When Does Biomass Belong in a Clean-Energy Portfolio?

Displacement, Health Externalities, and the Social Value of Woody Biomass Electricity

Woody biomass presents a distinctive policy tradeoff in the transition to cleaner electricity. Compared with wind and solar, biomass electricity can involve higher generation costs and produce conventional air pollutants. Yet biomass may also provide a broader bundle of services than electricity generation alone. In addition to supplying dispatchable power, biomass can create productive uses for forest residues and other low-value woody material, potentially reduce disposal costs, support forest-management and restoration activities, and contribute to economic activity in rural communities. Wind and solar provide noncombustion electricity, but they do not necessarily provide this same combination of services. These additional services may therefore provide an economic rationale for including biomass in some clean-energy portfolios even when lower-emission generation alternatives are available.

The central policy issue, however, is not simply whether biomass produces air pollution, but what generation it displaces. If biomass replaces coal or natural gas, its emissions must be evaluated against the fossil-fuel emissions avoided. If it replaces wind or solar, the same biomass generation may introduce combustion-related emissions into a portfolio that would otherwise rely on noncombustion generation. The public-health consequences, an important component of the social value of biomass, may consequently depend on the generation resource it displaces.

We propose to examine the following central question:

How does the social value of woody biomass electricity change depending on whether it displaces fossil generation or noncombustion renewable generation?

This study will focus on the air-quality and public-health component of this broader social-value question rather than provide a comprehensive benefit-cost assessment of woody biomass electricity. We will construct matched electricity-portfolio counterfactuals that hold the amount of additional biomass generation constant while varying the generation resource displaced by that biomass.

Under a **Renewable-Competition (RC) pathway**, additional biomass is assumed to replace wind and solar generation while fossil generation remains unchanged. Because displaced wind and solar have essentially no direct operational combustion emissions, this pathway primarily introduces additional biomass-combustion emissions.

Under a **Fossil-Displacement (FD) pathway**, the same increment of biomass generation is assumed to replace coal and/or natural gas while non-biomass renewable generation remains unchanged. Net emissions will therefore reflect both added biomass-combustion emissions and avoided fossil-fuel emissions.

The two pathways therefore evaluate the same public-health component of woody biomass use under different displacement counterfactuals. In the RC pathway, the estimated health effects primarily reflect the additional emissions associated with biomass generation, whereas in the FD pathway they reflect the net effect of added biomass emissions and avoided fossil-fuel emissions.

By comparing the matched RC and FD pathways, we will quantify the public-health opportunity cost of renewable displacement. For each state, year, and biomass increment, this measure will capture the difference in health outcomes when the same amount of biomass displaces wind and solar versus fossil generation. Holding biomass deployment constant isolates the public-health consequence of changing what biomass displaces. For adverse outcomes such as premature mortality or monetized health damages, a positive opportunity cost will indicate that Renewable-Competition produces greater health damages or smaller health benefits than the corresponding Fossil-Displacement pathway. These comparisons will help identify the displacement conditions under which the public-health consequences of woody biomass are more or less favorable, providing evidence that can inform broader decisions about when biomass may be appropriate within clean-energy portfolios.

We will use the U.S. Environmental Protection Agency's CO-Benefits Risk Assessment model (COBRA) to translate scenario-specific emissions changes into changes in air quality, associated health outcomes, and monetized health damages. COBRA applies established concentration-response and economic valuation functions to estimate mortality and morbidity impacts and their monetized value.

We will construct 18 matched Renewable-Competition and Fossil-Displacement comparisons, based on standardized increases of 5 and 10 percentage points in the woody biomass share of electricity generation for Arizona, Colorado, and New Mexico in 2030, 2040, and 2050. These states provide contrasting electricity-transition settings in which the role of biomass and the generation resources it may displace can differ substantially over time. A no-increment portfolio will serve as the reference case for each state-year combination. Scenario-specific emissions changes will be developed using county-level emissions information and electricity-generation data from the National Emissions Inventory (NEI), U.S. Energy Information Administration (EIA) Form 923, and EPA's Emissions and Generation Resource Integrated Database (eGRID). As a reduced-complexity screening model, COBRA is subject to uncertainty associated with atmospheric conditions and concentration-response relationships. The analysis focuses on operational air-pollution and public-health effects and does not monetize forest carbon, wildfire risk, avoided pile-burning, or other forest-management benefits.

We hypothesize that the public-health consequences of biomass will be more favorable when it displaces fossil generation and less favorable as electricity systems decarbonize and the relevant displaced generation shifts toward noncombustion renewables. This creates a potentially important dynamic policy tradeoff: the additional services and potential benefits that motivate woody biomass utilization, including dispatchable generation, productive use of low-value woody material, support for forest management, and rural economic activity, must be weighed against the public-health costs associated with biomass combustion. As electricity systems decarbonize, the public-health case for biomass may become less favorable when its displaced alternative shifts from fossil generation toward noncombustion wind or solar generation because the avoided fossil-fuel emissions associated with fossil displacement are no longer realized. Whether this shift reduces the overall social value of biomass will depend on how these public-health effects compare with the additional services and benefits biomass provides.

The results will provide evidence on how the public-health consequences of woody biomass depend on the generation resource it displaces and how those consequences may evolve

as electricity systems decarbonize. By comparing matched Renewable-Competition and Fossil-Displacement pathways, the study will help clarify how the public-health consequences of biomass utilization change with the generation resource displaced, providing one important component of the broader tradeoff between the potential services and benefits of biomass and the external costs associated with its use. More broadly, the analysis illustrates why the social value of an energy technology cannot be assessed solely from its own attributes or its classification as "renewable." Its value also depends on the counterfactual: what generation it replaces, how that counterfactual changes as the electricity system evolves, what additional services the technology may provide, and what external costs accompany the substitution.

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