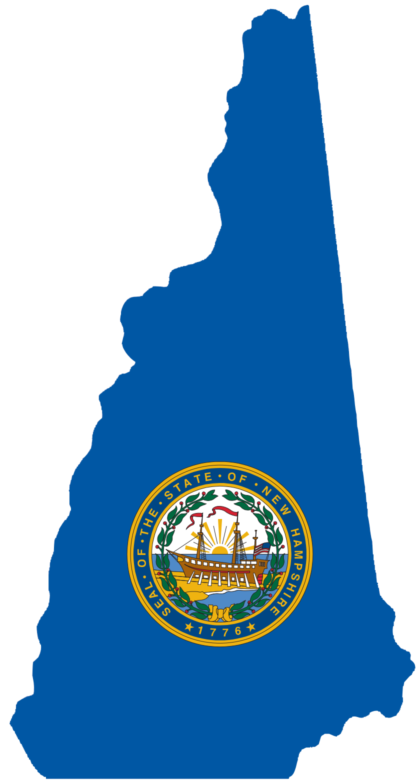
STATE OF NEW HAMPSHIRE

Study Pursuant to New Hampshire Chaptered Law 156:228 (2017)



Study on the economic viability of renewable portfolio standard Class III biomass electric generation resources in New Hampshire.

New Hampshire Office of Strategic Initiatives

12/1/2018

NEW HAMPSHIRE OSI OFFICE OF STRATEGIC INITIATIVES

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Preface

This study was written and designed as an overview of the viability of biomass feedstocks as part of the regional electric grid managed by ISO New England and New Hampshire's energy mix. Data used in this report has been peer-reviewed and published in leading industry, nonprofit, or government sources. All data included is the latest data available if published in a recurring series.

In producing this study for the New Hampshire General Court, the New Hampshire Office of Strategic Initiatives (OSI) met with a wide array of stakeholders including energy producers, utilities, manufacturers, advocacy organizations, and industries directly impacted by biomass. The purpose of this document is to inform the General Court of the current state of the biomass industry, including internal and external pressures that are currently or likely to affect the biomass industry.

In alignment with the 10 Year State Energy Strategy, any policy recommendations included in this report are technology neutral, promote a secure, reliable, and resilient energy system, and prioritize cost-effective energy policies.[1] It should be noted that the principle purpose of this report is to provide information and not recommend a specific policy solution.

Statutory Requirement

As enacted by HB 517 (2017), *an act relative to state fees, funds, revenues, and expenditures,* and chaptered under 156:228 (2017):

> *"Study required; Office of Strategic Initiatives. By December 1, 2018, the office of strategic initiatives, formerly the office of energy and planning, shall produce a study on the economic viability of electric renewable portfolio standard Class III biomass electric generation resources in New Hampshire. The study shall be filed with the senate president, the speaker of the house of representatives, the governor, and the state library, and:*
>
> *i. Shall analyze at what wholesale electricity rate the majority of New Hampshire Class III biomass facilities would be able to operate economically without reliance on other ratepayer-funded revenue mechanisms;*
>
> *ii. Shall assess the number of jobs and economic activity directly attributable to the operation of biomass plants, including only such economic activities or wood product resources that have no alternate use other than purchase by or relation to a Class III biomass plant; and*
>
> *iii. May compile the ratepayer costs attributable to Class III biomass plants beyond the wholesale electricity commodity cost from 2014 to 2017."* [2]

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[1] N.H. Office of Strategic Initiatives, *10 Year State Energy Strategy* (Concord, NH, 2018), 5 https://www.nh.gov/osi/energy/programs/documents/2018-10-year-state-energy-strategy.pdf

[2] *An Act relative to state fees, funds, revenues, and expenditures,* NH Laws of 2017 Chapter 156:228.

Stakeholders

New Hampshire's energy policy impacts all residents in New Hampshire as well as those in neighboring states who are served by the grid operator ISO New England. This report primarily focuses on the independent biomass plant operators in New Hampshire. While they are one industrial stakeholder, this report serves a legislative charge that impacts both electricity generators and end-users across the state of New Hampshire.

Disclaimer

The content of this study is not ordered or numbered with respect to any form of policy preference. The facts of this study are outlined to better inform policymakers with respect to the continued use of biomass feedstocks in New Hampshire. Numbering used in this report is solely used as a means of labelling and not prioritization.

Key Assumptions

The analyses conducted in this report are accurate as of its publication and submission to the New Hampshire General Court. Forward-looking predictions are subject to changes in both state and federal laws, rules, and regulations that may have a material effect on electricity generating resources. Forward-looking modeling maintains a baseline of 2018 or the latest year of available data.

Modeling Capabilities

Modeling included in this report used a variety of data sources and advanced modeling software, including Regional Economic Models, Inc. (REMI). Additional calculations and forecasts were executed in Microsoft Excel. Previous analyses specific to the biomass industry are also considered as a baseline.

Acknowledgements

This study was researched and written by Matthew Mailloux. Additional drafting and editing support was provided by David J. Creer. NH OSI would like to thank those who reviewed this document for revisions prior to publication, including Jared Chicoine, Joseph Doiron, Alexis LaBrie, and Christopher Ellms, Jr.

Acronyms

Alternative Compliance Payment	**ACP**
Billion cubic feet	**Bcf**
British thermal unit	**Btu**
Distributed Energy Resources	**DERs**
N.H. Department of Revenue Administration	**DRA**
Energy Information Administration	**EIA**
Forward Capacity Market	**FCM**
Federal Energy Regulatory Commission	**FERC**
Gigawatt hours	**GWh**
Independent Power Producer	**IPP**
ISO New England	**ISO-NE**
Kilowatt hour	**kWh**
Levelized Avoided Cost of Electricity	**LACE**
Levelized Cost of Electricity	**LCOE**
Lawrence Berkeley National Laboratory	**LBL**
Locational Marginal Price (of electricity)	**LMP**
Megawatt	**MW**
Megawatt hour	**MWh**
National Association of Securities Dealers Automated Quotations	**NASDAQ**
New England Power Pool	**NEPOOL**
N.H. Division of Forests and Lands	**NHDFL**
N.H. Office of Employment Security	**NHES**
New Hampshire Timber Owners Association	**NHTOA**
National Renewable Energy Laboratory	**NREL**
Office of the Consumer Advocate	**OCA**
Office of Strategic Initiatives	**OSI**
Pay for Performance	**PfP**
Power Purchase Agreement	**PPA**
Public Utilities Commission	**PUC**
Qualifying Facility (under PURPA)	**QF**
Renewable Energy Credits	**RECs**
Regional Economic Models, Inc.	**REMI**
Renewable Fuel Oil	**RFO**
Renewable Energy Portfolio Standard	**RPS**
Revised Statute Annotated	**RSA**

Executive Summary

New Hampshire's Class III biomass generating facilities are less competitive than other forms of renewable generation. As a form of baseload generation, these resources are less flexible than intermittent renewables and struggle to compete on price in the volatile spot market. While biomass is a major market for low-grade wood, it is not the only end use. Low-grade wood markets may be able to find alternative uses that do not require ratepayer funded subsidies. Biomass has a history of above market ratepayer subsidies, accounting for $3 million in above market costs between 2013 and 2017. These generators are likely to require continued above market ratepayer support to remain in operation.

Background

New Hampshire has a deregulated electricity generation market where independent power producers (IPPs) compete in the ISO New England (ISO-NE) market to sell electricity at auction at the prevailing market price. In recent years, natural gas has been the primary fuel source, with nuclear, renewables, and hydropower each accounting for important segments to provide fuel diversity. This study focused on the economic competitiveness of New Hampshire Class III biomass plants, as directed by the legislature. New Hampshire's Class III biomass facilities have been in operation since the mid- 1980s and serve as a market for low-grade wood from timber operations. In 2018 the legislature enacted SB 365, *an act relative to the use of renewable generation to provide fuel diversity*. This bill guaranteed Class III biomass facilities three years of above market price supports through mandated Power Purchase Agreements (PPAs) with electricity providers for all generation at a rate equal to 80 percent of default service. For the purposes of this study, economic competitiveness is focused on the period beyond the current subsidies, which are time limited.

New Hampshire enacted its Electric Renewable Portfolio Standard (RPS) in 2007.[3] Under the RPS, energy distributors are required to purchase a minimum requirement of their energy from different classes of qualifying energy generators, with Class III containing existing biomass plants. The energy distributor purchases renewable energy credits (RECs) from the generators, thus satisfying their requirement. If the distributor does not or is unable to purchase sufficient RECs from each class, they are required to make alternative compliance payments (ACPs) to the Renewable Energy Fund. These additional compliance costs are passed directly on to ratepayers.

As a member of ISO-NE, New Hampshire policy is not the sole influence upon New Hampshire ratepayers' electric costs. New Hampshire is directly impacted by the decisions made by other states within ISO-NE, which can have a material impact on the cost of electricity. Therefore, the policies of each New England state may influence the market prices for the entire regional grid managed by ISO-NE.

[3] Electric Renewable Portfolio Standard, NH RSA 362-F (2007), et seq.

Economic Competitiveness

Average wholesale electricity generation prices have been declining over the last decade. Market prices have steadily decreased since restructuring, which enabled a competitive market to drive wholesale prices.[4] In 2017, wholesale electricity prices in New England were the second-lowest since 2003.[5] Projections from the U.S. Energy Information Administration (EIA) indicate the real price of electricity generation will continue to decline slowly through 2050.[6]

Biomass plants are unlikely to become competitive generators without assistance from ratepayer-funded mechanisms. The levelized cost of electricity (LCOE) for biomass plants ranges between $55 and $114 per MW.[7] This is substantially higher than the avoided cost of electricity set by the New Hampshire Public Utilities Commission (PUC), which is equal to $33.32 per MW for 2018 and set according to the ISO-NE Hub Locational Marginal Price (LMP).[8] The difference in electricity costs between biomass and other sources is small enough that biomass may become economically competitive if the cost of other energy sources increases, but projections from EIA make this outcome unlikely.[9] Additionally, New Hampshire's current biomass plants are aging and will likely require additional maintenance, further increasing the cost to produce electricity from these sources. This indicates that biomass plants are unlikely to be able to generate electricity competitively with other sources.

Direct Economic Activity

According to the output generated by REMI, the Class III biomass facilities account for $76.5 million to $84.1 million annually in GDP. The combined direct, indirect, and induced impact on employment ranges between 398 and 575 total jobs. According to the New Hampshire Timber Owners Association (NHTOA), Class III biomass generation accounts for 121 direct jobs.[10]

The output from REMI was significantly lower than previously reported projections commissioned by NHTOA and produced by Plymouth State University. REMI tested two alternative scenarios compared to the reference case projections. The full REMI output can be found in Appendix B.

To the extent that Class III biomass facilities support low-grade wood markets, alternative end uses are important to maintain a vibrant forest products industry in New Hampshire. Stakeholders convened a preliminary meeting in October 2018 to identify new markets for low grade wood that would not rely on additional ratepayer supported subsidies.

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4 "New England's Wholesale Electricity Prices in 2017 Were the Second-Lowest Since 2003," ISO-NE Newswire, ISO New England, last modified March 6, 2018, https://www.iso-ne.com/static-assets/documents/2018/03/20180306_pr_2017prices.pdf

5 ISO New England, "Second Lowest Since 2003."

6 U.S. Department of Energy. Energy Information Administration, *Annual Energy Outlook 2018* (Washington, DC, 2018), 103, https://www.eia.gov/outlooks/aeo/pdf/AEO2018.pdf.

7 Lazard, *Levelized Cost of Energy Analysis—Version 11.0 (New York, 2017), 18, https://www.lazard.com/media/450337/lazard-levelized-cost-of-energy-version-110.pdf*

8 N.H. Public Utilities Commission, Electric Division, *Net Metering Utility Avoided Cost Rates for Energy and Capacity in Accordance with Puc 903.02(i)* (Concord, NH, 2018), https://www.puc.nh.gov/Electric/avoided_cost_calculation_puc_900_2018_final.xlsx.

9 Energy Information Administration, *Annual Energy Outlook,* 81

10 Plymouth State College, College of Business Administration, *Economic Contribution of the Biomass Electric Power Generation Industry in New Hampshire, by David S. Lee* (Plymouth, NH, 2017), 3, https://www.nhtoa.org/files/docs/Economic%20Contribution%20of%20the%20Biomass%20Electrical%20Power%20Gen%20in%20NH%202016.pdf.

Attributable Ratepayer Costs

Energy policy differences between New Hampshire and other New England states have created a market where biomass plants sell their RECs to other states, forcing New Hampshire electricity distributors to pay ACPs and pass the increased costs to the New Hampshire ratepayers.

From 2012 through 2017, New Hampshire biomass plants sold available RECs to out-of-state energy distributors, mainly those in Connecticut. New Hampshire's ACP rates, which serve as the price ceiling, were lower than Connecticut. The created a higher market price in Connecticut for biomass RECs.[11] Therefore, biomass plants sold RECs to Connecticut companies, leaving few available for New Hampshire distributors. As a result, New Hampshire electricity distributors were forced to pay high ACPs, thereby increasing the cost of electricity rates throughout the state.

Despite several adjustments to RPS requirements intended to mitigate these impacts, New Hampshire ratepayers have been forced to absorb substantial costs. From 2014 to 2017, ACPs for Class III biomass resulted in over $3 million of additional costs to ratepayers.[12] Furthermore, Class III biomass has resulted in over $31 million in ACPs for ratepayers since the RPS was first introduced in 2007.[13]

Conclusion

National trends indicate that biomass generation is less competitive than other renewable resources. The grid managed by ISO-NE is poised to see considerable increases in wind and solar capacity while biomass is likely to remain stagnant. This is partially due to biomass's nature as a baseload power source. In recent years, baseload forms of generation have struggled to compete on the spot market as intermittent renewables have injected greater market volatility with lower average market prices. While this is a boon to ratepayers, it is a significant challenge to baseload generators. The grid is likely to prefer more flexible resources, coupled with storage, in the future.

Biomass is an important market for low-grade wood; however it is not the exclusive market. Developing alternative markets for low-grade wood that do not rely on ratepayer funded subsidies would be an important backstop for New Hampshire's forest products industry.

The primary challenges facing the Class III biomass facilities in New Hampshire are macroeconomic developments that are not easily resolved. In order to keep these plants in operation, New Hampshire's ratepayers would need to provide above market price supports or other subsidies. This is directly counter to recommendations made in New Hampshire's 10-year State Energy Strategy.

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11 Joachim Seel, Andrew D Mills, and Ryan H Wiser, "Impacts of High Variable Renewable Energy Futures on Wholesale Electricity Prices, and on Electric-Sector Decision Making," *Lawrence Berkeley National Lab,* (May 2018) https://emp.lbl.gov/publications/impacts-high-variable-renewable.

12 N.H. Public Utilities Commission, Sustainable Energy Division, *Renewable Energy Fund Annual Report* (Concord, NH 2018), 19, https://www.puc.nh.gov/Sustainable%20Energy/Renewable%20Energy%20Fund/20181001-ref-report-to-legislature-2018-annual-report.pdf.

13 N.H. Public Utilities Commission, *Renewable Energy Fund Annual Report, 19.*

Energy Background

New Hampshire, along with all five other New England states, is served by the grid operator ISO-NE. As a member of this regional grid, New Hampshire is influenced by policy decisions made both in and out of state, which limits the level of control New Hampshire has over prices. Additionally, New Hampshire is a net importer of electricity.[14] Energy prices across ISO-NE are relatively similar; the retail electric price is above the national average for all six New England states.[15] New Hampshire pays the 7th highest retail electricity rates in the nation.[16]

Biomass is a renewable fuel source qualified under Class III of the New Hampshire RPS. In New Hampshire, biomass is primarily fueled by forest residues. In other regions of the country, crop residues, algae, and other organic matter are used as primary sources of biomass. These feedstocks are also used to create liquid fuels such as ethanol, biodiesel, or renewable fuel oil (RFO). None of these alternative practices presently exist in the state at a commercial scale.

There is a sizeable behind-the-meter market for biomass chips and pellets. Homeowners, commercial and industrial users, along with municipalities have all made investments in biomass boilers for heat.[17] While this study will not focus on heating resources or cogeneration resources, this section of the market is significant in New Hampshire.

Electric Renewable Portfolio Standard

New Hampshire has a mandatory RPS that was enacted in 2007.[18] Qualifying sources of renewable energy are divided by "class" as described by the following table.[19]

Figure 1: Qualifying sources under the RPS (RSA 362-F)

Class	Qualifying Sources
I	New Generating Sources
II	New Solar (began operation after January 1, 2006)
III	Existing Biomass/Methane
IV	Existing Small Hydroelectric

Providers of electricity are required to obtain RECs at a predetermined rate for each class each calendar year. Alternatively, providers may make payments to the Renewable Energy Fund under RSA 362-F:10. These payments are known as ACPs. The annual requirements are set by the legislature and have been amended by both legislative and administrative action since the law was originally enacted.

14 "New Hampshire Energy Profile" U.S. Chamber of Commerce, accessed September 18, 2018, https://www.globalenergyinstitute.org/sites/default/files/state_pdfs/Newhampshire.pdf.
15 "State Electricity Profiles – New Hampshire," Energy Information Administration, U.S. Department of Energy, published January 25, 2018, https://www.eia.gov/electricity/state/newhampshire/index.php.
16 Energy Information Administration, "State Electricity Profiles - New Hampshire."
17 N.H. Public Utilities Commission, *Renewable Energy Fund Annual Report, 22.*
18 Electric Renewable Portfolio Standard, NH RSA 362-F (2007), et seq.
19 Descriptions have been shortened in some cases compared to the fully delineated statute RSA 362-F

Figure 2: Minimum Electric Renewable Portfolio Standards (RSA 362-F:3)

Year	2008	2009	2010	2011	2012	2013	2014	2015	2025 and thereafter
Class I	0.00%	0.50%	1.00%	2.00%	3.00%	3.80%	5.00%	6.00%	15.00%
Class II	0.00%	0.00%	0.04%	0.08%	0.15%	0.20%	0.30%	0.30%	0.70%
Class III	3.50%	4.50%	5.50%	6.50%	1.40%	1.50%	0.50%	0.50%	8.00%
Class IV	0.50%	1.00%	1.00%	1.00%	1.00%	1.30%	1.40%	1.50%	1.50%
Total	4.00%	6.00%	7.54%	9.58%	5.55%	6.80%	7.20%	8.30%	25.20%

Pursuant to the legislative charge for this study, only the Class III biomass facilities will be considered. According to the PUC's annual report of certified facilities, there are five producers that qualify for Class III RECs.[20] Burgess Biomass Station and Schiller Station's biomass burner are not included in Class III due to nameplate capacity restrictions, which limit Class III sources to less than 25 MW in size.[21] Similarly, biomass units used for heat or cogeneration are not eligible for Class III RECs and are therefore also excluded.

Figure 3: Class III facilities located in New Hampshire certified by the PUC[22]

REC Cert. #	Facility Name	City	System Size (mW)
DE 08-024	Pinetree Power Inc., - Bethlehem	Bethlehem	17.10
DE 08-051	Pinetree Power - Tamworth	Tamworth	23.80
DE 09-104	Springfield Power LLC	Springfield	17.50
DE 14-209	Bridgewater Power	Bridgewater	15.00
RREC 17-90015	DG Whitefield	Whitefield	18.80
		Total	**92.2 MW**

When the legislature initially requested this study, there were six Class III certified biomass plants. Since that time, the biomass plant in Alexandria has curtailed operations and is no longer certified to produce Class III RECs.[23] Alexandria is not expected to operate at any point in 2018, as noted in Appendix A.[24]

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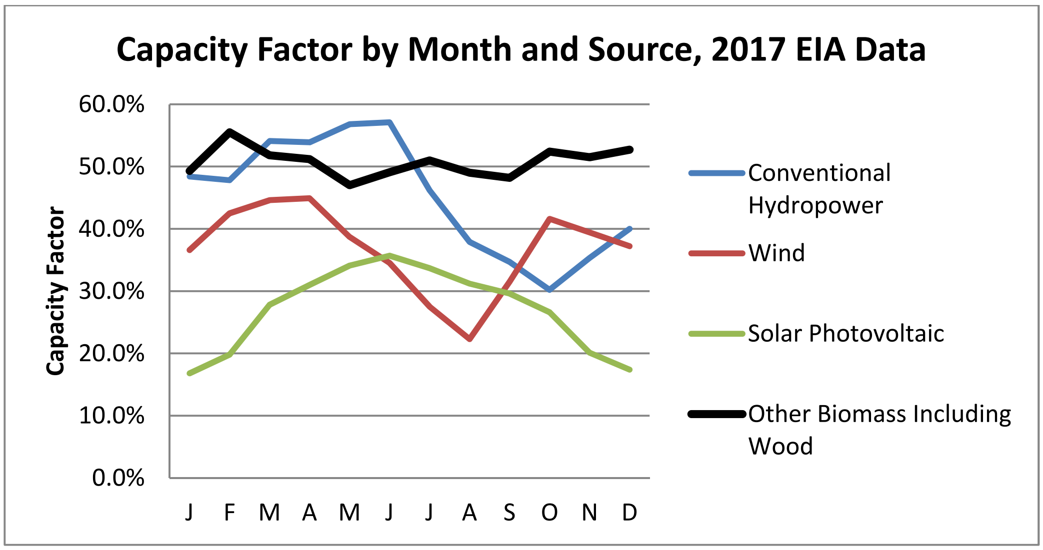
[20] N.H. Public Utilities Commission, Sustainable Energy Division, *NH Eligible Renewable Energy Facility Approvals* (Concord, NH, 2018) https://www.puc.nh.gov/Sustainable%20Energy/RPS/nh-eligible-renewable-energy-facility-approvals.pdf.
[21] Electric Renewable Portfolio Standard, NH RSA 362-F (2007), 4-3a.
[22] N.H. Public Utilities Commission, *NH Eligible Renewable Energy Facility Approvals.*
[23] Bea Lewis, "Plug Pulled on Alexandria Biomass Plant," *Union Leader,* April 9, 2017, http://www.unionleader.com/Plug-pulled-on-biomass-plant.
[24] See Appendix A for questions and responses. Jodi Grimbilas, email, October, 24, 2018.

Collectively, these plants represent less than 100 MW of electric generation nameplate capacity. It is important to note that peak demand across the regional grid reached a high of 23,968 MW in the summer of 2017.[25] Biomass represented less than 0.5 percent of the total summer peak. By comparison, New Hampshire's largest generating source, Seabrook Nuclear Station, has a nameplate capacity of 1,247 MW.[26]

According to EIA data, the annual capacity factor for woody biomass nationwide was 50.7 percent in 2017, a five year low.[27] Unlike other forms of renewable generation, biomass does not feature the seasonal capacity factor changes experienced by solar photovoltaic, wind, or conventional hydropower. While wind peaks in the winter months, hydro in late spring, and solar in the summer, biomass is stable year round, with minor fluctuations month-to-month—as is typical for forms of baseload power generation.

Figure 4: Renewable energy sources, graphed by monthly average capacity factors



Factors Affecting Fuel Supply

Like other combustion fuels, biomass burners are dependent on the supply of compatible fuels. In the case of these burners, forest residues serve as the primary feedstock. Factors that impact the availability of fuel supply include commodity prices as well as supply and demand constraints. According to data provided by the biomass plants, on average, fuel costs are equal to more than 67 percent of plant revenues.[28] This high ratio leaves little room for profit or liabilities such as labor, deferred maintenance, and taxes.

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[25] The peak occurred during the 5pm hour on Tuesday June 13, 2013. "ISO NE Seasonal Peaks Since 1980," ISO New England, last modified June 6, 2018, https://www.iso-ne.com/static-assets/documents/2018/06/seasonal_peak_data_summary.xls.

[26] "State Nuclear Profiles," Energy Information Administration, U.S. Department of Energy, Published April 26, 2012 https://www.eia.gov/nuclear/state/newhampshire/.

[27] "Capacity Factors for Utility Scale Generators Not Primarily Using Fossil Fuels, January 2013-June 2018," Energy Information Administration, U.S. Department of Energy, published August 24, 2018, https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_07_b.

[28] See Appendix A for questions and responses. Jodi Grimbilas, email, October, 24, 2018.

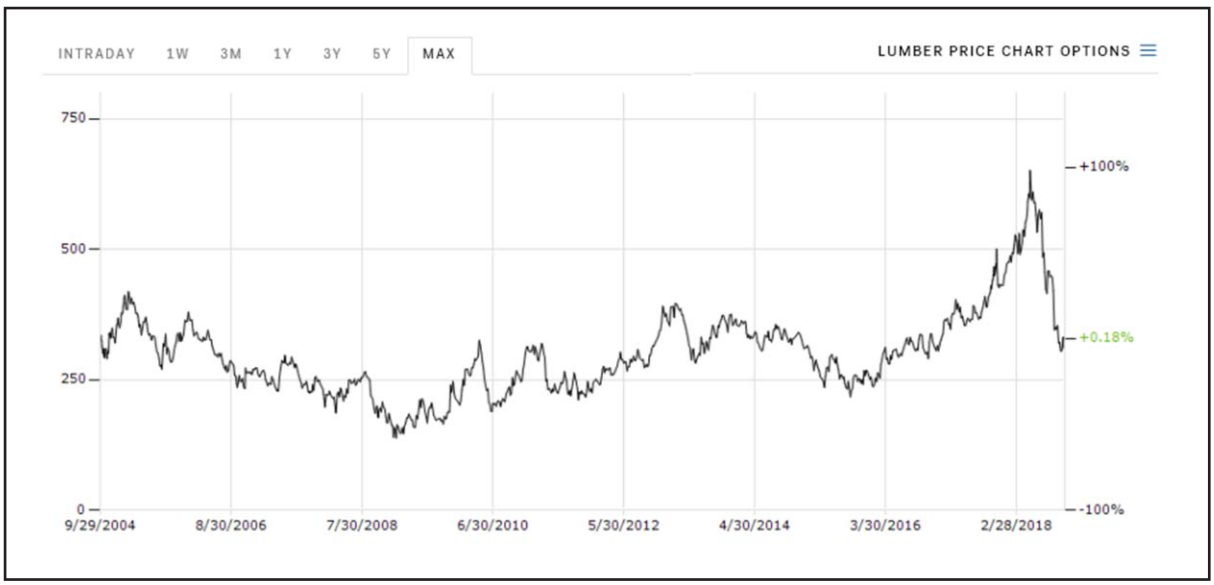
Figure 5: Fuel Costs as a percentage of plant revenues, plant reported

Plant	Fuel Costs/Revenues
Whitefield	69%
Springfield	69%
Bridgewater[29]	"greater than 50*"
Alexandria	60%*
Bethlehem	75%
Tamworth	58%
Average	**67.63%**

Commodity Prices

Woody biomass is dependent on forest residues primarily sourced from low-grade wood harvested by logging operations. To a certain extent, biomass facilities are dependent on demand for high-grade wood to maintain plentiful forest residues for their feedstocks. While the NASDAQ commodity index for lumber has doubled from its 2009 recession low, newly introduced trade tariffs at the federal level have had an adverse impact in the latter half of 2018.[30]

Figure 6: Lumber commodity futures NASDAQ price index



As timber production fluctuates with prevailing market conditions, so too does the supply of wood chips. Given the quantity of low-grade wood that is available, this does not appear to be a concern or potential constraint on biomass production. For the five qualifying Class III biomass facilities this translates to annual total consumption of 1,363,805 tons of low-grade wood.[31]

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[29] *Bridgewater and Alexandria are excluded from ratio calculations due to lack of specificity and time sensitivity, see Appendix A: Questions Submitted to Biomass Operators for full responses.

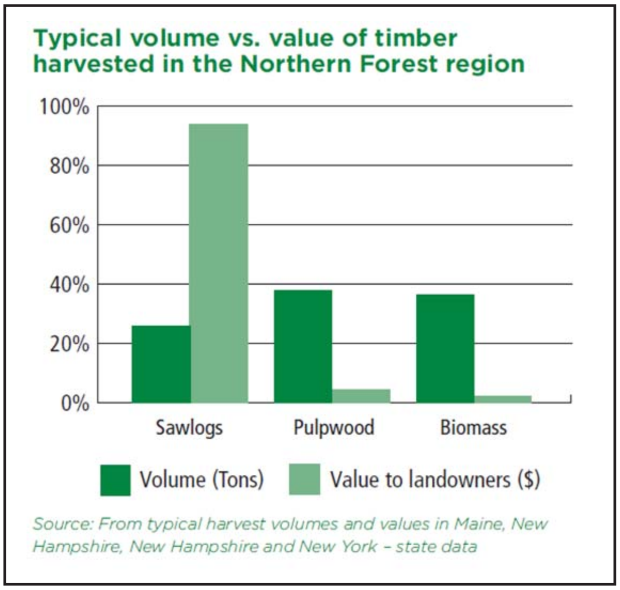
[30] "Lumber Commodity Latest Price & Chart." Accessed November 15, 2018. https://www.nasdaq.com/markets/lumber.aspx?timeframe=10y.

[31] See Appendix A for questions and responses. Jodi Grimbilas, email, October, 24, 2018.

Supply Constraints

Low-grade wood remains plentiful in New Hampshire, accounting for more than 70 percent of wood harvested by volume.[32]

Figure 7: Wood harvested by grade, in volume and value[33]



As shown in Figure 7, biomass accounts for an approximately equal share of low-grade wood by volume, with the remaining half used as pulpwood. The independent biomass plants reported operating at 88 percent of total capacity in 2017.[34] Given that these plants operated at or near maximum capacity, these plants are not likely to be able to expand the annual volume of fuel they are able to consume. Therefore, biomass is not constrained based on the supply of available fuel.

Figure 8: Annual Consumption of Wood Chips by Class III biomass plants, self-reported[35]

Plant	2017 Annual consumption (tons)	Maximum Potential consumption (tons/year)
Whitefield	233,000	250,000
Springfield	238,000	250,000
Bridgewater	227,500	235,000
Alexandria	193,000	220,000
Bethlehem	208,610	255,500
Tamworth	263,695	328,500
Average	**227,301**	**256,500**
Total	**1,363,805**	**1,539,000**

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32 Eric Kingsley, "Low Grade Wood Markets: Status in the Northeast." Presented at a timber markets roundtable. Plymouth State University, Plymouth, NH, July 2017.

33 N.H. Department of Natural and Cultural Resources, Division of Forests and Lands, *Tons of Chips Produced from Timber Sales on State lands Managed by the NHDFL, by Brad Simpkins, (*Concord, NH, 2018), 1.

34 See Appendix A for questions and responses. Jodi Grimbilas, email, October, 24, 2018.

35 See Appendix A for questions and responses. Jodi Grimbilas, email, October, 24, 2018.

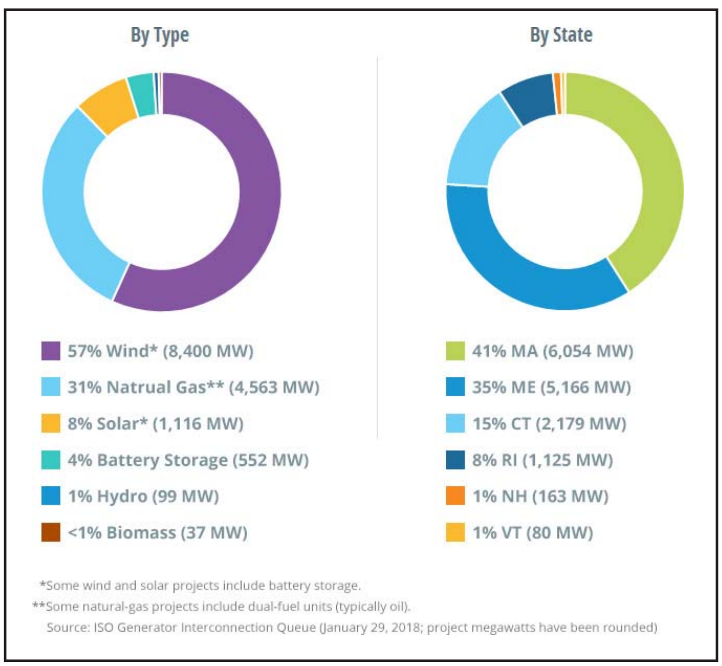
These self-reported estimates mirror trends seen over the lifetime of these facilities. In 1999, these generators "consumed 1.3 million tons of wood" generated by forestry operations.[36] Even with this track record of fuel stability, there are risks associated with woody feedstocks. In the northeast, woody biomass is subject to weather, seasonality, and trucking constraints.[37] Considering that biomass is not a high value product to the logging industry, it remains a byproduct of harvesting and is subject to fluctuations in lumber pricing for high-grade wood. When high-grade wood prices increase, more land is likely to be harvested, in turn producing larger volumes of low-grade biomass. While these trends are usually insignificant, there is risk associated with commodity pricing, as seen in southern pine forests.[38] New Hampshire is not immune from this risk.

Additionally, supply constraints could arise from a slowdown in wood harvesting due to macro-economic factors such as foreign trade tariffs or depressed commodity prices.[39]

Demand Constraints

Biomass face strong demand-side challenges. According to ISO-NE data, wood energy represents 2.9 percent of the total electricity generation and 2.5 percent of the net energy load.[40] According to the ISO-NE Generator Interconnection Queue, biomass accounts for just 37 MW of 14,370 MW of proposed new generation in New England.[41] Stated differently, biomass generation is equal to 0.01 percent of new projects in the region. At a time when other forms of energy are scheduled to add meaningful amounts of new capacity, including 8,400 MW of new wind projects in New England, new development for biomass facilities remains stagnant.

Figure 9: Proposed projects in the ISO-NE Interconnection queue, by state and fuel type[42]



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36 Innovative Natural Resource Solutions, *Use of Low Grade and Underutilized Wood Resources in New Hampshire. Phase I,* (New Hampshire 2001), 6..

37 Eric Kingsley, "Avoiding and Preparing for Volatility in Feedstock Availability and Pricing," *Biomass Magazine,* Published August 30, 2018, http://www.biomassmagazine.com/articles/15548/avoiding-and-preparing-for-volatility-in-feedstock-availability-and-pricing.

38 Ryan Dezember, "Thousands of Southerners Planted Trees for Retirement. It Didn't Work," *Wall Street Journal,* Published October 9, 2018, https://www.wsj.com/articles/thousands-of-southerners-planted-trees-for-retirement-it-didnt-work-1539095250?mod=hp_lead_pos5.

39 Jen Skerritt, "China's Tariffs on U.S. Hardwood Exports Deliver 'Painful' Blow," *Bloomberg,* Published August 3, 2018, https://www.bloomberg.com/news/articles/2018-08-03/china-s-tariffs-on-u-s-hardwood-exports-deliver-painful-blow.

40 "Resource Mix," ISO New England, accessed September 27, 2018, https://iso-ne.com/about/key-stats/resource-mix.

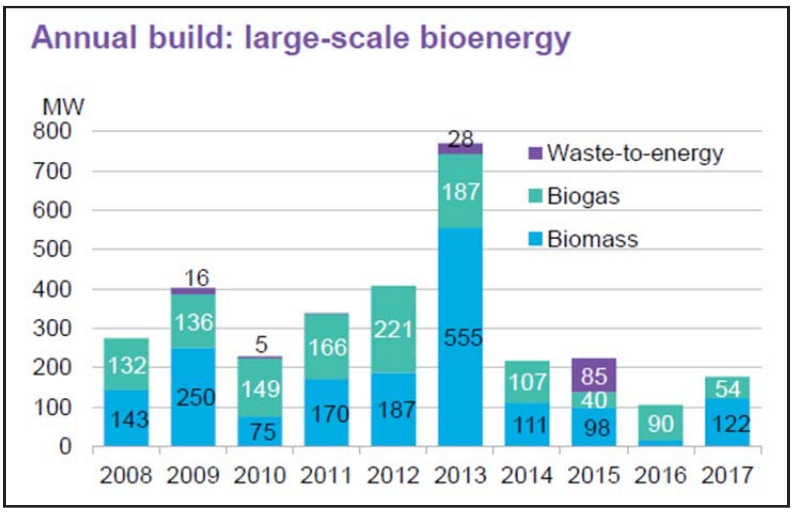
41 ISO New England, "Resource Mix."

42 ISO New England, "Resource Mix."

Figure 9 also reveals that New Hampshire currently has an absence of new projects compared to other New England states. Rhode Island, Connecticut, Maine, and Massachusetts all have more than 1,000 MW of new generation in the interconnection queue. There are likely a number of causes for the wide disparity of new development between states, including siting constraints that may be unique to New Hampshire.

With new development focused on different sources of electricity, market forces will likely cause biomass to cede its share of generating load to other forms of electricity. This is a nationwide trend; biomass, waste-to-energy, and biogas added just 176 MW of new capacity nationally in 2017, slowing from a surge of new builds in 2013.[43] This lack of new development existed even with a production tax credit (PTC) of $24/MWh for biomass facilities placed in service before the end of 2016.[44] As competing technologies continue to evolve and become more efficient at generating power, the cost of the electricity they produce will decline. While this is beneficial to ratepayers, it will prove to be a hurdle for biomass facilities, which are already struggling to compete unaided in a competitive market.

Figure 10: New Builds in Bioenergy[45]



Across New Hampshire, biomass units have entered into PPAs to secure demand for their power. PPAs are a common form of bilateral contract where a party agrees to purchase or deliver power at a set price for a predetermined length of time. These contracts offer both parties price certainty and remove the risk of the spot market price, which can vary dramatically based on real-time demand. As the grid shifts to favor more flexible resources, PPAs will continue to be a necessity for baseload power generators.[46]

PPAs set guaranteed prices that have the potential to differ dramatically from prevailing market prices. Longer term agreements exacerbate this risk as prices are locked in and are immune from market impacts.[47] This is one reason why the PUC is granted oversight of PPAs when a regulated utility is a party to the transaction. Conversely, the PUC does not oversee private market PPAs between independent generators and private purchasers.

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[43] Bloomberg New Energy Finance, *2018 Factbook: Sustainable Energy in America: Executive Summary* (Washington, DC: Business Council for Sustainable Energy, 2018), 1, https://www.bcse.org/wp-content/uploads/2018-Sustainable-Energy-in-America-Factbook_Executive-Summary.pdf.

[44] U.S. Department of Energy, Energy Information Administration, Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook (washington D.C., 2018), 2, https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf.

[45] Bloomberg New Energy Finance, *2018 Sustainable Energy Factbook,* 72.

[46] ISO New England, 2018 *Regional Electricity Outlook* (Holyoke, MA, 2018), 16, https://www.iso-ne.com/static-assets/documents/2018/02/2018_reo.pdf.

[47] U.S. Congress, House of Representatives, Committee on Energy and Commerce, Energy Subcommittee, *Powering America: Reevaluating PURPA's Objectives and its Effects on Today's Consumers,"* 115th Cong., 1st sess., 2017.

For baseload generators, price stability is important to avoid frequent stops and starts. These generators are designed to run continuously at or near maximum output. Where prices constantly fluctuate, baseload power generators are unable to ensure profitability. Given this uncertainty, PPAs will become increasingly important for these facilities.

RPS Adjustments Affecting Class III

Since its enactment in 2007, the RPS has seen frequent adjustments to its requirements, methodology, and penalties. Changes have stemmed from legislative action coupled with rules and regulations formed by the PUC.

Because RECs certified under the RPS are eligible regionally through NEPOOL, New Hampshire is directly impacted by actions taken in other states. Many of the adjustments to the RPS have been reactive measures in response to policies implemented by Connecticut or Massachusetts. Market inefficiencies resulting from differing state policy preferences have adverse impacts to ratepayers throughout the region. As a result, compliance costs can vary greatly year to year for factors outside of the control of any New Hampshire regulatory or legislative body. This underlying issue has become particularly relevant for Class III RECs in the past decade.

As stated in public comment from Eversouce on PUC Docket DE 15-035, "Class III RECs have been impossible to procure in New Hampshire since approximately 2011, and that the scarcity of Class III RECs is expected to continue through at least 2015."[48] The REC shortage was not due to a lack of biomass or methane production, rather a policy preference in Connecticut that placed higher value on biomass RECs than New Hampshire. Owners of biomass RECs reacted to market price signals and sold RECs to Connecticut at the prevailing higher price, leaving New Hampshire electricity providers with insufficient RECs to meet Class III requirements. Providers were forces to make ACPs to the Renewable Energy Fund in order to comply with the RPS statute. These higher compliance costs were passed directly on to New Hampshire ratepayers.

Impact of SB 365

SB 365 (2018), *an act relative to: the use of renewable generation to provide fuel diversity*, guaranteed three years of payments for biomass energy equal to 80 percent of the default service rate.[49] These guarantees are broken into six biannual capacity auctions where utilities are obligated to purchase any and all power generated by one of the qualifying Class III facilities.

In the wake of SB 365 becoming law, it is likely that the Class III biomass plants will operate at full capacity over the life of the subsidy. Since they have a mandated purchaser and a guaranteed price, these plants are not subject to market forces until the subsidy expires after the sixth solicitation for utility default service.

This report is focused on the period that follows the expiration of this subsidy when, barring additional legislative action, these facilities would once again compete in the open wholesale market.

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[48] N.H. Public Utilities Commission, Order Modifying Class III Requirements for 2014 and 2015 Compliance Years, (Concord, NH, 2015), 3, https://www.puc.nh.gov/Regulatory/Docketbk/2015/15-035/ORDERS/15-035%202015-03-13%20ORDER%20NO.%2025-768.PDF.

[49] The Preservation and Use of Renewable Generation to Provide Fuel Diversity, NH RSA 362-H (2018), 2-I

Public Utilities Regulatory Policy Act (PURPA) Impact

Congress passed the Public Utility Regulatory Policies Act (PURPA) in 1978 in response to an energy crisis tied to rising oil prices.[50] To reduce the country's dependence on foreign oil-based energy and promote stable energy prices, PURPA required electricity utilities to purchase power from independent generating sources, provided they met certain criteria. These Qualifying Facilities (QFs) were the first spark for commercial renewable generation. In the 40 years since its passage, this mandate has fundamentally changed the production and sale of electricity in the United States.

Previously, the energy market was dominated by vertical integrated monopolies where the utility companies controlled the generation, transmission, and distribution of all electricity. These entities were under the oversight of a regulatory body in each state and sold electricity at regulated prices. At the time, it was believed that this was the most efficient energy system. However, PURPA changed this monopolist system by requiring utilities to purchase any and all power generated by QFs at the price of avoided costs; costs which the utility would have incurred by producing the electricity itself.

This new segment of independent power producers (IPPs) ushered in a wave of utility restructuring, where states created competitive markets for all electricity generation. New Hampshire joined this trend of deregulation in 1996.[51]

QFs are broken into two categories: 1) small power production facilities, which have a nameplate capacity of 80 MW or less and use a renewable primary energy source, and 2) cogeneration facilities which produce both electricity and useful thermal energy such as steam.[52] New Hampshire's Class III biomass facilities were all eligible under PURPA as small power production facilities.

Because the utilities are required to purchase any power generated by QFs, starting a new qualified facility was a low-risk venture as any energy it produced had a mandated purchaser. Furthermore, the PUC set rates for avoided costs that were favorable to qualifying facilities. Each state's regulatory body is free to calculate avoided costs as they deem appropriate.[53] In New Hampshire, the PUC sets annual avoided costs equal to the ISO-NE Hub LMP[54]. For 2018 the rate is $33.32 per MW[55]. The safe haven provided by PURPA combined with a prevalent timber industry in New Hampshire made it easy for biomass electric plants to start and thrive in New Hampshire.

As a result of utility restructuring, electricity generation prices have substantially decreased in the wholesale market. As technology has improved and become more efficient, other forms of renewable power have become the technologies of choice as they are able to compete at lower wholesale rates. As a result, the very law the give rise to Class III biomass facilities is now contributing to the headwinds they face.

New Hampshire State Energy Strategy

In April 2018, OSI released an update to the 10 year State Energy Strategy. The strategy focuses on cost-effective energy solutions, a resilient and reliable energy grid, and competitive choice in the marketplace. The full strategy can be found on OSI's website at https://www.nh.gov/osi/energy/programs/sb191.htm.

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50 National Association of Regulatory Utility Commissioners, Aligning PURPA with the Modern Energy Landscape 2018, by Travis Kavulla and Jennifer M. Murphy, (Washington, D.C., 2018), 1, https://pubs.naruc.org/pub.cfm?id=E265148B-C5CF-206F-514B-1575A998A847.

51 Electrical Utility Restructuring, NH RSA 374-F (1996), et seq.

52 "What Is a Qualifying Facility," Federal Energy Regulatory Commission, last modified December 29, 2017, https://www.ferc.gov/industries/electric/gen-info/qual-fac/what-is.asp.

53 Committee on Energy and Commerce, Energy Subcommittee, Powering America: Reevaluating PURPA's Objectives and its Effects on Today's Consumers."

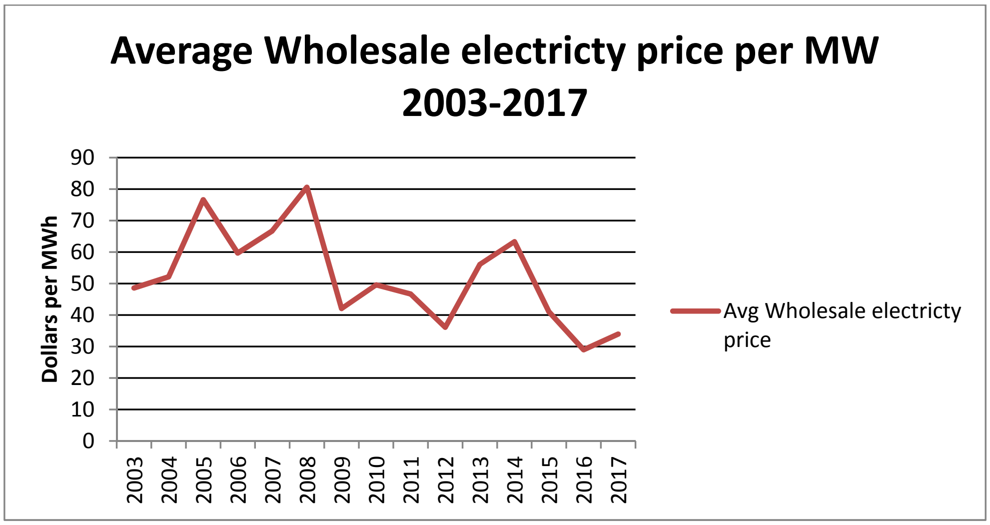
54 "Statutory and Other Requirements," N.H. Code of Administrative Rules, PUC 903.02 (2011):11, https://www.puc.nh.gov/Regulatory/Rules/PUC900.pdf

55 N.H. Public Utilities Commission, "Utility Avoided Cost Rates."

Economic Competitiveness

As a part of the grid managed by ISO-NE, New Hampshire's electricity generation is driven by competitive markets. Absent government intervention, all generating resources compete to sell their electricity at prevailing market prices. Over time, these prices have fluctuated as technologies change or improve and consumer demand shifts. Energy efficiency has yielded substantial energy savings to New Hampshire consumers, helping to shave periods of peak demand and avoid price spikes.[56]

Figure 11: Annual average wholesale electricity prices in ISO-NE [57]



There has been a general downward trend in prices since the deregulation of the energy generation market. Annual average prices reached their lowest point in 2016 when they dipped below $30. In 2017, wholesale electricity prices in New England were the second-lowest since 2003.[58]

The pricing data on a monthly breakdown reveals a clearer pattern. Outside of winter peaks where the price of electricity dramatically increases, the Hub LMP has largely held steady between $20 and $40 since 2012. ISO-NE notes that the "high average [prices] in 2013 and 2014 were largely due to spikes in natural gas prices during wintertime pipeline constraints."[59] Much of the annual price reduction year-over-year has been a result of lower winter peaks. For the 2017 year, ISO-NE attributed a lower winter peak to mild weather, energy efficiency, and reduced transmission congestion.[60] Additionally, ISO-NE credits the "high efficiency of natural-gas-fired generators and the generally low cost of nearby shale gas" as being "largely responsible for [the] 35% decrease in the average price of New England's wholesale electricity between 2004 and 2017."[61]

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[56] N.H. Public Utilities Commission, New Hampshire Statewide Energy Efficiency Plan (Concord, NH, 2017),10, https://www.puc.nh.gov/Electric/NH%20EnergyEfficiencyPrograms/14-216/14-216_2016-12-12_Rev_NH_UTILITIES_2017_NH_STATEWIDE_EE_PLAN.PDF.

[57] ISO New England, "Second Lowest Since 2003."

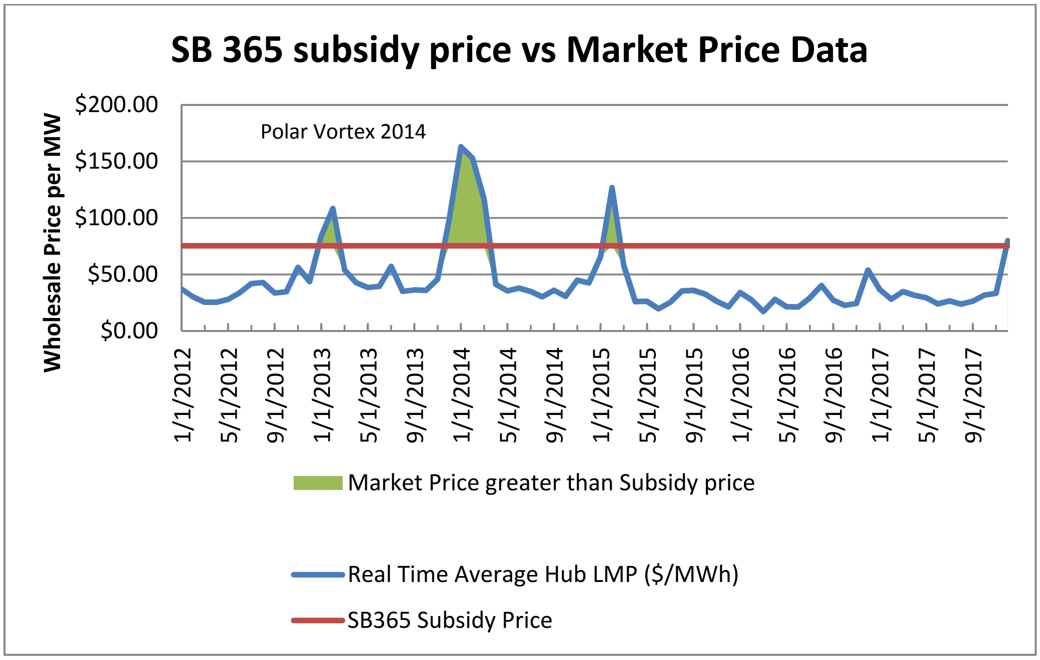
[58] ISO New England, "Second Lowest Since 2003."

[59] ISO New England, 2018 Regional Electricity Outlook, 16.

[60] ISO New England, "Second Lowest Since 2003."

[61] ISO New England, 2018 Regional Electricity Outlook, 16.

Figure 12: Hub LMP prices compared to the Subsidy price granted through SB 365[62]



For comparison, the subsidy granted to Class III biomass plants through SB 365 is included in Figure 12: Hub LMP prices compared to the Subsidy price granted through SB 365, denoted by the red line equal to $75.26 MW, which is equal to 80 percent of Eversource's current default service rate approved by the PUC. Areas shaded in green represent months between 2012 and 2017 where the wholesale price of electricity was greater than the subsidy enacted in SB 365. Wholesale competitive market prices have rarely eclipsed this value. This phenomenon is limited to winter peak months, and has only occurred between December and March.

The 2014 price spike coincided with the cold snap known as the "polar vortex." The cold weather snap in early January of 2014 drove "U.S. natural gas demand to reach an all-time peak of 137 bcf on January 7[, 2014]."[63] This surge in demand stretched regional pipeline capacity to its limit, leading to capacity constraint warnings and price spikes.[64] Even with these constraints, siting new pipeline infrastructure is contentious in New Hampshire. Opponents note that there are risks with new development such as underutilization, stranded costs, and changing market conditions.[65]

Given their mandate to ensure a reliable and resilient grid, ISO New England is concerned by these winter peak prices. Winter capacity constraints have been a subject of debate as early as 2004.[66] ISO-NE attributes these spikes to "insufficient pipeline and storage capacity" for natural gas.[67] These peaks are the rationale behind ISO-NE's "Winter Reliability Project," which is a new

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[62] ISO New England, Monthly History of Average DA and RT LMP and Mass. Avg. Natural Gas Price (Holyoke, MA, 2018), https://www.iso-ne.com/static-assets/documents/2015/04/da_rt_hub_gas_mnthly.xlsx.

[63] Federal Energy Regulatory Commission, *Winter 2013-2014 Operations and market Performance in RTOs and ISOs* (Washington, D.C., 2014), 3, https://www.ferc.gov/legal/staff-reports/2014/04-01-14.pdf

[64] Federal Energy Regulatory Commission, *Winter 2013-2014 Operations*, 3.

[65] Cameron Wake, Matt Magnusson, Christine Foreman, and Fiona Wilson, "New Hampshire's Electricity Future; Cost, Reliability, and Risk," *Carsey Perspectives,* no. 7 (Winter 2017):297, https://scholars.unh.edu/carsey/297/.

[66] "Fuel Security for the Region's Generators," ISO New England, accessed October 18, 2018, https://www.iso-ne.com/about/regional-electricity-outlook/grid-in-transition-opportunities-and-challenges/fuel-security.

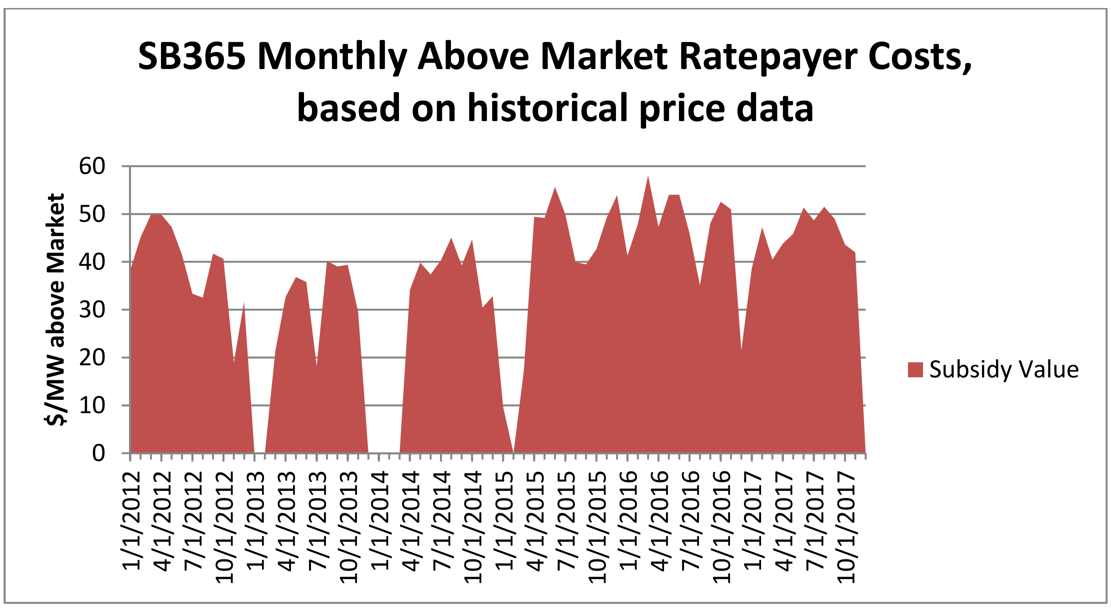
[67] "Natural Gas Infrastructure Constraints," ISO New England, accessed October 18, 2018, https://www.iso-ne.com/about/regional-electricity-outlook/grid-in-transition-opportunities-and-challenges/natural-gas-infrastructure-constraints.

market product that incentivizes "generators to boost winter fuel inventories of oil and LNG or to invest in dual-fuel technology" in an effort to address fuel security risks.[68] Biomass has not been a significant factor in these proposals, even though it could offer additional fuel diversity, as it did with addition of a biomass burner at Schiller Station in Newington, New Hampshire in 2006.[69]

From their efforts and proposals, it is clear that ISO-NE sees these price spikes as avoidable through proper infrastructure investments, rather than a long term reality. ISO-NE has developed new market tools, such as the Pay for Performance (PfP) enhancements that debuted in 2018 and will gradually increase through 2024.[70] This is good news for ratepayers as a more stable wholesale market is a desirable outcome. These performance incentives, designed to supplement the shortfalls in the Forward Capacity Market (FCM) "will result in a more efficient flexible fleet with lower energy prices" long term.[71] However, for energy generators who are already struggling to compete on the open market, the absence of these lucrative price spikes will add further pressure to their bottom lines. It should be noted that the PfP incentives have failed to meet expectations due to what the New Hampshire PUC described in its written comments to FERC as "strict environmental regulations imposed by Massachusetts."[72]

Market conditions are unlikely to yield steadily higher prices for generation in the future. Data from EIA's 2018 AEO shows a moderate decline in real energy prices between 2017 and 2050. If this trend holds it is unlikely that biomass generators would be profitable without additional ratepayer support.

Figure 13: Value above market price, based on historical ISO-NE price trends



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68 ISO New England, "Natural Gas Infrastructure Constraints."

69 Gretyl Macalaster, "PSNH biomass plant burns millions of tons of wood chips," *Union Leader,* December 16, 2012, http://www.unionleader.com/apps/pbcs.dll/article/?AID=/20121216/NEWS02/121219400.

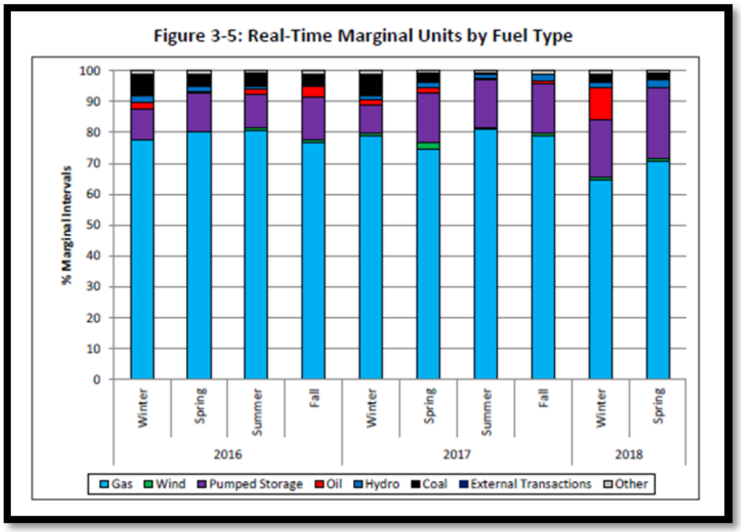
70 ISO New England, "Natural Gas Infrastructure Constraints."

71 George Katsigiannakis, Shanthi Muthiah, Himanshu Pande, Rachel Green, and Josh Ghosh, "How ISO-NE's Pay-for-Performance Initiative Will Shake Up New England," *ICF International,* (November 2014): 7, http://www.ourenergypolicy.org/wp-content/uploads/2014/11/ISO_NE_Pay_for_Performance_Initiative.pdf

72 Comments of the New Hampshire Public Utilties Commission. ISO-New England, "ISO-NE Filing to Establish a Fuel Security Reliability Standard," Federal Energy Regulatory Commission, No. ER18-2364, (September 21, 2018), 3, https://elibrary.ferc.gov/idmws/common/OpenNat.asp?fileID=15047318.

If price trends mimic those over the past five years, as projections indicate, Class III biomass facilities will receive a price premium of more than $50 above market price several months out of the year. If this subsidy is equal to the minimum wholesale price required for Class III biomass plants, it is unlikely that these plants will be able to compete in the future without additional above-market ratepayer support.

Figure 14: Marginal Fuel Source by season and type[73]



As a baseload power source, biomass is rarely the marginal fuel which sets the price of electricity. Baseload generators are less adaptable as real-time demand fluctuates, given that these plants were originally designed to run at full power with limited cycling.[74] In a competitive market where intermittent distributed energy resources (DERs) are concentrated, these resources displace base-load power generation such as biomass. Because of the inflexibility of baseload resources, at times they are forced to bid below market price—and in some cases even bid at negative prices—in order to continue running at full capacity.[75] Because of long start times, operational stress of frequent stops and starts, or the inability to scale generation up or down, these resources face pressure from intermittent resources, which can impact retirement decisions.[76] Frequent stops and starts can lead to higher capital maintenance costs due to "shorter component life expectancies."[77]

In forecasts compiled by Lawrence Berkeley National Lab (LBL), greater renewable penetration yields "a general decrease in average annual hourly wholesale energy prices" and "increased price volatility and frequency of very low-priced hours."[78] Because of the inherent nature of baseload generation, this new energy landscape does not pose a favorable scenario for these generators.[79] This has led ISO-NE and other grid operators to explore new market based mechanisms to account for the benefits of fuel secure generators.[80]

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[73] ISO New England, Internal Market Monitor, *Spring 2018 Quarterly Markets Report* (Holyoke, MA, 2018), 15, https://www.iso-ne.com/static-assets/documents/2018/07/2018-spring-quarterly-markets-report.pdf.

[74] U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, National Renewable Energy Laboratory, *Power Plant Cycling Costs,* by N Kumar, P Besuner, S Lefton, D Agan, and D Hilleman, (Golden, CO, 2012), iv, https://www.nrel.gov/docs/fy12osti/55433.pdf.

[75] "Negative prices in wholesale electricity markets indicate supply inflexibilities," Today in Energy, Energy Information Administration, U.S. Department of Energy, published February 23, 2013, https://www.eia.gov/todayinenergy/detail.php?id=5110.

[76] Chris Martin, "On-and-Off Wind and Solar Power Pushing Coal Plants to the Brink," *Bloomberg,* October 5, 2018, https://www.bloomberg.com/news/articles/2018-10-05/coal-plants-built-for-slow-and-steady-forced-to-sprint-then-halt.

[77] Martin, "On-and-Off."

[78] Seel, Mills and Wiser, "High Variable Renewable Energy," vii.

[79] U.S. Department of Energy. *Staff Report to the Secretary on Electricity Markets and Reliability* (Washington, D.C., 2017), 50, https://www.energy.gov/sites/prod/files/2017/08/f36/Staff%20Report%20on%20Electricity%20Markets%20and%20Reliability_0.pdf.

[80] ISO New England, "Fuel Security for the Region's Generators."

Intense competition on price has been a driving force for baseload power generators to secure PPAs for their generation. In an open and competitive market, these agreements would normally be fixed at a stable dollar value based at either prevailing market prices at the time of the agreement, or based on expectations of the future cost of electricity. However, the current arrangement between the Class III biomass plants and utility providers falls under neither of these circumstances and exists outside of market forces. It is unlikely that a PPA would exist at the SB 365 price absent a legislative mandate.

This issue of price predictability is not unique to biomass generators. As more DERs gain market penetration, baseload power generators will continue to look to PPAs to guarantee a set price for their power. When these agreements are mutually agreed upon, there are tangible benefits to each party and an absence of government subsidies.

Compared to other forms of DERs, biomass is less favorable for new development, a fact illustrated by Figure 9. One measure of the cost effectiveness of new builds is demonstrated by the LCOE, which accounts for the unsubsidized cost to produce a unit of electricity. Figure 15 below demonstrates the differences between biomass, onshore wind, and utility scale solar facilities based on 2018 data and projections.

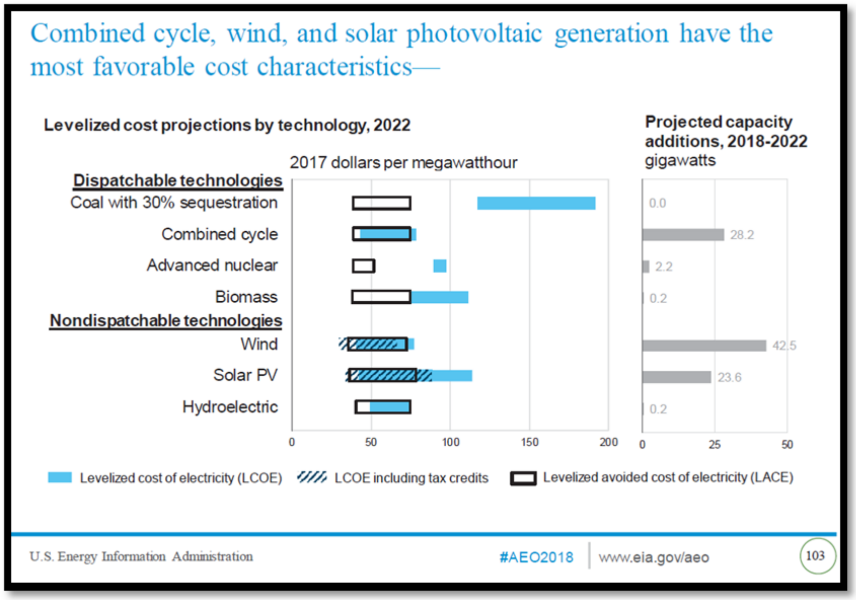
Figure 15: Assumptions for LCOE Analysis by Lazard [81]

	Biomass	Onshore Wind	Utility Scale Solar (thin film)
Net Facility Output (MW)	10	100	30
Total Capital Cost ($/kW)	$1,700 - $4,000	$1,200 – $1,650	$1,375 – $1,100
Fixed O&M ($/kW-year)	$50	$30.00 – $40.00	$12.00 – $9.00
Variable O&M ($MWh)	$10	$ -	-
Capacity Factor (%)	85% - 80%	55% - 38%	32% - 23%
Fuel Price ($/MMBtu)	$1 - $2	-	-
Facility Life (Years)	25	20	30
LCOE ($/MWh)	$55 -$114	$30 - $60	$43 - $48

Biomass has a lower facility energy output and higher associated cost compared to other forms of renewable energy generation. A key assumption in Figure 15: Assumptions for LCOE Analysis by Lazard is a 25 year lifespan for biomass facilities. While the Class III biomass facilities report that their facilities are able to operate indefinitely with regular facility maintenance, older plants will require additional maintenance at additional costs.[82]

[81] Lazard, *Levelized Cost of Energy Analysis—Version 11.0 (New York, 2017), 18, https://www.lazard.com/media/450337/lazard-levelized-cost-of-energy-version-110.pdf.*
[82] See Appendix A for questions and responses. Jodi Grimbilas, email, October, 24, 2018.

Figure 16: Levelized Cost of Electricity and Levelized Avoided cost of Electricity forecasted to 2022 [83]



The economic competitiveness of each form of energy generation can be determined by comparing the LCOE to the levelized avoided cost of electricity (LACE). LCOE is the unsubsidized cost of generation per unit of energy. LACE is the cost of generation of energy from a competing source, or the cost the utility would have incurred to generate that energy directly. The range of values in Figure 16 accounts for regional differences, such as policy preferences, feedstock availability, labor costs, or other prevailing factors that impact generation. When market conditions are favorable to development, both the LCOE and LACE will overlap. Taken together, these metrics provide "a better assessment of economic competiveness than either measure separately."[84] This is illustrated by the projected capacity additions of wind and solar PV, compared to the lack of new development of coal with 30 percent sequestration or advanced nuclear technologies.

Biomass is in a unique position where the LCOE and LACE are marginally divergent, but not as extreme as other baseload power generators. This indicates that future biomass builds may be cost effective in the market if certain conditions are met, but the future is exceedingly uncertain. The future prospects for biomass would be aided by technological improvements making biomass generation more efficient or an increase in wholesale market prices from competing electricity sources. Given the limited investment in biomass and prevailing market forces, both options appear to be unlikely in practice.

Options to Improve Competitive Standing

In the past decade there has been intense focus on innovations in wind, solar, battery storage, and advanced nuclear technologies. Biomass has not seen the same level of public or private investment as other competing resources. This is due largely in part to the unfavorable market dynamics and the highly favorable LCOE for technologies such as wind and solar.

In the absence of real increases in the wholesale market price of electricity, the future of biomass generation is likely to depend on reductions in costs, improvements in generation capabilities, or a diversification of revenues through co-location.

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[83] Energy Information Administration, *Annual Energy Outlook,* 103.
[84] Energy Information Administration, *Cost of New Generation*, 3.

Reduce Costs

Unlike generation sources that are not fuel dependent, such as wind and solar, biomass is heavily reliant on the availability of low-grade wood in the form of chips. While the volumetric supply is unlikely to constrain generation potential, the cost of these chips does pose a substantial expense for these facilities. As shown in Figure 5, fuel costs can account for up 70 percent of plant revenues.[85] A decrease in the price per ton of wood chips would be one such way to improve profitability of these plants.

The price per ton of woodchips harvested on state lands managed by the New Hampshire Division of Forests and Lands (NHDFL) has declined since 2016, as shown in Figure 17. The fall in prices has been accompanied by a surge in the volume of woodchips harvested year over year. This is due in large part to the closure of pulp and paper mills in the region. As a result the demand for chips has decreased while supply of chips has increased, placing downward pressure on the average price per ton.

Figure 17: Woodchip volume and price data from state land harvests

Tons of Chips Produced from Timber Sales on State Lands Managed by the NHDFL[86]

Fiscal Year	Operational Harvests	Harvests w/ Chipping	Tons of Chips Removed	Gross Value of 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

Statewide, wood chip prices can vary significantly. The New Hampshire Department of Revenue Administration (DRA) compiles annual price assessments for each region of the state, based on the quality of the wood and other important factors. These estimates materialize into timber tax revenues for harvests assessed according to the high and low price estimates included in Figure 18.

Figure 18: Biomass Chip Prices per ton and Class III plant expenses

Biomass Chip Prices

Source	Mean Price / Ton	Low Price / Ton	High Price / Ton
NHDFL 2018 Sale Price Data[87]	$ 1.66	N/A**	N/A**
DRA Northern 2018[88]	$ 1.75	$ 0.50	$ 3.00
DRA Central 2018	$ 1.00	$ 0.50	$ 1.50
DRA Southern 2018	$ 0.55	$ 0.10	$ 1.00
Unweighted Average	**$ 1.24**	**$ 0.37**	**$ 1.83**

For the purposes of economic modeling using REMI, the unweighted mean price per ton was used as the "low" impact of the biomass electric generators, which the DRA northern 2018 High estimate was used as the "high" impact value. The full REMI output can be found in Appendix B: Regional Economic Models, Inc. (REMI) Output

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85 See Appendix A for questions and responses. Jodi Grimbilas, email, October, 24, 2018.
86 N.H. Department of Natural and Cultural Resources, Timber Sales on State Lands, 1.
87 ** Sale Price data from NHDFL does not include High and Low price estimates as the mean value is calculated based on real sales data.
88 N.H. Department of Revenue Administration, Municipal and Property Division, Average Stumpage Value List October 1, 2018 – March 31, 2019 (Concord, NH, 2018), 1, https://www.revenue.nh.gov/mun-prop/property/documents/avg-stump-values-10-18-03-19.pdf.

Improve Energy Efficiency

While New Hampshire's Class III biomass facilities operate at or near maximum capacity, there may be opportunities to increase the efficiency of their generating process, such as minimizing waste heat. In the current Renewable Energy Fund, ACP revenues are reinvested in projects to generate additional RECs in future years. If Class III facilities are exempted from applying for a portion of this funding, a legislative amendment could help finance new upgrades.

Co-locate with heat intensive enterprises

One of the more innovative approaches diversify revenues would be to co-locate with heat intensive industries that would use the waste heat from generating electricity in an industrial process. This approach has been considered in Maine, where a local biomass plant secured a loan to build shrimp farms on the property.[89] An approach like this would create a closed loop that makes use of thermal energy for a separate process. While the idea of combined heat and power (CHP) is not new, applying it at this scale would be a first for New Hampshire.

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89 Tux Turkel, "Biomass plant owner gets loan approval for shrimp farm in West Enfield," *Portland Press Herald,* November 7, 2017, https://www.pressherald.com/2017/11/07/biomass-operator-gets-loan-ok-for-shrimp-farm/.

Direct Economic Activity

Direct economic activity was modeled in partnership with New Hampshire Employment Security (NHES) using REMI. OSI provided relevant data to NHES that included the direct employment from biomass facilities, the annual sales value of wood chips, and impacting derived from trucking chips from logging sites to the biomass facilities. The complete statewide report and output tables from REMI are available in Appendix B.

NHES tested "high" and "low" impact scenarios to demonstrate the effects of the closure of the biomass plants based on two sets of assumptions. REMI reports an output compared to a forward-looking reference case scenario. Based on the scenarios described, the impact of the biomass industry in New Hampshire ranges from $76.5 million to $84.1 million, annually, in Gross Domestic Product (GDP).[90] This represents between 0.10 - 0.11 percent of New Hampshire's annual GDP.

The direct, indirect, and induced impact on employment ranges between 398 and 575 total jobs, annually. This range equates to 0.05 - 0.07 percent of New Hampshire's total workforce. By means of comparison, NHES reported that 1,190 New Hampshire residents gained employment in October 2018 alone.[91]

The impacts reported from REMI are significantly different than the data cited by NHTOA in their recently cited reports.

In 2017, NHTOA commissioned a study through the Plymouth State University College of Business Administration. The report accounted for 121 jobs directly created by the Class III biomass facilities, equating to payroll wages of $11.6 million.[92] This number was used as the baseline in the REMI analysis. Additionally, the NHTOA report attributed $254.5 million in economic output to the biomass facilities.[93] This is approximately more than twice the value demonstrated by the REMI report.*

Fully noting that the Class III biomass facilities also support indirect and induced employment, biomass is not the exclusive end market for low-grade wood in New England. Identifying additional markets for low-grade wood was the focus of an industry and government stakeholder meeting in October 2018, including some opportunities that have been identified by the FOR/Maine initiative.[94] These alternative markets offer the potential for low-grade wood to be used without encumbering ratepayer funded subsidies.

As stated in the New Hampshire State Energy Strategy, policy makers should prioritize function over form and "generate in-state economic activity without reliance on permanent subsidization of energy."[95]

* Different econometric models and inputs were used to estimate the total value of the biomass industry in New Hampshire.

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90 See Appendix B.
91 "News Release," Economic and Labor Market Information Bureau, N.H. Employment Security, published November 14, 2018, https://www.nhes.nh.gov/media/press/2018/documents/nr-current.pdf.
92 Plymouth State College, *Economic Contribution of Biomass,* 3, https://www.nhtoa.org/files/docs/Economic%20Contribution%20of%20the%20Biomass%20Electrical%20Power%20Gen%20in%20NH%202016.pdf.
93 Plymouth State College, Economic Contribution of Biomass, 3.
94 FOR/Maine, *Vision and Roadmap for Maine's Forest Products Sector* (Maine, 2018), https://maineforest.org/wp-content/uploads/2017/09/Roadmap-presentation-9-18-2017.pdf.
95 N.H. Office of Strategic Initiatives, *10 Year State Energy Strategy*, 5.

Attributable Ratepayer Costs

The primary source of above market costs from biomass electric generation has been in the form of RPS compliance. The following timeline describes the actions taken by both the legislature and the PUC that were intended to mitigate the adverse impacts to ratepayers. It should be noted that the Class III biomass facilities reported that the underlying issues of the REC market have not be resolved to date.[96]

Other sources of above market costs stem from PURPA's original 20 year contracts awarded to QFs. Since the majority of biomass facilities in NH entered service in the 1980s, above market costs derived from these contracts would have ended in the mid-2000s. Therefore, these costs are outside the 2013-2017 period the legislature specified in this study's statutory charge.

Timeline of Class III RPS Adjustments

SB 218-FN (2012)[97]

This bill increased the Class III requirement from 6.5 percent in 2014 to 7 percent. For 2015 and thereafter, the requirement was increased to 8 percent.

Additionally, this bill increased the Class III ACP rate from $28 to $31.50 and tied future increases to the Consumer Price Index for Classes III and IV.

PUC Order 25,484 (2013)[98]

This order, filed under docket DE-13-021, focused on the "unprecedented level" of ACPs used to satisfy Class III requirements for compliance year 2011. PSNH commented that $15.5 million of the $19 million total of 2011 ACPs were related to Class III. The Wood-Fired IPPs (biomass facilities) stated that because Connecticut had a higher ACP price of $55 compared to New Hampshire's $31.50, companies with regulatory obligations in Connecticut were willing to pay a higher market price than those with New Hampshire obligations for RECs. Selling RECs in Connecticut maximized REC revenues as policy preferences in Connecticut effectively set a higher price cap than was available in New Hampshire. The Wood-Fired IPPs stated they would expect to continue selling RECs to fulfill requirements in Connecticut.

Liberty Utilities offered feedback on two potential adjustments: that (1) New Hampshire should not increase the ACP price to better align with Connecticut, as these higher prices are passed along to ratepayers; and (2) New Hampshire should redefine in operation dates from 2006 to 1997 to better align with other states.

The PUC ordered that the Class III requirement be downshifted to 1.4 percent of retail electricity sales for 2012 and 1.5 percent for 2013 to prevent increased ratepayer costs associated with ACPs. SB 148 was pending at the time of the order, which raised conversation of which forum was the most appropriate for RPS adjustments.

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96 See Appendix A for questions and responses. Jodi Grimbilas, email, October, 24, 2018.

97 An Act relative to Electric Renewable Portfolio Standards, Chaptered Law 272 (2012).

98 N.H. Public Utilities Commission, Regulatory Division, *Order Deferring Useful Thermal REC Requirement for One Year and Adjusting Class III Requirements Downward,* Order No. 25,484, DE 13-021, (Concord, NH, 2013), https://www.puc.nh.gov/Regulatory/Docketbk/2013/13-021/ORDERS/13-021%202013-04-04%20ORDER%20NO%2025,484%20DEFERRING%20USEFUL%20THERMAL%20REC%20REQUIREMENT%20FOR%20ONE%20YEAR%20AND%20ADJUSTING%20CLASS%20III%20REQUIREMENTS%20DOWNWARD.PDF.

SB 148-FN (2013)[99]

Following the PUC's order, SB 148-FN was amended to reflect the RPS adjustments for the 2012 and 2013 compliance years. In addition, the bill reduced the Class III requirement for 2014 from 7 percent to 3 percent. This was in direct contrast to legislative action taken just a year earlier, which had raised 2014's requirement from 6.5 to 7 percent.

Further, this bill repealed and reenacted RSA 362-F:10, III to set the ACP price for Class III RECs to $45 for the 2015, 2016, and 2017 compliance years.

Additionally, this bill chartered a study committee to examine further changes to the methodology or price for Class III ACPs, examine the impact of RPS laws in other New England states and their indirect effects on New Hampshire, and examine whether these laws should be better aligned throughout the region, among other focus areas.

HB 542 (2013)[100]

HB 542 shared much of the same language as SB 148-FN, including the ACP rate adjustment, the RPS study committee, and the Class III requirement for 2012, 2013, and 2014. Both bills became law in 2013.

Renewable Portfolio Standard Study Committee (2013)[101]

Pursuant to HB 542, the renewable portfolio standards study committee issued their report on November 6, 2013. The committee heard testimony from stakeholder groups on October 8, 2013 regarding "changes in law in other states as well as New Hampshire." Citing recent actions taken by New Hampshire in 2012 and 2013, Chairman Bradley and the committee recommended "no further legislation at this time."

In the absence of further legislation, the PUC proceeded to issue three additional orders concerning Class III generators under the RPS.

PUC Order 25,674 (2014)[102]

Revising the guidance issued in Order 25,484 and codified by SB 148-FN, the PUC further reduced the Class III requirement from 1.5 percent to 0.5 percent of retail electric sales for the 2013 compliance year. The PUC was "not inclined to adjust the RPS Class III requirement for any years beyond 2013."

The PUC implored the General Court to address the "root cause" of the Class III REC shortfall and increase the Class III ACP price to better align with Connecticut and Massachusetts.

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99 An Act relative to Electric Renewable portfolio Standards, Chaptered Law 272 (2013).

100 An Act relative to the renewable energy fund and regulation of telephone, Voice Over Internet Protocol, and IP-enabled service providers and relative to electric renewable portfolio standards, Chaptered Law 279 (2013).

101 N.H. General Court, Renewable Portfolio Standards Study Committee, *Final Report* (Concord, NH, 2013).

102 N.H. Public Utilities Commission, Regulatory Division, Order Reducing Class III Requirements for 2013 to 0.05% of Retail Sales, Order No. 25,674, DE 14-104, (Concord, NH, 2014), https://www.puc.nh.gov/Regulatory/Docketbk/2014/14-104/ORDERS/14-104%202014-06-03%20ORDER%20NO%2025-674.PDF.

PUC Order 25,768 (2015)[103]

In 2015, with Class III REC availability still at issue and with no action from the legislature, the market failure due to a mix of a) price inconsistency across state lines and b) fluctuating Class III requirements returned to the PUC again in the form of docket DE 15-035.

The PUC noted that the power to adjust ACP prices rests with the General Court, echoing their plea from Order 25,674 issued in the year prior. Eversource, Unitil and Liberty all called for the Class III requirement to be eliminated for compliance years 2014 and 2015 to prevent the additional ACP compliance costs from being passed along to ratepayers. Eversource estimated that without further action, ratepayers would be forced to pay an additional $3.6 million in 2014 and $14.4 million in 2015, respectively. The OCA recommended a rate of 0.5 percent for 2014 with the caveat that if the PUC were to reduce the rate to 0 percent, that PUC should then work with the General Court to amend the RPS law.

The PUC ordered that the Class III requirement for compliance years 2014 and 2015 be set equal to 0.5 percent of retail electric sales.

For 2015, the legislature had previously voted to increase the ACP rate to $45 to better align New Hampshire with other states in the region through SB 148-FN (2013). However, Connecticut's ACP for biomass RECs remained at $55, still higher than New Hampshire. As a result biomass facilities continued to sell their RECs in the more valuable Connecticut market. Because of overlapping but not identical Class qualifications, this is an example of supply migration.[104]

PUC Order 25,844 (2015)[105]

In the second RPS order issued in 2015, the PUC reduced the requirement for Class III RECs for the 2016 compliance year from 8 percent to 0.5 percent of retail electricity sales. Citing no change from previous orders revising the requirement down, the PUC opted to hold the Class III requirement near zero to minimize adverse impacts to New Hampshire ratepayers due to the laws of neighboring states.

Liberty utilities presented market data that demonstrated the challenge in New Hampshire. "Massachusetts's ACP rate in 2015 is $67.07 per REC, with a market price of $50.50. Similarly in Rhode Island, the ACP rate in 2015 is $67.07 per REC, with a market price of $50.00. In both states, the market price is higher than the 2015 ACP rate for N.H. Class III RECs of $45.00 per REC."

According to information provided by PUC staff, the Class III RPS requirements for 2016 ACPs could "amount to approximately $40 million."[106]

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[103] N.H. Public Utilities Commission, Regulatory Division, *Order Modifying Class III Requirements for 2014 and 2015 Compliance Years*, Order No. 25,768, DE 15-035, (Concord, NH, 2015), https://www.puc.nh.gov/Regulatory/Docketbk/2015/15-035/ORDERS/15-035%202015-03-13%20ORDER%20NO.%2025-768.PDF.

[104] Sustainable Energy Advantage, LLC, *2018 Review of the New Hampshire Renewable Portfolio Standard* (Framingham, MA, 2018), 4, https://www.puc.nh.gov/2018-NH-RPS-Scenario-Analysis-Report_Final.pdf.

[105] N.H. Public Utilities Commission, Regulatory Division, *Order Adjusting Class III Requirements for 2016* Order, No. 25,844, DE 15-477, (Concord, NH, 2015), https://www.puc.nh.gov/Regulatory/Docketbk/2015/15-477/ORDERS/15-477_2015-12-02_ORDER_25844.PDF.

[106] N.H. Public Utilities Commission, *Order Adjusting…2016,* 4.

SB 129 (2017)[107]

SB 129 increased the Class III ACP price to $55 for compliance years 2017, 2018, and 2019.

This legislation manifested after four PUC orders altering Class III requirements, including two that directly called on the General Court to review the root cause ACP rate for Class III—based on market pressures originating in other states. This bill passed more than three years after the Renewable Portfolio Standards Review study committee issued their report that recommended no further action. Over this period, the underlying issues had not materially changed; other states placed higher value on Class III biomass RECs, at the detriment to New Hampshire ratepayers.

Impact of Above Market Costs

While increasing the ACP price was one of several solutions presented in PUC dockets, legislation, and study committees, it proved to be a solution that had been discussed at length since at least 2013. In the intervening period between when the issue was first recognized (as early as 2011 during the stakeholder process for the 2011 RPS Review) and when the legislature finally took corrective action, Class III facilities had mounted costs on ratepayers exceeding $3 million.[108]

Figure 19: Class III ACP Costs per year, 2014-2017

Year	Class III ACP Costs
2014	$1,703,816
2015	$174,240
2016	$24,480
2017	$1,358,225
4 Year Total	**$3,260,761**

Over the life of the RPS, Class III has yielded the greatest value of ACPs, totaling more than $31 million since the program's inception.[109] These ACP costs have been directly passed to the ratepayers of New Hampshire.

Even prior to the implementation of the RPS, these plants operated under long term bilateral contracts under PURPA, which granted them wholesale electric rates "significantly above market prices."[110] In fact, as generation rates fell throughout the 1990s and early 2000s, these rates were "two to three times higher than the market rate for electric power in the Northeast."[111] This is an example of the risks that are inherent with long term PPAs in a volatile market. These risks are especially important for ratepayers, who bear the ultimate cost from these agreements.

As SB 365 takes effect, once again granting long term contracts absent market forces, the above market rate impacts are likely to continue through 2021.

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107 An Act relative to requiring a portion of the renewable energy fund to benefit low to moderate income residential customers, relative to electric renewable energy classes, relative to the class rate for biomass, and relative to requirements for incentive payments from the renewable energy fund, NH Chaptered Law 226 (2017).
108 N.H. Public Utilities Commission, Sustainable Energy Division, *2011 Renewable Portfolio Standard Review* (Concord, NH, 2011), 21, https://www.puc.nh.gov/Sustainable%20Energy/RPS/RPS%20Review%202011.pdf.
109 N.H. Public Utilities Commission, *Renewable Energy Fund Annual Report, 19.*
110 Innovative Natural Resource Solutions, *Use of Low Grade Wood*, 6.
111 Innovative Natural Resource Solutions LLC, *Identifying and Implementing Alternatives to Sustain the Wood-Fired Electricity Generating Industry in New Hampshire*: Phase III (Concord, NH, 2002), 6, http://www.inrsllc.com/download/wood_firedelectricityinNH.pdf

Conclusion

New Hampshire's forest products industry remains an important part of the state's economy. While biomass electricity generation has historically been one of several markets for low-grade wood, the electricity generated by Class III biomass facilities is no longer competitive in the ISO-NE spot market. As a form of baseload power generation, biomass is less flexible than intermittent renewable resources, creating market price pressures that the technology is unable to adapt to. Biomass power generators likely will continue to seek long-term PPAs to secure demand and a stable price for their power. These agreements reduce risk faced by the biomass facilities, even as volatile spot market prices shift hourly.

Class III biomass facilities have accounted for more than $3 million in above market costs to New Hampshire ratepayers during the period from 2013 to 2017. In the wake of SB 365 becoming law, ratepayers will continue to pay above market rates for power generated by Class III facilities through 2021. Class III biomass facilities have a combined nameplate capacity of 92.2 MW, a fractional amount compared to the total summer peak capacity served by ISO-NE. ISO-NE has not specified biomass generation as an issue or a potential solution to the challenges faced by the current grid. The grid managed by ISO-NE has a large amount of new capacity additions in the interconnection queue, a fractional minority of these are biomass. The grid served by ISO-NE has ample power generation resources that could provide an equal amount of power at a lower price in the prevailing market without ratepayer subsidies.

New Hampshire lags behind its neighboring states in terms of new generation projects in the ISO-NE interconnection queue. Given that one of the state's energy policy goals is to encourage local generation and diversify energy resources, adjustments to the state's siting procedure may need to be considered to attract new development and to alleviate local opposition.

According to the output generated by REMI, the Class III biomass facilities account for $76.5 million to $84.1 million annually to GDP. The combined direct, indirect, and induced employment impact ranges between 398 and 575 total jobs. The NHTOA reported that biomass generation accounts for 121 direct jobs.

Absent additional ratepayer support, it is unlikely that New Hampshire's Class III biomass facilities will continue to operate at full capacity. Biomass would be aided by increasing electricity generation rates, diversifying their revenue through co-location, or by identifying efficiencies in their generation process. Based on available energy price forecasts, the real price of electricity generation is expected to decline between 2018 and 2050. Additionally, given the advanced age of New Hampshire's existing biomass facilities and the lack of new investment nationally, it is unlikely that large scale research will be focused on modernizing biomass generation.

As new projects are connected to the grid, predominantly wind and solar, biomass will cede its market share to other forms of generation. These more flexible resources will contribute to more volatile, but lower market prices, leaving biomass generation at a steeper competitive disadvantage. New Hampshire ratepayers would likely need to provide continuous subsidies at above market prices to sustain Class III biomass generation. As noted, New Hampshire's 10 Year State Energy Strategy specifically advises against long term price supports for generation resources.

APPENDICES

APPENDIX A:
Questions Submitted to Biomass Operators

10-24-2018

Response to Questions submitted to Jodi Grimbilas, for Class III Biomass plants

1. What is the annual volumetric consumption of woody biomass for each plant? What have historical fuel consumption levels been?

    a) DG Whitefield: avg. 233,000 tons/ year (t/yr.).
    b) Springfield: avg. 238,000 t/yr.
    c) Bridgewater: 220,000 – 235,000 t/yr.
    d) Alexandria: about 193,000 t/yr.
    e) Bethlehem 2015 – 189,338 t/yr., 2016 – 196,719 t/yr., 2017 239,774 t/yr.
    f) Tamworth 2015 – 302,863 t/yr., 2016 – 200,747 t/yr., 2017 287,475 t/yr.

2. What is the maximum consumption level if each plant ran at or near 100% for a full year?

    A: Responses are approximate tonnages/year.

    a) DG Whitefield: 250,000
    b) Springfield: 250,000
    c) Bridgewater: 235,000
    d) Alexandria: 220,00
    e) Bethlehem: 255,500
    f) Tamworth: 328,500

3. What is the ratio of fuel supply costs to total revenues for each plant? Do you expect a material change in the price of wood biomass fuel supply in the next 3 years?

A: The ratio is variable, based on revenue fluctuations in various renewable portfolio standard (RPS) renewable energy certificate (REC) rates, energy, and capacity rates, operational time, and fuel price.

    a) DG Whitefield: about 69%
    b) Springfield; about 69%
    c) Bridgewater: greater than 50%
    d) Alexandria: about 60% (not in market last few years)
    e) Bethlehem: 70% to 80%
    f) Tamworth: 50% to 65%

Regarding future biomass fuel costs: Supply and demand and the price of fuel oil are major factors affecting price. Price could increase if demand from other sources (e.g., paper mills) within the biomass market used by each plant were to increase or transportation costs increase. A biomass fuel adjustment clause, similar to that provided to Burgess Biomass in Berlin, is an important policy option that can mitigate the impact of fuel increases while providing needed revenue to biomass suppliers for cost of production increases.

4. Alexandria is no longer certified to produce RECs according to the latest data from the PUC. Will the plant reapply for REC status following the passage of SB 365 (2018)?
    a. The PUC 2018 2nd quarter report and the New Hampshire DES 2018 2nd quarter report note that the unit did not operate. Non-operation did not create a need to reapply for REC status.

5. From 2014-2017, were these plants subjected to frequent stops and starts due to the increase in distributed energy resources in the ISO-NE territory? If not, is this a concern in the future as intermittent energy sources continue to grow?
    a. No. Historically, these biomass plants, which are designed as base-load generation, have operated as base-load. They are not designed to operate with frequent stops and starts. Operating with a contract can mitigate down-time and supports the operational time that is important for the use of low-grade biomass, provision of sustainable forestry and retention of jobs in the plants and forest products industry.

6. Do these plants face challenges related to wear and tear resulting from frequent stops and starts similar to those exhibited by other baseload power generators?
    a. These biomass plants are designed as base-load generation and have operated as base-load. They are not designed to operate with frequent stops and starts and would not operate in this manner reliably. Such operation would not benefit good forestry practices and would adversely affect biomass jobs, related businesses and low-grade wood usage. The units operate best at higher capacity factors.

7. Do any of these facilities, collectively or individually, believe that the underlying issues of the NEPOOL REC market have been resolved regarding REC pricing disparities in New Hampshire compared to other New England states?
    a. No.

8. Do these facilities plan to sell RECs into the New Hampshire market for compliance year 2018?
    a. Yes, to the extent possible when available and subject to demand, competition from other sellers, and price. The Alexandria unit, however, does not expect to operate in 2018.

9. When were these plants first placed into operation and what is the expected operational lifetime of a biomass plant?
    a. Whitefield: mid -1980s
    b. Springfield: mid-1980s
    c. Alexandria: about 1987
    d. Bridgewater: 1987
    e. Bethlehem: 1986
    f. Tamworth: 1987

    Like most power plants, regular facility maintenance means the expected operational lifetime is indefinite. The plants are designed such that facility components can be replaced or rebuilt.

Second Set of OSI Biomass Power Plant Questions

1. How many jobs does each plant directly support?

   A: The following response assumes "direct jobs" is intended to refer only to those jobs at the power plant for power plant employees. There are hundreds of additional jobs associated with the support of the power plant and its operations, including those related to biomass fuel procurement and delivery.

   a. Springfield and Whitefield: 20 to 21 jobs at the facility location

   b. Bethlehem: 20 jobs at the facility location.

   c. Tamworth: 20 jobs at the facility location.

   d. Bridgewater: 19 jobs at the facility location.

   e. Alexandria (when operating): 19 jobs at the facility location.

2. Is the cost of trucking chips included in the purchase price of fuel or is it an additional cost? For example, if chips cost $X/ton does this include delivery? If not, is delivery cost a significant factor?

   A. Generally, yes. There can be exceptions when transportation is priced separately.

3. Do plants contract with trucking operators to deliver chips regardless of where the wood originates, or are orders received based on which plant is closest to the logging site?

   A. Chips come from various logging/ harvesting job sites and are delivered to any particular plant based on supply, plant demand, and price. For example, chip deliveries may bypass a plant in favor of the Berlin biomass plant, which may be able to pay a higher price given its power sales contract.

APPENDIX B: Regional Economic Models, Inc. (REMI) Output

The economic impact of the potential closure of biomass plants in New Hampshire

The following assessment of the impact on the New Hampshire economy of the potential closure of biomass plants was carried out using the Economic and Labor Market Information Bureau's New Hampshire Econometric Model – a REMI Policy Insight+® model.[112]

By using this econometric model, we are able to estimate both the number of direct jobs lost as well as the indirect and induced jobs lost in the state due to the potential closure of all biomass plants in New Hampshire.

The New Hampshire statewide model was used for this analysis. Employment, biomass chips sales and investment spending were the policy variables that were reduced from the baseline over the timeframe 2019 to 2028.

Data from a recent study[113] was used to determine the number of direct jobs (121) at New Hampshire's six biomass electric power plants. This number was reduced from baseline in the REMI model from the detailed category: *Electric power generation, transmission and distribution* (NAICS 2211). As this industry group is very broad, the in-put averages do not reflect the real input needed for the biomass energy production (NAICS 221117 Biomass Electric Power Generation) as well as the investment needed for maintaining the biomass plant as opposed to maintaining the entire energy grid. Therefore both the intermediate inputs and investment spending were nullified. Instead industry sales for logging and investment spending were added as separate policy variables.

Two detailed scenarios were developed:

1. The low estimate used the $1,908,360 dollar amount as the reduction in Industry Sales (*Logging*) and reduce employment with 121 from *Electric power generation, transmission and distribution*, with nullifying intermediate inputs and nullifying investment spending. Investment spending in nonresidential structures was reduced separately by $6.08 million, annually.

2. The high estimate used the $4,617,000 dollar amount as the reduction in Industry Sales (*Logging*) and reduce employment with 121 from *Electric power generation, transmission and distribution*, with nullifying intermediate inputs and nullifying investment spending. Investment spending in nonresidential structures would be reduced by $12.16 million annually (doubling the amount in the low estimate).

Results of the economic impact of the closure of all biomass plants in New Hampshire

Low estimate scenario

- As a result of the potential closure of six biomass plants in New Hampshire, a total of 430 direct, indirect and induced jobs would be lost in 2019. On average over the 10-year period, total loss of jobs would be 398, annually.

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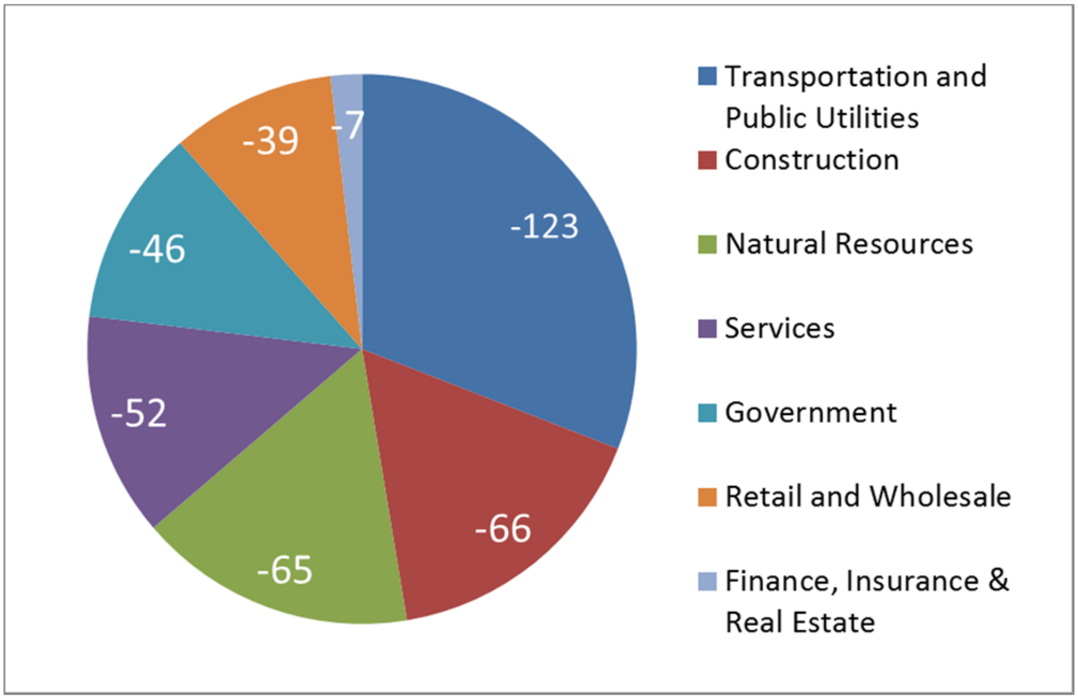
112 Product of Regional Economic Models, Inc. of Amherst, MA. Version 2.2.8 1-Region, 160 sector model.

113 Lee, Daniel S., Economic Contribution of the Biomass Electric Power Industry in New Hampshire, Plymouth State University. March 1, 2017.

- The distribution by industry of the secondary job losses would be as follows: Construction would be reduced by 66 jobs; Natural Resources by 65 and Services would be reduced by 52 jobs.

Figure 20: Low estimate scenario impact by industry, measured in total jobs



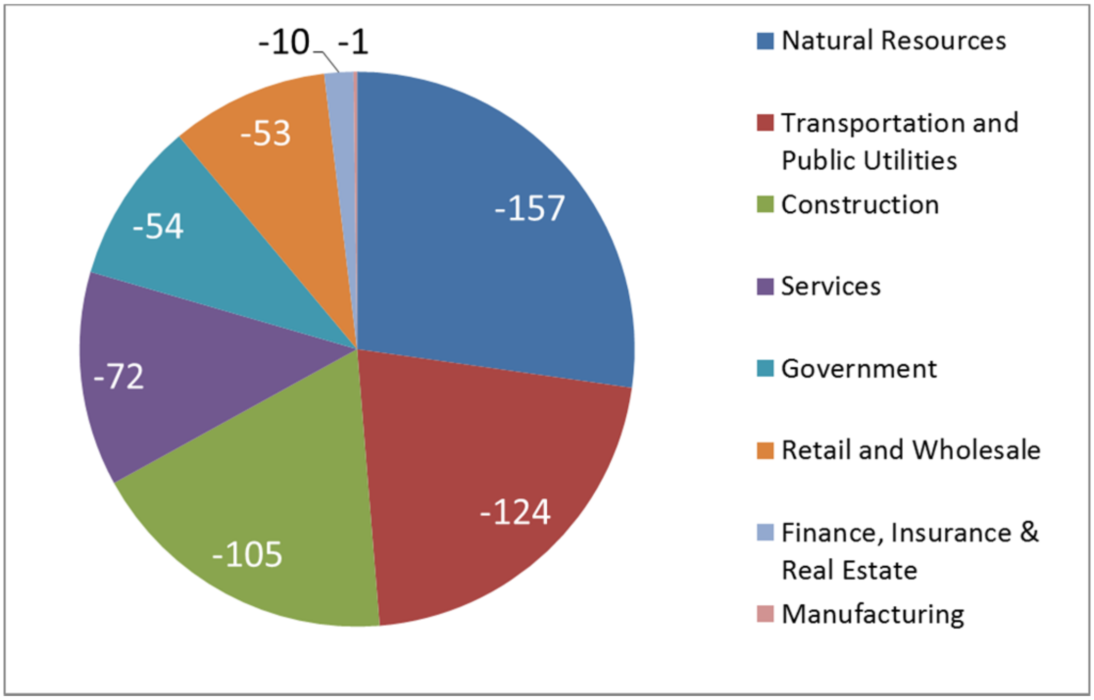
- The closure of these six biomass plants on the New Hampshire economy would have a negative impact of $72.8 million in fixed 2009 dollars to the state's Gross Domestic Product in 2019. Personal income would be reduced by $31.5 million in current dollars in 2019. On average, over the ten-year period, the negative impact would $76.5 million, annually, in GDP and $42.4 million in Personal income.

High estimate scenario

- As a result of the potential closure of six biomass plants in New Hampshire, a total of 645 direct, indirect and induced jobs would be lost in 2019. On average over the 10-year period, total loss of jobs would be 575, annually.

- The distribution by industry of the secondary job losses would be as follows: Natural Resources would be reduced by 157, Construction by 105 jobs; and Services would be reduced by 72 jobs.

Figure 21: High estimate scenario impact by industry, measured in total jobs



- The closure of these six biomass plants on the New Hampshire economy would have a negative impact of $81.5 million in fixed 2009 dollars to the state's Gross Domestic Product (GDP) in 2019. Personal income would be reduced by $42.2 million in current dollars in 2019. On average, over the ten-year period, the negative impact would $84.1 million, annually, in GDP and $55.9 million in Personal income.

Summary:

- Based on the two scenarios described above, the impact of the biomass industry in New Hampshire ranges from $76.5 million to $84.1 million, annually, in Gross Domestic Product.
- In terms of jobs, the impact ranges between 398 and 575 total jobs, annually.

The explanation below is the economic theory and empirical data behind the REMI model.

The REMI Model

REMI Policy Insight® is a structural model, meaning that it clearly includes cause-and-effect relationships.

The model is based on two key underlying assumptions from mainstream economic theory: households maximize utility and producers maximize profits. Since these assumptions make sense to most people, lay people as well as trained economists can understand the model. The tool is often used by economic developers and planners to gage the potential impact on a regional economy of proposed projects such as transportation infrastructure, office and retail development, relocation or expansion of businesses, etc.

In the model, businesses produce goods and services to sell locally to other firms, investors, governments, and individuals, and to sell as exports to purchasers outside the region. The output is produced using labor, capital, fuel, and intermediate inputs. The demand, per unit of output, for labor, capital, and fuel depends on their relative costs, since an increase in the price of any one of these inputs leads to substitution away from that input to other inputs. The supply of labor in the model depends on the number of people in the population and the proportion of those people who participate in the labor force. Economic migration affects the population size. People will move into an area if the real after-tax wage rates or the likelihood of being employed increases in a region.

Supply and demand for labor determine the wage rates in the model. These wage rates, along with other prices and productivity, determine the cost of doing business for each industry in the model. An increase in the cost of doing business causes either an increase in prices or a cut in profits, depending on the market for the product. In either case, an increase in costs would decrease the share of the local and U.S. market supplied by local firms. This market share, combined with the demand described above, determines the amount of local output. Many other feedbacks are incorporated in the model. For example, changes in wages and employment impact income and consumption, while economic expansion changes investment, and population growth impacts government spending.

The effects of a change scenario to the model are determined by comparing the baseline REMI forecast with an alternative forecast that incorporates the assumptions for the change scenario

Low Estimate Summary

Numeric Change		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Ten year average
Total Employment		-430.2	-446	-448.1	-434.6	-416.2	-395.8	-375.1	-357.4	-343.4	-331.9	-398
Private Non-Farm Employment		-404.8	-407.4	-402.4	-385.5	-365.6	-344.9	-324.6	-307.4	-294.1	-283.2	-352
Residence Adjusted Employment		-395.4	-404.7	-408.4	-397.9	-383.5	-367.3	-350.7	-336.6	-325.6	-316.4	-369
Population		-114.4	-199.7	-273.5	-330.4	-370.7	-398.8	-416.9	-428.4	-436.2	-440.4	-341
Labor Force		-107.8	-158.3	-192.5	-225.1	-242.4	-254.7	-261.9	-264.6	-265	-264.5	-224
Gross Domestic Product	Millions of Fixed (2009) Dollars	-72.8	-75.1	-76.5	-76.9	-77.1	-77	-77	-77.1	-77.5	-78	-76.5
Output	Millions of Fixed (2009) Dollars	-97.5	-100.9	-102.7	-102.9	-102.6	-102	-101.4	-101	-101.1	-101.5	-101.4
Value-Added	Millions of Fixed (2009) Dollars	-72.8	-75.1	-76.5	-76.9	-77.1	-77	-77	-77.1	-77.5	-78	-76.5
Personal Income	Millions of Current Dollars	-31.5	-36	-39.8	-42.1	-43.6	-44.6	-45.3	-46	-46.9	-47.9	-42.4
Disposable Personal Income	Millions of Current Dollars	-27.5	-31.6	-35	-37.1	-38.4	-39.3	-39.9	-40.2	-40.7	-41.6	-37.1

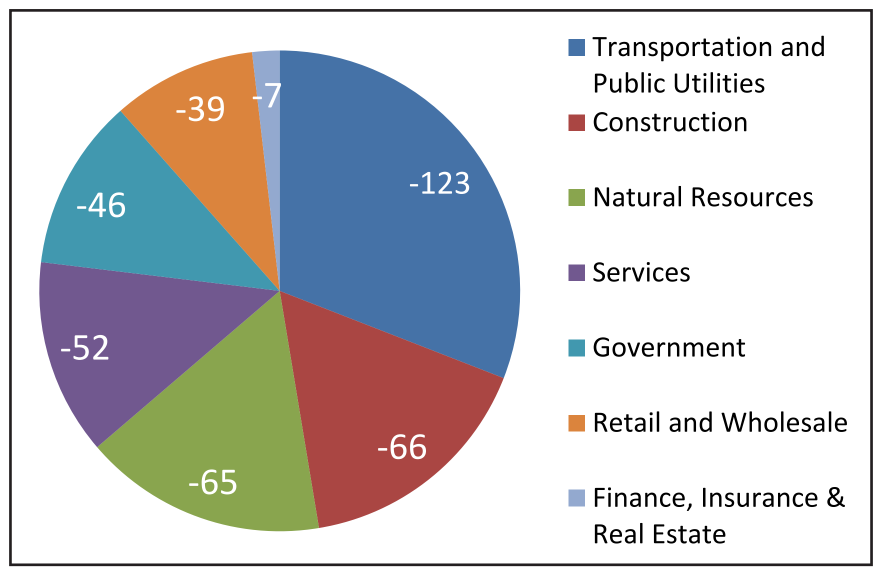
Percent Change Category	Units	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	
Total Employment	Thousands (Jobs)	-0.05%	-0.05%	-0.05%	-0.05%	-0.05%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	
Private Non-Farm Employment	Thousands (Jobs)	-0.05%	-0.05%	-0.05%	-0.05%	-0.05%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	
Residence Adjusted Employment	Thousands	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	-0.03%	
Population	Thousands	-0.01%	-0.02%	-0.02%	-0.02%	-0.03%	-0.03%	-0.03%	-0.03%	-0.03%	-0.03%	
Labor Force	Thousands	-0.01%	-0.02%	-0.03%	-0.03%	-0.03%	-0.03%	-0.03%	-0.03%	-0.03%	-0.03%	
Gross Domestic Product	Billions of Fixed (2009) Dollars	-0.10%	-0.10%	-0.10%	-0.10%	-0.10%	-0.09%	-0.09%	-0.09%	-0.09%	-0.09%	
Output	Billions of Fixed (2009) Dollars	-0.08%	-0.08%	-0.08%	-0.08%	-0.08%	-0.08%	-0.08%	-0.07%	-0.07%	-0.07%	
Value-Added	Billions of Fixed (2009) Dollars	-0.10%	-0.10%	-0.10%	-0.10%	-0.10%	-0.09%	-0.09%	-0.09%	-0.09%	-0.09%	
Personal Income	Billions of Current Dollars	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	
Disposable Personal Income	Billions of Current Dollars	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	
PCE-Price Index	2009=100 (Nation)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	

Low Estimate Industry

Industries	Units	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Ten year average
All Industries	Thousands (Jobs)	-0.43	-0.446	-0.448	-0.435	-0.416	-0.396	-0.375	-0.357	-0.343	-0.332	-0.3978
Natural Resources	Thousands (Jobs)	-0.075	-0.072	-0.07	-0.067	-0.065	-0.064	-0.062	-0.06	-0.058	-0.057	-0.065
Construction	Thousands (Jobs)	-0.086	-0.096	-0.095	-0.086	-0.075	-0.063	-0.051	-0.042	-0.034	-0.027	-0.0655
Manufacturing	Thousands (Jobs)	-0.005	-0.004	-0.003	-0.001	0	0.001	0.002	0.002	0.003	0.003	-0.0002
Retail and Wholesale	Thousands (Jobs)	-0.043	-0.043	-0.043	-0.042	-0.04	-0.038	-0.036	-0.035	-0.033	-0.032	-0.0385
Transportation and Public Utilities	Thousands (Jobs)	-0.124	-0.124	-0.124	-0.123	-0.123	-0.123	-0.122	-0.122	-0.122	-0.122	-0.1229
Finance, Insurance & Real Estate	Thousands (Jobs)	-0.01	-0.009	-0.009	-0.008	-0.008	-0.007	-0.006	-0.006	-0.005	-0.005	-0.0073
Services	Thousands (Jobs)	-0.061	-0.059	-0.059	-0.057	-0.054	-0.051	-0.048	-0.046	-0.045	-0.044	-0.0524
Government	Thousands (Jobs)	-0.025	-0.039	-0.046	-0.049	-0.051	-0.051	-0.051	-0.05	-0.049	-0.049	-0.046
Farm	Thousands (Jobs)	0	0	0	0	0	0	0	0	0	0	

	Industries	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Ten year average
	All Industries	-430	-446	-448	-435	-416	-396	-375	-357	-343	-332	-398
	Natural Resources	-75	-72	-70	-67	-65	-64	-62	-60	-58	-57	-65
	Construction	-86	-96	-95	-86	-75	-63	-51	-42	-34	-27	-66
	Manufacturing	-5	-4	-3	-1	0	1	2	2	3	3	0
	Retail and Wholesale	-43	-43	-43	-42	-40	-38	-36	-35	-33	-32	-39
	Transportation and Public Utilities	-124	-124	-124	-123	-123	-123	-122	-122	-122	-122	-123
	Finance, Insurance & Real Estate	-10	-9	-9	-8	-8	-7	-6	-6	-5	-5	-7
	Services	-61	-59	-59	-57	-54	-51	-48	-46	-45	-44	-52
	Government	-25	-39	-46	-49	-51	-51	-51	-50	-49	-49	-46
	Farm	0	0	0	0	0	0	0	0	0	0	0

Transportation and Public Utilities	-123
Construction	-66
Natural Resources	-65
Services	-52
Government	-46
Retail and Wholesale	-39
Finance, Insurance & Real Estate	-7
Manufacturing	0



High Estimate Summary

Numeric Change		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Ten year average
Total Employment		-644.5	-659.5	-656	-631.4	-600.7	-567.8	-534.8	-505.9	-483	-463.8	-575
Private Non-Farm Employment		-614.2	-613.6	-601.5	-572.8	-540.6	-507.5	-475.2	-447.4	-425.5	-407.3	-521
Residence Adjusted Employment		-592.6	-599.7	-599	-579.3	-554.8	-528.2	-501.3	-477.9	-459.4	-443.8	-534
Population		-168	-292.1	-397.6	-477.6	-533.1	-570.6	-593.6	-606.7	-614.5	-617.2	-487
Labor Force		-158.4	-232.6	-280.7	-326.6	-349	-364.7	-373.1	-374.8	-373.1	-370.4	-320
Gross Domestic Product	Millions of Fixed (2009) Dollars	-81.5	-84.1	-85.5	-85.5	-85.2	-84.6	-84	-83.6	-83.6	-83.8	-84.1
Output	Millions of Fixed (2009) Dollars	-111.5	-115.4	-117.1	-116.7	-115.5	-113.9	-112.3	-111.2	-110.6	-110.4	-113.5
Value-Added	Millions of Fixed (2009) Dollars	-81.5	-84.1	-85.5	-85.5	-85.2	-84.6	-84	-83.6	-83.6	-83.8	-84.1
Personal Income	Millions of Current Dollars	-42.2	-48.3	-53.4	-56.2	-58	-58.9	-59.5	-60	-60.8	-61.8	-55.9
Disposable Personal Income	Millions of Current Dollars	-36.9	-42.4	-47	-49.5	-51.1	-51.9	-52.4	-52.5	-52.8	-53.8	-49.0

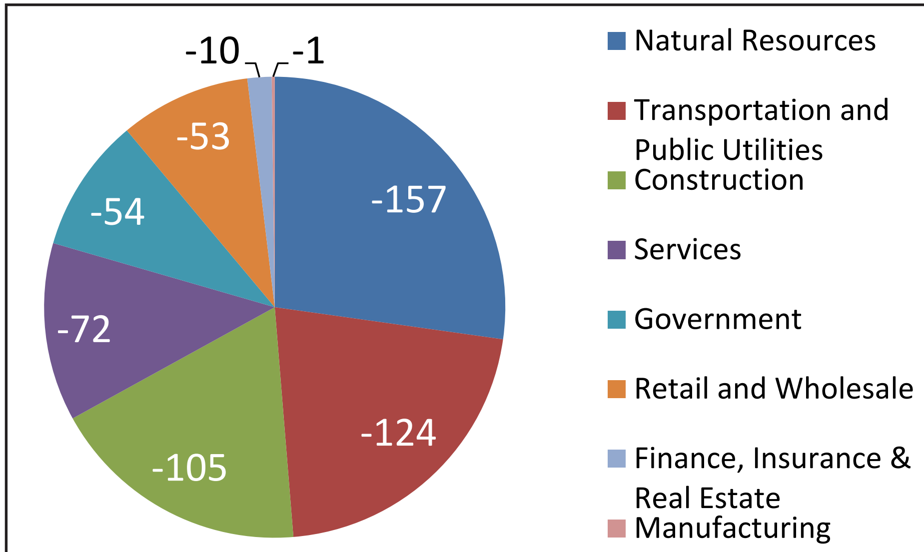
Percent Change												
Category	Units	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	
Total Employment	Thousands (Jobs)	-0.07%	-0.07%	-0.07%	-0.07%	-0.07%	-0.06%	-0.06%	-0.06%	-0.05%	-0.05%	
Private Non-Farm Employment	Thousands (Jobs)	-0.08%	-0.08%	-0.07%	-0.07%	-0.07%	-0.06%	-0.06%	-0.06%	-0.05%	-0.05%	
Residence Adjusted Employment	Thousands	-0.06%	-0.06%	-0.06%	-0.06%	-0.06%	-0.06%	-0.05%	-0.05%	-0.05%	-0.05%	
Population	Thousands	-0.01%	-0.02%	-0.03%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	
Labor Force	Thousands	-0.02%	-0.03%	-0.04%	-0.04%	-0.05%	-0.05%	-0.05%	-0.05%	-0.05%	-0.05%	
Gross Domestic Product	Billions of Fixed (2009) Dollars	-0.11%	-0.11%	-0.11%	-0.11%	-0.11%	-0.10%	-0.10%	-0.10%	-0.10%	-0.10%	
Output	Billions of Fixed (2009) Dollars	-0.09%	-0.09%	-0.09%	-0.09%	-0.09%	-0.09%	-0.08%	-0.08%	-0.08%	-0.08%	
Value-Added	Billions of Fixed (2009) Dollars	-0.11%	-0.11%	-0.11%	-0.11%	-0.11%	-0.10%	-0.10%	-0.10%	-0.10%	-0.10%	
Personal Income	Billions of Current Dollars	-0.05%	-0.05%	-0.06%	-0.06%	-0.06%	-0.05%	-0.05%	-0.05%	-0.05%	-0.05%	
Disposable Personal Income	Billions of Current Dollars	-0.05%	-0.05%	-0.06%	-0.06%	-0.06%	-0.05%	-0.05%	-0.05%	-0.05%	-0.05%	
PCE-Price Index	2009=100 (Nation)	0.00%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	

High Estimate Industry

Industries average	Units	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Ten year
All Industries	Thousands (Jobs)	-0.644	-0.66	-0.656	-0.631	-0.601	-0.568	-0.535	-0.506	-0.483	-0.464	-0.575
Natural Resources	Thousands (Jobs)	-0.181	-0.173	-0.167	-0.162	-0.158	-0.153	-0.149	-0.144	-0.141	-0.137	-0.157
Construction	Thousands (Jobs)	-0.143	-0.154	-0.151	-0.137	-0.119	-0.1	-0.082	-0.067	-0.054	-0.044	-0.105
Manufacturing	Thousands (Jobs)	-0.008	-0.006	-0.005	-0.003	-0.001	0	0.002	0.002	0.003	0.004	-0.001
Retail and Wholesale	Thousands (Jobs)	-0.06	-0.059	-0.06	-0.058	-0.055	-0.052	-0.049	-0.047	-0.045	-0.043	-0.053
Transportation and Public Utilities	Thousands (Jobs)	-0.126	-0.125	-0.125	-0.124	-0.124	-0.123	-0.122	-0.122	-0.122	-0.122	-0.124
Finance, Insurance & Real Estate	Thousands (Jobs)	-0.013	-0.013	-0.013	-0.011	-0.01	-0.009	-0.008	-0.007	-0.007	-0.006	-0.010
Services	Thousands (Jobs)	-0.084	-0.082	-0.082	-0.078	-0.074	-0.07	-0.066	-0.063	-0.061	-0.059	-0.072
Government	Thousands (Jobs)	-0.03	-0.046	-0.054	-0.059	-0.06	-0.06	-0.06	-0.059	-0.058	-0.056	-0.054
Farm	Thousands (Jobs)	0	0	0	0	0	0	0	0	0	0	0

	Industries	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Ten year average
	All Industries	-644	-660	-656	-631	-601	-568	-535	-506	-483	-464	-575
	Natural Resources	-181	-173	-167	-162	-158	-153	-149	-144	-141	-137	-157
	Construction	-143	-154	-151	-137	-119	-100	-82	-67	-54	-44	-105
	Manufacturing	-8	-6	-5	-3	-1	0	2	2	3	4	-1
	Retail and Wholesale	-60	-59	-60	-58	-55	-52	-49	-47	-45	-43	-53
	Transportation and Public Utilities	-126	-125	-125	-124	-124	-123	-122	-122	-122	-122	-124
	Finance, Insurance & Real Estate	-13	-13	-13	-11	-10	-9	-8	-7	-7	-6	-10
	Services	-84	-82	-82	-78	-74	-70	-66	-63	-61	-59	-72
	Government	-30	-46	-54	-59	-60	-60	-60	-59	-58	-56	-54
	Farm	0	0	0	0	0	0	0	0	0	0	0

Natural Resources	-157
Transportation and Public Utilities	-124
Construction	-105
Services	-72
Government	-54
Retail and Wholesale	-53
Finance, Insurance & Real Estate	-10
Manufacturing	-1



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