, public heath, and forest health. It is clear that a rigorous examination of the full range costs and benefits of biomass power is needed.

4 Detail of Calculations

Filename: `Detail of Biomass Benefit Values 2-15-16.pdf`

The section detailing emissions reductions does not include avoided emissions of black carbon from open burning of agricultural and forest residuals. Black carbon's Global Warming Potential used by the California Air Resources Board California Air Resources Board (2016) is 3200. See Springsteen et al. (2011) and Springsteen et al. (2015), for further detail on reduction in BC emissions from controlled vs uncontrolled emissions.

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GWP_{20}	$GWP\sigma_{20}$	GWP_{100}	$GWP\sigma_{100}$	GWP_{500}	$GWP\sigma_{500}$	Source
2200.0	888.82	633.33	255.41	193.33	77.67	Fuglestvedt et al. (2000)
3200.0		900.0				California Air Resources Board (2015)

Table 1: Range of GWP values and standard deviation (σ) where published for Black Carbon.

Nitrous Oxide emissions are also not included in this analysis.

4.1 Value of Emissions Reductions

The current methodbased on San Joaquin Valley and South Coast markets, overstates the value for emission reductions statewide. If transaction prices from criteria pollutant emissions reductions offset markets is used, then the air basin market value for each power plant should be used (criteria pollutant impacts are local). However, this approach might incent material to flow to dirty air basins because offsets have high value in those basins. An improvement on the used method would be to use a weighted average of emission transaction prices based on

recent proportion of statewide biopower emissions occurring in each air basin. Additionally, individual power plant emission factors should be used to determine offset. They vary widely depending on air district. Permit values for one plant (Tracy) were used in this analysis. The method for urban wood benefit funding seems arbitrary and is not consistent with the other resource types. The main alternative to urban wood is mulch and compost, so emissions offsets from these markets and processes should be the basis for consistency. See McPherson (2014) for an approach to evaluating alternate fates of urban wood residuals. Landfilled wood has very low methane potential and is sometimes considered a carbon sequestration technique. The methods described for calculating the value of emissions reactions are unclear due to the following language:

> "*Since the value we are seeking is the emissions allowed on a single amount, this value was used to imply an annual emissions value.*"

It seems the results in the preceding table have been annualized assuming a 20 year lifetime and 8% discount rate. The choice of these values is not explained. Assuming all agricultural and in-forest biomass would otherwise be burned in field is a key assumption. While California allows burning if there is no economically viable alternative for residual disposal, in some regions such as the San Joaquin Valley growers are mostly constrained to burn at officially designated times. In addition, not all nut shells and other residuals from food processing currently used in some biomass power plants would be disposed of through open burning. Amore detailed analysis of alternate fates would be useful in determining how much of the current feedstock, if released from the power plant fuels market, would be open-burned.

4.2 Review of Biomass Benefits Excel Workbook

The following sections detail specific comments worksheets in the file titled `Biomass Benefits 2-15-16.xls`

4.2.1 In Forest

Methane GWP It is noted that current practice in most of the world for developing GHG emission inventories, including California's inventory, is to use GWP values from the 4th Assessment Report of the IPCC (AR4)[1], which was released in 2007. However in the AR5[2] report, the GWP for biogenic methane was increased to 28 (GWP_{100}) and 84 (GWP_{20}). It would seem that the use of 28 reflects the most recent scientific consensus and would therefore be most appropriate for use here.

Transmission It is unclear how the figure of $5/MWh was arrived at.

4.2.2 Agricultural

Methane emissions No CH_4 emissions for in-field agricultural burning are assumed. See Jenkins et al. (1996)

4.2.3 Urban

Methane emissions The methane production factor from landfilled wood seems incorrect as it appears to assume that 100% of C in wood become fugitive methane. Actual methane release from landfilled wood

[1] This Synthesis Report with its Summary for Policymakers is the fourth and final part of the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) – "Climate Change 2007". Table of GWP values can be found at `https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html`

[2] The Fifth Assessment Report (AR5) is the most comprehensive assessment of scientific knowledge on climate change since 2007 when the Fourth Assessment Report (AR4) was released. It was released in four parts between September 2013 and November 2014. AR5 can be found at `https://www.ipcc.ch/report/ar5/`

is much lower. Additionally, ≈ 75-80% of methane is recovered and flared or burned in engine. LandGEM[3] (Alexander et al., 2005) is one simple model that could be used for CH_4 generation rates. This is a rather old EPA model, but the reference documents could potentially be used to make simple estimates of landfill gas generation.

Tipping fees It's unclear why the decision to allocate 50% of the median tipping fee instead of 100%.

5 Summary

In addition to, and inextricable from near term investment in the existing industry should be a broad, objective assessment of environmental costs and benefits that accrue to biomass in CA. Air, water delivery, forest health, rural economic development, forest fire suppression costs, health care costs, and mortality are notable externalities directly impacted by the existence of a biomass power industry that should be assessed.

References

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[3]The Landfill Gas Emissions Model (LandGEM) is an automated estimation tool with a Microsoft Excel interface that can be used to estimate emission rates for total landfill gas, methane, carbon dioxide, nonmethane organic compounds, and individual air pollutants from municipal solid waste landfills.