



WOODY BIOMASS COST-BENEFIT ANALYSIS FOR RURAL COUNTIES IN MARYLAND

Prepared for the Tri-State Growth & Commerce Coalition, Rural Maryland Council,
and Maryland Clean Energy Center
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Prepared By



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EXECUTIVE SUMMARY

This report evaluates the potential costs and benefits of woody biomass thermal energy at the institutional scale as a replacement for fuel oil in rural counties in Maryland, with a particular focus on Garrett and Allegany Counties. Prepared for the Maryland Clean Energy Center, the analysis integrates forest resource data, economic impact modeling (based on regional studies), and environmental life-cycle assessment to assess whether expanded use of woody biomass for heat can advance Maryland's climate, energy resilience, and rural economic development goals.

Maryland's buildings account for approximately 16 percent of statewide greenhouse gas emissions, largely from fossil-fuel based space and water heating. Many public and institutional buildings, especially in rural areas, are over 50 years old and rely on electricity, oil, propane, or natural gas systems. At the same time, Maryland imports nearly all of its fossil fuels, exposing communities to price volatility and supply-chain risks. These conditions create a strong opportunity for locally sourced renewable thermal energy alternatives.

Maryland has a substantial and sustainably managed forest resource base, with approximately 2.45 million acres of forestland and a growth-to-harvest ratio of roughly 3:1. Forest and urban wood residues significantly exceed current demand, with an estimated 92 million tons of economically accessible woody biomass statewide. Existing forestry and wood-products infrastructure, particularly in Western Maryland, positions the state to expand biomass heating without overharvesting or compromising forest health. Importantly, biomass boilers would provide a market for low value wood. By creating a stable, local market for low-value and underutilized wood, biomass heating systems can incentivize the removal of excess material that currently contributes to overcrowded stands, increased wildfire risk, and heightened vulnerability to pests and disease. This includes small-diameter trees, poor quality stems, tops and limbs, and urban wood residues that often lack viable end markets. Improved utilization of this material supports active forest management, enhances stand resilience, and helps landowners and managers offset the costs of thinning and fuel reduction treatments. In this way, biomass heating can serve as a complementary tool for improving forest health while strengthening rural economies and advancing sustainable forest management objectives across Maryland.

Feasibility-stage case studies from Garrett and Allegany Counties were used as the basis for regional models of economic impacts. Economic impact modeling using Impact Analysis for Planning (IMPLAN) economic modeling software indicates that woody biomass heating systems generate meaningful local and statewide economic benefits. Construction of small-, medium-, and large-scale systems are predicted to support short-term employment and business activity, while ongoing operations are expected to create recurring demand for fuel supply, transportation, maintenance, and professional services.

Over a 15-year operating period, modeled systems generate tens to hundreds of millions of dollars in cumulative economic output, supporting sustained employment in rural regions, and producing measurable local, state, and federal tax revenues. A large scale (5,000 tons per year) biomass installation in Garrett County could generate \$137.5 million in total output and support 53 total jobs over a 15-year period. Importantly, biomass systems retain a larger share of energy spending within Maryland as compared to imported fossil fuels. While capital costs of biomass boiler systems are higher than conventional fossil fuel and hot water boilers, long-term operational savings and available state and federal incentives can significantly improve project economics.

Environmental impacts were evaluated primarily through Life Cycle Assessment (LCA), with IMPLAN Environmental Data used as a supplementary tool. While biomass combustion produces particulate emissions, modern systems equipped with appropriate emissions controls can meet regulatory requirements and minimize localized air-quality impacts.

Overall, the findings indicate that woody biomass thermal energy represents a viable and strategic option for rural and institutional heating modernization in Maryland. When deployed responsibly, biomass heating can improve energy security, strengthen forest health, and deliver durable economic benefits to rural communities. Strategic use of capital incentives, technical assistance, and regulatory clarity will be critical to overcoming upfront cost barriers and enabling broader adoption. This report provides a data-driven foundation to inform policy development, investment decisions, and next-stage feasibility planning for woody biomass heat in Maryland.

INTRODUCTION

Maryland’s rural counties face a convergence of challenges and opportunities related to energy costs, aging building infrastructure, forest management, and economic resilience. Many public, institutional, and commercial facilities in Western Maryland continue to rely on imported fossil fuels such as fuel oil, propane, and natural gas for space and water heating. These fuels expose communities to price volatility, supply-chain disruptions, and ongoing greenhouse gas and air pollutant emissions, while directing energy expenditures out of state. At the same time, Maryland possesses substantial and sustainably managed forest resources that generate low-grade wood and residual material well suited for renewable thermal energy applications.

Woody biomass thermal energy represents a technology capable of addressing these intersecting challenges. When sourced locally and used in high-efficiency heating systems, woody biomass can displace fossil fuels, stabilize long-term heating costs, support sustainable forest management, and retain energy dollars within rural economies. Unlike many renewable energy technologies, biomass heating directly addresses thermal energy demand, one of the largest sources of emissions from buildings, making it particularly relevant for schools, campuses, correctional facilities, hospitals, and other institutional-scale users.

This report, *Woody Biomass Cost-Benefit Analysis for Rural Counties in Maryland*, was prepared to support informed decision-making by policymakers, public agencies, and community stakeholders. The report compiles and synthesizes data on forest resources, heating fuel use, economic impacts, environmental performance, and policy context to evaluate the role woody biomass heating could play in Maryland, with a particular focus on Allegany and Garrett Counties. The analysis integrates economic modeling using IMPLAN and environmental assessment grounded primarily in life cycle analysis.

The document is not intended to propose or endorse specific projects. Rather, it provides a data-driven foundation for evaluating woody biomass heating as one component of Maryland’s broader clean energy, climate, and rural development strategies. By presenting representative scenarios, modeled impacts, and policy considerations, this working report aims to clarify where biomass thermal energy may offer the greatest value, what conditions are necessary for successful deployment, and how future investments could align economic, environmental, and equity objectives across the state.

WOODY BIOMASS AND ENERGY USE IN MARYLAND

This section provides a comprehensive overview of the biomass energy landscape across rural Maryland, examining the availability, current utilization, and future potential of woody biomass as a renewable heating solution for rural communities. The discussion supports subsequent cost-benefit and feasibility analyses for biomass conversion projects in institutional, commercial, and residential settings, highlighting how sustainable biomass deployment can improve local economies, reduce emissions, and enhance energy security.

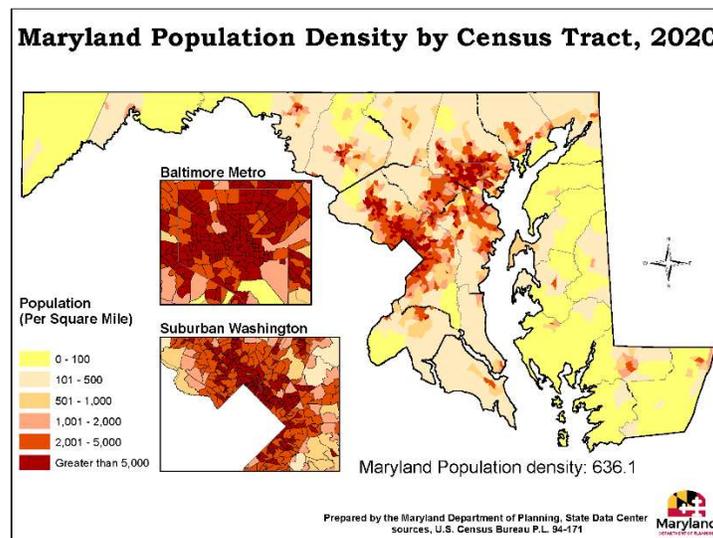
Demographic and Energy Profile

Population and Housing

Maryland’s population reached 6.17 million in 2020, making it the 18th most populous and fifth-most densely populated state in the nation (U.S. Census Bureau, 2020). The state contains roughly 2.57 million housing units (Maryland Department of Planning, 2021) and maintains over 7,000 public buildings encompassing more than 97 million square feet, many of

which are over 50 years old and equipped with outdated, inefficient heating systems (Maryland Department of General Services, 2021). These aging facilities represent significant opportunities for heating system modernization using renewable thermal energy sources such as woody biomass. While population density (Figure 1.1) is highest in central and coastal regions, large portions of rural Maryland, particularly in Western Maryland, Southern Maryland, and the Eastern Shore, are characterized by smaller communities, lower population densities, and a higher concentration of public facilities that serve dispersed populations. Facilities in these communities frequently rely on aging, fossil fuel-based heating systems and face higher per-unit energy costs due to limited access to natural gas infrastructure. As a result, rural public buildings present particularly strong opportunities for heating system modernization. Deploying renewable thermal energy solutions such as woody biomass in these settings can reduce operating costs, improve energy resilience, and support local forest-based economies while addressing the unique energy challenges faced by rural Maryland communities.

Figure 1.1: Maryland Population Density, 2020



Energy Use and Emissions

Energy use within buildings, primarily for space heating, water heating, and appliances, accounts for approximately 16% of Maryland’s statewide greenhouse gas (GHG) emissions (Environmental Protection Agency, 2024). This category reflects emissions from fuel burned inside homes, schools, businesses, and public facilities, not emissions from building construction or materials.

Between 2017 and 2023, nitrogen oxide (NO_x) emissions associated with building energy use increased by 3.7%, surpassing electric power plants as Maryland’s largest stationary source of these pollutants (Atwell, 2023). Oil- and gas-fired boilers and furnaces in residential, commercial, and institutional buildings now contribute substantially to smog formation and public health burdens, especially in densely populated regions.

Because building energy use represents a significant and growing share of statewide emissions, reducing reliance on fossil fuels for heating is essential for Maryland to meet its 2031 GHG reduction commitments. Transitioning institutional and residential heating to renewable thermal systems, particularly those utilizing sustainably sourced, locally available woody biomass, can provide immediate carbon and air-quality benefits while strengthening rural economies.

Heating Fuel Distribution

Residential Sector

Most Maryland households use either natural gas or electricity for space heating (Table 1.1), while a small percentage use heating oil. The remaining households rely on propane, wood, and other fuels, which together account for roughly 6% of residential heating in the state (HeatFleet, 2024). Though small in share, wood remains an important secondary fuel for rural households and represents a viable renewable alternative where access to natural gas is limited.

Table 1.1: Percentage of Households by Fuel Type in Maryland

Fuel Type	% of Households
Natural Gas	43.8%
Electric	43.0%
Heating Oil	7.5%
Propane/Wood/Other	~6%

Commercial and Institutional Sector

Energy-use patterns in Maryland’s commercial and institutional buildings closely mirror those in the residential sector, with natural gas and electricity serving as the predominant heating fuels. Although state-specific data for commercial heating fuels are limited, national estimates suggest that approximately 60% of commercial building energy consumption is from electricity and 34% from natural gas, with the remainder coming from heating oil, propane, and other sources (U.S. Energy Information Administration, 2018). In Maryland, the combined residential, commercial, and institutional sector accounts for roughly 16% of statewide greenhouse gas emissions, underscoring the importance of decarbonizing heating systems (Maryland Department of the Environment, 2023).

Because heating remains one of the largest direct emission sources for public facilities, these buildings represent a significant opportunity for renewable energy adoption and long-term cost stabilization. This role is particularly notable as the state implements new reporting requirements for heating fuel deliveries by sector (Maryland Department of the Environment, 2024).

Fossil Fuel Dependence and Supply Chain Risks

Maryland imports nearly all its fossil fuels, as it has no significant in-state reserves. Natural gas is delivered through interstate pipelines connecting to Pennsylvania, West Virginia, and Ohio. Heating oil and propane are transported by truck or rail from regional terminals, often in New Jersey or the Gulf Coast (U.S. Energy Information Administration, n.d.). This dependence exposes Maryland to price volatility and supply disruptions, emphasizing the strategic value of developing local renewable heat sources such as woody biomass.

Forest Resources, Economy, and Industry Overview

Forest Cover and Composition

Maryland contains approximately 2.45 million acres of forestland, dominated by oak–hickory hardwoods (60%) and loblolly pine (15%) (Maryland Forest Service, 2021). Roughly 1.45 million acres are privately owned, and about 10% of all forestland is under permanent harvest restrictions. Mature stands (over 40 years old) comprise nearly 78% of total forest area, representing a significant and underutilized renewable resource base.

Economic Significance

The forest products industry remains vital to Maryland’s rural economy, generating between \$3.5 and \$4.2 billion in annual economic output and supporting roughly 18,000 direct and indirect jobs (University of Maryland Extension, 2021). Activities span logging, sawmilling, manufacturing, paper and pulp production, and wood energy operations. Every \$1

million in forest product output supports an estimated 11–13 jobs, underscoring the sector’s high economic multiplier effect.

Garrett and Allegany counties are the state’s leading forest product regions, with extensive milling and logging infrastructure. These operations create a steady supply of wood fiber, pulpwood, and byproducts suitable for biomass energy. Central Maryland hosts a concentration of secondary manufacturers producing furniture, flooring, and cabinetry, while the Eastern Shore focuses primarily on timber management and raw wood production valued at approximately \$139 million annually (Maryland Forestry Economic Adjustment Strategy Summary, 2021). This industrial infrastructure, paired with sustainable forest growth and a strong workforce, positions the state to expand biomass utilization efficiently and responsibly.

Biomass Utilization and Potential

Overview

Maryland’s biomass energy sector remains modest but strategically positioned for growth. Historically, biomass use has centered on electricity generation from waste-to-energy facilities and small-scale residential heating. However, the state’s abundant urban wood waste, maturing forests, and existing industrial infrastructure create significant opportunities for scaling woody biomass as a renewable thermal energy source, particularly in rural and institutional settings.

Woody biomass refers to organic material derived primarily from trees and wood-processing residues, including logging slash, sawmill by-products, small-diameter trees, and urban wood waste (Perlack et al., 2005; U.S. Department of Energy, 2016). When used for heat or combined heat and power (CHP), these materials offer high conversion efficiency and can displace fossil fuels while maintaining sustainable forest management.

Policy and Program Context

The Maryland Clean Energy Center (MCEC), established in 2008, serves as the state’s primary instrument for advancing clean energy adoption. In collaboration with the Maryland Department of Natural Resources (DNR), Western Maryland Resource Conservation and Development Council (RC&D), and supported by the USDA Forest Service Wood Innovations Program and the Rural Maryland Council (RMC), MCEC conducted a comprehensive Wood Fuel Supply Chain Analysis in 2024 (MCEC & DNR, 2024). The study assessed resource availability, supply chain logistics, and potential market expansion pathways for woody biomass utilization across Maryland.

Key findings indicated that:

- Available wood fuel resources far exceed current demand,
- Forest and urban wood residues could sustainably supply heating, electricity, or CHP systems,
- Increased utilization could enhance forest health, carbon sequestration, and rural economic resilience, and
- Education and outreach are necessary to improve public understanding of forest management and fuelwood harvesting.

The analysis confirmed that Maryland’s forests exhibit a growth-to-harvest ratio of approximately 3:1, meaning forest growth significantly exceeds removals, indicating sustainable potential for expanded biomass use (MCEC & DNR, 2024).

Resource Availability

According to the 2024 MCEC analysis, Maryland generates substantial quantities of biomass suitable for energy use from a range of sources, including forest residues, wood processing byproducts, and urban wood waste. Collectively, these resources represent a significant renewable energy opportunity; urban wood waste alone accounts for approximately 1.38 million tons annually, enough to heat more than 800 public schools or supply fuel for up to 50 combined heat and power (CHP) facilities. Across the State:

- 120.4 million tons of total woody biomass exist statewide,
- 92 million tons are economically accessible,
- 53 forest product mills already produce slabwood, sawdust, and chips suitable for energy use, and
- 44 recycling facilities processed nearly 500,000 tons of wood waste in 2021, much of which was downcycled to mulch (MCEC & DNR, 2024).

With forests replenishing faster than harvest rates, Maryland’s wood supply is both renewable and resilient. Expanding local biomass markets would improve forest management while displacing imported fuels.

Case Studies

The following case studies present two examples of how woody biomass heating systems can be evaluated and planned in Western Maryland. These case studies were completed prior to this report and are not products of the present study; they are included here solely as existing sources of feasibility-stage data. They are not descriptions of final or approved project designs; instead, they serve as sources of feasibility-based data used to inform the economic modeling in this report. The examples reflect conditions typical of rural Western Maryland, where heating demand is high, forest resources are abundant, and energy system modernization can have notable economic impacts.

These scenarios illustrate how organizations assess system feasibility, consider technical and financial requirements, and evaluate long-term heating modernization options. They provide representative data, such as fuel needs, system sizing, cost ranges, and operational considerations, that inform the economic analysis presented later in this report. Because these examples draw from feasibility-stage information, the values presented here should not be interpreted as descriptions of finalized project decisions or institutional commitments.

Together, these case studies offer practical insight into how woody biomass heating can perform in real-world applications and provide examples that other counties, campuses, or public facilities may adapt to their own needs.

Example Institutional Heating Scenario in Garrett County, Maryland

A feasibility assessment was conducted for a group of public facilities in Garrett County, Maryland to evaluate whether replacing aging fossil-fuel heating systems with a shared biomass installation could be cost-effective. This assessment was used to generate representative technical and economic assumptions for this report and should not be interpreted as a description of a finalized or approved project.

The assessment examined four buildings in close proximity of one another with varied heating loads and fuel types, including administrative and educational facilities currently heated by fuel oil, propane, or electric resistance systems. Taken together, these facilities showed historical combined heating expenditures of approximately \$160,000–\$170,000 per year, based on data compiled during the feasibility evaluation (Maryland Department of the Environment, 2023). Modeled baseline heating expenditures for these buildings are shown in Table 2.2.

Table 1.2: Modeled Average Annual Fuel Costs for Representative Institutional Buildings (2012-2024)

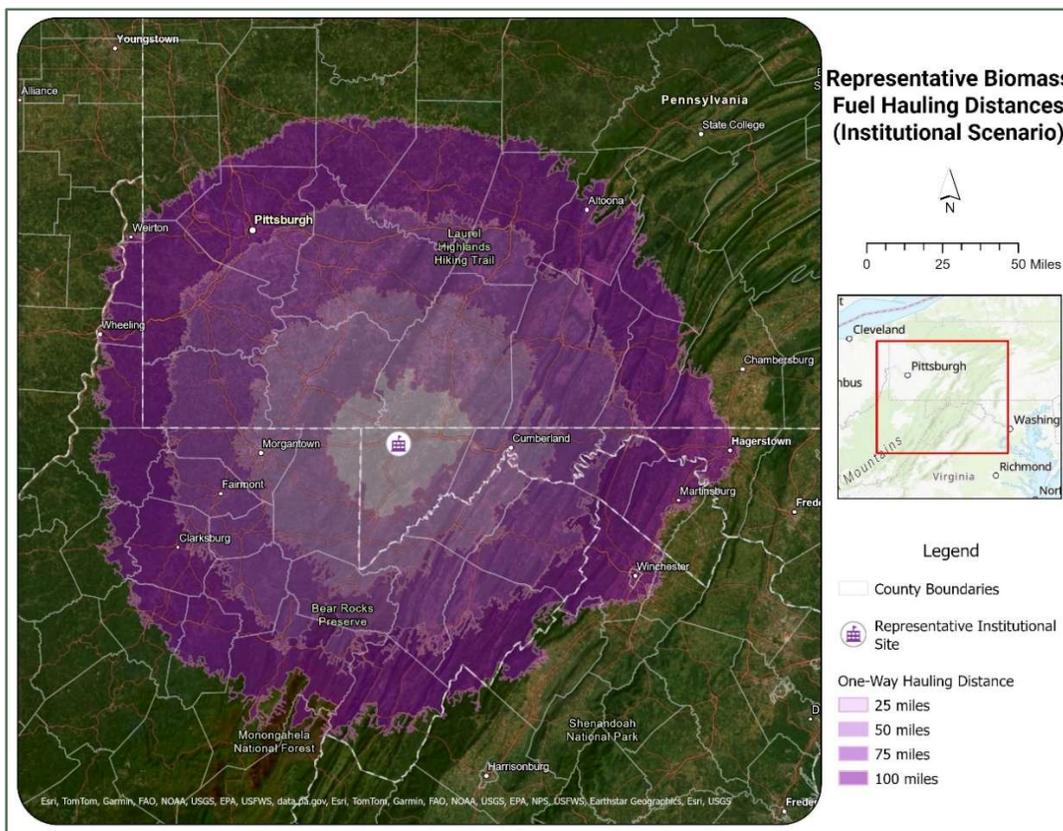
Example Building (Representative)	Modeled Annual Fuel Cost
Building A (Large School)	\$98,976
Building B (Middle School)	\$138,078
Building C (Education Center)	\$8,664
Building D (Operations Facility)	\$6,952

These modeled values (Table 1.2) provide per-building context for the aggregate heating expenditures referenced above. Technical evaluations included heating profiles, boiler sizing, distribution piping requirements, and potential locations for boiler plant and chip storage. Analysts also evaluated regional fuel sourcing, estimating that approximately 700–750 tons

of green wood chips could meet annual demand. Delivered fuel cost modeling assumed an average price of approximately \$65 per green ton, consistent with Maryland’s market for 45–50% moisture chips (U.S. Forest Service, 2024).

To evaluate typical supply chain logistics, a modeled analysis of potential biomass hauling distances using road networks in Western Maryland was conducted (Figure 1.2). These distances reflect representative sourcing zones for green wood chips and illustrate how fuel availability would support a woody-biomass system in Garrett County. According to the MCEC Wood Fuel Supply Chain Analysis, Garrett County has nearly 10 million tons of biomass which is economically accessible.

Figure 1.2: Biomass Fuel Hauling Distances in Garrett County



These modeled hauling distances demonstrate that the rural Western Maryland landscape provides adequate supply radius for a system of this scale. In practice, most of the required fuel could be sourced within 50–75 miles, aligning with transportation cost thresholds commonly used in regional biomass supply assessments.

Table 1.3: Volume of Biomass (GT) Within Specified Haul Distances in Garrett County

County	0-25 Miles	26-50 Miles	51-75 Miles	76-100 Miles
Garrett	6.7 million	3.4 million		
Allegany	66k	4.3 million	2.7 million	185k
Washington			233k	928k

Table 1.3 demonstrates the estimated volume of economically accessible biomass within 25-, 50-, 75-, and 100-mile haul distances from a hypothetical installation. Maryland counties could potentially contribute roughly 14.5 million green tons of biomass within a 50-mile radius of this hypothetical location and roughly 18.5 million green tons within 100 miles. Volumes were calculated by dividing the acres of timberland by the total acres of land in each county to determine the percentage of timberland per county. The percentage of timberland was then multiplied by the number of acres in each travel haul radius. The total number of land acres within each travel haul radius per county was then multiplied by the biomass per acre figure defined in the 2024 Maryland Wood Fuel Supply Chain Analysis to quantify total biomass available

per haul distance per county. Acres of timberland on slopes greater than 40%, within surface water buffers, or within parcels of less than 10 acres were removed and deemed economically inaccessible.

In addition to fuel-cost modeling, capital and infrastructure needs were also evaluated. Modeled capital costs for a system of this scale were approximately \$6 million, including a boiler building, thermal storage, fuel handling equipment, and hot-water distribution piping between buildings. These values reflect feasibility-stage calculations intended to show what such a conversion would require and do not represent committed expenditures.

Table 1.4: Modeled Fuel Cost Differences Under a Hypothetical Biomass Conversion Scenario

Example Building	Current Fuel Cost	Projected Fuel Cost Savings
Building A	\$98,899	\$75,443
Building B	\$47,500	\$24,012
Building C	\$8,461	\$6,454
Building D	\$7,067	-\$4,868

Source: Adapted from technical assistance data provided to the USDA Wood Energy Technical Assistance Team (values shown for illustrative modeling purposes).

This feasibility study conducted for institutional-scale facilities in Western Maryland indicated that woody biomass heating systems could offset a substantial portion of fossil-fuel heating demand and also provide fuel cost savings under typical rural conditions (Table 1.4). It is important to note that due to the specifics of this feasibility study and the layout of the individual buildings, not all buildings would experience similar cost savings. Building D, currently uses propane and is a smaller facility, because of the low cost of fuel and an expected increase in maintenance, this building would cost more to heat with woody-biomass. Key technical and cost assumptions from these studies were used to inform the region-specific economic modeling presented later in this report.

Example Campus-Scale Biomass Heating Scenario in Allegany County, Maryland

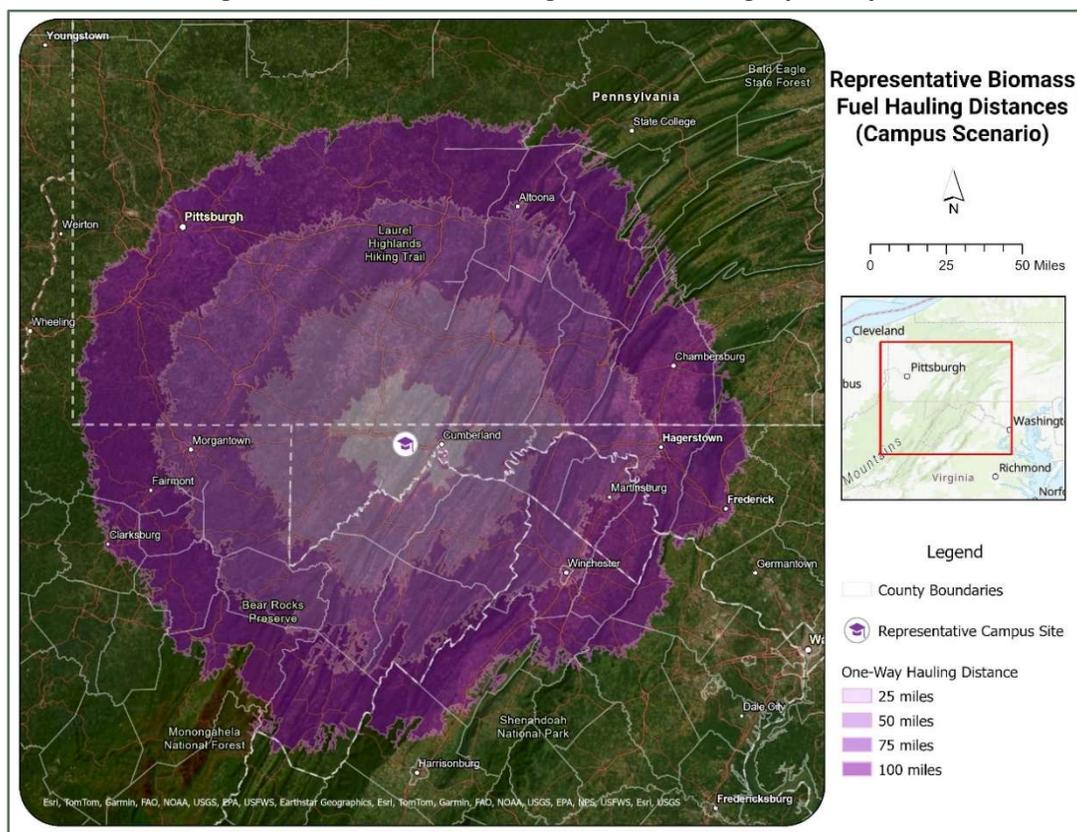
A second feasibility scenario evaluated the potential for converting a multi-building educational campus in Allegany County, Maryland from dispersed natural gas boilers to a centralized biomass district heating system. This scenario is presented solely as a feasibility-based example and should not be interpreted as a finalized institutional plan or commitment.

The campus consists of multiple buildings heated by natural gas systems, many approaching 25–30 years of service life. Feasibility analysis explored whether consolidating these loads into a modern district heating system could improve reliability, reduce operating costs, and lower greenhouse gas emissions. Recent annual natural gas consumption has ranged from 1.1 to 1.3 million therms (U.S. Energy Information Administration, 2018), making thermal modernization a high-impact opportunity.

System configurations were modeled at varying scales, with estimated annual biomass fuel requirements between 3,000 and 14,000 tons of green wood chips. To understand sourcing feasibility, a modeled hauling-distance analysis was conducted.

This report conducted an analysis of the potential sourcing zones for a higher-demand system such as the one in this feasibility scenario. Similar to the Garrett County scenario, hauling distances would remain roughly 50 miles or less (Figure 1.2). According to the MCEC Wood Fuel Supply Chain Analysis, Allegany County contains roughly 7 million Tons of biomass which is economically accessible.

Figure 1.2: Biomass Fuel Hauling Distances in Allegany County



As shown in this representative mapping, a campus-scale system would require a broader but still regionally feasible sourcing radius. Most comparable district-energy systems in the Appalachian region obtain fuel within 50–100 miles, aligning well with the modeled values used in this study.

Table 1.5: Volume of Biomass (GT) Within Specified Haul Distances in Allegany County

County	0-25 Miles	26-50 Miles	51-75 Miles	76-100 Miles
Garrett	2.8 million	6.9 million	427k	
Allegany	3.9 million	3.2 million	186k	
Washington		219k	819k	1.2 million
Carroll				228
Frederick				1.6 million

Maryland counties could potentially contribute roughly 17 million green tons (Table 1.5) of economically accessible biomass within 50 miles to a biomass installation near this hypothetical location. If the haul distance is increased to 100 miles, Maryland counties could potentially contribute roughly 21 million green tons (Table 1.5) of economically accessible biomass.

Table 1.6 summarizes modeled greenhouse gas reductions in Metric Tons of Carbon Dioxide Equivalent (an industry-standard unit to measure and compare the climate impact of different greenhouse gases) under several hypothetical system configurations.

Table 1.6: Modeled Potential Greenhouse Gas (GHG) Reductions Under Biomass Conversion Scenarios

Biomass System Configuration	GHG Reduction (MTCO ₂ e)
Pilot Thermal District System	1,769
Full-Campus District System	5,679
District System + CHP	8,435

For the campus-scale example, modeled capital costs ranged from approximately \$3 million for a pilot-scale system to \$20 million for a full district network, including distribution piping and emissions controls. Preliminary economic modeling suggested potential long-term operational savings, especially when paired with federal or state clean-energy incentives (Maryland Energy Administration, 2024; Maryland Clean Energy Center, 2024).

This scenario remains at the feasibility and exploratory planning stage. No final decisions have been made regarding system configuration, procurement, or implementation. These modeled values provide representative inputs used in the economic modeling presented in the *Economic Assessment* section.

ECONOMIC ASSESSMENT

Introduction

The following section evaluates the modeled economic impacts of installing and operating woody biomass thermal energy systems across Garrett County, Allegany County, and the state of Maryland. The analysis measures how both one-time capital investments and long-term operational activities influence regional economies by creating jobs, generating income, and stimulating local business growth.

The assessment models the economic effects of three representative system sizes:

- Small (700 tons/year)
- Medium (3,000 tons/year)
- Large (5,000 tons/year)

Note: “Tons” refers to green tons of wood fuel consumed annually. Green tons include moisture content (typically 45–50%) and represent the total wet weight of woody biomass feedstock required to operate each system over one year.

For each system scale and region, the analysis estimates:

- One-time capital investment impacts, reflecting economic activity during construction and installation; and
- Recurring annual impacts, reflecting sustained benefits from system operation, biomass fuel purchases, and employee spending.

All reported results include direct, indirect, and induced effects, which together capture the full ripple of economic activity created by biomass heating systems.

Comprehensive tables, including annual subtotals, multi-year (5-, 10-, and 15-year) projections, and detailed fiscal breakdowns, are available in Appendix A.

Economic Methodology

Modeling Approach

Economic impacts were estimated using the Impact Analysis for Planning (IMPLAN) software and 2023 dataset. IMPLAN models how changes in one sector (such as renewable energy investment) affect employment, income, and business output in related industries.

Because IMPLAN lacks a dedicated biomass heating sector, a customized “Bill of Goods” approach, also known as Analysis-by-Parts (ABP), was developed in consultation with Michigan State University forest economists. This bottom-up method traces project spending through its individual cost components (e.g., construction, equipment, labor, fuel supply), producing a more precise picture of the biomass sector’s local economic footprint.

Model inputs were based on feasibility-stage data from hypothetical institutional and campus-scale biomass heating scenarios representative of Western Maryland conditions. These inputs were adapted to 2025 U.S. dollars and reflect typical construction costs, fuel requirements, and operational profiles identified in similar Appalachian biomass heating assessments and do not include inflation escalation. The analysis employed IMPLAN’s multi-region input-output feature to capture trade flows and supplier interactions among counties and statewide markets.

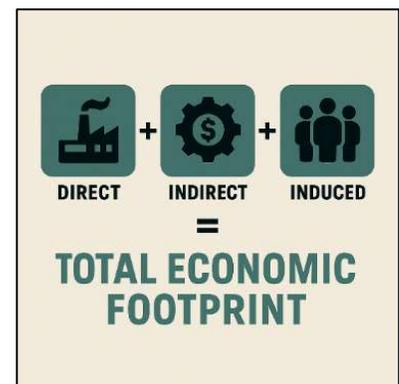
All capital investment impacts are reported as one-time events, representing the construction and installation phase, while operational impacts are modeled as recurring annual effects, projected over 5-, 10-, and 15-year periods to illustrate cumulative benefits.

Key Terms

Key economic terms are defined below:

- **Direct Impacts:** On-site jobs, wages, and spending directly associated with biomass system construction and operation.
- **Indirect Impacts:** Business-to-business purchases, such as local equipment supply, fuel transport, and maintenance services, within the regional supply chain.
- **Induced Impacts:** Household spending by employees whose jobs are supported directly or indirectly by the project.
- **Employment:** Combined total number of full- and part-time jobs.
- **Labor income:** Employee compensation, including wages, benefits, and proprietor income.
- **Value added:** The share of output retained locally as wages, profits, or taxes, comparable to a contribution to regional GDP.
- **Output:** The total value of goods and services generated through direct, indirect, and induced effects.

In IMPLAN, the total economic footprint of an activity is measured through the combined effects of direct, indirect, and induced impacts, which together capture how spending flows through an economy. When summed up, these three impact types provide a comprehensive view of the total economic footprint, illustrating how an initial investment or operational expenditure ripples through the regional economy and supports broader employment, income, and output beyond the primary activity.



Capital and Operating Assumptions

Modeling inputs were developed using cost information from existing representative feasibility assessments of institutional and campus-scale biomass heating systems conducted in Garrett and Allegany Counties to allow for an accurate regional representation. These assessments offered estimates for installed capital capacity and operational requirements and were used solely to establish generalized modeling inputs, not to represent finalized project budgets or commitments for any specific institution or county.

Across all reviewed feasibility scenarios, installed capital costs ranged from approximately \$900 to \$1,200 per ton of annual fuel-throughput capacity, depending on scale and site conditions. Annual fuel through input is the maximum quantity that a system is designed to consumer over the course of one year. For modeling purposes, the analysis applied a mid-range estimate of \$1,040 per ton, resulting in the following representative capital values:

- 700 tons/year system → ≈ \$2.5 million
- 3,000 tons/year system → ≈ \$3.11 million
- 5,000 tons/year system → ≈ \$5.19 million

Operating costs were modeled using an average delivered green-chip fuel price of \$65 per ton, reflecting typical market conditions for 45–50% moisture chips in Western Maryland (U.S. Forest Service, 2024). Operating cost shares, covering fuel, maintenance, labor, electricity, and ash management, were adapted from national biomass heating benchmarks and cross-checked with IMPLAN expense categories for consistency.

Note: All dollar values are presented in constant 2025 USD and do not include inflation escalation, fuel-price changes, or financing effects.

Percentages in Table 2.1 represent each category’s share of total annual operating costs. Because IMPLAN does not include a specific category for woody biomass heating and only provides a category for woody-biomass electricity generation, operating cost share percentages were applied to develop a more accurate model of woody biomass heat systems. Cost share percentages were obtained through verbal communications with a reputable engineering firm in the industry.

Table 2.1: Annual Operating Costs by System (dollar values and percentage of total annual operating costs)

Category	Small (700 tons)		Medium (3,000 tons)		Large (5,000 tons)	
Fuel	\$24,500	62%	\$105,000	72%	\$175,000	72%
Maintenance	\$8,250	21%	\$22,500	15%	\$37,500	15%
Labor (Employees)	\$2,500	6%	\$5,000	3%	\$12,500	5%
Utilities / Electric	\$2,000	5%	\$9,000	6%	\$14,000	6%
Other / Ash Management	\$2,000	6%	\$4,250	4%	\$5,750	3%

For modeling purposes, “local” refers to economic activity occurring within the county where the biomass system operates and its immediate surrounding trade area, typically within a 50-mile radius, reflecting IMPLAN’s regional purchase coefficient assumptions. Regional Purchase Coefficient assumptions represent the share of goods and services demanded by an industry that are supplied by producers within the defined region, rather than imported from outside the study area. Incorporating these assumptions is critical because they help determine how much project-related spending is likely to remain the local economy, thereby capturing realistic supplier relationships and preventing the overstatement of in-county economic impacts.

All values are expressed in 2025 USD and represent local economic activity rather than broader national impacts.

Economic Results

The following analysis applies the modeling framework described above to quantify the economic outcomes of biomass system deployment in each study region. These results highlight the localized and long-term economic effects of biomass heating investment across multiple scales of development.

Results are organized by county and scale of installation, with all estimates reflecting direct, indirect, and induced effects.

Results are grouped into:

- **One-time capital investment impacts**, reflecting the construction phase.
- **Recurring annual impacts**, showing sustained local benefits from operation and fuel sourcing.
- **Cumulative impacts**, projecting outcomes over 5-, 10-, and 15-year periods.
- **Tax revenue impacts**, estimating fiscal returns at the local, state, and federal levels.

The following tables include concise explanations of assumptions and key takeaways, while full datasets with detailed subtotals and breakdowns are available in Appendix A for reference.

The results begin with Garrett County, followed by Allegany County and Maryland statewide findings.

Garrett County Economic Impacts

Garrett County serves as a representative modeling region used to estimate how biomass heating systems could affect rural communities in Western Maryland through both short-term construction activity and long-term operational spending. The following tables summarize modeled results for small (700 tons/year), medium (3,000 tons/year), and large (5,000 tons/year) systems using IMPLAN data for direct, indirect, and induced effects.

Each table presents total estimated impacts (including direct, indirect, and induced effects) for employment, income, output, and tax revenue. These summarize how spending from construction, operations, and worker households circulates through the regional economy.

Complete detailed tables, including annual subtotals, year-over-year outputs, and full tax disaggregation, are available in Appendix A for reference.

Table 2.2: Estimated One-Time Economic Impacts from Capital Investment in Garrett County

System Size	Jobs Supported (Total)	Labor Income	Value Added	Total Output
Small (700 tons/yr)	20	\$1.16 M	\$2.00 M	\$3.46 M
Medium (3,000 tons/yr)	25	\$1.44 M	\$2.49 M	\$4.31 M
Large (5,000 tons/yr)	42	\$2.40 M	\$4.15 M	\$7.19 M

Context and Assumptions:

These one-time economic impacts capture spending on labor, materials, engineering, and equipment installation. Total outputs include direct effects from on-site employment and wages within construction teams, indirect effects from local purchases of materials and subcontracted services, and induced effects from household spending by workers whose income is tied to the project.

Key Takeaways:

Modeled construction impacts for all three system sizes indicate meaningful short-term economic activity within the Garrett County region. Table 2.2 indicates, in the small-system scenario, construction spending is associated with approximately 20 jobs and about \$3.5 million in total output, reflecting the scale of activity tied to modest infrastructure upgrades. The medium-system scenario corresponds to roughly 25 jobs and \$4.3 million in output, while the large-system scenario shows more than 40 associated jobs and over \$7 million in output. These modeled results illustrate how

construction of biomass heating systems could stimulate local economic activity, with impacts increasing proportionally as system capacity expands.

Table 2.3: Estimated Recurring Annual Economic Impacts from Operation of Biomass Heating System in Garrett County

System Size	Annual Jobs Supported	Labor Income	Value Added	Total Output
Small (700 tons/yr)	0.5	\$42,000	\$63,000	\$139,000
Medium (3,000 tons/yr)	2.1	\$163,000	\$249,000	\$546,000
Large (5,000 tons/yr)	3.5	\$273,000	\$419,000	\$909,000

Context and Assumptions:

Annual impacts account for recurring expenditures such as biomass fuel procurement, maintenance, utility costs, and local services, plus household spending by plant employees. Estimates assume stable year-to-year operations with local sourcing (as defined in the methodology section) whenever possible.

Key Takeaways:

Although smaller in scale than construction impacts, the modeled annual operational effects show steady, recurring economic activity within the Garrett County region. Table 2.3 indicates, in the small-system scenario, yearly operations are associated with roughly one part-time equivalent job and about \$140,000 in total output, reflecting ongoing fuel purchases and service needs. The medium-system scenario corresponds to approximately two full-time equivalent jobs and over \$500,000 in annual output, while the large-system scenario is associated with three to four jobs and nearly \$1 million in yearly output. These modeled outcomes illustrate how ongoing biomass system operations can retain energy spending within the local economy over time.

Table 2.4: Estimated Multi-Year Cumulative Economic Impacts (5-, 10-, and 15-Year Projections) for Garrett County

System Size	5-Year Total Output	10-Year Total Output	15-Year Total Output	Total Jobs Supported (15 Years)
Small (700 tons/yr)	\$6.7 M	\$14.5 M	\$22.3 M	8
Medium (3,000 tons/yr)	\$25.4 M	\$51.0 M	\$82.0 M	32
Large (5,000 tons/yr)	\$42.5 M	\$94.0 M	\$137.5 M	53

Context and Assumptions:

These cumulative estimates sum annual operational impacts over 5-, 10-, and 15-year periods in constant 2025 dollars (no inflation escalation), assuming stable operations throughout. They represent the ongoing economic benefits of keeping energy spending within the local economy through fuel purchases, service contracts, and labor income. Complete annual breakdowns are available in Appendix A.

Key Takeaways:

Modeled cumulative impacts (Table 2.4) highlight how ongoing biomass system operations can generate long-term economic activity within a rural county setting. Over a five-year period, the small-system scenario is associated with approximately \$6.7 million in total output, while the medium-system scenario reaches about \$25 million and the large-system scenario exceeds \$42 million. Extending operations to fifteen years, cumulative modeled impacts rise to roughly \$22 million for the small system, \$82 million for the medium system, and \$137 million for the large system. These results illustrate the scale of economic activity that can accumulate over time when operational spending, such as fuel procurement, services, and labor, continues to circulate within the local economy.

Table 2.5: Estimated One-Time and Recurring Tax Revenue Impacts for Garrett County

System Size	Local & County Taxes	State Taxes	Federal Taxes	Total Taxes
One-Time Tax Revenue Impacts				
Small (700 tons/yr)	\$69,000	\$89,000	\$291,000	\$449,000
Medium (3,000 tons/yr)	\$86,000	\$110,000	\$362,000	\$558,000
Large (5,000 tons/yr)	\$144,000	\$184,000	\$604,000	\$931,000
Recurring Tax Revenue Impacts				
Small (700 tons/yr)	\$1,863	\$2,487	\$9,593	\$13,944
Medium (3,000 tons/yr)	\$7,183	\$9,714	\$38,600	\$55,498
Large (5,000 tons/yr)	\$11,765	\$15,997	\$63,831	\$91,593

Context and Assumptions:

Tax impacts represent income, property, and sales-tax revenues generated by the direct, indirect, and induced effects of both construction and operation. These estimates combine one-time revenues generated during construction with recurring taxes accrued over ongoing operations. Full fiscal tables by tax category appear in Appendix A.

Key Takeaways:

Modeled tax impacts (Table 2.5) show that biomass heating systems of all sizes are associated with measurable fiscal activity at the local, state, and federal levels. In the small-system scenario, cumulative construction corresponds to approximately \$450,000 in total tax revenues, including about \$70,000 accruing to local and county governments. The medium-system scenario is associated with roughly \$560,000 in total tax revenues, while the large-system scenario corresponds to nearly \$1 million, with more than \$140,000 estimated at the local level. Recurring operational tax revenue is far less per year, however over the lifetime of a system can be significant. These modeled results illustrate the scale of potential fiscal activity linked to biomass system development under the assumptions used in this analysis.

Overall Interpretation of Garrett County

The Garrett County modeling scenario illustrates how a community-scale biomass heating system could influence a rural economy under representative assumptions. Construction activity generates short-term employment and supplier demand, while ongoing operations sustain recurring economic value through local fuel purchases, maintenance, and contracted services. In this scenario, every \$1 million in construction spending is associated with approximately 7–8 local jobs and \$1.5–\$1.8 million in economic output. Over 15 years, the large modeled system produces an estimated \$137 million in cumulative economic activity and nearly \$1 million in state and local tax revenue. These outcomes demonstrate the scale and distribution of economic effects that biomass heating may produce in rural Western Maryland when modeled under typical conditions.

Allegany County Economic Impacts

Allegany County serves as a second modeled region representing conditions typical of a mid-sized institutional hub in Western Maryland. Its mix of educational, governmental, and service-oriented facilities provides a useful framework for evaluating how biomass heating systems might perform in areas with higher baseline energy demand. The following results summarize modeled outcomes for small, medium, and large systems under representative operating assumptions, including direct, indirect, and induced impacts, without implying active project development or county-level commitments. Complete datasets are provided in Appendix A.

Table 2.6: Estimated One-Time Economic Impacts from Capital Investment in Allegany County

System Size	Jobs Supported (Total)	Labor Income	Value Added	Total Output
Small (700 tons/yr)	18	\$1.02 M	\$1.81 M	\$3.08 M
Medium (3,000 tons/yr)	27	\$1.58 M	\$2.70 M	\$4.68 M
Large (5,000 tons/yr)	45	\$2.53 M	\$4.34 M	\$7.50 M

Context and Assumptions:

These estimates capture the short-term construction and installation impacts associated with each system size. They include direct employment and wages from construction and engineering activities, indirect impacts through local material and service purchases, and induced effects from household spending by project-supported workers.

Key Takeaways:

Modeled construction impacts (Table 2.6) for all three system sizes indicate meaningful short-term economic activity within the Allegany County region. In the small-system scenario, construction spending is associated with approximately 18 jobs and about \$3.1 million in total output. The medium-system scenario corresponds to roughly 27 jobs and \$4.7 million in output, while the large-system scenario aligns with about 45 jobs and more than \$7 million in output. These modeled results illustrate how capital investment in biomass heating infrastructure could stimulate regional economic activity under representative construction and supply-chain assumptions.

Table 2.7: Estimated Recurring Annual Economic Impacts from Operation of Biomass Heating System in Allegany County

System Size	Annual Jobs Supported	Labor Income	Value Added	Total Output
Small (700 tons/yr)	0.4	\$37,000	\$57,000	\$123,000
Medium (3,000 tons/yr)	2.0	\$151,000	\$232,000	\$512,000
Large (5,000 tons/yr)	3.3	\$255,000	\$391,000	\$858,000

Context and Assumptions:

Annual impacts account for recurring expenditures such as biomass fuel procurement, maintenance, utility costs, and local services, plus household spending by plant employees. Estimates assume stable year-to-year operations with local sourcing (as defined in the methodology section) whenever possible.

Key Takeaways:

Modeled annual operating impacts (Table 2.7) indicate steady, recurring economic activity associated with biomass heating systems in the Allegany County region. In the small-system scenario, yearly operations correspond to approximately \$123,000 in total output, while the medium-system scenario is associated with about \$512,000 and the large-system scenario with roughly \$858,000. These modeled results reflect how ongoing expenditures, such as fuel procurement, maintenance services, and system operation, can generate modest but consistent economic activity over time within the local economy.

Table 2.8: Estimated Multi-Year Cumulative Economic Impacts (5-, 10-, and 15-Year Projections) for Allegany County

System Size	5-Year Total Output	10-Year Total Output	15-Year Total Output	Total Jobs Supported (15 Years)
Small (700 tons/yr)	\$5.9 M	\$12.9 M	\$20.0 M	7
Medium (3,000 tons/yr)	\$23.2 M	\$46.9 M	\$75.4 M	31
Large (5,000 tons/yr)	\$39.5 M	\$87.5 M	\$128.3 M	50

Context and Assumptions:

These cumulative estimates sum annual operational impacts over 5-, 10-, and 15-year periods in constant 2025 dollars (no inflation escalation), assuming stable operations throughout. They represent the ongoing economic benefits of keeping energy spending within the local economy through fuel purchases, service contracts, and labor income. Complete annual breakdowns are available in Appendix A.

Key Takeaways:

Modeled cumulative impacts (Table 2.8) illustrate how long-term biomass system operations can be associated with growing economic activity over time. In the small-system scenario, cumulative output reaches approximately \$5.9 million at five years and \$20 million by fifteen years. The medium-system scenario corresponds to about \$23 million over five years and \$75 million over fifteen years, while the large-system scenario reaches roughly \$40 million and \$128 million over the same periods. These results demonstrate how ongoing operational spending can accumulate into substantial long-term economic activity under the modeled assumptions.

Table 2.9: Estimated One-Time and Recurring Tax Revenue Impacts for Allegany County

System Size	Local & County Taxes	State Taxes	Federal Taxes	Total Taxes
One-Time Tax Revenue				
Small (700 tons/yr)	\$61,000	\$84,000	\$273,000	\$418,000
Medium (3,000 tons/yr)	\$81,000	\$106,000	\$350,000	\$537,000
Large (5,000 tons/yr)	\$135,000	\$176,000	\$574,000	\$885,000
Recurring Tax Revenue				
Small (700 tons/yr)	\$1,035	\$2,549	\$8,774	\$12,358
Medium (3,000 tons/yr)	\$3,900	\$9,736	\$34,768	\$48,405
Large (5,000 tons/yr)	\$6,465	\$16,150	\$57,800	\$80,414

Context and Assumptions:

Tax impacts represent income, property, and sales-tax revenues generated by the direct, indirect, and induced effects of both construction and operation. These estimates combine one-time revenues generated during construction with recurring taxes accrued over ongoing operations. Full fiscal tables by tax category appear in Appendix A.

Key Takeaways:

Modeled tax impacts (Table 2.9) indicate that biomass heating systems of all sizes are associated with measurable fiscal activity at the local, state, and federal levels. In the small-system scenario, cumulative construction corresponds to approximately \$418,000 in total tax revenues, while the medium-system scenario is associated with about \$537,000 and the large-system scenario with roughly \$885,000. Recurring operational tax revenue is far less per year, however over the lifetime of a system can be significant. Across all system sizes, an estimated 15–20% of total tax revenues accrue at the local and county levels. These modeled results illustrate the scale and distribution of potential fiscal activity under the assumptions used in this analysis.

Overall Interpretation of Allegany County

The Allegany County modeling scenario shows higher overall economic activity than the rural scenario due to the region’s larger institutional footprint and more diverse service-sector base. Modeled results indicate that biomass heating could yield substantial economic contributions through construction spending, retained energy expenditures, and operational service demand. Under the large-system scenario, cumulative economic output exceeds \$128 million over 15 years, supporting up to 50 cumulative jobs and generating measurable tax revenue. These findings highlight how biomass systems may function in areas with concentrated building clusters and higher heating demand when evaluated through a modeling framework.

Maryland Statewide Economic Impacts

When scaled to the state level, woody biomass heating presents a clear opportunity for economic development and rural energy resilience. Statewide modeling totals effects from representative scenarios across multiple counties, accounting for supply chain linkages, fuel procurement, and professional services within Maryland’s forestry sector. Each table below summarizes direct, indirect, and induced effects, with full statewide modeling outputs available in Appendix A.

Table 2.10: Estimated One-Time Economic Impacts from Capital Investment – Maryland Statewide

System Size	Jobs Supported (Total)	Labor Income	Value Added	Total Output
Small (700 tons/yr)	55	\$3.2 M	\$5.5 M	\$9.8 M
Medium (3,000 tons/yr)	77	\$4.5 M	\$7.6 M	\$13.3 M
Large (5,000 tons/yr)	125	\$7.5 M	\$12.9 M	\$22.3 M

Context and Assumptions:

Statewide construction impacts reflect aggregate investment activity distributed across Maryland’s regions. Impacts include local contracting, equipment manufacturing, transportation, and professional services sourced within the state.

Key Takeaways:

Modeled statewide construction impacts (Table 2.10) indicate that biomass heating systems of varying sizes are associated with notable short-term economic activity across Maryland. In the small-system scenario, construction spending corresponds to approximately 55 jobs and nearly \$10 million in total output. The medium-system scenario is associated with about 77 jobs and \$13.3 million in output, while the large-system scenario aligns with roughly 125 jobs and more than \$22 million in total output. These modeled results illustrate the scale of economic activity that could occur when construction-related spending is distributed across Maryland’s construction, manufacturing, transportation, and professional service industries.

Table 2.11: Estimated Recurring Annual Economic Impacts from Operation of Biomass Heating Systems – Maryland Statewide

System Size	Annual Jobs Supported	Labor Income	Value Added	Total Output
Small (700 tons/yr)	1.3	\$95,000	\$143,000	\$310,000
Medium (3,000 tons/yr)	5.4	\$396,000	\$590,000	\$1.3 M
Large (5,000 tons/yr)	8.7	\$654,000	\$970,000	\$2.1 M

Context and Assumptions:

Annual results reflect statewide operations for representative facilities, aggregating effects from local fuel purchases, maintenance, logistics, and support services. All values are presented in constant 2025 U.S. dollars, with results reflecting in-state sourcing for the majority of expenditures.

Key Takeaways:

Modeled annual operating impacts (Table 2.11) show that ongoing biomass system activity can be associated with steady economic effects across Maryland’s fuel supply, transportation, and facility service sectors. In the small-system scenario, annual operations correspond to approximately \$310,000 in total output, while the medium-system scenario is associated with about \$1.3 million and the large-system scenario with roughly \$2.1 million in yearly output. These modeled results illustrate how recurring expenditures, such as fuel procurement, logistics, and maintenance services, can contribute to sustained economic activity when considered at a statewide scale.

Table 2.12: Estimated Multi-Year Cumulative Economic Impacts (5-, 10-, and 15-Year Projections) – Maryland Statewide

System Size	5-Year Total Output	10-Year Total Output	15-Year Total Output	Total Jobs Supported (15 Years)
Small (700 tons/yr)	\$13.2 M	\$28.9 M	\$44.5 M	22
Medium (3,000 tons/yr)	\$53.3 M	\$107.8 M	\$169.5 M	68
Large (5,000 tons/yr)	\$87.0 M	\$189.3 M	\$277.9 M	110

Context and Assumptions:

These cumulative results aggregate annual impacts over time in constant 2025 U.S. dollars, assuming continuous statewide biomass operation and consistent production. This modeling captures both rural and urban supply chain interactions, reflecting Maryland’s diverse economic landscape. Complete annual breakdowns are available in Appendix A.

Key Takeaways:

Modeled cumulative impacts (Table 2.12) illustrate how long-term biomass system operations could be associated with substantial statewide economic activity. In the small-system scenario, cumulative output reaches approximately \$44 million over fifteen years, while the medium-system scenario corresponds to about \$170 million and the large-system scenario to roughly \$278 million. These modeled results demonstrate how sustained operational spending can accumulate into significant long-term economic activity when considered across Maryland’s statewide supply chain.

Table 2.13: Estimated One-Time and Recurring Tax Revenue Impacts – Maryland Statewide

System Size	Local & County Taxes	State Taxes	Federal Taxes	Total Taxes
One-Time Tax Revenue				
Small (700 tons/yr)	\$178,000	\$243,000	\$810,000	\$1.23 M
Medium (3,000 tons/yr)	\$237,000	\$305,000	\$1.01 M	\$1.55 M
Large (5,000 tons/yr)	\$392,000	\$508,000	\$1.63 M	\$2.53 M
Recurring Tax Revenue				
Small (700 tons/yr)	\$1,826	\$2,548	\$8,662	\$13,035
Medium (3,000 tons/yr)	\$6,840	\$9,716	\$34,044	\$50,600
Large (5,000 tons/yr)	\$11,352	\$16,138	\$56,644	\$84,134

Context and Assumptions:

Tax estimates include income, property, sales, and excise taxes accrued during both construction and operation. Statewide impacts are cumulative of all modeled facility locations and reflect proportional fiscal contributions across local, state, and federal levels. Full fiscal tables by tax category appear in Appendix A.

Key Takeaways:

Modeled statewide tax impacts (Table 2.13) indicate that biomass heating systems of varying sizes are associated with measurable fiscal activity across local, state, and federal levels. Depending on system scale, cumulative construction corresponds to approximately \$1.2 million to \$2.5 million in total tax revenues, with a notable share retained in-state through income, property, and sales-tax pathways. Recurring operational tax revenue is far less per year, however over the lifetime of a system can be significant. These modeled results illustrate the scale and distribution of potential fiscal activity associated with biomass heating systems under the assumptions used in this statewide analysis.

Overall Interpretation – Maryland Statewide

Statewide modeling indicates that biomass heating systems, if deployed across representative public- and institutional-scale settings, could produce substantial cumulative economic activity. Construction stimulates engineering, manufacturing, and logistics sectors, while ongoing operations support forestry, transportation, and facility service industries. Over 15 years, the modeled statewide scenario yields more than \$275 million in output, supports over 100

cumulative jobs, and generates about \$2.5 million in estimated tax revenue. These results reflect the potential magnitude of economic effects associated with broader biomass system adoption, rather than forecasts of actual implementation.

Economic Summary and conclusions

The economic analyses for Garrett County, Allegany County, and the Maryland statewide models demonstrate that woody biomass energy investments deliver consistent, measurable, and long-term benefits. Across all scales of development – small, medium, and large systems – biomass projects stimulate construction employment, generate new tax revenues, and sustain economic activity through ongoing operations and fuel procurement. These findings reinforce that biomass energy is not only a renewable alternative but also a practical strategy for rural economic development and local energy resilience.

Regional Insights

Garrett County

In Garrett County, where biomass heating scenarios were modeled for school and public facilities, even small-scale systems yielded meaningful benefits, supporting around 20 construction jobs and over \$3 million in total output. Larger systems provided greater proportional returns, generating more than \$7 million in output during construction and nearly \$1 million in recurring annual economic activity. Over 15 years, cumulative county-level benefits could exceed \$130 million in total output and nearly \$1 million in combined tax revenues.

Allegany County

Similarly, the Allegany County modeling scenario produced strong local multipliers due to its larger institutional base and existing service infrastructure. Modeled systems there produced slightly higher returns than Garrett, with the largest configuration contributing more than \$128 million in long-term output and 50 cumulative jobs over 15 years. In both counties, operational benefits extended beyond immediate job creation, supporting forestry, maintenance, transportation, and related service sectors that retain energy spending within the local economy.

Maryland Statewide

When scaled statewide, the modeled results suggest that a coordinated approach to woody biomass energy could produce significant, distributed economic activity across Maryland. Construction of representative systems statewide was estimated to support between 55 and 125 jobs per project, depending on system size, and generate \$10–22 million in total output during installation. Annual operations add an additional layer of economic value, up to \$2.1 million in statewide output per large system, and create stable employment in forestry and supply chain industries. Over a 15-year period, cumulative statewide impacts could exceed \$275 million in total output, supporting more than 100 ongoing jobs and generating over \$2.5 million in new tax revenue.

Economic Implications

Taken together, the modeled results exhibit a consistent pattern: biomass heating systems of varying sizes are associated with local economic activity that grows with both system scale and duration of operation. Modeled construction impacts correspond to short-term increases in employment and regional spending, while ongoing operations are associated with recurring annual expenditures for fuel, maintenance, services, and labor. Because many of these inputs can be sourced within Maryland, a larger share of total energy spending remains in-state rather than flowing to external fuel markets.

Modeled tax impacts add another dimension to these findings. Across all system sizes, cumulative fiscal activity is associated with income, sales, and, in some configurations, property tax pathways at local, state, and federal levels. For rural regions such as those represented in the Garrett County and Allegany County scenarios, the distribution of modeled tax revenues illustrates how biomass heating systems may intersect with the overall economic framework that depends on forestry, transportation, and service-sector activity. These results should be interpreted as indicators of potential fiscal effects under modeled assumptions rather than forecasts of specific county or state revenue outcomes.

Conclusion

Overall, the modeled economic results highlight the dual role of woody biomass energy in Maryland: an economic development driver and a renewable energy solution. The data shows that biomass heating can create durable economic value while advancing environmental and energy goals. In rural counties, the technology leverages existing forest resources, promotes sustainable management practices, and fosters local supply chain development.

These findings provide a strong economic foundation for the following sections of this report, which examine the cost-benefit implications, policy considerations, and implementation strategies necessary to expand woody biomass energy use in Maryland. As the analysis moves from economic impact to policy assessment, the evidence remains clear, investing in biomass heating offers not only environmental and energy returns but tangible, long-lasting benefits for Maryland's people, communities, and local economies.

ENVIRONMENTAL ASSESSMENT

Introduction

This section evaluates the environmental implications of deploying institutional and community-scale woody biomass thermal energy systems in Western Maryland. The assessment examines potential environmental trade-offs associated with fuel sourcing, fuel processing, transportation of fuel, and combustion across small, medium, and large biomass heating configurations.

The environmental analysis is anchored in a Life Cycle Assessment (LCA) framework designed to quantify emissions and resource use across the biomass supply chain, including feedstock harvesting, processing, transportation, and combustion. The LCA evaluates key impact categories such as greenhouse gas (GHG) emissions, fine particulate matter (PM_{2.5}), and forest carbon dynamics.

Methodical Framework

Life Cycle Assessment (LCA) is a comprehensive analytical framework used to evaluate the environmental impacts of a product or activity across its life cycle, from raw material extraction through processing and use. This inclusive look at the environmental impacts from raw material extraction through end use is recognized as a “cradle to grave” analysis. In this study, LCA is applied to assess the cradle-to-grave environmental impacts associated with increased use of woody biomass for thermal energy in Garrett County, Allegany County, and Maryland more broadly.

The analysis evaluates and compares woody biomass heating systems with conventional fuel oil–based heating, focusing on key stages of fuel extraction, processing, transportation, and heat production. Impacts associated with manufacturing, fuel supply, and combustion are included for both energy pathways, with an emphasis on regionally relevant practices and assumptions. Figure 3.1 represents the stages of the cradle to grave analysis of biomass from cultivation to emissions from combustion. Figure 3.2 alternatively demonstrates the cradle to grave analysis of fuel oil as a comparison. Both process flow diagrams have labeled individual stream numbers (identifiers assigned to material or energy flows entering or leaving each process stage) and values are reported in Appendix B.

Figure 3.1: Process flow diagram showing biomass cultivation through combustion (stream numbers are included in Appendix B)

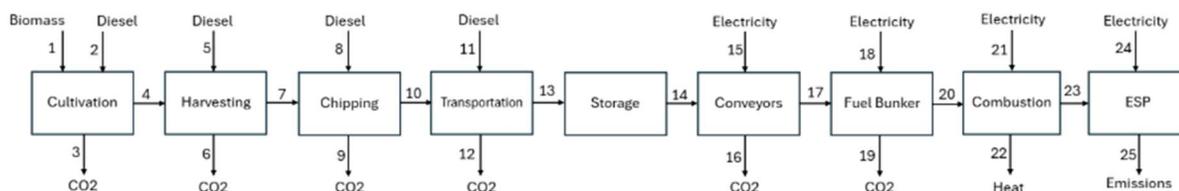
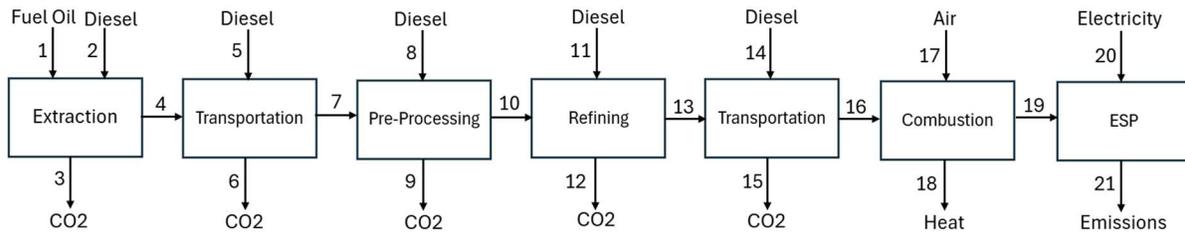


Figure 3.2: Process flow diagram showing fuel oil extraction through combustion (stream numbers are included in Appendix B)



The LCA follows the framework established under ISO 14040:2006, which defines four phases: goal and scope definition, life cycle inventory analysis, life cycle impact assessment, and interpretation. Impact categories evaluated in this assessment include greenhouse gas emissions, expressed as global warming potential (GWP) in carbon dioxide equivalents (CO₂e); fine particulate matter (PM_{2.5}); and carbon sequestration associated with forest management and biomass sourcing.

Forest Carbon and Lifecycle Environmental Considerations

The use of woody biomass for thermal energy can support sustainable forest management and local energy systems when fuel is sourced responsibly, transported over relatively short distances, and combusted in modern, high-efficiency systems. Under these conditions, biomass heating can help stabilize markets for low-value wood fuels, reduce reliance on long-distance transport of fossil fuels, and support regional forest-based economies.

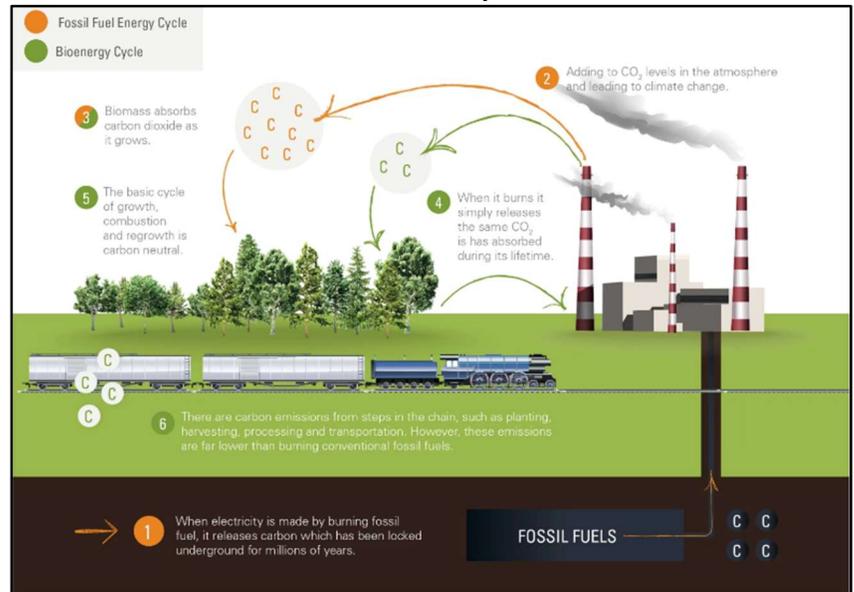
Forest management plays an important role in climate change mitigation and ecosystem health. In many regions, declining pulpwood and low-grade timber markets have reduced incentives for forest thinning and active management. Properly timed thinning removes diseased or dying trees, reduces susceptibility to insect infestations, lowers wildfire risk, and allows remaining trees improved access to water, nutrients, and sunlight. The utilization of woody biomass for energy can help sustain markets for forest residues and low-value material, supporting management practices that promote long-term forest health. Much of the woody biomass used for energy is derived from forestry residues and byproducts of existing forest operations rather than from dedicated harvests (IEA Bioenergy, 2018).

From a carbon perspective, woody biomass differs fundamentally from fossil fuels. Carbon released during biomass combustion is considered biogenic because it was recently absorbed from the atmosphere during forest growth and remains part of the short-term carbon cycle. In contrast, fossil fuels release carbon that has been sequestered underground for millions of years, resulting in a net increase in atmospheric carbon. Active forest management can further enhance carbon sequestration by promoting forest growth and resilience, while unmanaged forests may experience increased wildfire risk, leading to sudden and uncontrolled carbon emissions.

Although woody biomass combustion does not release fossil carbon, the harvesting, processing, transportation of biomass require fossil fuel energy inputs. These supply-chain emissions are accounted for in lifecycle-based evaluations. Prior analyses indicate that even when biomass is transported over longer distances, fossil energy inputs typically represent a relatively small fraction of the total energy content delivered by the bioenergy system (IEA Bioenergy, 2018). As a result, the overall climate performance of biomass heating depends on feedstock sourcing, management practices, system efficiency, and logistics rather than combustion alone. The figure on the right illustrates contrasting carbon pathways and highlights how woody biomass participates in a short-term carbon cycle, in contrast to fossil fuels.

Figure 3.3: Conceptual comparison of fossil fuel and woody biomass carbon cycles.

and



Source: Adapted from The US Industrial Hemp Association, "Biogenic Carbon," <https://theusipa.org/biogenic-carbon>.

Environmental Impact Pathways

Greenhouse Gas Emissions

Greenhouse gases (GHGs) trap heat in the atmosphere and contribute to global climate change. Carbon dioxide (CO₂) is the primary GHG associated with energy use and is released during the combustion of fossil fuels and biomass, as well as through certain industrial processes such as cement production (U.S. Environmental Protection Agency [EPA], 2025). Other GHGs, including methane (CH₄) and nitrous oxide (N₂O), are emitted through activities such as fossil fuel extraction and transport, agricultural practices, and industrial operations.

For space and water heating systems, CO₂ emissions dominate lifecycle greenhouse gas impacts. As discussed previously, carbon released during woody biomass combustion is considered biogenic, reflecting its recent uptake from the atmosphere during forest growth. In contrast, fossil fuel-based heating systems emit carbon that has been stored underground for millions of years, resulting in a net increase in atmospheric CO₂. Lifecycle-based assessments evaluate not only combustion emissions, but also upstream emissions associated with fuel extraction, processing, and transportation. These factors are incorporated into the life cycle assessment framework used in this study to compare biomass heating with conventional fuel oil systems.

Fine Particulate Matter (PM_{2.5})

Particulate matter (PM) consists of solid particles or liquid droplets suspended in the air and is commonly categorized by particle size. PM_{2.5} refers to fine particles with diameters of 2.5 micrometers or less, which are of particular concern due to their ability to penetrate deep into the lungs and enter the bloodstream (EPA, 2025). Sources of PM_{2.5} include combustion processes, industrial activity, vehicle emissions, construction activities, and natural events such as wildfires.

In the context of heating systems, PM_{2.5} emissions are primarily associated with fuel combustion and, to a lesser extent, upstream activities such as fuel processing and transportation. Modern biomass heating systems equipped with advanced combustion controls and emissions control technologies can significantly reduce PM_{2.5} emissions compared to older or uncontrolled combustion sources. Lifecycle analysis accounts for PM_{2.5} emissions across the biomass supply chain,

including harvesting, processing, transport, and combustion, and evaluates these emissions within the context of regional air quality conditions and regulatory standards. Results from this analysis help inform how biomass heating systems compare to conventional fossil fuel–based heating from an air quality perspective.

Biomass Harvesting and Forest Carbon Dynamics

Evaluating woody biomass as a heating fuel requires accounting for fossil fuel inputs associated with harvesting, processing, and transportation, in addition to changes in forest carbon stocks. This assessment focuses on differences in environmental impacts between woody biomass (in the form of green wood chips) and fuel oil used for space and water heating.

Wood chips used for energy are typically derived from low-value and/or small-diameter timber, forest residues, and thinning operations. Because of their relatively low market value, these materials are generally sourced locally, often within a two-hour hauling radius of the harvest site. This localized sourcing is a key factor in limiting transportation-related emissions and maintaining favorable lifecycle performance.

Common harvesting equipment includes cut-to-length processors, feller-buncher/skidder/slasher systems, and chainsaw-based operations. Harvest methods vary by site conditions and management objectives and may include selective cutting, shelterwood harvests, or clearcutting. Equipment selection and harvest type influence both productivity and fossil fuel use, which in turn affect lifecycle emissions.

Transportation and Processing Assumptions

In addition to harvesting, transportation of woody biomass requires fossil fuel inputs. Transportation emissions are strongly correlated with haul distance, truck efficiency, and payload. Because chip trucks typically return empty, minimizing round-trip haul distances is particularly important for reducing lifecycle emissions.

For the purposes of this assessment, biomass feedstocks are assumed to consist primarily of common Maryland species, including sugar maple, red maple, yellow poplar, white oak, red oak, beech, and pitch pine. Harvesting is assumed to occur primarily through selective cutting, which is common in Maryland forest management.

Wood chips are assumed to be produced on-site using whole-tree chippers typically ranging from 800 to 1,200 horsepower. Chips are transported directly from logging sites to biomass heating facilities using tractor-trailers (approximately 450–500 horsepower) equipped with chip vans carrying an average payload of 25 tons. No pre-processing or artificial drying of chips is assumed prior to delivery.

At the time of this analysis, regional market prices for green whole-tree chips averaged approximately \$65 per ton.

Energy Inputs and On-Site Handling

Harvesting, processing, chipping, and transportation stages all rely on diesel fuel, lubricants, and grease, which contribute to upstream emissions captured in the LCA. Once delivered to a biomass facility, wood chips are typically offloaded into a fuel bunker and conveyed to the boiler using electrically powered augers and conveyors.

Although on-site handling systems do not involve direct combustion, electricity use associated with chip handling contributes indirectly to emissions depending on the regional electricity generation mix. These indirect emissions are accounted for in lifecycle-based analyses rather than attributed solely to facility operations.

To integrate these assumptions into a consistent lifecycle framework, the assessment applies a cradle-to-grave system boundary that captures energy and material inputs from forest harvesting through fuel delivery and combustion. This boundary allows upstream emissions associated with harvesting, processing, transportation, and on-site handling to be evaluated alongside forest carbon dynamics and downstream heat production.

Life Cycle Assessment Methodology

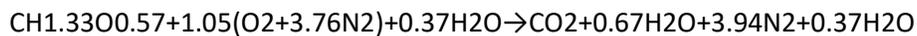
The functional unit was defined as the quantity of fuel required to provide sufficient thermal energy to heat a representative 26,000 square meter elementary school for one day during the academic year. The size of the school is representative of the average elementary school in the region. The academic year was specified as a 9 month period. School energy demand was determined using building envelope characteristics, local climate conditions, HVAC air exchange rates, and heat losses through walls, windows, ceilings, and doors.

Life cycle inventories were developed using a combination of project-specific assumptions, peer-reviewed literature, and established databases. Mass and energy balance modeling was performed to calculate fuel requirements and combustion emissions. Carbon dioxide and equivalent emissions were quantified using published emission factors, and data quality was assessed using the Weidema method to evaluate reliability, age, and geographic relevance of data sources.

Collected life cycle inventory data were used to develop a process-based model to quantify carbon dioxide emissions associated with each component of the biomass and fuel oil (heptadecane) heating systems. The model consists of coupled mass and energy balances applied across all interconnected system components, from fuel input through combustion and heat delivery.

The mass flow rate of dry woody biomass required for heating was determined by first calculating the thermal load necessary to maintain indoor comfort conditions in a representative elementary school. Once the required biomass flow rate was established, it was used to back-calculate upstream biomass handling requirements, including transportation volumes and the forest cultivation area necessary to supply fuel to elementary schools.

Because combustion is a chemically reactive process, a stoichiometric combustion equation was formulated to ensure elemental balance of carbon, hydrogen, oxygen, and nitrogen. The empirical formula for pine wood was obtained from the Phyllis 2 database (record 880, Jack pine waste wood). The balanced combustion reaction for biomass is shown in the following equation:



The two water terms on the product side distinguish between combustion water generated chemically and physical moisture carried with the biomass in its green state. The quantity of physical water included in the reaction was determined based on the mass-based moisture content of the biomass.

The required fuel mass flow rates for biomass and fuel oil were determined using a school-wide energy balance. Energy inputs to the system include the chemical energy of the fuel, conditioned air supplied through the HVAC system, and air exchange resulting from door openings. Energy outputs include flue gas from combustion, HVAC exhaust air, air loss through doorways, and heat transfer through the building envelope. The steady-state energy balance for biomass combustion is expressed in the following equation:

$$\dot{m}_B h_B + \dot{m}_{a,HVAC,in} h_{a,HVAC,in} + \dot{m}_{w,in} h_{w,in} + \dot{m}_{a,door,in} h_{a,door,in} = \dot{m}_{a,HVAC,out} h_{a,HVAC,out} + \dot{m}_{w,out} h_{w,out} + \dot{m}_{a,door,out} h_{a,door,out} + Q_{out} + \dot{m}_{CO_2} h_{CO_2} + \dot{m}_{H_2O} h_{H_2O} + \dot{m}_{N_2} h_{N_2}$$

The heat loss term (Q_{out}) represents conductive and convective heat transfer through the building envelope, including walls, windows, and ceilings. This term was determined by evaluating the surface areas, material compositions, thicknesses, heat transfer coefficients, and thermal conductivities for a 26,000 m² elementary school. Heat fluxes through individual building components were calculated independently and summed to obtain a total heat loss of 106.5 kJ/s, which must be offset by fuel combustion to maintain indoor temperature.

To complete the energy balance, fuel stream enthalpies were calculated using heats of formation for biomass and fuel oil. These were derived from analyzing a steady-state combustion process with pure oxygen as the oxidizing agent. The higher heating value (HHV) of each fuel was calculated using the Gaur and Reed correlation, which relies on the elemental composition (C,H,O) of the fuel. The HHV values were then used to determine the enthalpy of formation for each fuel stream.

Enthalpy values for air entering and exiting the system through the HVAC system were obtained from standard air property tables in Cengel et al. The HVAC airflow rate was assumed to be 15 cubic feet per second per occupant, consistent with EPA guidance. Assuming approximately 321 occupants, the resulting airflow and enthalpy difference between indoor and outdoor air temperatures produced and HVAC-related heat transfer of approximately 93.35 kJ/s.

Additional heat loss due to door opening and closing was included as a separate mechanism. The volumetric airflow associated with door operation was taken as 90 L/s based on literature values. This airflow rate was converted to a mass flow rate using the specific volume of air at indoor (298K) and outdoor (283K) temperatures. When combined with corresponding air enthalpies, this term accounts for transient air exchange through doorways and was incorporated into the overall energy balance.

In addition to greenhouse gas emissions (CO₂e), the study evaluated fine particulate matter (PM_{2.5}) emissions from biomass and fuel oil combustion based on values reported in the scientific literature, recognizing PM_{2.5} as a key indicator of air quality and public health impacts.

Life Cycle Assessment Results

The LCA results indicate that approximately 2,158 kg or 2.38 tons per day of dry woody biomass or 321 kg or 109 gallons per day of fuel oil are required to meet the daily heating demand of the modeled elementary school.

Total life cycle greenhouse gas emissions for the woody biomass system were estimated at approximately 4,229 kg CO₂-equivalent per functional unit, compared to approximately 1,181.773 kg CO₂-equivalent for the fuel oil system as seen in Figure 3.4. As previously mentioned, the carbon emissions produced from burning woody biomass are considered biogenic, meaning the released carbon is part of the natural carbon cycle and is expected to be reabsorbed by new plant growth through photosynthesis in the near future. Therefore, -4,229 kg CO₂-equivalent was also applied to the total CO₂-equivalent emissions. In contrast, carbon emissions from burning fuel oil release fossil carbon that has been stored underground for millions of years and has not recently been part of the active carbon cycle, resulting in a net addition of carbon dioxide to the atmosphere.

Figure 3.4: Contribution Analysis of Carbon Dioxide Equivalent Emissions from Biomass and Fuel Oil Systems Including Combustion

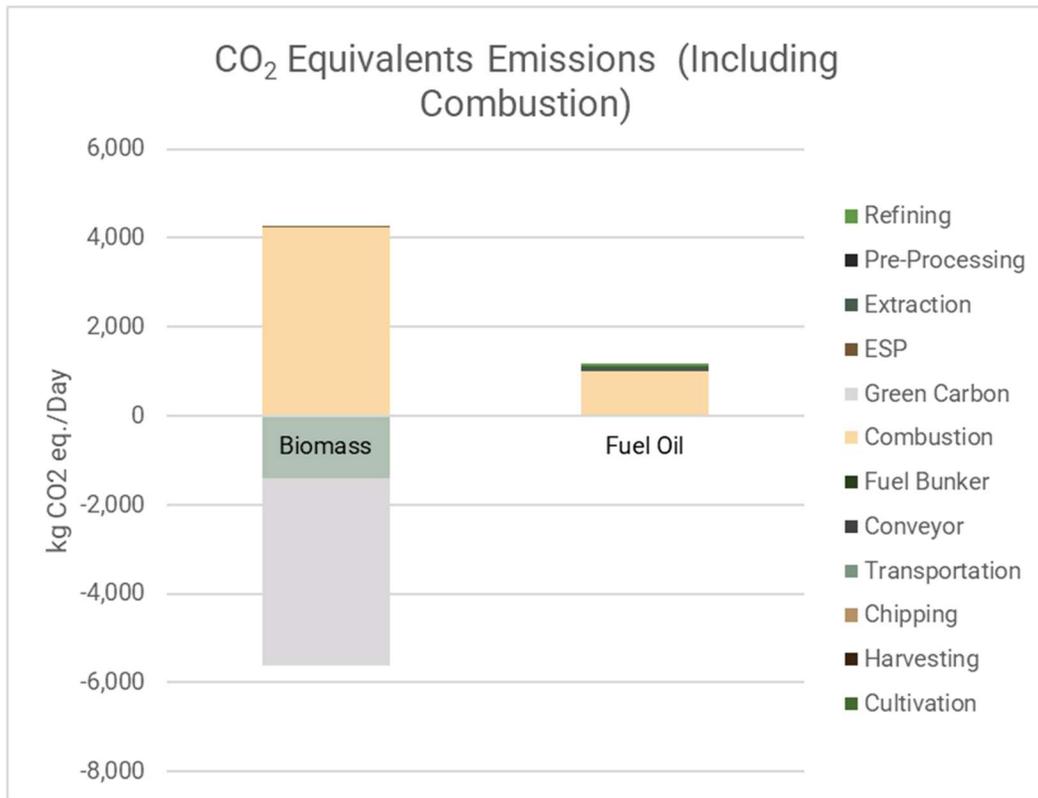


Table 3.1: Contribution Analysis of Carbon Dioxide Equivalent from Biomass Combustion

	CO ₂ Producer	Quantity	CO ₂ Equivalent
	Fuel	x/yr	kgCO ₂ /FU
Cultivation	Biomass	-	-1,400.000
	Diesel	1.323 kgCO ₂ /hkm	0.007
Harvesting	Diesel	1.323 kgCO ₂ /hkm	0.013
Chipping	Diesel	0.012 kgCO ₂ /hkm	1.296
Transportation	Diesel	1.323 kgCO ₂ /hkm	0.066
Conveyor	Electricity	0.1097 kgCO ₂ /MJ	0.008
Fuel Bunker	Electricity	0.1097 kgCO ₂ /MJ	0.001
Combustion	Biomass/Energy	-	4,229.000
Green Carbon	Biomass/Energy	-	-4,229.000
ESP	Emissions	-	0.005
		Total	-1,398.604

As seen in Table 3.1, contribution analysis shows combustion as the largest contribution to CO₂-equivalent emissions. Chipping was the second largest contribution to CO₂-equivalent emissions. A value of -1,400 kgCO₂/FU was assigned to cultivation based on a calculation assuming a sequestration rate of 0.33 tonne/ha-yr to account for carbon sequestration completed by biomass through photosynthesis. The total carbon dioxide emissions associated with the production and use of biomass as a thermal energy source were estimated to be -1,398.604 kg CO₂ per functional unit.

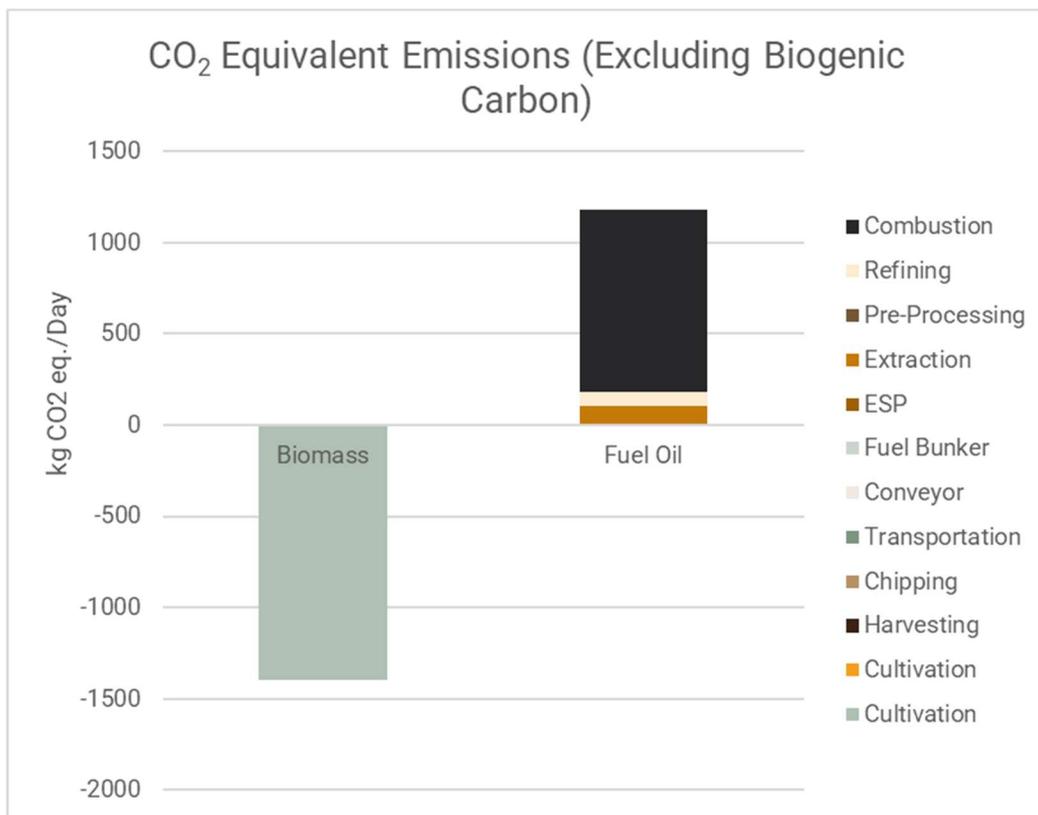
As seen in Table 3.2, contribution analysis shows combustion as the largest contribution to the CO₂-equivalent emissions from fuel oil similar to biomass. The extraction of fuel oil and refining process were significant contributors to the CO₂-equivalent emissions. Because there is no photosynthesis taking place in this system, no carbon sequestration is reported.

Table 3.2: Contribution Analysis of Carbon Dioxide Equivalent from Fuel Oil Combustion

	CO ₂ Producer	Quantity	CO ₂ Equivalent
	Fuel	x/yr	kgCO ₂ /FU
Extraction	Fuel Oil	-	100.000
	Diesel	-	-
Transportation	Diesel	1.323 kgCO ₂ /hkm	2.646
Pre-Processing	Diesel	0.012 kgCO ₂ /MJ	0.864
Refining	Diesel	0.012 kgCO ₂ /MJ	75.600
Transportation	Electricity	1.323 kgCO ₂ /hkm	1.323
Combustion	Electricity	-	1,001.335
ESP	Emissions	-	0.005
		Total	1,181.773

For both fuel pathways, combustion was the dominant source of carbon dioxide emissions. However, upstream emissions differed substantially between systems. As seen in Figure 3.5, the fuel oil system exhibited significant additional emissions from extraction and refining, while upstream emissions for the biomass system such as harvesting, chipping, and transportation were comparatively small. The biomass system also included a credit for carbon sequestration during forest growth due to photosynthesis and below ground sequestration, offsetting supply chain emissions.

Figure 3.5: Contribution Analysis of Carbon Dioxide Equivalent Emissions from Biomass and Fuel Oil Systems excluding Combustion



To fully evaluate the environmental impacts of biomass and fuel oil combustion, it is important to also examine each system's particulate matter emissions. In this study, PM_{2.5} was selected as a key emissions indicator. These particles are associated with environmental degradation and pose significant risks to human health.

According to NESCAUM (2013), a report prepared for the state of Massachusetts comparing combustion systems in the United States and Europe indicates that European biomass combustion technologies, particularly smaller-scale units, generally achieve lower PM_{2.5} emission rates than comparable U.S. systems. The report notes that emission levels of approximately 0.2 lb PM_{2.5} per MMBtu can be achieved in some European installations without add-on abatement controls. This performance is below current Maryland particulate emission limits for biomass fuel-burning equipment in the 350,000-1,500,000 BTU/hr range (0.35 lb PM/MMBtu) and the 1,500,000-10,000,000 Btu/hr range (0.23 lb PM/MMBtu (COMAR 26.11.09.12B).

Comparable low emission levels are also reflected in international research. Murillo et al. evaluated PM_{2.5} emissions from large stationary boilers in Costa Rica (defined as producing more than 7,500 kg of steam per hour) and reported average concentrations of 183 mg PM_{2.5} per cubic meter for biomass combustion compared to 119 mg PM_{2.5} per cubic meter for gasoil combustion. For the purposes of this cost-benefit analysis, emissions were normalized to a daily mass basis. Under the modeled biomass scenario, particulate emissions were estimated at approximately 0.26 lb PM_{2.5} per day. When an electrostatic precipitator (ESP) with 80% collection efficiency is applied, the effective emission rate decreases to approximately 0.05 lb PM_{2.5} per MMBtu.

These results suggest that certain modern biomass systems may approach or even meet regulatory emission thresholds without additional controls. However, the inclusion of particulate abatement technologies remains a prudent design and compliance strategy. This is especially important in jurisdictions with more stringent air quality requirements or in situations where potential public health impacts are a primary concern.

Overall, the results demonstrate that woody biomass heating can significantly reduce life cycle greenhouse gas emissions relative to fuel oil for rural school heating applications, while also presenting air quality considerations that must be addressed through system design and operation.

Environmental Justice Screening

Environmental justice (EJ) considerations were evaluated using Maryland EnviroScreen 3.0 to identify whether the modeled deployment of woody biomass heating systems in Allegany and Garrett Counties could result in disproportionate environmental burdens or inequitable distribution of benefits. The screening focused on identifying overburdened or underserved communities, evaluating exposure and sensitivity indicators, and highlighting areas where additional mitigation or planning considerations may be warranted.

The analysis considered institutional-scale facilities such as public schools, hospitals, correctional facilities, and other public buildings, which represent both substantial energy users and essential community services. Potential benefits of biomass heating in these settings include reduced or stabilized heating costs, improved fuel reliability, and decreased dependence on imported fossil fuels, which may strengthen the long-term financial sustainability of rural public services.

EnviroScreen Findings

Maryland EnviroScreen indicators were reviewed for census tracts in Allegany and Garrett Counties, with particular attention to metrics associated with air quality, transportation exposure, and public health. Indicators examined include:

- Diesel particulate matter (Diesel PM)
- Fine particulate matter (PM_{2.5})
- Traffic proximity and traffic volume

- Asthma-related hospital discharges

Several census tracts, particularly in and around Cumberland, show elevated percentiles for individual indicators related to transportation emissions and respiratory health. These conditions reflect existing exposure patterns associated with roadway corridors, legacy infrastructure, and population sensitivity.

However, the analysis found that no census tracts in Allegany or Garrett Counties meet or exceed the statewide 75th percentile threshold for overall EJ scores under Maryland EnviroScreen. This indicates that while localized environmental burdens exist, these counties are not classified as disproportionately overburdened relative to other regions of Maryland.

Potential Environmental Justice Considerations

Although overall EJ scores are below the statewide threshold, localized impacts may still arise if biomass projects increase truck traffic, noise, or short-term construction activity near sensitive communities. In particular, census tracts near Cumberland exhibit low to moderate climate vulnerability combined with elevated exposure indicators, suggesting that project design and logistics could influence whether benefits and burdens are equitably distributed.

Without appropriate planning, communities already experiencing higher traffic or air-quality stressors may not receive equivalent net benefits from biomass deployment. As such, these areas warrant additional attention during project siting, design, and implementation.

Mitigation and Equity-Oriented Practices

To support equitable outcomes and align with Maryland's environmental justice principles, the following mitigation strategies are recommended where biomass heating projects are evaluated or pursued:

- Optimized truck routing to avoid residential neighborhoods and sensitive receptors such as schools, hospitals, and eldercare facilities
- Construction-hour limitations to minimize noise impacts during retrofits
- Dust and noise control measures during fuel delivery, storage, and handling

When implemented proactively, these measures can help ensure that communities experience net-positive outcomes, including improved air quality relative to oil-based heating, more reliable energy services, and new local employment opportunities, without disproportionate localized burdens.

Summary

While Allegany and Garrett Counties do not contain census tracts classified as highly overburdened under Maryland EnviroScreen, targeted EJ screening remains an essential planning tool, particularly near transportation corridors and population centers such as Cumberland. Integrating EJ considerations early in the evaluation of biomass heating projects can guide equitable siting, reduce localized risks, and help ensure that the economic and environmental benefits of renewable thermal energy are shared broadly across rural Western Maryland.

POLICY LANDSCAPE & RECOMMENDATIONS

Maryland's policy framework plays a central role in shaping the conditions under which woody biomass heating systems could be considered, evaluated, and potentially adopted. As demonstrated in the economic analysis, modeled community-scale biomass systems indicate the potential for local economic activity, including job creation, tax revenue, and rural development benefits. Translating these modeled outcomes into real-world applications depends on policies that

recognize woody biomass as a renewable thermal resource, clarify regulatory pathways, and support communities and institutions through financial incentives and technical assistance.

Woody biomass energy aligns with several of Maryland’s long-term priorities, including reducing fossil fuel dependence, enhancing forest health, advancing rural economic resilience, and lowering greenhouse gas emissions. However, existing renewable energy policies have focused primarily on electricity generation, leaving small- and medium-scale thermal biomass systems without a clearly defined or consistently applied policy structure. Improved interagency coordination, clearer regulatory structure, and integration of thermal biomass into the state’s broader clean energy strategy would enable a more complete evaluation of woody biomass as a heating option.

Current Policy

Federal Policy and Program Overview

At the federal level, biomass energy policy is shaped primarily by the U.S. Department of Agriculture (USDA), the U.S. Department of Energy (DOE), and the U.S. Environmental Protection Agency (EPA). Together, these agencies administer programs and regulations that influence biomass energy development, ranging from forest resource management and technical research to emissions regulations. Most federal initiatives, however, have historically emphasized transportation fuels and electricity generation rather than community-scale thermal energy applications (U.S. Department of Energy, 2024; U.S. Environmental Protection Agency, 2024a).

USDA Wood Innovations Grant Program

The Wood Innovations Program supports projects that expand the use of forest products and wood energy while promoting forest health and rural economic vitality. Grants fund feasibility studies, engineering design, and technology deployment for wood heating, combined heat and power (CHP), and biomass supply-chain projects. Award amounts typically range from \$250,000 to \$1 million, often requiring non-federal cost-share (USDA Forest Service, 2024).

USDA Community Wood Energy and Innovations Program

This program funds equipment purchases and installation for large-scale wood heating or CHP systems in public facilities and district energy networks. The program encourages the replacement of fossil fuel-based systems with high-efficiency, low-emission wood boilers, supporting both energy resilience and local forestry industries.

DOE Bioenergy Technologies Office (BETO)

BETO advances research, development, and deployment of sustainable bioenergy systems and focuses on improving feedstock logistics, conversion technologies, and lifecycle emissions performance. Although it primarily supports research, its findings help inform best practices for community-scale biomass projects and integration with decarbonization policies (U.S. Department of Energy, 2024).

EPA Renewable Fuel Standard (RFS)

The RFS establishes categories for renewable fuels under the Clean Air Act. While historically centered on liquid biofuels such as ethanol and biodiesel, it provides a regulatory model for quantifying renewable energy generation and associated emissions reductions (U.S. Environmental Protection Agency, 2024a). Some stakeholders have noted that extending similar frameworks to thermal biomass could provide a structured pathway for recognizing renewable heat generation.

Federal Investment Tax Credits and Clean Electricity Incentives

Federal tax policy provides additional tools that may support certain components of biomass heating systems. The Investment Tax Credit (ITC) and the Clean Electricity Investment Credit support a range of clean energy and energy storage technologies. In some cases, thermal energy storage systems may qualify as energy storage property when properly classified, co-located with eligible energy projects, and placed into service in accordance with federal guidance. While

eligibility depends on system configuration and tax interpretation, these credits may offer supplemental financial considerations for projects incorporating thermal storage alongside biomass heating.

Rural Energy for America Program (REAP)

The REAP provides grants and guaranteed loans to agricultural producers and rural small businesses for renewable energy and energy efficiency projects. REAP supports installation of renewable energy systems, including biomass, as well as energy efficiency improvements that reduce overall energy consumption. This program can be particularly relevant for rural institutions and businesses evaluating biomass heating systems as part of broader energy modernization efforts (U.S. Department of Agriculture, n.d.).

Taken together, these federal programs provide a range of financial tools, research support, and regulatory context relevant to biomass energy and rural renewable development. However, because these initiatives are generally broad in scope and not specifically designed to support community-scale biomass heating systems, state and local policies play a central role in determining how such projects are evaluated, permitted, and supported in practice.

Regional Policy Comparison

Several northeastern states provide useful examples of how state-level policy frameworks can support the evaluation and deployment of biomass heating systems through a combination of renewable energy standards, targeted incentives, and regulatory clarity:

- **Vermont** integrates biomass heating into its statewide energy strategy and provides capital and operational support for school and municipal heating systems, reflecting a long-standing emphasis on renewable thermal energy in public facilities (Vermont Department of Public Service, 2023).
- **Maine** maintains statutory programs that explicitly support wood-fired combined heat and power (CHP) and community-scale biomass systems. Institutional projects in Maine typically navigate air permitting through the Maine Department of Environmental Protection, alongside procurement and incentive programs that recognize biomass as a renewable thermal resource (State of Maine, n.d.).
- **New Hampshire** recognizes biomass as a renewable thermal resource within its Renewable Portfolio Standard (RPS) and has, at various times, administered state funding mechanisms that supported commercial-scale biomass boiler installations. These policies provide an example of how thermal biomass can be incorporated into a broader renewable energy framework (New Hampshire Department of Energy, 2024).
- **Pennsylvania** includes thermal biomass within its Alternative Energy Portfolio Standard (AEPS), enabling eligible systems to generate renewable energy credits. This explicit inclusion provides clearer eligibility pathways for institutional and commercial biomass heating systems (Pennsylvania Department of Environmental Protection, 2024).

By comparison, Maryland's Renewable Portfolio Standard (RPS) allows renewable energy credits (RECs) for certain thermal energy systems, including eligible biomass thermal applications, though participation pathways for thermal resources are more limited and less standardized than those for electricity-generating technologies. As a result, woody biomass heating systems must meet specific criteria and documentation requirements to participate. Clarifying and strengthening these existing pathways could improve transparency and accessibility for rural institutions evaluating renewable thermal options.

Maryland Biomass Energy Policy and Regulatory Framework

Maryland's approach to woody biomass energy is defined by a combination of renewable energy policy, emissions regulations, and resource sustainability standards. Together, these mechanisms establish the state's regulatory framework for the development and operation of biomass energy systems.

Maryland’s renewable energy policy is governed by the Renewable Portfolio Standard (RPS), codified in *Public Utilities Article §7-701 et seq.* The RPS mandates that 50% of electricity sales originate from renewable sources by 2030, with 14.5% designated for solar generation (Maryland Department of the Environment, 2024a). Woody biomass is classified as a Tier I renewable energy resource, provided it meets sustainability and emissions criteria.

Emissions Regulations and Compliance

Maryland’s Code of Maryland Regulations (COMAR) 26.11.09.12 governs air quality standards for biomass fuel-burning equipment equal to or greater than 350,000 Btu/hr. The regulation sets limits for particulate matter (PM) and Nitrous Oxide (NO_x) emission standards.

Table 4.1: COMAR Emission Standards for Biomass Combustion Units

Boiler Size	Particulate Matter (PM)	Nitrous Oxide (NO _x)	Required Maintenance
≥10 million Btu/hr	0.03-0.07 lb/MMBtu	0.25-0.30 lb/MMBtu	An initial and biennial tune-ups are conducted.
>1.5 MMBtu/hr – 10 MMBtu/hr	0.1-0.23 lb/MMBtu	0.30 lb/MMBtu	An initial and biennial tune-ups are conducted.
350,000 Btu/hr – 1.5 MMBtu/hr	0.1-0.35 lb/MMBtu	0.30 lb/MMBtu	An initial and biennial tune-ups are conducted.

Source: Maryland Department of the Environment, n.d.

Note: Specific testing and permit conditions may vary depending on system design, fuel type, and location. Further details on emission testing, monitoring, and control technologies are provided in Appendix B (Tables B-1 through B-3).

Interpretation and Policy Relevance

In Table 5.1, *applicability* refers to the size or capacity of a biomass combustion system, measured in million British thermal units per hour (MMBtu/hr), that determines which regulatory limits apply. Larger systems (greater than 10 MMBtu/hr) are subject to stricter emission thresholds because they process more fuel and have higher potential emissions. The *emission limits* shown in the table express the maximum allowable amount of a specific pollutant released per unit of energy produced. For example, particulate matter (PM) is limited to 0.10 pounds per million British thermal units (BTU) of heat output (lb/MMBtu), and carbon monoxide (CO) is capped at 200 parts per million (ppm), standardized to 7 percent oxygen in the exhaust stream.

Typical control technologies are the equipment and methods used to ensure emissions stay within those limits. A multicyclone, baghouse filter, or ESP removes fine particles before exhaust gases are released, while oxygen trim systems and combustion controls automatically adjust airflow and fuel feed to maintain efficient burning and low CO emissions. *Opacity*, which measures visible smoke or haze, is limited to 20 percent over a six-minute average to ensure efficient combustion and minimal particulate release.

These thresholds indicate that modern biomass systems equipped with appropriate combustion and filtration technologies can be designed to operate within Maryland’s environmental standards. Because smaller institutional systems, such as those serving schools, county buildings, or campuses, typically produce much lower emissions than the regulatory thresholds, their permitting processes could be streamlined without compromising air quality. Simplified permitting and pre-approved control configurations would lower project costs, reduce administrative delays, and make biomass energy more accessible for rural and public-sector facilities while maintaining environmental integrity.

Together, these performance and permitting standards form the regulatory baseline for biomass energy development in Maryland. Regional air quality designations further determine how these requirements are applied across the state.

Air Quality Designations and Regional Applicability

Maryland’s permitting stringency for biomass systems depends on local air quality designations under the Clean Air Act (CAA). The EPA classifies regions as *attainment* or *nonattainment areas* based on the National Ambient Air Quality Standards (NAAQS) (U.S. Environmental Protection Agency, 2024b).

Projects in attainment areas, such as Garrett and Allegany Counties, face simpler Prevention of Significant Deterioration (PSD) requirements. By contrast, non-attainment areas (including Baltimore City and parts of Montgomery, Anne Arundel, and Prince George’s Counties) require Nonattainment New Source Review (NNSR) permits, which demand stricter emission offsets (Maryland Department of the Environment, 2024c).

Table 4.2: Maryland Air Quality Designations and Policy Implications

Attainment Areas	Non-attainment Areas	Policy Implication
Garrett, Allegany, Washington, most western counties	Baltimore City, Montgomery, Prince George’s, Anne Arundel, and portions of central Maryland	Projects in attainment areas face simpler permitting and lower compliance costs.

Source: Maryland Department of the Environment (2024c); U.S. Environmental Protection Agency (2024b).

These designations may make rural western Maryland comparatively well-positioned to evaluate biomass heating applications, combining cleaner baseline air quality, lower permitting complexity, and proximity to local fuel resources.

Qualifying Biomass in Maryland

Under Maryland’s RPS, “qualifying biomass” refers to sustainably sourced woody materials that comply with state environmental and forest management criteria. These resources must comply with sustainability and emissions standards defined by MDE and DNR (Maryland Department of the Environment, 2024a).

Table 4.3: Eligible and Excluded Biomass Feedstocks in Maryland

Eligible Biomass Sources	Excluded Biomass Sources
Forest residues and thinnings	Treated or painted wood
Mill byproducts (bark, chips, sawdust)	Plastics and synthetic composites
Clean wood waste	Municipal solid waste
Short-rotation energy crops	Materials violating air quality standards

Source: Maryland Code, Public Utilities §7-701; Maryland Department of the Environment (2024a).

Maryland’s RPS currently provides REC eligibility for certain thermal energy systems, including qualified biomass thermal applications, though participation requirements are more restrictive than for electricity-generating systems. Enhancing clarity or accessibility of these pathways could support evaluation of biomass heating options at institutional and community scales.

Incentives and Funding Mechanisms

Maryland's biomass energy development depends on a combination of federal, state, and regional funding sources that support feasibility, infrastructure, and implementation. While these programs collectively provide strong financial and technical foundations, coordination among agencies remains essential to ensure accessible, streamlined support for rural and institutional projects.

Appalachian Regional Commission (ARC)

ARC provides economic development funding for infrastructure, workforce, and clean energy projects in Appalachian counties, including Garrett and Allegany in Maryland. ARC grants often support feasibility studies, workforce training, and community-scale renewable energy installations that align with regional economic diversification goals. For biomass energy, ARC's flexible funding framework helps bridge the gap between planning and implementation, particularly for public-sector or multi-institutional projects.

Maryland Energy Administration (MEA)

MEA administers programs such as the Clean Energy Grant Program and the Resilient Maryland program, which support planning, feasibility analysis, and infrastructure upgrades for various renewable and resilient energy technologies. While MEA's program offerings have included limited support for biomass-related assessments in the past, the level of assistance has varied year to year. As presently structured, MEA's programs provide frameworks that could be used by local governments or institutions to evaluate a range of heating alternatives, including biomass, depending on program priorities and eligibility criteria (Maryland Department of the Environment, 2024a).

Maryland Clean Energy Center (MCEC)

MCEC offers low-interest loans, bond financing, and technical support for various clean energy and efficiency projects. While MCEC's authority allows consideration of biomass technologies, funding decisions for biomass, particularly thermal systems, have been subject to board-level scrutiny. Clarifying MCEC's role with respect to biomass could help determine whether and how such projects might be evaluated within its financing portfolio (Maryland Clean Energy Center, 2024).

Integration and Policy Implications

While each of these programs provides critical support, their fragmented administration can make access challenging, particularly for smaller or resource-limited applicants. Developing a coordinated statewide funding strategy, integrating MEA, MCEC, ARC, and relevant federal programs such as USDA Wood Innovations, would create a clearer pipeline from feasibility to deployment. A unified approach could also align Maryland's renewable energy financing with broader economic development priorities, ensuring that biomass projects contribute simultaneously to clean energy goals, forest health, and rural resilience.

Local Policy Alignment

At the county level, planning frameworks in parts of Western Maryland reflect long-standing interests in renewable energy, forest utilization, and rural economic development. Comprehensive plans in both Garrett and Allegany Counties reference the importance of sustainable forest management and diversified local energy strategies, creating a policy environment that could support the evaluation of biomass heating systems where appropriate.

Recent feasibility studies and exploratory analyses conducted for facilities in these counties illustrate how local governments or institutions might assess biomass heating as part of their broader facility modernization and energy planning efforts. Although these studies do not represent commitments to pursue biomass projects, they demonstrate how county-level priorities, such as cost stability, energy security, and responsible forest resource use, could intersect with state and federal clean energy goals.

Local governments also play important roles in zoning, permitting coordination, public engagement, and workforce development. Counties with strong forestry sectors may already have relevant infrastructure, contractors, or training programs that could support biomass energy evaluation. By incorporating renewable energy considerations into comprehensive plans and public facility planning, counties can position themselves to better assess whether biomass heating is an appropriate and beneficial option within their overall energy strategy.

Policy gaps and recommendations

While Maryland's renewable energy policies have created a strong foundation for clean energy development, several structural and administrative barriers continue to limit the deployment of woody biomass systems. The following recommendations outline key opportunities to refine the state's framework, promote local investment, and align renewable energy policy with the state's greenhouse gas reduction and forest management goals.

Expand Renewable Portfolio Standard (RPS) Eligibility

Maryland's Renewable Portfolio Standard (RPS) allows renewable energy credits (RECs) for certain thermal energy systems, including qualified biomass thermal applications; however, participation pathways for thermal resources have historically been more limited, less standardized, and less accessible than those available to electricity-generating technologies. As a result, many institutional-scale biomass heating systems face uncertainty regarding eligibility, documentation requirements, and long-term participation in the REC market.

Maryland could consider clarifying and strengthening RPS pathways for qualified woody biomass thermal systems by establishing clearer eligibility criteria, standardized verification processes, and more predictable crediting mechanisms. Such adjustments would not create a new policy category, but rather improve the consistency and usability of existing thermal REC provisions. Institutional boilers, district heating systems, and combined heat and power (CHP) installations have the potential to offset significant fossil fuel use, and clearer REC pathways could support more transparent evaluation of these systems.

Neighboring states such as Pennsylvania, Vermont, Maine, and New Hampshire provide more clearly defined renewable credit frameworks for biomass thermal energy. Aligning Maryland's RPS implementation with these approaches could improve policy clarity and enable institutions to more readily assess whether biomass heating systems fit within the state's broader clean energy and emissions reduction strategies.

Streamline Permitting

Project developers, schools, and municipalities often face complex permitting requirements under Maryland's Code of Maryland Regulations (COMAR) 26.11.09.12. While these standards are essential for maintaining air quality, the permitting process can be time-consuming and costly, especially for smaller systems that already operate well within emissions limits. Streamlining permitting for biomass systems under 10 million Btu per hour would lower barriers to entry and promote local adoption without compromising environmental safeguards. Standardized permit templates, pre-approved emissions models, and clear compliance pathways could substantially shorten approval timelines. This approach would mirror successful models in Vermont and New Hampshire, where streamlined permitting has accelerated community-scale biomass heating installations while maintaining strong environmental oversight.

Develop Workforce and Technical Support Programs

Sustained growth of Maryland's biomass energy sector would require a skilled workforce and accessible technical assistance. Maryland could explore expanding existing training and technical support programs to include biomass heating system design, operation, and maintenance. Partnerships with regional colleges, trade schools, forestry organizations, and relevant state agencies could provide operator training, safety certifications, and best practices for fuel production and

combustion system management. Strengthening workforce capacity would help ensure that any future biomass heating installations operate efficiently and safely.

Strengthen Interagency Coordination

Biomass energy sits at the intersection of forestry, energy, and environmental regulation, yet current coordination across agencies remains limited. Creating an interagency Biomass Energy Working Group, comprising representatives from the Maryland Department of the Environment (MDE), Maryland Energy Administration (MEA), Department of Natural Resources (DNR), and Maryland Clean Energy Center (MCEC), would help integrate funding, permitting, and technical assistance efforts. This group could streamline communication, standardize project evaluation metrics, and develop unified guidance for developers and municipalities. Furthermore, aligning biomass policy with the Greenhouse Gas Reduction Act (GGRA) would ensure that thermal energy systems are recognized as part of Maryland's long-term decarbonization strategy. Coordinated leadership would also enable better data collection on project performance, emissions, and economic outcomes, informing future policy adjustments.

Support Supply Chain and Market Development

A reliable biomass energy sector depends on a consistent and sustainable fuel supply. Maryland's forest industry already produces substantial residues, but much of this material is underutilized or exported to neighboring states. The state can strengthen its biomass market by offering targeted grants, tax incentives, and low-interest loans to support local fuel producers, chipping operations, and transporters. Encouraging partnerships between private forestry companies and public institutions can ensure a steady flow of affordable, high-quality fuel while supporting forest management and wildfire risk reduction. Incentives could also be structured to reward sustainable harvesting practices, reducing waste and improving carbon outcomes. A well-developed supply chain not only stabilizes biomass fuel costs but also generates long-term employment in rural communities, aligning economic development with environmental stewardship.

Conclusion

Maryland's renewable energy policies have evolved significantly over the past decade, establishing ambitious clean energy targets while supporting a diverse set of technologies. Within this landscape, woody biomass represents a potential tool for meeting the state's goals related to emissions reduction, forest management, rural economic development, and energy diversification. Federal programs administered by USDA, DOE, and EPA offer important research and funding mechanisms, and Maryland's Renewable Portfolio Standard and related state initiatives create a framework within which biomass heating could be evaluated.

While some counties and institutions in Western Maryland have explored biomass heating through feasibility studies and planning efforts, these activities remain exploratory and do not reflect confirmed commitments or outcomes. Nonetheless, these studies show how biomass heating might be assessed within the context of local priorities such as cost stability, facility modernization, and responsible forest utilization.

The recommendations in this report, including potential adjustments to RPS eligibility, streamlined permitting pathways, workforce and supply-chain development, and improved interagency coordination, offer Maryland options for evaluating whether and how woody biomass could fit into its broader clean energy and forest management strategies. These approaches are intended to provide clarity, improve planning capacity, and support informed long-term decision-making.

Looking ahead, Maryland has the opportunity to continue assessing how woody biomass can complement other renewable energy and decarbonization efforts. By building on existing policy structures, addressing identified gaps, and fostering collaboration across agencies, the state can develop a more comprehensive framework for evaluating whether, and under what conditions, woody biomass heating may contribute to a diversified and resilient clean energy future.

STRATEGIC PATHWAYS AND CONCLUSIONS

Maryland's woody biomass sector is at an inflection point. With abundant forest resources, a capable forestry industry, and a policy environment increasingly focused on renewable and resilient heating solutions, the state is well-positioned to expand biomass thermal energy use, particularly in rural and institutional settings where heating demand is high. The feasibility scenarios illustrated earlier in this report demonstrate that modern biomass systems can meet substantial heating loads, support local supply chains, and offer clear opportunities for cost stabilization when designed and sourced sustainably.

Economic and Environmental Rationale

Expanding woody biomass utilization offers dual economic and environmental benefits. From an economic standpoint, investments in biomass heating infrastructure circulate dollars within Maryland's rural economies by supporting harvesting, chipping, transportation, system operation, and ongoing maintenance. Modeled examples show that replacing imported heating fuels with locally sourced biomass can reduce exposure to volatile oil and propane prices, provide predictable long-term energy costs, and generate employment opportunities that align with existing forestry and logistics industries.

Environmentally, sustainable biomass utilization complements Maryland's forest management goals. Increased demand for low-grade wood can support thinning, regeneration, and the productive use of material that might otherwise contribute to declining forest health, disease vulnerability, or fuel buildup. When paired with sustainable sourcing practices and lifecycle carbon accounting, high-efficiency woody biomass systems can operate as low-carbon or carbon-neutral heating solutions within a regional circular carbon cycle.

Policy Levers and Investment Opportunities

Achieving these benefits requires strategic policy support and clear investment pathways. Rather than highlighting specific agencies, the emphasis should be on the types of mechanisms that help overcome the high upfront capital costs common to biomass thermal systems. These may include:

- **Capital Incentives:** Grants, low-interest loans, and cost-sharing programs that reduce initial financial barriers for schools, counties, and institutions evaluating system upgrades. Such mechanisms are especially important for public-sector buildings with constrained budgets and long planning horizons.
- **Operational Support:** Instruments such as renewable thermal credits, carbon reduction incentives, or long-term performance-based payments that improve financial viability throughout the system's operational life.
- **Technical Assistance:** Expanded support for feasibility studies, engineering assessments, procurement guidance, and permitting navigation to ensure that prospective project hosts have access to unbiased, high-quality information before making decisions.
- **Regulatory Clarity:** Streamlined permitting processes, transparent emissions requirements, and consistent guidance across air-quality jurisdictions to reduce uncertainty for project developers and public agencies.
- **Education and Outreach:** Clear communication about forest sustainability, emissions performance, supply-chain practices, and community benefits to strengthen public understanding and support.

Scaled together, these mechanisms can empower counties and public institutions to explore biomass heating as a component of modernization, resilience, and clean-energy planning.

Priority Applications

Several sectors in Maryland are especially well-suited for woody biomass heating based on load profiles, building characteristics, and proximity to fuel supply. The most promising near-term applications include:

- **Public Schools and Educational Campuses:** These facilities typically have large, steady heating loads and predictable occupancy patterns that are compatible with high-efficiency biomass systems or district heating loops.
- **Municipal and County Buildings:** Groups of courthouses, libraries, and public works facilities often have co-located or campus-style layouts that lend themselves to shared heating infrastructure.
- **Correctional Facilities, Hospitals, and Care Centers:** Year-round thermal demand and the need for reliable, uninterrupted heating make these sites strong candidates for biomass systems when located near sustainable wood supply.

Integrating biomass heating projects into existing state or local modernization programs, such as energy-efficiency initiatives, resilience planning, or facility renewal cycles, can streamline deployment and amplify cost and environmental benefits.

Long-Term Strategic Pathways

Over the longer term, Maryland can position woody biomass as a complementary component of its clean-energy portfolio. If even a modest share of eligible public facilities adopted high-efficiency biomass heating systems based on modeled heating loads and feasibility indicators, statewide fossil-fuel consumption for space heat could decline substantially, while rural counties would see ongoing economic activity tied to harvesting, processing, transportation, and system operation.

The feasibility scenarios highlighted in this report illustrate the kinds of heating loads, fuel requirements, sourcing radii, and capital needs associated with modern systems. Collectively, these insights can inform:

- Statewide screening criteria to help identify suitable public buildings or clusters of buildings.
- Funding alignment strategies that match project scales with appropriate financial mechanisms.
- Supply-chain planning frameworks ensure sustainable and reliable access to low-grade wood.
- Emissions monitoring and reporting protocols that maintain transparency and public confidence.

While each facility or county will face unique conditions, a unified strategy grounded in feasibility data can help decision-makers pursue opportunities where biomass heating offers the strongest value proposition.

Conclusion and Transition

Maryland's path forward lies in aligning forest management, renewable heating policy, and rural development objectives into a cohesive strategy. The state has the technical potential, resource base, and institutional interest needed to expand woody biomass heating in ways that reduce emissions, enhance energy resilience, and strengthen rural economies.

As demonstrated throughout this report, modern woody biomass systems can reduce long-term heating costs, support local job creation, and provide meaningful carbon benefits when sourced and managed responsibly. By investing strategically, guided by feasibility data, sustainability criteria, and coordinated state–local partnerships, Maryland can position its rural counties as leaders in renewable thermal energy, demonstrating that climate action and rural economic development can reinforce one another.

APPENDIX A

Appendix A includes the full economic model outputs for all system sizes and regions, including detailed IMPLAN tables, tax breakdowns, and annualized values.

Garrett County Data Tables

One-time capital investment of establishing a small, medium, or large-scale wood-based thermal system in Garrett County, MD				
	Employment	Labor Income (\$ 2025)	Value Added (\$ 2025)	Output (\$ 2025)
700 Tons/Yr				
Impact Type				
Direct	15	\$894,936	\$1,461,787	\$2,500,000
Indirect	2	\$138,246	\$265,500	\$519,315
Induced	3	\$124,870	\$273,296	\$445,007
Total	20	\$1,158,053	\$2,000,583	\$3,464,321
3,000 Tons/Yr				
Direct	19	\$1,113,301	\$1,818,463	\$3,110,000
Indirect	3	\$171,979	\$330,282	\$646,028
Induced	3	\$155,338	\$339,980	\$553,588
Total	25	\$1,440,618	\$2,488,725	\$4,309,616
5,000 Tons/Yr				
Direct	32	\$1,857,888	\$3,034,669	\$5,190,000
Indirect	5	\$287,000	\$551,178	\$1,078,098
Induced	6	\$259,230	\$567,363	\$923,834
Total	42	\$2,404,117	\$4,153,210	\$7,191,931

Garrett County Recurring Annual Impacts Resulting From Operations of Wood-Based Thermal Energy Systems				
	Employment	Labor Income (\$ 2025)	Value Added (\$ 2025)	Output (\$ 2025)
700 Tons/Yr				
Impact Type				
Direct	0.1	\$2,500	\$2,500	\$60,250
Indirect	0.4	\$34,842	\$50,699	\$62,528
Induced	0.1	\$4,494	\$9,835	\$16,015
Total	0.5	\$41,837	\$63,033	\$138,793
3,000 Tons/Yr				
Direct	0.2	\$5,000	\$5,000	\$235,750
Indirect	1.5	\$140,262	\$205,407	\$248,271
Induced	0.4	\$17,507	\$38,308	\$62,383
Total	2.1	\$162,769	\$248,715	\$546,404
5,000 Tons/Yr				
Direct	0.4	\$12,500	\$12,500	\$394,750
Indirect	2.4	\$230,914	\$341,986	\$409,954
Induced	0.7	\$29,311	\$64,137	\$104,445
Total	3.5	\$272,725	\$418,623	\$909,149

Garrett County Recurring Annual Impacts Resulting From Operations of Wood-Based Thermal Energy Systems

Impact Type	Labor Income (\$ 2025)					Value Added (\$ 2025)					Output (\$ 2025)					
	5YR	10YR	15YR	Value Added	700 Tons/Yr	5YR	10YR	15YR	Output	5YR	10YR	15YR	Output	5YR	10YR	15YR
Total	\$41,837	\$418,370	\$627,555	\$63,033	\$315,165	\$630,330	\$945,495	\$138,793	\$693,965	\$1,387,930	\$2,081,895					
3,000 Tons/Yr																
Direct	\$5,000	\$50,000	\$75,000	\$5,000	\$25,000	\$50,000	\$75,000	\$235,750	\$1,178,750	\$2,357,500	\$3,536,250					
Indirect	\$140,262	\$1,402,620	\$2,103,930	\$205,407	\$1,027,035	\$2,054,070	\$3,081,105	\$248,271	\$1,241,355	\$2,482,710	\$3,724,065					
Induced	\$17,507	\$175,070	\$262,605	\$38,308	\$191,540	\$383,080	\$574,620	\$62,383	\$311,915	\$623,830	\$935,745					
Total	\$162,769	\$1,627,690	\$2,441,535	\$248,715	\$1,243,575	\$2,487,150	\$3,730,725	\$546,404	\$2,732,020	\$5,464,040	\$8,196,060					
5,000 Tons/Yr																
Direct	\$12,500	\$125,000	\$187,500	\$12,500	\$62,500	\$125,000	\$187,500	\$394,750	\$1,973,750	\$3,947,500	\$5,921,250					
Indirect	\$230,914	\$2,309,140	\$3,463,710	\$341,986	\$1,709,930	\$3,419,860	\$5,129,790	\$409,954	\$2,049,770	\$4,099,540	\$6,149,310					
Induced	\$29,311	\$293,110	\$439,665	\$64,137	\$320,685	\$641,370	\$962,055	\$104,445	\$522,225	\$1,044,450	\$1,566,675					
Total	\$272,725	\$2,727,250	\$4,090,875	\$418,623	\$2,093,115	\$4,186,230	\$6,279,345	\$909,149	\$4,545,745	\$9,091,490	\$13,637,235					

One-time tax revenue generated due to the establishment of small, medium, or large-scale wood-based thermal system in Garrett County, MD

	Sub County General	Sub County Special Districts	County	State	Federal	Total
700 Tons/Yr						
Impact Type						
Direct	\$724	\$0	\$20,511	\$38,401	\$219,443	\$279,080
Indirect	\$1,005	\$0	\$26,976	\$28,816	\$36,587	\$93,383
Induced	\$715	\$0	\$19,228	\$21,437	\$34,694	\$76,074
Total	\$2,444	\$0	\$66,715	\$88,655	\$290,723	\$448,537
3,000 Tons/Yr						
Direct	\$900	\$0	\$25,516	\$47,771	\$272,987	\$347,175
Indirect	\$1,250	\$0	\$33,558	\$35,847	\$45,514	\$116,169
Induced	\$890	\$0	\$23,919	\$26,668	\$43,159	\$94,636
Total	\$3,040	\$0	\$82,993	\$110,286	\$361,660	\$557,980
5,000 Tons/Yr						
Direct	\$1,502	\$0	\$42,582	\$79,721	\$455,564	\$579,369
Indirect	\$2,086	\$0	\$56,002	\$59,822	\$75,954	\$193,864
Induced	\$1,485	\$0	\$39,917	\$44,504	\$72,024	\$157,930
Total	\$5,073	\$0	\$138,500	\$184,047	\$603,542	\$931,162

Garrett County Recurring Annual Tax Revenue Resulting From Operations of Wood-Based Thermal Energy Systems

	Sub County General (\$ 2025)	Sub County Special Districts (\$ 2025)	County (\$ 2025)	State (\$ 2025)	Federal (\$ 2025)	Total (\$2025)
700 Tons/Yr						
Impact Type						
Direct	\$33	\$0	\$929	\$1,522	\$8,000	\$10,484
Indirect	\$7	\$0	\$177	\$193	\$344	\$721
Induced	\$26	\$0	\$692	\$772	\$1,249	\$2,738
Total	\$65	\$0	\$1,798	\$2,487	\$9,593	\$13,944
3,000 Tons/Yr						
Direct	\$126	\$0	\$3,548	\$5,964	\$32,484	\$42,123
Indirect	\$26	\$0	\$688	\$744	\$1,252	\$2,710
Induced	\$100	\$0	\$2,696	\$3,005	\$4,864	\$10,665
Total	\$252	\$0	\$6,931	\$9,714	\$38,600	\$55,498
5,000 Tons/Yr						
Direct	\$205	\$0	\$5,753	\$9,789	\$53,697	\$69,444
Indirect	\$40	\$0	\$1,086	\$1,176	\$1,991	\$4,293
Induced	\$168	\$0	\$4,513	\$5,032	\$8,143	\$17,856
Total	\$413	\$0	\$11,352	\$15,997	\$63,831	\$91,593

Allegany County Data Tables

One-time capital investment of establishing a small, medium, or large-scale wood-based thermal system in Allegany County, MD				
	Employment	Labor Income (\$ 2025)	Value Added (\$ 2025)	Output (\$ 2025)
700 Tons/Yr				
Impact Type				
Direct	15	\$830,070	\$1,508,412	\$2,500,000
Indirect	2	\$119,434	\$242,949	\$452,626
Induced	3	\$128,479	\$258,328	\$419,300
Total	19	\$1,077,983	\$2,009,689	\$3,371,926
3,000 Tons/Yr				
Direct	18	\$1,032,607	\$1,876,465	\$3,110,000
Indirect	3	\$148,576	\$302,229	\$563,067
Induced	3	\$159,828	\$321,359	\$521,609
Total	24	\$1,341,011	\$2,500,053	\$4,194,675
5,000 Tons/Yr				
Direct	30	\$1,723,225	\$3,131,464	\$5,190,000
Indirect	5	\$247,946	\$504,363	\$939,652
Induced	5	\$266,722	\$536,288	\$870,466
Total	40	\$2,237,894	\$4,172,114	\$7,000,118

Allegany County Recurring Annual Impacts Resulting From Operations of Wood-Based Thermal Energy Systems				
	Employment	Labor Income (\$ 2025)	Value Added (\$ 2025)	Output (\$ 2025)
700 Tons/Yr				
Impact Type				
Direct	0.1	\$2,500	\$2,500	\$60,250
Indirect	0.5	\$30,581	\$52,736	\$60,593
Induced	0.1	\$4,759	\$9,574	\$15,537
Total	0.7	\$37,840	\$64,810	\$136,380
3,000 Tons/Yr				
Direct	0.2	\$5,000	\$5,000	\$235,750
Indirect	2	\$120,627	\$214,115	\$239,590
Induced	0.4	\$18,184	\$36,581	\$59,367
Total	2.6	\$143,811	\$255,696	\$534,707
5,000 Tons/Yr				
Direct	0.4	\$12,500	\$12,500	\$394,750
Indirect	3.3	\$199,990	\$355,274	\$396,439
Induced	0.6	\$30,699	\$61,755	\$100,223
Total	4.3	\$243,189	\$429,530	\$891,413

Allegany County Recurring Annual Impacts Resulting From Operations of Wood-Based Thermal Energy Systems

Impact Type	Labor Income (\$ 2025)					Value Added (\$ 2025)					Output (\$ 2025)					
	5YR	10YR	15YR	Value Added	700 Tons/Yr	5YR	10YR	15YR	Output	5YR	10YR	15YR	Output	5YR	10YR	15YR
Total	\$37,840	\$189,200	\$567,600	\$64,810	\$324,050	\$681,900	\$1,363,800	\$972,150	\$136,380	\$681,900	\$1,363,800	\$972,150	\$136,380	\$681,900	\$1,363,800	\$2,045,700
3,000 Tons/Yr																
Direct	\$5,000	\$25,000	\$75,000	\$5,000	\$25,000	\$75,000	\$235,750	\$75,000	\$235,750	\$1,178,750	\$2,357,500	\$3,536,250	\$235,750	\$1,178,750	\$2,357,500	\$3,536,250
Indirect	\$120,627	\$603,135	\$1,809,405	\$214,115	\$1,070,575	\$3,211,725	\$239,590	\$3,211,725	\$239,590	\$1,197,950	\$2,395,900	\$3,593,850	\$239,590	\$1,197,950	\$2,395,900	\$3,593,850
Induced	\$18,184	\$90,920	\$272,760	\$36,581	\$182,905	\$548,715	\$59,267	\$548,715	\$59,267	\$296,835	\$593,670	\$890,505	\$59,267	\$296,835	\$593,670	\$890,505
Total	\$143,811	\$719,055	\$2,157,165	\$255,696	\$1,278,480	\$3,835,440	\$534,707	\$3,835,440	\$534,707	\$2,673,535	\$5,347,070	\$8,020,605	\$534,707	\$2,673,535	\$5,347,070	\$8,020,605
5,000 Tons/Yr																
Direct	\$12,500	\$62,500	\$187,500	\$12,500	\$62,500	\$187,500	\$394,750	\$187,500	\$394,750	\$1,973,750	\$3,947,500	\$5,921,250	\$394,750	\$1,973,750	\$3,947,500	\$5,921,250
Indirect	\$199,990	\$999,950	\$2,999,850	\$355,274	\$1,776,370	\$5,329,110	\$396,439	\$5,329,110	\$396,439	\$1,982,195	\$3,964,390	\$5,946,585	\$396,439	\$1,982,195	\$3,964,390	\$5,946,585
Induced	\$30,699	\$153,495	\$460,485	\$61,755	\$308,775	\$926,325	\$100,223	\$926,325	\$100,223	\$501,115	\$1,002,230	\$1,503,345	\$100,223	\$501,115	\$1,002,230	\$1,503,345
Total	\$243,189	\$1,215,945	\$3,647,835	\$429,530	\$2,147,650	\$6,442,950	\$891,413	\$6,442,950	\$891,413	\$4,457,065	\$8,914,130	\$13,371,195	\$891,413	\$4,457,065	\$8,914,130	\$13,371,195

One-time tax revenue generated due to the establishment of small, medium, or large-scale wood-based thermal system in Allegany County, MD

Impact Type	Sub County Special		County	State	Federal	Total
	Sub County General	Districts				
700 Tons/Yr						
Direct	\$2,366	\$11	\$11,877	\$39,354	\$208,659	\$262,267
Indirect	\$3,137	\$17	\$9,359	\$27,693	\$30,918	\$71,124
Induced	\$2,486	\$14	\$7,627	\$22,802	\$33,009	\$65,938
Total	\$7,989	\$41	\$28,864	\$89,849	\$272,586	\$399,329
3,000 Tons/Yr						
Direct	\$2,944	\$13	\$14,776	\$48,957	\$259,571	\$326,260
Indirect	\$3,902	\$21	\$11,643	\$34,450	\$38,462	\$88,478
Induced	\$3,093	\$17	\$9,488	\$28,365	\$41,064	\$82,027
Total	\$9,939	\$52	\$35,906	\$111,772	\$339,097	\$496,765
5,000 Tons/Yr						
Direct	\$4,912	\$22	\$24,658	\$81,700	\$433,175	\$544,467
Indirect	\$6,512	\$36	\$19,430	\$57,490	\$64,185	\$147,653
Induced	\$5,162	\$28	\$15,834	\$47,336	\$68,528	\$136,887
Total	\$16,585	\$86	\$59,921	\$186,526	\$565,888	\$829,007

Allegany County Recurring Annual Tax Revenue Resulting From Operations of Wood-Based Thermal Energy Systems

Impact Type	Sub County Special		County (\$ 2025)	State (\$ 2025)	Federal (\$ 2025)	Total (\$2025)
	Sub County General (\$ 2025)	Districts (\$ 2025)				
700 Tons/Yr						
Direct	\$105	\$0	\$504	\$1,592	\$7,336	\$9,538
Indirect	\$12	\$0	\$38	\$113	\$215	\$378
Induced	\$92	\$1	\$283	\$845	\$1,223	\$2,443
Total	\$209	\$1	\$825	\$2,549	\$8,774	\$12,358
3,000 Tons/Yr						
Direct	\$385	\$2	\$1,913	\$6,134	\$29,442	\$37,876
Indirect	\$40	\$0	\$127	\$375	\$654	\$1,196
Induced	\$352	\$2	\$1,079	\$3,227	\$4,673	\$9,333
Total	\$777	\$4	\$3,119	\$9,736	\$34,768	\$48,405
5,000 Tons/Yr						
Direct	\$628	\$3	\$3,145	\$10,100	\$48,859	\$62,735
Indirect	\$64	\$0	\$204	\$602	\$1,052	\$1,923
Induced	\$594	\$3	\$1,822	\$5,448	\$7,888	\$15,756
Total	\$1,287	\$6	\$5,172	\$16,150	\$57,800	\$80,414

Allegany County Recurring Annual Tax Revenue Resulting From Operations of Wood-Based Thermal Energy Systems

Impact Type	700 Tons/Yr										Total	5 Yr	10 Yr	15 Yr	Total	5 Yr	10 Yr	15 Yr	Total (\$ 2025)										
	Sub County General (\$ 2025)					Sub County Special Districts (\$ 2025)														Federal (\$ 2025)					State (\$ 2025)				
	5 Yr	10 Yr	15 Yr	County	5 Yr	10 Yr	15 Yr	State	5 Yr	10 Yr										15 Yr	Federal	5 Yr	10 Yr	15 Yr	15 Yr	5 Yr	10 Yr	15 Yr	
Direct	\$105	\$525	\$1,050	\$1,575	\$0	\$0	\$0	\$504	\$2,520	\$5,040	\$7,560	\$1,592	\$7,960	\$15,920	\$23,880	\$7,336	\$36,680	\$73,360	\$110,040	\$9,538	\$47,690	\$95,380	\$143,070						
Indirect	\$12	\$60	\$120	\$180	\$0	\$0	\$0	\$38	\$190	\$380	\$570	\$113	\$565	\$1,130	\$1,695	\$215	\$1,075	\$2,150	\$3,225	\$378	\$1,890	\$3,780	\$5,670						
Induced	\$92	\$460	\$920	\$1,380	\$1	\$5	\$10	\$283	\$1,415	\$2,830	\$4,245	\$846	\$4,230	\$8,460	\$12,690	\$1,723	\$6,115	\$12,230	\$18,345	\$2,443	\$12,215	\$24,430	\$36,645						
Total	\$209	\$1,045	\$2,090	\$3,135	\$1	\$5	\$10	\$825	\$4,125	\$8,250	\$12,375	\$2,549	\$12,745	\$25,490	\$38,235	\$8,774	\$43,870	\$87,740	\$131,610	\$12,358	\$61,790	\$123,580	\$185,370						
3,000 Tons/Yr																													
Direct	\$385	\$1,925	\$3,850	\$5,775	\$2	\$10	\$20	\$1,913	\$9,565	\$19,130	\$28,695	\$6,134	\$30,670	\$61,340	\$92,010	\$29,442	\$147,210	\$294,420	\$441,630	\$37,876	\$189,380	\$378,760	\$568,140						
Indirect	\$40	\$200	\$400	\$600	\$0	\$0	\$0	\$127	\$635	\$1,270	\$1,905	\$375	\$1,875	\$3,750	\$5,625	\$654	\$3,270	\$6,540	\$9,810	\$1,196	\$5,980	\$11,960	\$17,940						
Induced	\$352	\$1,760	\$3,520	\$5,280	\$2	\$10	\$20	\$1,079	\$5,395	\$10,790	\$16,185	\$3,227	\$16,135	\$32,270	\$48,405	\$4,673	\$23,365	\$46,730	\$70,095	\$9,333	\$46,665	\$93,330	\$139,995						
Total	\$777	\$3,885	\$7,770	\$11,655	\$4	\$20	\$40	\$3,119	\$15,595	\$31,190	\$46,785	\$9,736	\$48,680	\$97,360	\$146,040	\$34,768	\$173,840	\$347,680	\$521,520	\$48,405	\$242,025	\$484,050	\$726,075						
5,000 Tons/Yr																													
Direct	\$628	\$3,140	\$6,280	\$9,420	\$3	\$15	\$30	\$3,145	\$15,725	\$31,450	\$47,175	\$10,100	\$50,500	\$101,000	\$151,500	\$48,859	\$244,295	\$488,590	\$732,885	\$62,735	\$313,675	\$627,350	\$941,025						
Indirect	\$64	\$320	\$640	\$960	\$0	\$0	\$0	\$204	\$1,020	\$2,040	\$3,060	\$602	\$3,010	\$6,020	\$9,030	\$1,052	\$5,260	\$10,520	\$15,780	\$1,923	\$9,615	\$19,230	\$28,845						
Induced	\$594	\$2,970	\$5,940	\$8,910	\$3	\$15	\$30	\$1,822	\$9,110	\$18,220	\$27,330	\$5,448	\$27,240	\$54,480	\$81,720	\$7,888	\$39,440	\$78,880	\$118,320	\$15,756	\$78,780	\$157,560	\$236,340						
Total	\$1,287	\$6,435	\$12,870	\$19,305	\$6	\$30	\$60	\$5,172	\$25,860	\$51,720	\$77,580	\$16,150	\$80,750	\$161,500	\$242,250	\$57,800	\$289,000	\$578,000	\$867,000	\$80,414	\$402,070	\$804,140	\$1,206,210						

Maryland Statewide Data Tables

One-time capital investment of establishing a small, medium, or large-scale wood-based thermal system in Maryland				
	Employment	Labor Income (\$ 2025)	Value Added (\$ 2025)	Output (\$ 2025)
700 Tons/Yr				
Impact Type				
Direct	13	\$957,046	\$1,631,982	\$2,500,000
Indirect	2	\$169,601	\$314,075	\$536,543
Induced	4	\$242,543	\$477,394	\$739,469
Total	19	\$1,369,190	\$2,423,451	\$3,776,012
3,000 Tons/Yr				
Direct	16	\$1,190,565	\$2,030,185	\$3,110,000
Indirect	3	\$210,984	\$390,709	\$667,460
Induced	5	\$301,723	\$593,878	\$919,899
Total	23	\$1,703,272	\$3,014,773	\$4,697,359
5,000 Tons/Yr				
Direct	26	\$1,986,827	\$3,387,994	\$5,190,000
Indirect	4	\$352,092	\$652,019	\$1,113,864
Induced	8	\$503,519	\$991,071	\$1,535,137
Total	39	\$2,842,438	\$5,031,083	\$7,839,001

Maryland Recurring Annual Impacts Resulting From Operations of Wood-Based Thermal Energy Systems				
	Employment	Labor Income (\$ 2025)	Value Added (\$ 2025)	Output (\$ 2025)
700 Tons/Yr				
Impact Type				
Direct	0.1	\$2,500	\$2,500	\$60,250
Indirect	0.5	\$30,419	\$53,813	\$62,236
Induced	0.1	\$7,125	\$14,024	\$21,723
Total	0.7	\$40,044	\$70,337	\$144,210
3,000 Tons/Yr				
Direct	0.2	\$5,000	\$5,000	\$235,750
Indirect	1.9	\$119,304	\$217,474	\$244,991
Induced	0.4	\$26,976	\$53,095	\$82,243
Total	2.5	\$151,281	\$275,569	\$562,984
5,000 Tons/Yr				
Direct	0.4	\$12,500	\$12,500	\$394,750
Indirect	3.2	\$197,743	\$360,625	\$405,206
Induced	0.7	\$45,602	\$89,754	\$139,027
Total	4.3	\$255,844	\$462,879	\$938,983

State Recurring Annual Impacts Resulting From Operations of Wood-Based Thermal Energy Systems

		Labor Income (\$ 2025)					Value Added (\$ 2025)					Output (\$ 2025)				
		700 Tons/Yr														
Impact Type	Labor Income	5YR	10YR	15YR	Value Added	5YR	10YR	15YR	Output	5YR	10YR	15YR	Output	5YR	10YR	15YR
Direct	\$2,500	\$12,500	\$25,000	\$37,500	\$2,500	\$12,500	\$25,000	\$37,500	\$60,250	\$301,250	\$602,500	\$903,750	\$60,250	\$301,250	\$602,500	\$903,750
Indirect	\$30,419	\$152,095	\$304,190	\$456,285	\$53,813	\$269,065	\$538,130	\$807,195	\$62,236	\$311,180	\$622,360	\$933,540	\$62,236	\$311,180	\$622,360	\$933,540
Induced	\$7,125	\$35,625	\$71,250	\$106,875	\$14,024	\$70,120	\$140,240	\$210,360	\$21,723	\$108,615	\$217,230	\$325,845	\$21,723	\$108,615	\$217,230	\$325,845
Total	\$40,044	\$200,220	\$400,440	\$600,660	\$70,337	\$351,685	\$703,370	\$1,055,055	\$144,210	\$721,050	\$1,442,100	\$2,163,150	\$144,210	\$721,050	\$1,442,100	\$2,163,150
		3,000 Tons/Yr														
Direct	\$5,000	\$25,000	\$50,000	\$75,000	\$5,000	\$25,000	\$50,000	\$75,000	\$235,750	\$1,178,750	\$2,357,500	\$3,536,250	\$235,750	\$1,178,750	\$2,357,500	\$3,536,250
Indirect	\$119,304	\$596,520	\$1,193,040	\$1,789,560	\$217,474	\$1,087,370	\$2,174,740	\$3,262,110	\$244,991	\$1,224,955	\$2,449,910	\$3,674,865	\$244,991	\$1,224,955	\$2,449,910	\$3,674,865
Induced	\$26,976	\$134,880	\$269,760	\$404,640	\$53,095	\$265,475	\$530,950	\$796,425	\$82,243	\$411,215	\$822,430	\$1,233,645	\$82,243	\$411,215	\$822,430	\$1,233,645
Total	\$151,281	\$756,405	\$1,512,810	\$2,269,215	\$275,569	\$1,377,845	\$2,755,690	\$4,133,535	\$562,984	\$2,814,920	\$5,629,840	\$8,444,760	\$562,984	\$2,814,920	\$5,629,840	\$8,444,760
		5,000 Tons/Yr														
Direct	\$12,500	\$62,500	\$125,000	\$187,500	\$12,500	\$62,500	\$125,000	\$187,500	\$394,750	\$1,973,750	\$3,947,500	\$5,921,250	\$394,750	\$1,973,750	\$3,947,500	\$5,921,250
Indirect	\$197,743	\$988,715	\$1,977,430	\$2,966,145	\$360,625	\$1,803,125	\$3,606,250	\$5,409,375	\$405,206	\$2,026,030	\$4,052,060	\$6,078,090	\$405,206	\$2,026,030	\$4,052,060	\$6,078,090
Induced	\$45,602	\$228,010	\$456,020	\$684,030	\$89,754	\$448,770	\$897,540	\$1,346,310	\$139,027	\$695,135	\$1,390,270	\$2,085,405	\$139,027	\$695,135	\$1,390,270	\$2,085,405
Total	\$255,844	\$1,279,220	\$2,558,440	\$3,837,660	\$462,879	\$2,314,395	\$4,628,790	\$6,943,185	\$938,983	\$4,694,915	\$9,389,830	\$14,084,745	\$938,983	\$4,694,915	\$9,389,830	\$14,084,745

One-time tax revenue generated due to the establishment of small, medium, or large-scale wood-based thermal system in Maryland

Impact Type	Sub-County		County	State	Federal	Total
	Sub-County General	Special Districts				
700 Tons/Yr						
Direct	\$2,640	\$8	\$21,740	\$40,813	\$215,172	\$280,373
Indirect	\$3,016	\$15	\$17,298	\$24,116	\$39,969	\$84,414
Induced	\$3,683	\$18	\$21,380	\$30,605	\$58,188	\$113,873
Total	\$9,339	\$40	\$60,418	\$95,534	\$313,329	\$478,660
3,000 Tons/Yr						
Direct	\$3,284	\$10	\$27,045	\$50,771	\$267,674	\$348,783
Indirect	\$3,752	\$18	\$21,518	\$30,001	\$49,722	\$105,011
Induced	\$4,581	\$22	\$26,597	\$38,072	\$72,385	\$141,658
Total	\$11,617	\$50	\$75,160	\$118,844	\$389,781	\$595,453
5,000 Tons/Yr						
Direct	\$5,480	\$16	\$45,132	\$84,727	\$446,698	\$582,053
Indirect	\$6,261	\$30	\$35,910	\$50,065	\$82,976	\$175,243
Induced	\$7,646	\$37	\$44,386	\$63,535	\$120,797	\$236,401
Total	\$19,387	\$83	\$125,428	\$198,328	\$650,471	\$993,697

Maryland Recurring Annual Tax Revenue Resulting From Operations of Wood-Based Thermal Energy Systems

Impact Type	Sub County General (\$ 2025)	Sub County Special Districts (\$ 2025)	County (\$ 2025)	State (\$ 2025)	Federal (\$ 2025)	Total (\$2025)
	700 Tons/Yr					
Direct	\$116	\$0	\$851	\$1,499	\$6,583	\$9,050
Indirect	\$17	\$0	\$104	\$150	\$369	\$640
Induced	\$108	\$1	\$628	\$899	\$1,709	\$3,345
Total	\$242	\$1	\$1,583	\$2,548	\$8,662	\$13,035
3,000 Tons/Yr						
Direct	\$429	\$2	\$3,207	\$5,807	\$26,407	\$35,852
Indirect	\$59	\$0	\$354	\$506	\$1,165	\$2,084
Induced	\$410	\$2	\$2,378	\$3,404	\$6,472	\$12,665
Total	\$897	\$4	\$5,939	\$9,716	\$34,044	\$50,600
5,000 Tons/Yr						
Direct	\$701	\$2	\$5,268	\$9,571	\$43,816	\$59,360
Indirect	\$95	\$0	\$569	\$813	\$1,888	\$3,365
Induced	\$692	\$3	\$4,020	\$5,754	\$10,940	\$21,409
Total	\$1,489	\$6	\$9,857	\$16,138	\$56,644	\$84,134

APPENDIX B

Biomass Stream Numbers			
Stream No.	Component	Flow Rate	
		Value	Unit
1	Biomass	2272	kg/day
2	Diesel	1.3	L/day
3	CO2	-3.74	kgCO2/FU
4	Biomass	2272	kg/day
5	Diesel	0.6	L/day
6	CO2	0.013	kgCO2/FU
7	Biomass	2272	kg/day
8	Diesel	3	L/day
9	CO2	1.296	kgCO2/FU
10	Biomass	2158	kg/day
11	Diesel	17	L/day
12	CO2	0.066	kgCO2/FU
13	Biomass	2158	kg/day
14	Biomass	2158	kg/day
15	Electricity	0.075	MJ/day
16	CO2	0.088	kgCO2/FU
17	Biomass	2158	kg/day
18	Electricity	0.005	MJ/day
19	CO2	0.001	kgCO2/FU
20	Biomass	2158	kg/day
21	Electricity	1,000	kWh/day
22	Heat	11503655	kJ/day
23	Biomass	2158	kg/day
24	Electricity	1	MJ/day
25	Emissions	4229	kgCO2/FU

Fuel Oil Stream Numbers			
Stream No.	Component	Flow Rate	
		Value	Unit
1	Fuel Oil	0.1	tonne/day
2	Diesel	50	L/day
3	CO2	100	kgCO2/FU
4	Crude Oil	479	kg/day
5	Diesel	70	tonne/day
6	CO2	2.646	kgCO2/FU
7	Crude Oil	479	kg/day
8	Diesel	2	L/day
9	CO2	0.864	kgCO2/FU
10	Fuel Oil	321	kg/day
11	Diesel	175	L/day
12	CO2	75.6	kgCO2/FU
13	Fuel Oil	321	kg/day
14	Diesel	35	L/day
15	CO2	1.323	kgCO2/FU
16	Fuel Oil	321	kg/day
17	Electricity	1,200	kWh/day
18	Heat	11503665	kJ/day
19	Fuel Oil	321	kg/day
20	Electricity	1	MJ/day
21	Emissions	1001	kgCO2/day

APPENDIX C

Detailed COMAR Emission Standards for Biomass-Fueled Boilers (26.11.09.12)

This appendix provides a detailed summary of Maryland’s air quality and emissions requirements for woody biomass combustion units as established in the Code of Maryland Regulations (COMAR) 26.11.09.12 – Standards for Biomass Fuel-Burning Equipment Equal to or Greater Than 350,000 Btu/hr. These standards are administered by the Maryland Department of the Environment (MDE) and ensure that biomass energy systems operate in compliance with state and federal Clean Air Act requirements.

Emission limits vary by equipment capacity (measured in million British thermal units per hour [MMBtu/hr]) and region. The tables below summarize the primary regulatory thresholds for particulate matter (PM), Nitrous Oxide (NO_x), and common control technologies which apply to most institutional- and community-scale biomass systems.

Table B-1: COMAR 26.11.09.12 – General Emission Standards for Biomass Fuel Combustion Units

Boiler Size	Particulate Matter (PM)		Nitrous Oxide (NO _x)	
	≥10 million Btu/hr	0.03 lb/MMBtu if total heat input capacity is <30MMBtu/hr	0.07 lb/MMBtu if total heat input is ≥ 30MMBtu/hr	0.25 lb/MMBtu if heat input is > 250 MMBtu/hr
>1.5 MMBtu/hr – 10 MMBtu/hr	0.1 lb/MMBtu heat input in Areas III and IV	0.23 lb/MMBtu heat input in Areas I, II, V, and VI	0.30 lb/MMBtu heat input	
350,000 Btu/hr – 1.5 MMBtu/hr	0.1 lb/MMBtu heat input in Areas II and IV	0.35 lb/MMBtu heat input in Areas I, II, V and VI	0.30 lb/MMBtu heat input	

Source: Maryland Department of the Environment, COMAR 26.11.09.12 (n.d.).

Table B-3: Common Control Technologies and Compliance Strategies for Biomass Systems

Control Technology	Primary Function	Typical Reduction Efficiency	Applicability
Multicyclone Separator	Reduces particulate matter (PM) emissions	70-90%	Most common for small- and medium-scale boilers (<20 MMBtu/hr).
Fabric Filter (Baghouse)	Removes fine particulate emissions	95-99%	Standard for larger installations or where PM limits are stringent.
Electrostatic Precipitator (ESP)	Captures submicron particulates	95-99%	Typically used for industrial or district-scale systems.
Oxygen Trim Control	Optimizes combustion efficiency and CO reduction	Variable	Used across most modern biomass systems to maintain clean combustion.
Automated Combustion Controls	Balances fuel feed and air input	Variable	Reduces CO and opacity during load changes.

Source: Adapted from U.S. Department of Energy, Biomass Energy Resource Center, and Maryland Department of the Environment (2024).

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