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BIOMASS ELECTRICITY GENERATION IN NEW HAMPSHIRE

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PRESENTED TO THE NEW HAMPSHIRE HOUSE COMMITTEE ON SCIENCE, TECHNOLOGY, AND ENERGY

Rep. Michael Vose, Chair

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EXECUTIVE SUMMARY

In a world increasingly impacted by warming temperatures and climate change, utility companies have been working to develop new forms of renewable energy that do not emit greenhouse gases. In heavily forested areas, such as New Hampshire, wood may be a viable alternative to fossil fuels for electricity generation. Thus, biomass could serve as a potential bridge fuel for the transition between carbon-intensive forms of energy, such as coal and oil, and renewables.

We decided to perform an economic analysis of case studies in our research. By extracting data from wood power plants in these areas, as well as from national and New Hampshire sources, we hoped to be able to find a cost estimate to operate plants in the state. Although we were unable to collect enough data to calculate a levelized cost of energy, the most accurate method of determining feasibility, we were able to compare fuel costs, which is one of the most influential factors in determining the ultimate cost of energy. Through our research, we determined that without any subsidies, biomass is not only unlikely to be cost-competitive with other energy sources, but it is also unlikely to be profitable.

1 INTRODUCTION

In late October of 2022, professor emeritus Andrew Friedland of Dartmouth College authored an opinion column on wood-fired electricity generation to the *Valley News*. He argued that wood-fired or wood biomass electricity has "hidden costs" from emissions that make it the wrong choice for the Upper Valley, Vermont, and New Hampshire.[1] Days later, professor emeritus Ben Steele of Colby-Sawyer College responded to Friedland's column. He noted instead that biomass plants have managed these emissions, and that—to reduce a global reliance on fossil fuels—sustainably harvested biomass electricity should be part of the electrical generation mix.[2]

Clearly, the debate over biomass electricity is ongoing within the sciences. That said, assuming it is technically feasible, how does biomass fare economically? Are these plants able to provide baseline power to customers while also being profitable? Before this work proposes a research plan to answer these questions, a background on biomass electricity must be provided.

In this paper, we are interested in identifying the short-term economic viability of running biomass power plants as a base load power course. To accomplish this goal, we collected national and New England-centric data on wood power plants in order to find a cost estimate to operate biomass plants compared to other fuel sources. The case studies we undertake include the Bridgewater power plant in New Hampshire, the McNeil power plant in Vermont, and Maine biomass data.

2 METHODOLOGY

To acquire the information we need, we conducted expert interviews of biomass plant operators, members of regulatory agencies and utilities, and other stakeholders. During our research process, we interviewed biomass plant operators from Vermont and New Hampshire, as well as the senior planner in the Energy Office of the Governor of Maine. Through these interviews, we collected data about sources of revenue and the costs of operation of wood biomass power plants in the Northeast. We also asked about their outlook for biomass electricity to try to get a sense of how confident they were in the sustainability of such power plants. Once we had collected the data from publicly available data sources like the U.S. Energy Information Administration (EIA), we compared the data we received to the costs associated with other types of electricity generation.

3 INTRODUCTION TO BIOMASS

What is biomass? "Biomass" refers to any plant or plant-derived material that can be converted into energy. This includes not only wood, but also agricultural residues, municipal solid waste, and gas extracted from landfills.[3] These products can be burned to produce heat that powers electric generators or processed into biofuels for transportation applications. Biomass is converted to energy through various processes including direct combustion (burning to produce heat), thermochemical conversion (to produce solid, gaseous, and liquid fuels), chemical conversion (to produce liquid fuels), and biological conversion (to produce liquid and gaseous fuels).[4] However, direct combustion is the most common form of conversion. In 2021, biomass provided 4,835 trillion Btu to the United States—about five percent of the national energy consumption.[5] Only nine percent of this energy (435 trillion Btu) went towards generating electricity, and only 2.8 trillion Btu of that electricity came from New Hampshire biomass.[6]

Biomass plants operate in a similar fashion to coal plants, extracting and transporting a resource to a central location to burn for electricity generation. In the case of biomass, "low-grade wood" that would otherwise be undesirable is cut down by loggers, or "waste wood" is procured from sawmills or other wood processing facilities. This wood is then processed into pellets or wood chips and stored until it can be burned. Biomass power is currently 25-30 percent efficient; only this amount of the total fuel energy is converted into electricity.[7] Although other sources of energy are not much more efficient, biomass is still slightly less efficient. For example, nuclear energy powers more than 50 percent of New Hampshire's electricity, and is 34-36 percent efficient, while newer plants can be up to 39 percent efficient.[8] However, efficiency can be improved through combined cycle generation or by using the waste heat for buildings in a system called "combined heat and power" (CHP).[9]

This section will cover the use of wood biomass as an electricity source in the United States, the current state of biomass in New Hampshire, how the costs of these operations compare to those for other energy sources, the economics of biomass electricity, and finally present a key economic formula to measure the viability of biomass electricity.

3.1 BIOMASS IN THE UNITED STATES

Existing research within the United States suggests that biomass is not profitable without a subsidy of some form. Indeed, a 2018 report created for the state of New Hampshire found that Class III (existing before 2006) biomass was less competitive than other renewable energy sources.[10] The New Hampshire Portfolio Standard (RSA 362-F) also requires utilities to purchase Renewable Energy Certificates (RECs) from a certain number of renewable energy providers.[11] Despite this requirement, plants are dependent on subsidies to remain in the energy utility market, as evidenced by the plant closures that followed an elimination of previous subsidies in 2019.[12]

The aforementioned report does not investigate the economic viability of new biomass facilities that began operating in 2006 or later. With the newest technology improvements, biomass electricity may be cost-competitive. Wood-fired biomass power also exists in other parts of the United States, especially areas with similar forest cover to New Hampshire. Furthermore, biomass electricity in Europe has shown great economic promise, with nearly 50 percent of the renewable energy in the European Union coming from biomass sources.[13]

Through our research, we identified neighboring states as ideal case studies that currently have biomass plants in operation. Vermont and Maine are both heavily forested Northeastern states that are very close to New Hampshire. Vermont’s Renewable Energy Standard has encouraged the development of wood biomass power plants as a source of local and renewable energy.[14] Meanwhile, wood fuel is cheaper than other sources of fuel for Maine, causing this state to have the lowest average energy retail price in New England.[15] In New Hampshire, biomass has unfavorable market dynamics that have discouraged investors from focusing on it as much as on competing resources. Fuel costs equal almost 70 percent of biomass plant revenues, posing a substantial expense for facilities and driving up the price of generated electricity.[16]

3.2 BIOMASS IN NH

According to the EIA, New Hampshire consumed 347 trillion Btu of energy in 2020. More than 50 percent of New Hampshire's electricity generation comes from nuclear sources and another quarter comes from natural gas.[17] Other sources such as biomass, hydropower, wind, and coal make up the last quarter of electricity generation. Only six percent of the energy production in the state currently comes from biomass.[18] However, according to the EIA, there is a potential for biomass production in the state. Wood is the chief support for New Hampshire's biomass production in terms of power generation and space heating, with 7.1 percent of homes using wood as their primary heating source. Forests cover over 80 percent of the state and this wood and wood waste from the forest industry provides 86 percent of the biomass-fuel generation in the state.[19]

Fuel Type	Energy Consumption Estimate (Tril. Btu)
Nuclear Electric Power	103.1
Motor Gasoline Excluding Ethanol	68.9
Natural Gas	53.6
Distillate Fuel Oil	44.6
Biomass	34.4
Combined Consumption of Other Fuel Sources	42.4

Table 1: New Hampshire energy consumption in 2020.

3.3 COMPARING FUEL COSTS

To understand fully if biomass is economically viable compared to other energy sources, it is important to compare the fuel costs of these other sources—both non-renewable and renewable—to determine how they compare to biomass. In the field of energy production, fuel costs are often the greatest expense for power plants, and fluctuations in the price of feedstock can significantly influence the cost of the electricity being produced.

Fuel Source	Biomass	Natural Gas	Coal
Average Fuel Cost in New Hampshire	\$18.50-\$32/ton	\$7.64/thousand cubic feet	Lack of data in New Hampshire: Coal no longer supplies base load power for the state, but the Merrimack power plant will operate intermittently to provide electricity on high demand days.[20]
US Average Fuel Cost	\$28-\$33/dry ton[21]	Natural Gas (CNG): \$2.88/GGE (gallon of gasoline equivalent) Liquefied Natural Gas: \$3.63/DGE (diesel gallon equivalent)[22]	\$36.50/short ton

Table 2: Comparison of fuel costs of various energy sources.

In New Hampshire, the average price of wood for biomass electricity generation is around \$18.50-\$32 per ton. Dry wood is produced by stacking freshly cut lumber for a few years before burning it in order to decrease its moisture content. Usually, one ton of dry wood is expected to generate one MWh of electricity.[23] Natural gas in New Hampshire usually costs about \$7.64 per thousand cubic feet. Producing one MWh of electricity requires the combustion of about 7,600 cubic feet of natural gas.[24] The data in Table 2 from the EIA shows that biomass electricity has slightly lower fuel costs than natural gas. It usually takes $18.50-$32 of wood to produce one MWh of electricity; whereas the natural gas required to produce the same MWh would cost around $58.06.[25]

3.4 ECONOMICS OF BIOMASS ELECTRICITY

Preliminary analysis reveals many costs to consider in the economics of wood-fired biomass electricity production. The cost of energy from biomass is determined by the cost of the wood fuel, the cost of building and maintaining the power plant, and the revenues of any additional products or subsidies that offset these costs.

Beginning from the bottom up, the cost of wood feedstock is highly variable. For instance, the New Hampshire report on the economic viability of Class III biomass provides a value of one to two dollars per million Btu, but also shows that this price has fallen sharply since 2016 (see Table 3).[26] Meanwhile, a study on the price of biomass feedstock in Maine estimated an average cost of $11 per green ton of wood, but noted that the low and high estimates were $4 and $24, respectively.[27] Yet another source estimates a price between $30 and $40 per ton of wood, but this price increases with other manufacturing considerations.[28] Thus, as Dana Doran of the Professional Loggers of Maine explained, wood prices fluctuate in accordance with natural gas prices that influence competition and demand for alternate sources of energy.[29]

Tons of Chips Produced from Timber Sales on State Lands Managed by the NHDFL

Fiscal Year	Operational Harvests	Harvests w/ Chipping	Tons of Chips Removed	Gross Value of Chips	Average Price Per Ton
2016	19	10	20,219	$91,703.93	$4.54
2017	18	11	36,878	$93,425.43	$2.53
2018	20	16	40,021	$66,292.86	$1.66

Table 3: Wood chip production from lands managed by the New Hampshire Division of Forests and Lands.[30]

The costs of plant construction and maintenance are also highly variable but tend to be higher than the costs of other energy sources relative to their output. The EIA reported a generator construction cost of $2,886 per kWh of installed capacity, far higher than other sources as shown in Figure 1.[31] The New Hampshire Economic Viability report in 2018 instead provided construction costs between $1,700 and $4,000 per kWh of capacity (higher than the wind or solar costs), with fixed operation and maintenance costs of $50 and variable costs of $10. Yet again, price estimates come in large ranges, but it is notable that even the low values for biomass are above the high values for other energy sources.

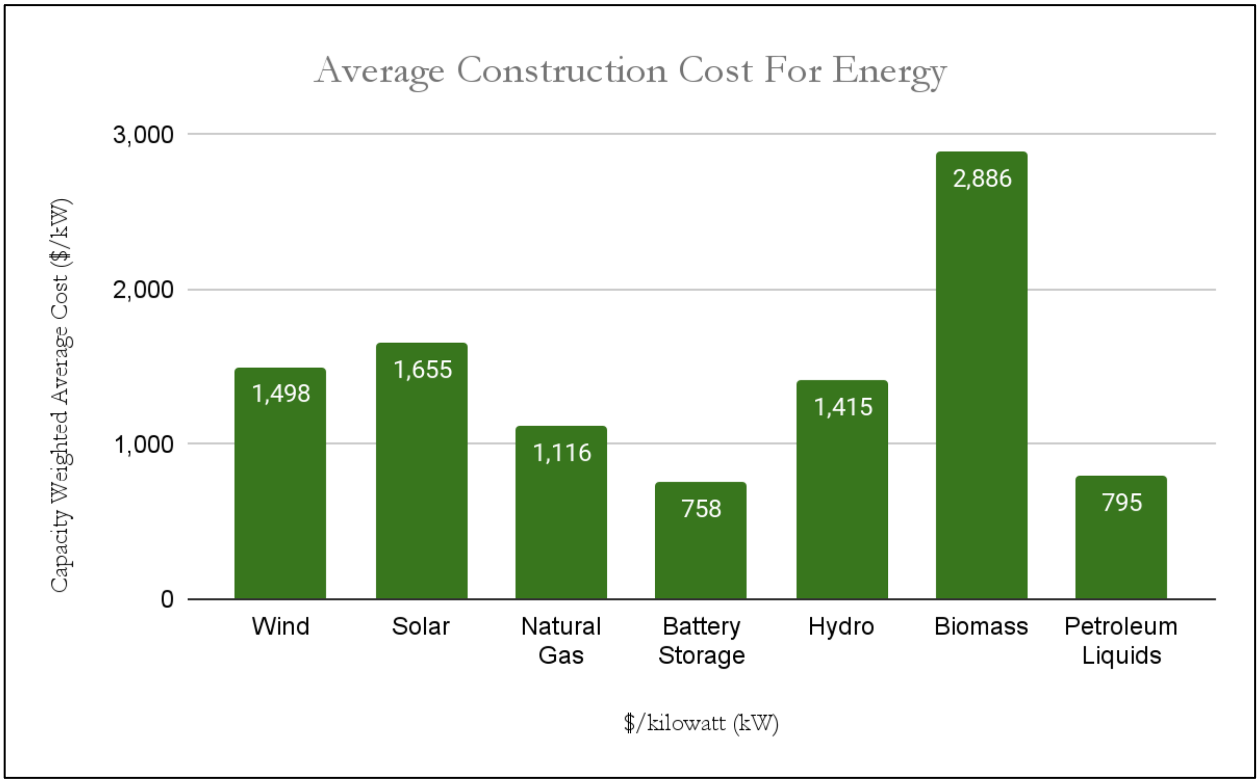

Figure 1: Capacity-weighted average construction cost for various forms of energy generation.[32] **Derived from EIA Data*

Finally, reported revenues from CHP generation are difficult to find, and subsidies are reported as relatively high. CHP from biomass is far more efficient than only making electricity, but the amount of heat generated is dependent on the size of the power plant and installing the heating infrastructure would require greater construction costs.[33] Meanwhile, Figure 2, sourced from the New Hampshire Study on the economic viability of a renewable portfolio in 2018, shows the monthly cost of subsidizing biomass power between 2012 and 2017, which remains around an additional $40/MWh. Since the market price of energy is around $40-50/MWh at the same time, the necessary subsidy in New Hampshire was nearly double the price of energy at $79.26 MW.[34] However, this finding highlights that there have been times when the wholesale price of electricity has exceeded the subsidy in winter peak months such as during the 2014 "polar vortex," which led to capacity constraints.[35] As extreme weather situations continue to occur, these demand spikes remain likely. More generally, this data, based on historical ISO New England (ISO-NE) price trends, displays variability between 2012 and 2017. There are a couple reasons for this. ISO-NE attributes winter peaks and declines to "insufficient pipeline and storage capacity" issues in the winter. Even in California, the difference in energy prices is more drastic, contributing to ratepayers subsidizing biomass at nearly $150/MWh.[36]

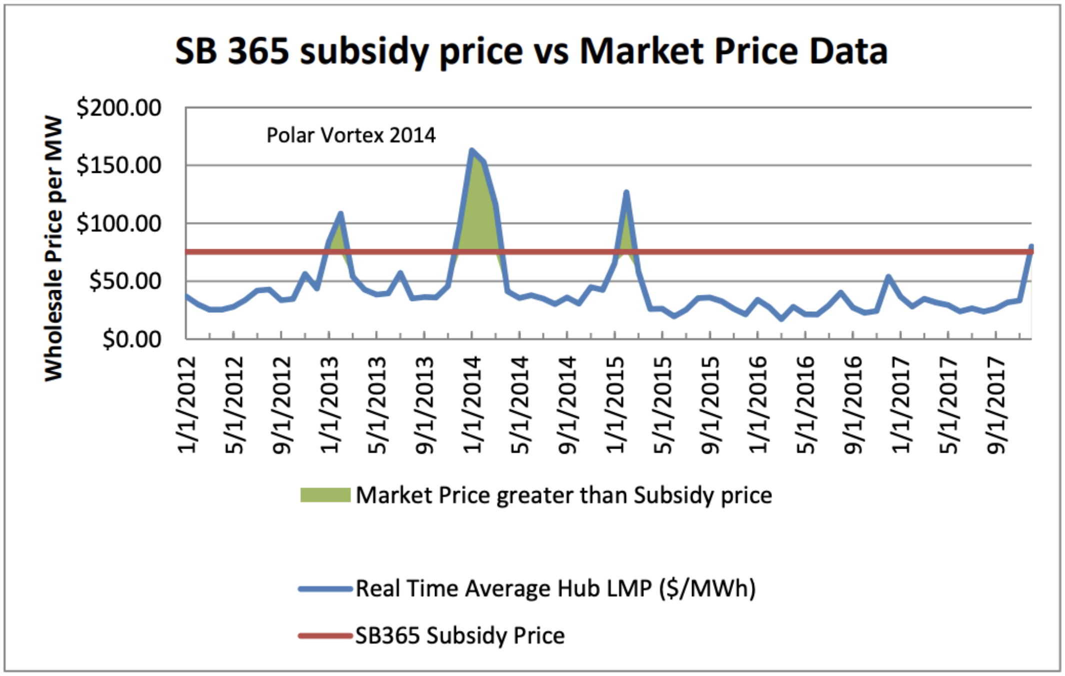

Figure 2: Hub Locational Marginal Price of Electricity Compared to the Subsidy Price[37]

3.5 LEVELIZED COST OF ENERGY CALCULATION

A key metric used to determine viability of biomass electricity is the levelized cost of energy (LCOE). LCOE provides a minimum price for energy on a per unit basis by considering the capital expenditures, operational expenditures, material prices, revenues, and co-products of an energy production process.[38] LCOE is therefore given in $/kWh, and is defined by the following equation:

$$LCOE = \frac{CRF * TPI}{PP} + \frac{OPC}{PP} + \frac{FC}{PP} - \frac{CPC}{PP}$$

where:

$CRF = \frac{i(1+i)^n}{(1+i)^n - 1}$ = capital recovery factor

(i = interest rate)

(n = years of project lifetime)

TPI = total project investment

PP = product produced annually

OPC = operational costs annually

FC = feedstock costs annually

CPC = co-product credits annually

Co-product credits include renewable energy certificates (RECs) and subsidies of any form, as well as revenues from co-generated heat or other products. If the LCOE of a project is determined to be below the market price for electricity, then the project is considered to be cost-competitive without subsidies. If the LCOE of a project is below the LCOE of other forms of energy, then the project is considered to be the most favorable and profitable.

National financial advisory and asset management firm Lazard assessed the national LCOE for renewable and conventional energy sources without subsidies and found that only specific forms of renewable energy (solar and wind) resources are cost competitive with fossil fuels.[39] However, it is crucial to note that environmental, regional, and topographical factors can affect this data. (See Figure 3 below.)

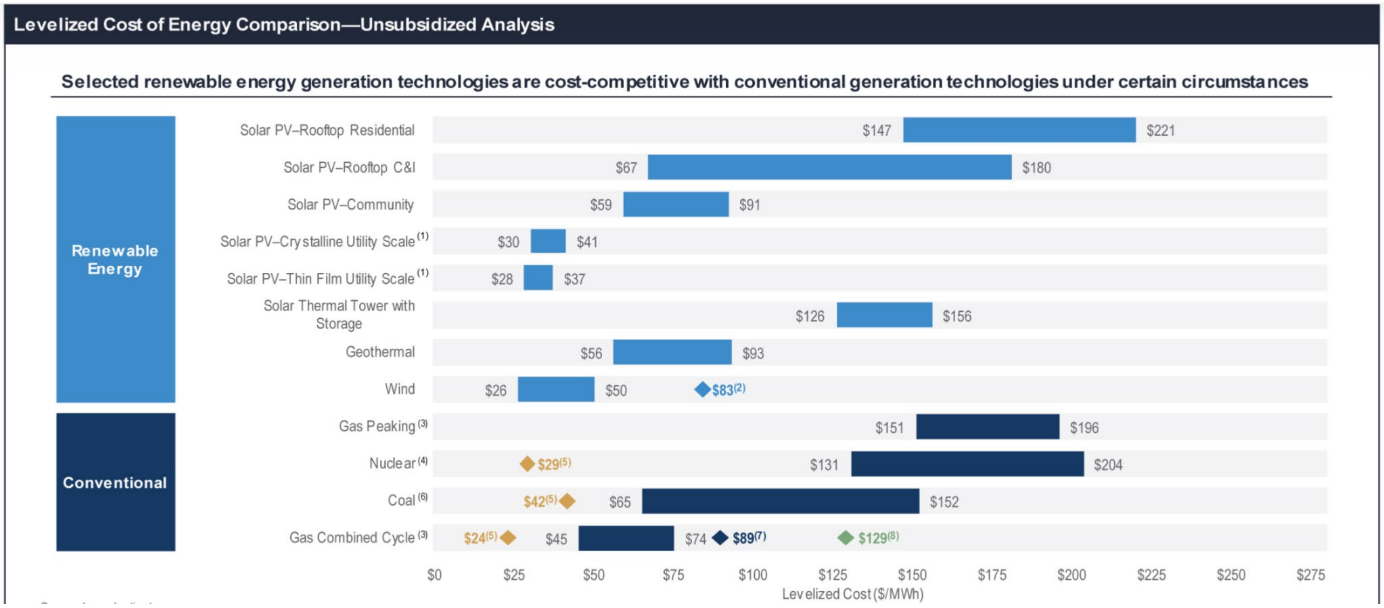

Figure 3: Levelized Cost of Energy Comparison – Unsubsidized Analysis [40]

This analysis couples with the findings of the New Hampshire 10-Year Energy Strategy released by the New Hampshire Department of Energy in July 2022, which found that renewable sources like biomass cannot maintain "competitiveness" in regional electricity markets without state intervention.[41] The report mentions that several biomass facilities have recently shut down or suspended their operations and ISO-NE., the state's non-profit Regional Transmission Organization, only projects 8MW coming from biomass facilities based on the ISO-NE Generator Interconnection Queue in February 2021.[42]

We do note, however, to determine the actual LCOE of New Hampshire biomass, the values of all of the inputs to the equation must be determined. Unfortunately, we were unable to obtain capital expenses from our research, preventing us from being able to complete the equation.

4 CASE STUDIES

By looking at the costs of plants in Vermont, New Hampshire, and Maine and the price of the electricity they produce and comparing them to the data we extract from sources such as the EIA, we can try to adapt these numbers to New Hampshire specifically to determine if scaling up biomass production in the state is feasible.

4.1 CASE STUDIES

For this project, we conducted case studies of wood biomass power plants that are currently in operation. We researched the plants and the costs associated with their operation. Our focus was on Vermont, Maine, and New Hampshire.

4.1.1 VERMONT

The first possible state to use as a case study we explored was Vermont, due to its proximity and similar topography. Vermont is a heavily forested state that is in the same Northeast region as New Hampshire, with a similar climate, population density, and energy demand. The Vermont Renewable Energy Standard (RES) that was implemented in 2015 mandates that all retail electricity suppliers obtain 75 percent of their annual electricity from renewable sources by 2032.[43] To meet the RES goal, Vermont has turned to its forest resources as a source of wood biomass. More than 20 percent of the net energy production in the state comes from burning biomass.[44]

We reached out to officials at the McNeil Generating Station located in Burlington for information about facility capacities and costs. At full capacity, McNeil burns 76 wet tons of wood chips (chips that have not been left out to dry before combustion) per hour to generate 50 megawatts of electricity. The wood fuel costs the plant between $22 and $33 per ton if delivered by truck. Delivery by rail and extra handling adds about seven dollars per ton.[45] McNeil's fuel costs in the last two audited fiscal years have ranged between $56.50 and $62.20 per MWH, with the more recent value being the higher number. These costs are inclusive of truck and rail transportation as well as including ancillary fuel uses such as startup and fuel costs related to wood handling at the plant. Net operating costs, including transportation, for the last two fiscal years have ranged between $91 and $101 per MWH, with the more recent value being the higher number.

Beyond these operating, fuel, and transportation costs, we also asked the McNeil plant managers about other costs and impacts to the production of biomass such as subsidies. They explained that the Joint Owners do not pay transmission fees and receive some federal and state subsidies. One such program is the federal Renewable Electricity Production Tax Credit, an inflation-adjusted tax credit per-kilowatt-hour of electricity generated. Vermont provides a similar tax credit to facilities through its Renewable Energy Systems Sales Tax Exemption that applies to systems with up to 500 kilowatts of capacity that generate electricity using renewables.

When asked about the long-term outlook for biomass, McNeil remains positive. The plant's representative explained that "biomass remains a key renewable resource and Burlington Electric Department (BED) pursues sustainable harvesting practices using an on-staff team of foresters. Some debate about the relative carbon benefits occurs from time-to-time, but BED believes that sustainably harvested biomass is far superior to any other dispatchable that would likely replace it in New England at this time (i.e., oil/natural gas)."[46]

4.1.2 NEW HAMPSHIRE

New Hampshire is a heavily forested state. These dense forest resources make wood biomass seem like an appealing candidate as an energy source. Currently, biomass is the only renewable source of energy that can be burned as a base load power source. Power plants for other forms of renewable energy must pay for increased capacity on their systems when they cannot operate. However, New Hampshire has a much lower renewable portfolio standard than any other New England state, requiring that 23.4 percent of the state's electricity is generated by renewables in 2023.[47] This amount will increase to 25.2 percent by 2025. This creates less of an incentive to develop biomass resources in lieu of more traditional base load power sources. There are currently ten biomass plants in operation in New Hampshire. Figure 4 lists them below.

Biomass Plant	Fuel
Burgess BioPower	Wood
Stored Solar Whitefield	Wood
Stored Solar Bethlehem	Wood
Stored Solar Tamworth	Wood
Bridgewater Power	Wood
Stored Solar Springfield	Wood
Wheelabrator Concord	Mun. Waste
Turnkey Landfill	Landfill gas
UNH 7.9 MW	Landfill gas
Nashua Plant	Landfill gas

Figure 4: Biomass plants in operation in NH[48]

Mike O'Leary, the general manager of the Bridgewater Power Plant, explained that biomass power plants receive three main revenue streams, although he did not quantify these amounts for Bridgewater. They are able to sell their energy by the kilowatt hour generated and they receive money per kilowatt-month of their capacity as well. In addition to this, the plant receives one renewable energy credit per megawatt generated.

Due to the costs of maintaining the plant, all three revenue streams are required to keep a biomass plant viable. At Bridgewater, fuel costs between $18.50-$32 per ton. Labor costs $2,350,000 in wages, benefits, FICA, and Workers' Compensation costs, as well as $18-20 per megawatt of full base load output. O'Leary explained that Bridgewater pays about $2.5 million in other operations and management as well as general and administrative costs.[49]

4.1.2 MAINE

We reached out to Lisa Smith, the Senior Planner of the Governor's Energy Office (GEO) in Maine. Smith has facilitated and participated in biomass advisory boards, making her a useful contact for this project.

Smith explained that generally, without any kind of subsidies or policy help to lower costs or raise revenues, wood biomass is not profitable. Due to the volatility of prices, the estimated total revenues of biomass plants in Maine fall between $18 to $21 million. However, the estimated total costs of operation are usually between $20 to $22 million.[50] While there is a small window where biomass has the potential to be profitable, generally it does not fall within this range, especially without policy intervention either to lower costs or to raise revenues.

Smith also directed us to reach out to Eric Kingsley. Kingsley is the Vice President of Innovative Natural Resource Solutions LLC, a forest and natural resource consulting firm that was contracted by Maine GEO to conduct an analysis of the energy and environmental economics of Maine's biomass industry in 2017.

Kingsley explained some of the sensitivities of wood biomass electricity generation to price volatility. He shared a 2002 report developed for the New Hampshire Department of Resources and Economic Development explaining that to break even, biomass plants must sell their electricity at $0.0542 per kilowatt hour. They must also buy their fuel at less than $10.08 per ton.[51] However, when looking at capital costs, plants will always operate at a deficit. As a result, Kingsley agreed with Smith that without policy intervention, it will be difficult for biomass plants to stay open. This is especially applicable to most of New Hampshire's plants, as they are smaller than average in the Northeast region, apart from Burgess Biopower in Berlin.[52]

In addition, Kingsley shared some reports that detailed the additional ways in which wood biomass has a positive economic impact through its support of the timber industry. For the foreseeable future, there is no other market to consume the roughly 1.3 tons of low-grade wood and by-products produced annually by Maine timber and sawmill industries.[53] When biomass operations are scaled back or the quality of timber harvested is increased, the state experiences a loss of open space and a loss of logging infrastructure and employment as the property value of forested land drops.

4.2 WHY BIOMASS IS NOT CURRENTLY FEASIBLE IN NH

All three of these states share a similar climate, high forest cover, population density, and energy demand. However, what generally separates them is their renewable energy standards and subsidies that they offer energy providers. All three states also have unique class distinctions. To start off, New Hampshire's renewable portfolio standard (RPS), established in 2007, has a requirement for its electricity providers to obtain Renewable Energy Certificates (RECs) equivalent to 25.2 percent of retail electricity sold to end-customers by 2025.[54] Of that total requirement, 8.0 percent falls under the Class III distinction. Instead of meeting these requirements, a provider can also pay into the renewable energy fund as an alternative compliance payment.[55] The Class III alternative payment was $55.00/MWh in 2018. The New Hampshire Public Utilities Commission adjusts these payments on an annual basis. Biomass also falls under a Class I distinction (New Renewable Energy) if the generator began operation after January 1, 2006.[56] The total Class I RPS obligation will be 15.0 percent by 2025. Following the establishment of the Renewable Portfolio Standard, New Hampshire S.B. 51 (enacted in June 2017) established a committee to study subsidies for energy projects. The studies from this bill are referenced throughout this paper (such as *The Study on the economic viability of renewable portfolio standard Class III biomass electric generation resources in New* Hampshire) and found that high and consistent subsidies for the biomass industry would be needed to work with New Hampshire's renewable portfolio standard.[57] This low renewable portfolio energy standard has deterred the biomass industry from taking off.

On the other hand, Vermont's Renewable Energy Standard, established in 2015, does not have any distinctions for when a facility began operations. Even though the state has a much higher standard, requiring 55 percent of its energy to come from renewable sources in 2017, it states that the Vermont electric distribution utilities (DU) "procure a defined percentage of their retailed electric sales from new distributed renewable generation," which are plants that have a capacity of 5W or less and are directly connected to a DUs sub-transmission or distribution system.[58] This system allows for flexibility in the Vermont renewable portfolio standard. Similarly, Maine has high standards. It requires that 80 percent its electricity must be supplied by renewable sources by 2030. Maine requires that 30 percent of its load must be "satisfied" by renewable electricity generation existing in 2019 (Class II) and 10 percent must be satisfied by new renewable resources (Class I) and increasing amounts of Class IA and thermal renewable energy credits.[59] Thus, both states have higher standards for renewable energy production. Because both Vermont and Maine require that such a high portion of their energy portfolio come from renewable sources and biomass is in excess because of the high forest cover in their respective states, they also facilitate a process for biomass with state assistance. These considerations could potentially point to why New Hampshire struggles more with supporting biomass production and will likely continue to do so.

5 CONCLUSION

As New Hampshire is committed to a renewable portfolio standard, it may need to seek alternative energy sources in order to generate its electricity more cleanly and sustainably. With the state's vast forest resources, wood is a possible alternative to traditional fossil fuels. However, adopting a new fuel source in the state's energy portfolio generates questions of its viability and cost.

To examine the economic costs associated with the potential integration of wood biomass into New Hampshire's energy portfolio, we collected data from already existing power plants in Vermont and New Hampshire. We combined the data from these case studies with information provided by the Maine Governor's Energy Office to determine whether biomass is a viable source of electricity. With the information we were able to collect, we found that without policy intervention such as subsidies, biomass is likely not a profitable venture.

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