RENEWABLE ENERGY PORTFOLIO STANDARD TECHNICAL ANALYSIS OF BIOMASS

Prepared for:

EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS

DEPARTMENT OF ENERGY RESOURCES

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Executive Summary

Background

The purpose of this report is to evaluate the potential impact of DOER's proposed changes to the Massachusetts Class I and Class II RPS regulations on the future operations and development of biomass generation units in the region. The RPS regulations require all retail electricity suppliers to obtain specified minimum percentages of electricity supply from certified renewable energy generation resources. The MA RPS was established in 1997 and has been modified several times since. Biomass-to-electricity generation units are eligible to participate in the MA Class I and Class II programs, provided that they demonstrate compliance with eligibility criteria on an ongoing basis. In April 2019, DOER proposed modifications to the Class I and Class II RPS regulations, including changes to the eligibility criteria affecting biomass generation units. This report focuses primarily on the potential impact of the proposed changes on existing biomass-to-electricity generators, as well as the potential for the changes to enable development of new biomass generation units. The potential opportunity for such generation units to participate in either MA Class I or MA Class II is considered.

Key Findings

Existing Biomass Generation Units

- Vintage and NOx Emissions Requirements: RPS Class I vintage eligibility requirements will not change, limiting the pool of biomass generation units that could qualify for Class I under the proposed RPS regulations. Existing NO_x emissions eligibility requirements within the RPS regulation are strict and will not change; many operating biomass generation units cannot meet them without major incremental investments in emissions control systems that are cost-prohibitive in the absence of a long-term revenue guarantees.

- Limited Existing Biomass Generation Units May Expand Production: Technical screening analysis identified only a small pool of existing biomass generation units that may potentially respond based on the proposed RPS regulations, with only six of the 46 existing biomass generation units in New England identified whose production might increase materially. In addition to the Massachusetts RPS eligibility thresholds noted above, additional limiting factors include generation units that are already eligible for the Massachusetts RPS; that have already retired or ceased to produce under more favorable market conditions; that have made prior commitments under long-term contract or to on-site load; that rely on fuel that is an onsite ineligible waste product or whose operations as pulp and paper mills are generally insensitive to REC prices. Additional projects are too small to make a material difference.

- Participation in RPS Markets Elsewhere: Analysis demonstrated that other states' RPS markets may be more financially lucrative, and regardless of any changes to the RPS regulations, a facility will not participate in the MA RPS market if it can earn more revenues through its participation in another RPS market.

- Additional Costs to Procure Eligible Salvage and Non-Forest Derived Fuel: Biomass generation units seeking to procure forest salvage and non-forest derived fuel may pay additional costs to procure such fuels in comparison to other fuel mixes currently used to supply the existing biomass fleet. While this type of biomass would reduce overall emissions, the additional costs can be attributed to increased transportation costs and more complicated procurement logistics to replace the currently used fuel sources that would no longer be eligible.

- Low Probability of a Small Increase in Production for Existing Biomass Generation Units: Detailed plant-by-plant analysis demonstrates that adoption of the proposed changes would have a very small impact on the production of the six existing biomass generation units. Of the years studied (2020 to 2025), only one generation unit is expected to increase production for one year under base case assumptions, and under the most aggressive assumptions, only two generation units are expected to increase production over the span of two years.

New Biomass Generation units

- **Revenue from RPS market is extremely unlikely to be sufficient to finance a new biomass facility:** Under Base Case assumptions, a levelized REC price above the proposed RPS ACP cap of $70 would be required to support the financing of a new biomass facility, and even under the Aggressive Case assumptions, the levelized REC requirement is almost three times higher than the 20-year levelized Class I REC revenue projected.

Lifecycle GHG Emissions

- **Lifecycle GHG Emission reductions are above 50% minimum requirement:** The adoption of the proposed amendments to the RPS regulations will lead to the reduction of lifecycle GHG emissions, with a more than 50% lifecycle GHG reduction over 20- and 30-year timeframes compared to a base case predicated on maintenance of 2013 RPS guidelines for biomass eligibility.

- **Characteristic of Feedstock drives lifecycle GHG emission reductions:** While extending the timeframe of the lifecycle greenhouse gas analysis to 30 years does increase the amount of greenhouse gas emissions reductions that occur, the restriction of Forest Derived Thinnings to no more than 5% in order to waive the overall efficiency requirement is more impactful on the total amount of greenhouse gas emissions reduced.

- **Opportunity to realize lifecycle GHG emission reductions:** If the proposed changes to the regulations are not implemented, there is a lost opportunity to reduce lifecycle greenhouse gas emissions.

1 Introduction

1.1 Background

The Massachusetts Department of Energy Resources (DOER) develops and implements policies and programs aimed at ensuring the adequacy, security, diversity, and cost-effectiveness of the Commonwealth's energy supply to create a clean, affordable and resilient energy future. Among these policies is the Renewable Energy Portfolio Standard (RPS). The RPS regulations require all retail electricity suppliers in the Commonwealth to obtain specified minimum percentages of their electricity supply from certified renewable energy generation sources that must meet a defined set of technology-specific eligibility criteria.

The Massachusetts RPS was established by legislation in 1997 and has been modified several times since. The first compliance year for Class I was 2003[1]. Class II, Class II-Waste-to-Energy, and the Alternative Energy Portfolio Standard (APS) compliance all began in 2009, and the Solar Renewable Energy Carveout I (SREC-I) and SREC-II were added in 2010 and 2014, respectively.

Biomass-to-electricity generation units are eligible to participate in the Commonwealth's Class I and Class II RPS programs, provided that they demonstrate compliance with eligibility criteria on an ongoing basis. In April 2019, DOER proposed changes to the Class I and Class II RPS regulations, including changes to the eligibility criteria affecting biomass generation units.

1.2 Purpose

The purpose of this report is to evaluate the potential impact of DOER's proposed changes to the Massachusetts Class I and Class II RPS regulations on the future operation and development of biomass generation units in the region. This report summarizes a technical analysis that first evaluates the current participation of biomass-to-electricity generation units' in New England RPS markets, and then considers the potential impact of the proposed changes on biomass feedstock procurement, annualized production estimates at biomass generation units, and the associated greenhouse gas emissions. The potential opportunity to participate in either Massachusetts Class I or MA Class II is considered in this analysis. This report focuses primarily on the potential impact of the proposed changes on existing biomass-to-electricity generators, but also assesses the potential impact of the proposed regulations on the viability of new biomass generation units.

1.3 Report Organization

Section 2 provides an overview of biomass to electricity in New England, including biomass eligibility in Massachusetts and other New England states. It provides an overview of DOER's pertinent proposed changes to RPS as they pertain to biomass eligibility. It also provides an overview of the New England region's current biomass to electricity fleet, as well as recent biomass development trends.

[1] Early compliance from production in 2002 was allowed to count toward the 2003 obligation.

In Section 3, we present a technical analysis of existing biomass generation units' potential response to DOER's proposed changes in Massachusetts biomass eligibility, by comparing:

(1) expected annual energy production from 2020 through 2025 under a 'reference case' with current rules, given expected energy, capacity and Renewable Energy Certificate (REC) revenues and;

(2) the projected production in an alternative future, a 'policy case', in which the Massachusetts DOER enacts proposed RPS changes pertaining to biomass eligibility.

This section reviews a screening process used to identify which generation units might respond to proposed changes, and then presents the analytical approach used to project levels of increased electricity production from generation units passing the screening test. It concludes by detailing results of the analysis of electricity production changes stimulated by Massachusetts RPS proposed rules changes.

Section 4 presents analysis of the proposed RPS changes to stimulate development of new biomass generation units.

In Section 5, we discuss other potential impacts of proposed RPS changes if adopted, including impacts on forest ecosystems and greenhouse gas impacts.

Finally, we summarize key findings, study limitations and recommendations for additional analysis in Section 6, the Conclusions section.

The technical analysis included herein relies in part on our evaluation of biomass feedstock availability. A range of RPS-eligible feedstocks under the proposed rules - including forest salvage, residues, and wood wastes - available to existing biomass generation units are considered. The Biomass Feedstock Analysis report, summarizing this analysis in detail, is provided as Appendix A. Additionally, the quantitative analysis in Section 5 on the lifecycle greenhouse gas emissions analysis was undertaken by DOER, with inputs derived from the consultants, and is provided as Appendix B.

1.4 Consulting Team & Scope

After issuing draft regulations, DOER engaged Sustainable Energy Advantage, LLC (SEA) and its subcontractor Antares Group Inc. (Antares) (together, the Consulting Team) through a competitive process to complete two core technical analyses in consideration of the proposed regulatory amendments.

Biomass Feedstock Analysis

The Consulting Team reviewed publicly-available data on forest salvage and non-forest derived residues[2] - the fuel supply sources that must comprise at least 95% if a biomass generation unit's fuel input for DOER to waive applicability of a minimum overall efficiency requirement under its proposed RPS regulation changes - to assess the availability and current pricing of such fuels as delivered to each biomass-to-electricity generation unit located in New England or New York identified with potential to participate in the Massachusetts Class I and Class II RPS if the minimum efficiency standard is waived. The team also conducted a similar analysis for the assumed location of a hypothetical new biomass generation unit in Western Massachusetts. The biomass feedstock analysis included the following resources:

1. *Forest salvage and wood generated through land use change (forest to agricultural)*
2. *Residues generated though forest products industry manufacturing*
3. *Wood waste: post-consumer wood products from clean wood*
4. *Agricultural wood waste*

The results of this analysis are fuel 'supply curves' consisting of the availability of projected fuel quantities and their respective delivered costs, as detailed in Appendix A: Biomass Feedstock Analysis Report.

Renewable Energy Certificate (REC) Market Analysis

This analysis includes an assessment of:

1. The sufficiency of market revenues (including expected energy, capacity, and REC prices) to cause increased production at existing biomass generation units – taking into account the proposed changes to biomass feedstock eligibility and efficiency, compared to the Reference Case.
2. The REC prices necessary to cause increased operation at existing biomass generation units.
3. The sufficiency of market revenues, in the proposed Policy Case, for a new biomass facility to be built.

The Consulting Team deployed SEA's proprietary Renewable Energy Market Outlook (REMO) models to assess potential changes in the operations and annual energy production of biomass generation units as a result of proposed changes to Class I or Class II MA RPS regulations. The analysis includes a Reference Case (to establish a business-as-usual baseline) and a Policy Case (in which the proposed changes are assumed to take effect). The analysis focuses on the period 2020 through 2025 (although qualitative observations are made for later periods)[3]. The analysis considers both MA Class I and MA Class II markets.

2 Biomass-to-Electricity in New England

2.1 RPS Market Characterization

Biomass-to-electricity generation units are currently eligible for multiple RPS markets across New England. As a result of technology-specific eligibility criteria, however, not all generation units are able to

[2] As defined in proposed Massachusetts Renewable Portfolio Standard rules (225 CMR 14.00 and 225 CMR 15.00

[3] Beyond 2025, current conditions suggest that REC prices throughout the region may be inadequate to support ongoing operation; furthermore, beyond 2025 regional REC prices are increasingly dependent on future policy decisions throughout the region. Therefore, the analysis focused on a period during which projected REC prices in Massachusetts would be most likely to support biomass operation.

achieve – or maintain – certification in all RPS markets. Table 1 provides a high-level summary of *current* RPS eligibility criteria for biomass generation units.

Table 1: Summary of RPS Criteria for Biomass Generation Units

RPS Market	Vintage Requirement	Emissions Limit	Other Criteria
MA Class I	1/1/1998 or later	NOx ≤ 0.065 lbs/MMBtu[4] PM ≤ 0.012 lbs/MMBtu[5]	≥ 50% efficiency for ½ REC/MWh ≥ 60% efficiency for 1 REC/MWh
MA Class II	12/31/1997 or earlier		
CT Class I	None	NOx ≤ 0.075 lbs/MMBtu	
RI New	1/1/1998 or later	None	Sustainable fuel plan required
RI Existing	12/31/1997 or earlier	None	Sustainable fuel plan required
ME Class I/IA	After 9/1/2005	None	Allows black liquor[6]
ME Class II	None	None	
NH Class I	After 1/1/2006 or later	NOx ≤ 0.075 lbs/MMBtu PM ≤ 0.02 lbs/MMBtu	
NH Class III	12/31/2005 or earlier	NOx ≤ 0.075 lbs/MMBtu PM ≤ 0.02 lbs/MMBtu	Capacity ≤ 25 MW
VT Tier I	None	None	

Biomass facility participation in RPS markets is a function of the intersection between the cost required to achieve and maintain certification and the benefit derived from the *potential* ability to sell RECs – the price of which varies by RPS market and is itself a function of market-specific supply and demand dynamics.[7] Markets in which RPS targets increase over time *generally* provide a greater opportunity (though not certainty) for higher REC revenue than markets with static (or managed) RPS targets. Ultimately, however, the total annual production at eligible generation units that maintain their certification in good standing contributes to determining annual supply/demand balance and REC price. Since the inception of the RPS, regional Class I markets have experienced conditions of shortage, surplus, and equilibrium. Most of the the regional Class I markets (MA, CT, RI, NH) are presently in approximate equilibrium. In shortage, prices may approach a price cap established in each RPS tier by an Alternative Compliance Payment (ACP); in surplus, they fall. However, during such periods of imbalance, load-serving

[4] For facilities > 10 MW.

[5] For facilities > 10 MW.

[6] Black Liquor: A biproduct of pulp and paper manufacturing.

[7] Today, each of these RPS markets conveys to eligible facilities one REC per MWh produced. However, Connecticut is in the process of implementing a statutorily-required phase-down of RECs conveyed to Class I-eligible biomass and landfill methane facilities. Following the effective date of implementation, DEEP will reduce to 50% the number of Connecticut Class I RECs granted per MWh production from eligible generation for Class I biomass and landfill gas generators after (i) 20 years, for new facilities, and (ii) 15 years for existing facilities from the time they were approved as a Class I renewable energy source in Connecticut. Most Connecticut Class I-eligible biomass plants are at or will pass the 15-year threshold in the next few years. The remaining 50% of RECs will be eligible to be sold elsewhere.

entities' (LSE's) ability to "bank" excess compliance (or use previously banked compliance) helps to moderate REC price volatility.

Regional Class II markets are less homogenous. Some are characterized by systemic surplus, in which eligible supply – by definition – is expected to far outpace long-term demand. Other markets, like MA Class II, have certified less supply than the minimum standard, leading to sustained shortage conditions. Massachusetts Class II REC prices are expected to remain near the Alternative Compliance Payment (ACP), as Section 15.07(1) provides for increasing the Class II minimum obligation up to a maximum of 3.6% of load in the event additional supply is certified, suggesting continued shortage and REC prices nearing the ACP in the future. Table 2 summarizes RPS target characteristics and recent REC prices.

Table 2: RPS Target Characteristics and Recent REC Prices

RPS Market	RPS Targets	Current Market Dynamics	Recent REC Price
MA Class I	Increasing	Approx. Equilibrium	~$40/MWh
MA Class II	Static/Managed	Shortage	~$25/MWh
CT Class I	Increasing	Approx. Equilibrium	~$40/MWh
CT Class II	Static/Managed	Shortage	~$20/MWh
RI New	Increasing	Approx. Equilibrium	~$40/MWh
RI Existing	Static/Managed	Systemic Surplus	< $1/MWh
ME Class I/IA	Increasing[8]	Surplus[9]	~$1/MWh
ME Class II	Static/Managed	Systemic Surplus	< $1/MWh
NH Class I	Increasing	Approx. Equilibrium	~$40/MWh
NH Class III	Static/Managed	Shortage	~$40/MWh
VT Tier I	Increasing	Systemic Surplus	< $1/MWh

2.1.1 Biomass Resources Under the Current MA RPS

Presently, no stand-alone biomass-to-electricity generation units are certified for either the MA Class I or Class II RPS. Of six very small combined heat-and-power units[10] burning biomass or biodiesel certified for MA Class I, only two – Cooley Dickenson and Seaman Paper – use woody biomass. These units' co-location with generation units capable of using both electricity and a material proportion of the energy produced as thermal energy, enables the generation units to achieve the MA RPS's minimum efficiency standards.

Several existing biomass-to-electricity generation units have historically held MA Class I certifications, but the on-set of minimum efficiency standards and air emission thresholds in 2016 caused all such projects to lose their MA RPS eligibility. These generation units continue to participate (in varying combinations)

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[8] In 2019, the Maine legislature revised its RPS to include a Class IA with increasing targets. This may cause Maine REC prices to converge with MA/CT/RI/NH over the next several years.
[9] In 2019, the Maine legislature revised its RPS to include a Class IA with increasing targets. This may cause Maine REC prices to converge with MA/CT/RI/NH over the next several years.
[10] With a combined capacity of 1.935 MW.

in either Connecticut Class I, New Hampshire Class III, Maine I and/or Rhode Island "New" markets – some of which apply emissions thresholds or limited fuel sourcing standards but none of which impose a minimum efficiency requirement. When evaluating MA DOER's proposed RPS changes, existing biomass generation units will compare the potential benefits of participating in the MA RPS market to the benefits of continuing participating in these other regional RPS programs.

2.2 Proposed Changes to MA RPS Impacting Biomass

In April 2019, DOER filed draft regulations proposing to amend portions of the RPS and opened a period of public comment and stakeholder engagement. Changes proposed in the amended draft regulations included "those required by Chapter 227 of the Acts of 2018, changes made to improve the regulation, streamline requirements, reduce costs, and eliminate unnecessary or onerous provisions as contemplated by Executive Order 562, and other policy related changes that were identified by DOER during its comprehensive review of the existing regulations".[11] Among these, DOER proposed to make the following changes to the eligibility rules applicable to woody biomass generators under the RPS Class I[12] and RPS Class II[13]. As summarized in DOER's April 11, 2019 notice to stakeholders, proposed changes relevant to biomass generators include:

1. no longer allowing fuel sourced from land clearings related to development,
2. eliminating the sliding scale that allowed generation units to earn between ½ REC and a full REC based on their overall efficiency. Under the proposed draft regulation, the overall efficiency requirement is set at 50% to earn a full REC for generation units utilizing fuel that is comprised of 5% or more Forest Derived Thinnings or Forest Derived Residues,
3. exempting generation units utilizing fuel that is comprised of more than 95% Forest Salvage or Non-Forest Derived Residues from the overall efficiency requirement,
4. extending the timeframe of the lifecycle greenhouse gas analysis to 30 years, and
5. eliminating the ability for generators to make payments to DOER in order to retain their Statement of Qualification in the event they are unable to demonstrate compliance with the lifecycle greenhouse gas requirements in a particular year.

2.3 Existing Biomass-to-Electricity Generation Units

New England's fleet of existing biomass-to-electricity generators includes a variety of facility types. Some are stand-alone and produce only electricity for regional markets, while others are co-located with industry (paper mills, for example) and provide both electricity to serve power needs and thermal energy to support industrial processes. Most generation units are interconnected on the utility's side of the

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[11] DOER's April 11, 2019 notice:
https://www.mass.gov/files/documents/2019/05/15/RPS%20and%20APS%20Stakeholder%20Announcement.pdf

[12] 225 CMR 14.00 Renewable Energy Portfolio Standard - Class I (REDLINE):
https://www.mass.gov/files/documents/2019/04/08/225%20CMR%2014.00%20Draft%20RPS%20Class%20I%20REDLINE%20%28030119%29_0.pdf

[13] 225 CMR 15.00 Renewable Energy Portfolio Standard - Class II (REDLINE):
https://www.mass.gov/files/documents/2019/04/08/225%20CMR%2015.00%20Draft%20RPS%20Class%20II%20REDLINE%20%28040519%29_0.pdf

meter, but some are connected behind a retail customer's meter. These characteristics, along with vintage, capacity, actual emissions, and fuel(s) consumed, dictate whether a facility is eligible for one or more regional RPS markets.

2.3.1 Existing Biomass Fleet & Participation in RPS Markets

Whether a facility will change its operational profile in response to MA DOER's proposed changes is a function of its present certification and participation in other RPS markets and the value of RECs in those markets relative to that in Massachusetts Class I or Class II, as applicable on a facility-by-facility-basis. Regardless of any changes to the RPS regulations, a facility will not participate in the MA RPS market if it can earn more revenues through its participation in another RPS market. A total of 46 biomass plants were identified and considered. From that group, this table excludes plants that (i) have been retired/mothballed; (ii) are already eligible for Massachusetts Class I, and (iii) include another 12 very small plants collectively totaling 7.75 MW capacity that are some combination of either sized to serve load, whose operations are expected to be insensitive to REC prices, or for which any changes would be trivial for purposed of this analysis. Table 3 summarizes generation units within the existing regional biomass fleet that are currently participating in one or more RPS markets and are candidates for participation in the revised Massachusetts RPS market, if all (proposed) requirements are met.

Table 3: Characterization of Existing Biomass Generation Units[14]

Facility Name	Location	Current RPS Eligibility
Sappi Westbrook	ISO-NE, ME	ME-1
Burgess Biomass	ISO-NE, NH	CT-1,ME-I,RI-New,NH-I
Catalyst Paper Cogen	ISO-NE, ME	ME-I
Fort Drum/Black River	NYISO	NY Main Tier RPS
McNeil Generating Station	ISO-NE, VT	CT-I
Stratton Energy	ISO-NE, ME	CT-I,ME-I
Schiller Station	ISO-NE, NH	CT-1,ME-I,RI-New,NH-I
Catalyst Paper Recovery Boiler	ISO-NE, ME	ME-I
Plainfield Renewable Energy	ISO-NE, CT	CT-I
Livermore Falls	ISO-NE, ME	CT-I,ME-I
Sappi Somerset	ISO-NE, ME	ME-I
Jonesboro	ISO-NE, ME	ME-I,RI-New
West Enfield	ISO-NE, ME	ME-I,RI-New
Tamworth	ISO-NE, NH	CT-I,NH-III
Ryegate	ISO-NE, VT	CT-I,NH-III
Springfield Power	ISO-NE, NH	CT-I,NH-III
Whitefield Power	ISO-NE, NH	CT-I,NH-III
Pinetree-Fitchburg	ISO-NE, MA	CT-I,NH-III
Verso Androscoggin RB#1	ISO-NE, ME	ME-I
Bridgewater Power	ISO-NE, NH	CT-I,NH-III
Bethlehem	ISO-NE, NH	CT-I,NH-III
SAPPI Somerset HB#1	ISO-NE, ME	ME-I
Woodland Pulp Biomass	ISO-NE, ME	ME-I
Georges River Energy	ISO-NE, ME	ME-I,RI-New
Verso Androscoggin RB#2	ISO-NE, ME	ME-I

[14] Not all of these generation units were operating at the time of this report.

Athens Energy	ISO-NE, ME	CT-1,ME-I,RI-New,NH-I

As further described in Section 3, this analysis reviews the likelihood that each facility's will be influenced by the proposed changes to the MA RPS. This evaluation includes a review of each facility's current operating status (several generation units have recently shut), whether it is interconnected behind a retail meter or otherwise serving a substantial on-site load (such as a paper mill), or whether the facility is fully or partially selling energy under a long-term contract. By applying these criteria, and overlaying each facility's RPS eligibility, the analysis focuses on the potential for the MA RPS changes to affect a much narrower set of generation units than the entire existing fleet.

2.4 Future Market Participation

The future viability of regional biomass-to-electricity generation units, and by extension their potential participation in RPS markets, is uncertain. Most projects don't have any form of long-term contract, and annual average wholesale market electricity prices may be insufficient to support long-term operation. Occasionally, consistently cold weather will spur higher prices for several weeks, but such periodic and unpredictable events are inadequate to sustain any particular biomass-to-electricity facility.

While the early 2000's brought a wave of activity exploring the potential development of new, stand-alone biomass-to-electricity generation units in Massachusetts, Connecticut, Maine, New Hampshire, and Vermont, only Plainfield Renewable Energy (CT, 2013) and Burgess Biopower (NH, 2014) were completed. Both projects have long-term contracts with investor-owned utilities. Biomass development activity in the region today is primarily limited to potential on-site heating or combined heat and power installations sized to load. Only one large-scale facility in the region is currently proposed – Palmer Renewable Energy near Springfield, MA. The exact status of this facility is not known, but press reports suggest that the proposed project continues to seek permits and off-take contracts necessary for financing.[15]

3 Analysis of Existing Fleet Response to Proposed MA RPS Changes

The purpose of this section is to evaluate the potential impact of proposed RPS modification to biomass feedstock and efficiency criteria on operations of existing biomass generation units, using expected annual production as an indicator. This section seeks to answer the following questions:

- Would participation in the revised MA RPS provide the potential for additional revenues at existing biomass generation units?
- Would it be profitable for an existing biomass generation unit to change its fuel supply to be eligible for a revised Massachusetts RPS?

[15] In an April 2019 press release, Energy New England, LLC suggested Palmer Biomass as one of several renewable energy supply portfolio options to municipal light plants. See: https://www.ene.org/ene-provides-customers-with-green-portfolio-options/

- If so, how would energy production be expected to change as a result of the revised MA RPS eligibility at existing biomass generation units?

3.1 Approach

This analysis focuses on the period spanning 2020 through 2025. To quantify the impact of the proposed Massachusetts RPS regulation biomass eligibility changes, the analysis considers two scenarios:

- A **"Reference Case"** (to establish a business-as-usual baseline), wherein operation at biomass generation units are driven by market revenues available under existing and expected market conditions, including eligibility, committed monetary support (e.g., long-term contracts), and dynamics such as Connecticut's plans to reduce the credit per REC for most biomass generation units to 50% commencing in 2020; and

- **A "Policy Case"** under which Massachusetts adopts the proposed MA RPS regulation changes, enabling the biomass generation units' potential access to increased revenues but subject to the additional costs associated with more limited biomass feedstocks.

To understand whether the proposed MA RPS regulation changes could incentivize existing biomass generation units to participate in MA RPS Class I or Class II, and whether the changes would influence operations, the analysis assesses the level of REC market revenues available to a biomass generation unit if it stays with its status quo (i.e., the Reference Case), compared to level that would be available if it participates in the revised MA RPS in the Policy Case. In cases where participating in the revised RPS would potentially provide an increase in REC revenue surpassing increased fuel costs, the analysis examines whether the biomass facility would have enough revenues to stimulate increases in expected annual production at the existing biomass generation units from the Reference Case to the Policy Case.

The analysis consists of the following steps:

1. Identify which existing biomass generation units could potentially respond to MA RPS changes by accessing biomass feedstock, and the applicable Massachusetts RPS tier (screening).
2. Identify expected 'business-as-usual' biomass facility annual energy production for each existing biomass facility surviving the screening step.
3. Identify for each generation unit surviving the screening, for each year, which RPS market is the 'driving market' to provide the highest revenue, and the resultant business-as-usual REC revenue source.
4. Assessing the maximum revenue source available to the generation unit if it were to choose (by limiting its fuel use) to become Massachusetts RPS eligible.
5. Comparing the revenues available business-as-usual (from #3) and as Massachusetts RPS-eligible under the proposed regulations, to identify the generation units and calendar years in which there is any possibility of an improved economic outcome. This step identifies the population of generation units and years for which detailed economic analysis was conducted.
6. Generation units identified in the prior step, for each year in which potential economic upside from becoming Massachusetts Class I or II eligible under revised rules, were subjected to a detailed analysis of dispatch economics utilizing the fuel supply curve of eligible fuels, to assess the potential for a profitable level of dispatch exceeding the projected business-as-usual dispatch.

3.2 Screening

This analysis focuses on operations at existing biomass generation units that could potentially respond to the proposed MA RPS regulation changes. The full list of 46 generation units identified in New England plus New York was screened through a process depicted in Figure 1. The screening process filtered out generation units from the biomass fleet inventory in Section 2.3.1 (including those not listed in this section, see footnote to Table 3) that:

i. Have recently been retired or (while not formally retired) have not operated under more favorable economic conditions than offered by the proposed revised Massachusetts RPS;
ii. Would need to import energy from outside New England into ISO-NE when a material part of the supply is committed to on-site load;[16]
iii. Are already eligible for the Massachusetts RPS (and would be unmotivated to incur increased fuel costs for the same revenue);
iv. Serve on-site load from generation units with less than 2 MW. Collectively these projects amount to 7.75 MW and any potential changes would be expected to be trivial;
v. Already have output committed under long-term contracts supporting full output, or energy sold pursuant to Maine's Community-based Renewable Energy Pilot Program and can sell RECs into other states with revenues similar to MA Class I without constraints on fuel supply;
vi. Are large Maine-based pulp and paper generation units whose operations are driven primarily by pulp-and-paper industry economics (and therefore whose production is generally and has historically been insensitive to REC prices), and/or rely at least in part on industrial waste fuel sources such as black liquor that would fail to meet Massachusetts fuel eligibility requirements; or
vii. Based on emission data including air permits would fail to meet Massachusetts' strict emission limits. We did not apply this limit strictly, allowing generation units whose emissions were close to the limits to pass the screen, in the event that modest changes might be feasible if justified by increased net revenues.

[16] The only candidate facility is partially contracted to NYSERDA. Adapting to revised fuel criteria and delivering energy from New York to New England would undermine economics of the existing contract.

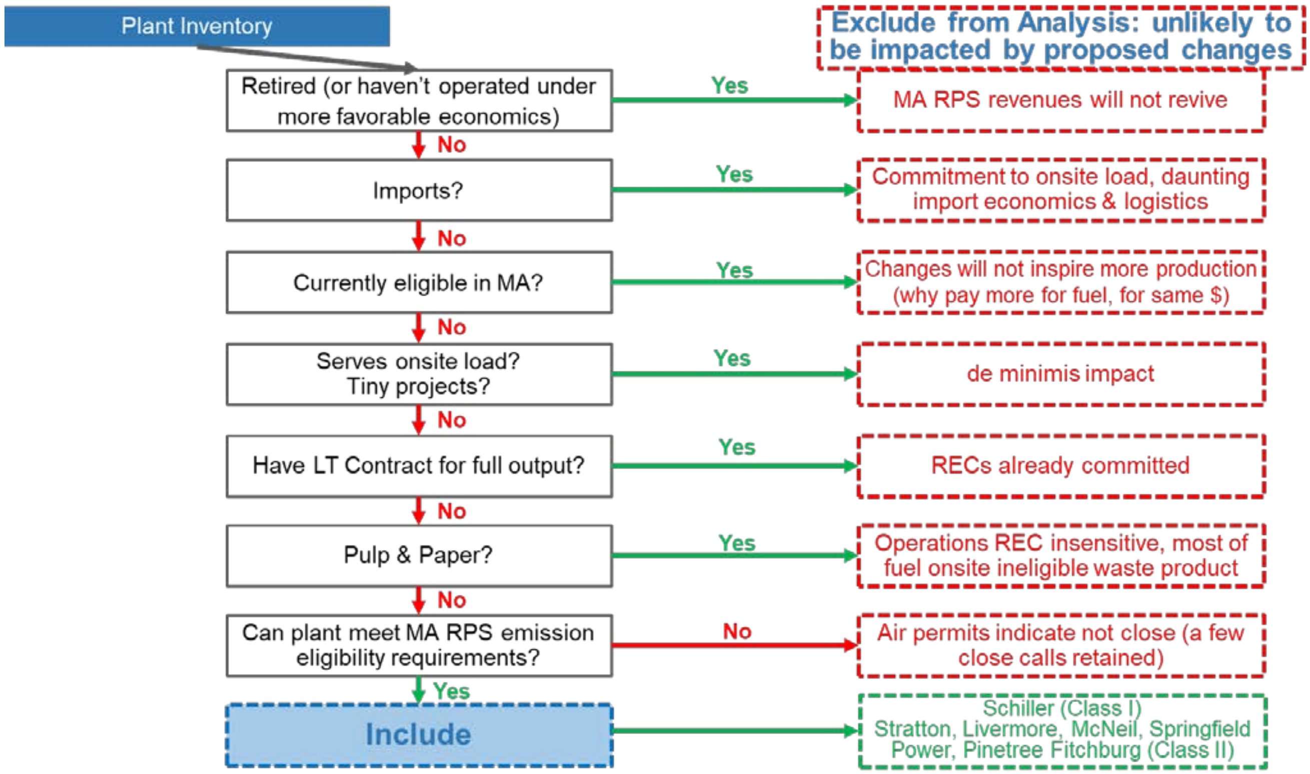

Figure 1: Screening Process for Potential to Seek MA RPS Eligibility

Applying these screening criteria, the Consulting Team identified six (6) biomass generation units for further consideration in this analysis. Considering the Massachusetts RPS Class I vintage eligibility requirements, only one of those generation units reached commercial operation after December 31, 1997, while the remaining generation units could only qualify as Class II. The results of the screening are shown in Table 4.

Table 4: Existing Biomass Generation Units That May Participate in the Revised MA RPS

Generation unit	Location	Project Size (Net MW[17])	MA RPS Class
McNeil Station	VT	50	Class II
Stratton Energy	ME	45	Class II
Schiller Station	NH	43	Class I
Livermore Falls	ME	36	Class II
Springfield Power	NH	16	Class II
Pinetree- Fitchburg	MA	16	Class II

[17] DOE NEEDS Database 2018: https://www.epa.gov/sites/production/files/2019-10/needs_v6_09-30-19_1.xlsx

3.3 Reference Case

The purpose of the Reference Case is to establish a business-as-usual baseline for measuring the potential changes in annual production at existing biomass generation units. SEA conducts a detailed proprietary market fundamentals analysis of the New England REC markets as part of its New England Renewable Energy Market Outlook (NE-REMO). The analysis projects RPS compliance market supply-demand balances in Massachusetts and other New England states based on analysis considering the full range of market drivers, as well as associated spot Class I and NH Class 3 REC prices. It also estimates the level of expected annual energy and REC production at each biomass generation unit eligible for any state RPS. Projected energy and capacity revenues used for the analysis are considered in estimating projecting biomass generation unit production. The most recent analysis was performed in October 2019 and consisted of a range of scenarios. The Reference Case – generally reflecting current laws and regulations, and not incorporating the DOER's proposed RPS biomass eligibility changes – is used as the Reference Case for this analysis. Some of the key assumptions used in the October 2019 NE-REMO Reference Case are summarized in Table 5.

Table 5: Key New England REMO Reference Case Assumptions

Variable	Assumption
MA RPS Class 1 targets	2% annual growth 2020 – 29; 1% in 2030 and thereafter
ME RPS targets	50% by 2030 (10% Class 1; 40% Class 1A)
RPS targets in other New England states	Current statutes
Load forecast	ISO-NE 2019 Base CELT forecast, adjusted by SEA's behind-the-meter generation and electrification projections
MA SMART	DOER adopts proposed expansion to 2,400 MW
MA additional OSW procurement (beyond committed authority)	2,400 MW commencing operation by 2031
CT additional OSW procurement (beyond committed authority)	2,000 MW commencing operation by 2031
CT phase-down of biomass and landfill gas REC value start date	1/1/2020
National Grid RI 400 MW RFP	40 MW solar selected
ME large-scale procurement of new renewables	10.5% of load, commencing operation in 2022 – 2026
ME DG procurement	250 MW of "large-scale shared DG" + 125 MW of "commercial & institutional" projects

For the Reference Case, biomass generation unit operations are modeled to predict an equilibrium solution for annual dispatch by comparing expected operating costs and expected market revenues (comprised of energy, capacity and REC revenues). To project dispatch, a monthly test is conducted to assess whether a generation unit's expected market revenues would exceed its operating revenue requirement; generation units are assumed to operate or not depending on whether expected market revenues are sufficient.

For each of the six biomass generation units passing the screening described above, operating revenue requirement is a function of:

- assumed weighted average fuel prices delivered to the generation unit (based on the North American Wood Fiber Review data (see Appendix A) and delivered price differentials by generation unit informed by market data ad interviews with market participants);
- generation unit net heat rate based on historic average data from the Energy Information Administration (EIA)'s 923 Power Plant Operations Report;
- estimates of nonfuel short-run operating costs and fixed O&M costs informed by public data sources; and
- assumed minimum contributions to margins.[18]

Market revenues include zonal energy and capacity market revenues as determined by each facility's physical location, and REC revenues as determined by REC market eligibility and supply-demand dynamics.

3.4 Policy Case

The analysis then examines whether the proposed MA RPS regulation changes in the Policy Case would provide enough revenues to support the operation of existing biomass generation units if they were to become MA Class I or Class II eligible, based on short-run economics. Except for fuel costs, we utilized the same cost inputs and assumptions as the Reference Case. For the estimation of market revenues, we also utilized the same zonal energy and capacity price forecasts from the October 2019 NE-REMO analysis. For biomass generation units that are or could become MA Class I eligible, we utilized the same spot REC price projections from the NE-REMO analysis as the Reference Case. With respect to MA Class II, annual demand has historically exceeded certified supply, a situation we expect to continue. As such, we assumed MA Class II REC prices will remain near the Alternative Compliance Payment (ACP) level.[19]

To measure the impact of the proposed changes to biomass feedstock, we leveraged generation unit-specific county-level biomass feedstock supply curves of forest salvage and non-forest derived residues for each of the generation units analyzed in Biomass Feedstock Analysis[20]. Each supply curve represents the volume of biomass feedstock meeting the proposed MA RPS criterial available on an annual basis by county, ranked from the lowest to highest delivered prices. As one would expect, the fuel costs for the constrained fuel supply necessary to qualify under the proposed modified Massachusetts RPS rules are higher than the fuel costs under the business as usual without such eligibility constraints.

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[18] While a plant's owner might accept no contribution to margins for a short period for strategic reasons – such as to preserve the opportunity to make an expected future profit – this assumption is predicated on the assumption that no business will choose to stay in business long-term just covering its labor, fuel, maintenance, tax and insurance costs without contributing some return to its owners.

[19] We note that, like many other assumptions in this analysis, this assumption is likely to yield the highest projection of potential biomass production increase, as any alternative assumption would lead to less Massachusetts Class II REC revenue.

[20] See details in Appendix A: Biomass Resource Evaluation.

For each generation unit and each year passing the tests described in steps 2, 3, 4 and 5 in Section 3.1, an economic analysis of generation unit operation under Policy Case costs and revenues was conducted to test for the likelihood if there would be an increase in annual dispatch. We developed an independent model incorporating the fuel supply curves to compare, for every price point along the fuel supply curve on a month-by-month basis whether a generation unit's expected production-dependent market revenues (i.e., energy and REC revenues) would exceed its short-run marginal cost (fuel cost and non-fuel variable operations and maintenance cost). The feasible dispatch at each price point along the supply curve is the lesser of the quantity economically dispatched at that price, and the quantity of fuel available at that price. The total revenues for this quantity of dispatch (including variable energy and REC revenues plus fixed capacity revenues) are compared against annual costs (including variable, as described above, plus fixed operations and maintenance costs), to assess whether there is a profitable solution. Only when there is a profitable solution where annual revenues exceed annual costs and the annual energy production exceeds that in the reference case would production be expected to increase if the generation unit chose to become Massachusetts RPS eligible.

3.5 Analysis and Results

The remainder of this Section examines whether the proposed changes to the MA RPS would incentivize the six analyzed biomass generation units to participate in the revised MA RPS and stimulate changes in expected annual production at each generation unit.

3.5.1 Would participation in a revised MA RPS provide *potential* for additional revenue?

We conducted a series of screening tests to determine whether participation in a revised MA RPS would provide potential for additional revenue for each of the six analyzed biomass generation units. The examination focuses on REC revenues as it is assumed that energy and capacity market revenues would remain the same for both the Reference Case and the Policy Case.

Test 1: *Which REC market determines each facility's maximum revenue opportunity in the Reference Case?* This determination considers each generation unit's existing eligibility and, for generation units that are eligible in multiple markets, the relative value of each market (ACP, supply-demand conditions, price projections based on NE-REMO Reference Case). For biomass generation units that are eligible for CT Class I, the determination also considered when the phase-down of CT Class I RECs per MWh would take place for that specific facility. The results of this test based on the Reference Case are shown in in Table 6.

Table 6: Which REC market determines facility's maximum revenue opportunity?

	2020	2021	2022	2023	2024	2025
McNeil Station	CT-1	CT-1	CT-1	CT-1	CT-1	CT-1
Stratton	CT-1	ME-1	ME-1	ME-1	ME-1	ME-1
Schiller Station	RI-New	RI-New	RI-New	RI-New	RI-New	RI-New
Livermore Falls	CT-1	CT-1	ME-1	ME-1	ME-1	ME-1
Springfield Power	CT-1	CT-1	CT-1	NH-3	NH-3	NH-3
Pinetree - Fitchburg	CT-1	CT-1	CT-1	NH-3	NH-3	NH-3

Test 2: *What REC value is each facility expected to receive in the Reference Case?*
Based on the market identified in Table 6, what price level is each generation unit expected to receive in the Reference Case? In most instances, the REC revenue is set at the driving market's spot REC market price. For Stratton Energy, the phase-down (if effective) would begin in 2020, therefore reducing its REC revenue potential to effectively equal half of the CT Class I spot price. For NH Class III, annual demand is expected to exceed available supply during the applicable years under existing market conditions. As such, NH Class III REC prices are expected to approach the ACP. The result is shown in Table 7

Table 7: What REC value is facility expected to receive in the Reference Case?

	2020	2021	2022	2023	2024	2025
McNeil Station	CT-1 Spot	CT-1 Spot	CT-1 Spot	CT-1 Spot	CT-1 Spot	CT-1 Spot
Stratton	½ CT-1 Spot	ME-1 Spot	ME-1 Spot	ME-1 Spot	ME-1 Spot	ME-1 Spot
Schiller Station	RI-N Spot	RI-N Spot	RI-N Spot	RI-N Spot	RI-N Spot	RI-N Spot
Livermore Falls	CT-1 Spot	CT-1 Spot	ME-1 Spot	ME-1 Spot	ME-1 Spot	ME-1 Spot
Springfield Power	CT-1 Spot	CT-1 Spot	CT-1 Spot	NH-3 ACP	NH-3 ACP	NH-3 ACP
Pinetree - Fitchburg	CT-1 Spot	CT-1 Spot	CT-1 Spot	NH-3 ACP	NH-3 ACP	NH-3 ACP

Test 3: *Which MA RPS market (Class I or Class II) would determine each generation unit's REC revenue if it participated in the revised MA RPS in the Policy Case?* For Schiller – the only biomass facility of the six that could become MA Class I eligible – the Massachusetts RPS REC revenue is set at the MA Class I spot price. For all other generation units, REC revenue potential is determined by the Class II ACP level.[21]

[21] Historically, annual MA Class II demand has exceeded certified supply, resulting in MA Class II REC prices near the ACP. We note that, following the completion of this analysis, DOER increased the RPS Class II target to 3.5634% for 2021, due to a material increase in certified eligible (primarily hydroelectric) supply. DOER 225 CMR 15.07(1)(c) sets a maximum level for the Class II RPS target at 3.6% of load. Should additional hydroelectric or biomass supply become eligible for MA Class II, Class II could swing into surplus at some point in 2022 or later, which could result in a drop in Class II REC prices below the ACP. If, however, MA Class II-eligible hydroelectric supply were to certify for and sell its RECs into the New Hampshire Class IV RPS market (which is current in shortage), a surplus in the MA Class II might be forestalled or delayed. If MA Class II prices do fall below the ACP level, the Massachusetts Class II RPS would be a less attractive outlet for biomass RECs than indicated in the analysis presented in this report.

Test 4: *Would participation in the revised MA RPS potentially provide additional revenue to each generation unit?* This test uses the results of Test 2 and Test 3, for each generation unit in each year, to compare the REC revenue potential between the Reference Case and the Policy Case. The *potential* for higher REC revenue level in the Policy Case suggests that the affected facility might choose to meet the revised feedstock criteria in order to be certified for the opportunity to participate in the revised MA RPS, *if the generation unit could produce at a higher level of annual energy production while incremental revenue exceeds incremental cost*. The generation units and years where the Massachusetts revenue opportunity has the potential to exceed the business-as-usual revenue from the Reference Case are designated as 'Test' in Table 8, indicating that four generation units would be subjected to a detailed economic analysis described in Section 3.4.1 for the years indicated.

Table 8: Could participation in the revised MA RPS *potentially* provide additional revenue to each generation unit?

	2020	2021	2022	2023	2024	2025
McNeil Station	No	No	No	Test	Test	Test
Stratton	Test	No	No	Test	Test	Test
Schiller Station	No	No	No	No	Test	Test
Livermore Falls	No	No	No	Test	Test	Test
Springfield Power	No	No	No	No	No	No
Pinetree - Fitchburg	No	No	No	No	No	No

3.5.2 Would it be profitable to change fuel supply to be eligible for a revised MA RPS?

For each year where the screening exercise in Section 3.5.1indicates that participation in the revised MA RPS could potentially provide additional revenue, we examined whether switching fuel supply to participate in the revised MA RPS would (i) stimulate an increase in the expected annual production at the existing biomass generation unit relative to the Reference Case; and (ii) be profitable to do so. We used the model described in Section 3.4 to estimate the pre-tax operating profits associated with participation in the revised MA RPS by comparing each facility's total annual operating revenue requirement (fuel cost plus non-fuel variable operating cost plus fixed operations and maintenance cost plus contribution to margins) for the indicated year, against the total annual market revenues for energy, capacity and RECs at each incremental step on the fuel supply curve (price level and associated production level based on projected volume of fuel available to the generation unit at that price). We then compared the maximum profitable production for each generation unit in the indicated year against the production level in the Reference Case to identify any potential increase in expected annual production. The analysis was conducted using two fuel ratios that are described in Appendix A, whereby the degree of competing demand for the fuel in the supply shed[22] for each generation unit, and therefore the delivered price of biomass paid, varies in each case. The cases are as follows:

[22] Supply shed is defined in Appendix A as an area within a 75-mile radius from the generation unit.

- **Base Case:** The demand within the supply shed for each generation unit is 1.5 times the demand required by the generation unit (a 1.5:1 ratio).
- **Low Cost Case:** The demand within the supply shed for each generation unit is solely for the derived by the demand for the respective generation unit (a 1:1 ratio).

Utilizing these two cases allows the study to identify the maximum degree of increased production that could be expected under unlikely conditions (i.e., the low cost case), whereby competition for the fuel is removed and a the floor price for biomass can be calculated.

Table 9 and Table 10 provide a summary of the results under each case. The tables show, for each biomass generation unit identified in Test 4 of Section 3.5.1, the projected increase in production that is profitable if the generation unit switches fuel supply to participate in the revised MA RPS versus production under the status quo. No change in production indicates that switching fuel supply would not be profitable for a generation unit in the indicated year.

Table 9: Increase in Production from Reference Case (Base Case)

GWh	2020	2021	2022	2023	2024	2025
McNeil Station	/	/	/	No change	No change	No change
Stratton	No change	/	/	No change	No change	No change
Schiller Station	/	/	/	No change	No change	No change
Livermore Falls	/	/	/	No change	No change	**248**
Springfield Power	/	/	/	/	/	/
Pinetree - Fitchburg	/	/	/	/	/	/

Table 10: Increase in Production from Reference Case (Low Cost Case)

GWh	2020	2021	2022	2023	2024	2025
McNeil Station	/	/	/	No change	No change	**345**
Stratton	No change	/	/	No change	No change	No change
Schiller Station	/	/	/	No change	No change	No change
Livermore Falls	/	/	/	No change	**166**	**289**
Springfield Power	/	/	/	/	/	/
Pinetree - Fitchburg	/	/	/	/	/	/

3.6 Findings for Existing Biomass Generation units

Under the Base Case (1.5:1 Fuel Ratio), participation in the revised Massachusetts RPS would only be profitable and stimulate an increase in production at Livermore Falls in 2025. Under the more aggressive Low Cost Case (1:1 Fuel Ratio), participation in the revised Massachusetts RPS would be expected to stimulate an increase in production at existing biomass generation units in 2024 (Livermore Falls) and in 2025 (both McNeil Station and Livermore Falls). Thus, we find that during the 2020 to 2025 analysis period, at most both McNeil Station and Livermore Falls could seek to become Massachusetts Class II eligible under the proposed regulation changes, and the potential incremental biomass generation increase would represent, at most, approximately 0.33% of total ISO-NE load during 2024 and 2025 (in Low Cost Case) .

Beyond the analysis period, the Massachusetts Class II REC price is expected to remain near the ACP level for the foreseeable future.[23] With increasing Massachusetts Class II ACP (capped at $35) and *potential* growth in energy and capacity market revenues, we expect that the revised Massachusetts RPS could continue to support production in a profitable manner at McNeil Station and Livermore Falls beyond 2025, assuming other generation unit operation conditions and market conditions remain unchanged. In addition, while we found that Stratton would not find it profitable to pivot to the Massachusetts Class II RPS, as the ACP rises to $35 Stratton might also find participation in the revised Massachusetts Class II RPS attractive and *potentially* increase production shortly after 2025. Meanwhile, Springfield Power and Pinetree – Fitchburg would be expected to continue to find New Hampshire Class 3 a more attractive market than Massachusetts Class II, assuming that targets and ACPs are maintained at current levels. In contrast, Class I RPS market conditions in the foreseeable future give no clear indication that participating in the revised MA Class I RPS would be justifiable for Schiller Station during the period of 2020 through 2025 or beyond.

4 Analysis of Potential for Change in MA RPS Regulations to Stimulate New Biomass Generation units

The purpose of this section is to evaluate the sufficiency of market revenues to cause the construction and operation of one or more new biomass generation units that would not have been viable under current Massachusetts Class I RPS regulations. This section considers the viability of one or more new generation units under either the minimum overall efficiency requirement of 50%, or the proposed waiver of the minimum overall efficiency requirement for biomass generation units using forest salvage and non-forest derived residues.

In considering this question, we first observe that very few RPS-eligible renewable energy generation units of any type have been developed in New England without the additional benefit of policy driven long-term contracts or similar revenue hedges, and this is particularly the case with biomass generation units. As other states' RPS requirements would provide at least the revenue level as the revised Massachusetts RPS, and at lower cost (due to less restrictive requirements), it is difficult to envision the proposed changes stimulating, by themselves, additional construction of new biomass generation units. Nonetheless, in this section, we test the economics under aggressive assumptions to evaluate the potential for economic viability.

[23] If the Massachusetts Class II REC price were to fall below this level due to a surplus caused, for instance, by the influx of biomass generation, then a smaller increase in production would result.

For a biomass generation unit to meet the minimum overall efficiency requirement of 50% to receive a full REC, it would have to be configured as a combined heat-and-power (CHP) generation unit with significant thermal load on-site. There are limited opportunities at existing biomass power generation units to serve a thermal load sufficient to meet the 50% overall efficiency requirement.[24] New biomass generation units at scales over 10MW face a similar challenge. Retrofitting existing biomass generation units and new generation units also face hurdles due to the region's commodity markets, RPS markets and the absence of other supporting policy drivers. Generation units meeting eligibility rules of such stringency would be eligible for meeting the eligibility requirements of other states' RPS – including New Hampshire and Rhode Island – whose REC prices have and should continue to be similar to those of Massachusetts Class I, but with a more flexible fuel supply which results in lower costs. Yet such generation units have not been developed under far more favorable revenue conditions for energy, capacity and RECs than what is anticipated to be available going forward.

For generation units up to 10 MW, none (other than several very small on-site CHP generation units) have been developed other than those supported by Maine's now discontinued Community-based Renewable Energy Pilot Program[25] – which provides for purchase of energy at up to $100 per MWh under long-term contract, while allowing generation units to retain their capacity and RECs to generate a supplemental revenue stream by selling them into the ISO-NE capacity market and to other RPS markets, respectively. Again, since the closure of this program, no CHP generation units of any material scale have been developed that are not either already eligible for the Massachusetts Class I RPS, or would be eligible for other states' RPS policies that offer revenues at least as high as those available under the proposed Massachusetts RPS revisions and under more favorable energy and capacity revenue conditions, without any the restrictions on thermal efficiency.

The remainder of this section focuses on potential economic viability of a new biomass generation unit seeking waiver of the minimum efficiency requirement for biomass generation units by virtue of using more than 95% forest salvage and non-forest derived residue.

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[24] The net conversion efficiency for biomass power generation plants is typically around 21-26% (corresponding to a heat rate of 12,000 – 15,000 Btu/kWh, HHV). Even highly efficient plants would not be able to achieve a 50% overall conversion efficiency using existing technologies, unless a material amount of the thermal energy generated was used in a co-generation or combined heat and power facility. This may be possible in a 'thermal-led' application where a very large and highly-concentrated thermal demand is immediately proximate to the plant; however, the power-led existing biomass facilities by virtue of their location are ill-equipped to access the volume of thermal load needed for such a substantial boost in their efficiency. The lack of response to this opportunity historically (with a 60% efficiency threshold) is one indicator of the low likelihood of achieving such efficiencies. Further, attempts in recent years by several of the larger biomass-to-electricity facilities in the region to attract adjacent thermal load have yet to be successful under times of more favorable economics, and we have not seen any indication from existing plant owners that a 50% threshold is technically feasible.

[25] In 2009, the Maine Legislature enacted *An Act To Establish the Community-based Renewable Energy Pilot Program (Act), P.L. 2009, ch. 329*. Part A of the Act established a pilot program, administered by the Maine Public Utilities Commission, which provided through competitive solicitation incentives for the development of locally-owned community-based renewable projects up to 10 MW in scale. See: https://www.maine.gov/mpuc/electricity/community_pilot.shtml.

4.1 Approach

The analysis of a hypothetical new biomass generation unit's eligibility focuses on technology types that are not currently eligible but that would benefit from the proposed eligibility change (i.e., not CHP) and be primarily driven by access to the Massachusetts Class I RPS market. For purposes of this assessment, a biomass-to-electricity fluidized bed generation unit with a net capacity of 35 MWe capacity was assumed. This is consistent with recent experience and industry literature as a likely technology and scale, and the technological requirements needed to meet Massachusetts RPS emission limits. A new project of this technology was posited as being located in Western Massachusetts, near one or more major highways. The range of cost and operating characteristics were developed for this generation unit are summarized in Table 11.

Table 11: Assumptions for Characteristics of a New Biomass Generation unit

	Units	Low	Mid	High
CAPEX	Nominal 2018 $/kW	$3,960	$ 4,513	$5,663
Interconnection Cost	Nominal 2018 $/kW	$ 25	$ 50	$ 100
Capacity Factor	%	80%	85%	90%
Fixed O&M	Nominal 2018 $/kW-yr	$121.02	$125.81	$ 130.45
Non-Fuel Variable O&M	Nominal 2018 $/MWh	$5.87	$6.98	$ 8.15
Fuel Cost	$/MMBTU	$2.45	$3.27	$3.47
Heat Rate	BTU/kWh	13,500	13,500	13,500
Carrying Charge	%	10.00%	11.10%	14.14%

Notes on key assumptions and sources:

- CAPEX (all-in capital expenditures including construction financing and soft-costs for permanent financing), Fixed O&M, Non-Fuel Variable O&M, and heat rate are based on a literature review of the most recent public data sources available.[26] An inflation index (EIA AEO 2019 Chain Type Index) is applied to the cost figures to adjust them to the project's assumed commercial operation year.
- Interconnection costs reflect an assumed typical range
- Fuel costs: High and Mid based on the weighted average price from the forest salvage and non-forest derived residues fuel supply curve analysis for a 1.5:1 and 1:1 fuel ratio, respectively. To test project financial viability in the presence of an unusually low fuel cost, Low reflects an assumed value reflecting access to unusually inexpensive fuel supply arrangements, set at a 25% discount to the 1:1 fuel supply to demand.
- Carrying charge: a factor which when multiplied by the CAPEX will calculate an annual levelized amount required to provide return on investment to equity investors and lenders, plus

[26] ANTARES and SEA reviewed the following sources to guide development of the data used here:

- California Energy Commission Staff Report: Estimated Cost of New Utility-Scale Generation in California: 2018 Update. See: https://ww2.energy.ca.gov/2019publications/CEC-200-2019-005/CEC-200-2019-005.pdf
- NREL (National Renewable Energy Laboratory). 2019. 2019 Annual Technology Baseline. Golden, CO: National Renewable Energy. See: https://atb.nrel.gov/electricity/data.html
- EIA November 2016 Capital Cost Estimates for Utility Scale Electricity Generating Plants. See: https://www.eia.gov/analysis/studies/powerplants/capitalcost/pdf/capcost_assumption.pdf

depreciation/amortization of the initial investment and other tax-driven factors. The figures for High and Mid come from SEA's most recent New England Renewable Energy Market Outlook, and reflect assumptions applicable to a biomass generation unit for an imperfect, or market, hedge on revenues (High), and a perfect hedge on revenues consistent with a long-term power purchase agreement but exposed to an unhedged fuel supply (Mid). The Low assumption reflected the possibility of a unique, below-market source of financing.
- Assumed economic life for financing purposes of 20 years.

We selected 2022 as the year of commercial operation, based on the assumption that biomass generation units of this scale typically take 24 to 36 months to construct.

To test the economic viability of the new generation unit, we first generate a nominal levelized cost of energy (LCOE), which represents the total revenue per MWh needed on average each year, in nominal terms, to cover costs and a threshold return to investors. We then subtract from the LCOE the projected 20-year nominal levelized energy and capacity market revenue expected to accrue to a new biomass generation unit. This value, derived by SEA for the New England Renewable Energy Market Outlook Refence Case, is equal to $50.55 per MWh[27] for a generation unit reaching commercial operation on January 1, 2022. The difference represents a revenue gap, the minimum average incremental revenue required from supplement revenues from Class I RECs to attract investment. This REC revenue requirement can be compared to expected REC revenues from participating in the Massachusetts RPS to assess the likelihood of such a project to be economically viable.

4.2 Analysis and Results

We tested economic viability under two sets of assumptions. For a Base case, the Mid case assumptions from Table 11 were used, reflecting the *expected* cost and performance characteristics. A second case was crafted to test the result under a combination the all the most favorable cost, financing and performance assumptions, a combination which can be considered extremely aggressive assumptions. The assumptions and results are shown in Table 12.

[27] Calculated using a discount rate of 10%.

Table 12: LCOE and REC Revenue Gap for New Biomass Generation Unit

	Unit	Base Case Assumptions	Aggressive Case Assumptions
CAPEX	Nominal 2018 $/kW	**Mid**	**Low**
Interconnection Cost	Nominal 2018 $/kW	**Mid**	**Low**
Capacity Factor	%	**Mid**	**High**
Fixed O&M	Nominal 2018 $/kW-yr	**Mid**	**Low**
Non-Fuel Variable O&M	Nominal 2018 $/MWh	**Mid**	**Low**
Fuel Cost	$/MMBTU	**Mid**	**Low**
Heat Rate	BTU/kWh	**Mid**	**Mid**
Carrying Charge	%	**Mid**	**Low**
Analysis Results			
20-Year Levelized COE	Nominal $/MWh	$146	$113
20-Yr Levelized Mkt Rev	Nominal $/MWh	$51	$51
20-Year Levelized REC Requirement	Nominal $/MWh	$95	$62

4.3 Findings for New Biomass Generation Units

Table 12 shows that under the Base Case assumptions, the levelized REC requirement of $95 per MWh exceeds the $70 proposed Class I ACP, so the generation unit would not be viable because the required REC revenue could never surpass the Class I ACP, in the absence of other revenue streams. Under the Aggressive Case assumptions, the levelized REC requirement is a much lower $40 per MWh. While under the Class I ACP, this amount is almost three times higher than the 20-year levelized Class I REC revenue projected under the NE-REMO 2019#2 Reference Case. Even under a wide range of sensitivity analyses conducted by SEA for NE-REMO, no cases demonstrate a sustained REC revenue level anywhere near $40 per MWh. Since a generation unit failed to produce a result showing a viable target REC revenue stream under these assumptions, we can conclude that it is extremely unlikely that a generation unit would be financeable as a result of DOER's proposed changes for the Massachusetts Class I RPS market without significant additional financial support.

5 Other Potential Impacts of Proposed Policy

5.1 Potential Impacts of Proposed Rules on Forest Ecosystems

The change in biomass procurement practices associated with the proposed policy changes could have potential impacts on both forest ecosystem services and forest landowners. In this section, we describe some of the types of potential impacts that may be considered in the rulemaking process. The impacts described here focus geographically on the generation units identified in the preceding analysis as potential new participants in the Massachusetts RPS program. Some of the potential impacts on forest ecosystems and landowners described here are already being felt in regions around those generation units, to the degree that some of the generation units are currently idled, or have significantly curtailed operations in recent years. For example, biomass fuel production from forest sources has dropped in areas surrounding idled generation units, impacting associated economic benefits such as employment and landowner revenue. Non-market ecosystem services impacted by these changes may include wildlife habitat/biodiversity and carbon storage.

Across New England and New York, forest ecosystems are diverse and forest landowners employ a wide variety of management practices to meet different management objectives. Forests are a vital element of the landscape of the Northeastern U.S. and they provide important ecosystem services, such as flood mitigation, carbon storage, habitat for wildlife, recreational enjoyment. Forest biomass utilization can have a wide range of impacts on forest ecosystem services, depending upon the harvesting technique utilized. Table 13 summarizes some of the potential impacts that biomass utilization can have on forest ecosystem services.

Table 13: Potential Impacts to Forest Ecosystem Services

Fuel type	Service	Impact
Examples of Potential Negative Impacts of Forest Biomass Utilization – Impacts are Treatment and Site-Specific		
Forest residues	Habitat	Reduces the quantity of woody debris for wildlife habitat that may be important resources for some bird communities.
Forest residues	Carbon storage Fiber and timber production Water quality	Increases deer browse and reduce seedling survival.[28] This can reduce growth rates following harvest.
Forest thinning	Carbon storage Fiber and timber production	Soil nutrient losses following a harvest can be detrimental depending on intensity of removals.[29]
Forest thinning	Habitat	May have a negative impact for species that favor closed-canopy conditions.[30] Impacts on mammalian, amphibian and reptiles may also be significant but vary considerably by region, species and scale of harvest.
Land clearing	Biodiversity Water quality Carbon storage	Impacts vary on planned alternative use, but generally multiple ecosystem services are negatively impacted by land clearing.
Examples of Potential Positive Impacts of Forest Biomass Utilization – Impacts are Treatment and Site-Specific		
Forest thinning	Habitat Recreation	Can result in positive impacts on bird and small mammal populations due to increases in understory vegetation.

[28] Evans, A. (2008, September). *Synthesis of Knowledge from Woody Biomass Removal Case Studies.* Retrieved from Forest Guild/U.S. Forest Service: https://www.firescience.gov/projects/07-3-2-02/project/07-3-2-02_07_3_2_02_biomass_case_studies_report.pdf

[29] Ibid.

[30] The Wildlife Society. (2012, December). *Effects of Bioenergy Production on Wildlife and Wildlife Habitat.*

Fuel type	Service	Impact
Forest thinning	Biodiversity Carbon storage Fiber and timber production	Biomass markets can defray the costs of forest management that encourages the growth of trees with a higher commercial value, thereby maintaining or enhancing forest land values. This incentivizes landowners to keep land in forest cover instead of other, less beneficial uses.
Land clearing	Multiple	Impacts vary on planned alternative use, but generally biodiversity, water quality and other services provided by forests are negatively impacted by land clearing.
All types	Fuel and fiber production	Supports economies with employment and landowner revenue

It is important to note that the characterizing the impact caused by harvesting timber is very dependent upon the specific application and must be analyzed on a case by case basis. Often, a management activity that may be perceived as having a negative impact may actually provide meaningful benefits. For example, clearing all trees in all or part of a forest stand is a significant visual alteration of the land and can be considered a negative impact. However, in discrete applications, this same clearing may provide meaningful benefits by creating new habitat for wildlife that thrive in successional growth forests. Therefore, the comments here are meant to provide a high level description of the potential impacts caused by forest harvesting.

5.2 Lifecycle GHG Emissions Impact from Proposed Changes

The first part of this section provides a qualitative analysis of whether key proposed policy changes are likely to generally increase or decrease GHG emissions. In the second section we summarize the results of a DOER analysis of the quantitative impacts of the proposed policy changes on GHG emissions.

Table 14 summarizes the relevant proposed changes in the regulation, as well as the likely or potential GHG emissions impact associated with each change. This is a high-level assessment based on available information and professional judgement. The information and section references in the current regulation are based on the RPS Class I regulation dated 7/12/2016.[31] The information and section references for the proposed policy changes are based on the draft RPS Class I Regulation released on April 5, 2019[32]. The regulatory changes for Class II are similar and are expected to have equivalent GHG emissions impacts.

[31] https://www.mass.gov/regulations/225-CMR-14-renewable-energy-portfolio-standard-class-i
[32] https://www.mass.gov/service-details/rps-class-i-ii-rulemaking

Table 14: Expected Qualitative GHG Emissions Impact from Proposed RPS Changes

Current Regulation	Proposed Regulation	Qualitative GHG Emissions Impact
ELIGIBLE BIOMASS WOODY FUEL *225 CMR 14.02 – definitions {pg 3}* The following feedstocks are included as eligible woody biomass feedstocks. Forest Derived Residues include portions of trees produced as a byproduct, and invasive species that interferes with natural growth Forest Derived Thinnings is defined as unacceptable growing stock that does not have the potential to yield a 12 foot sawlog or survive for at least the next 10 years. Non-forest Derived Residues included: Primary and secondary forest products industry; Land Use Change – Non-Agricultural; Land Use Change – Agricultural; Yard Waste; and Wood Waste.	ELIGIBLE BIOMASS WOODY FUEL *225 CMR 14.02 – definitions {pg 4}* The proposed changes for eligible woody biomass feedstocks are summarized below. Forest Derived Residues expanded to include qualifying harvests from restoration and management activities Forest Derived Thinnings eligibility is further constricted by reducing the unacceptable growing stock definition to have the potential to yield an 8 foot sawlog. Non-forest Derived Residues removed Land Use Change – Non-Agricultural, and Yard Waste; added Post-consumer wood products from clean-wood, Agricultural wood waste.	At a constant level of operation, changes that result in generation units using more residue-based fuel sources is expected to result in a net decrease in lifecycle GHG emissions.[33] The stricter requirement on forest thinning could reduce the amount of eligible biomass fuel in that category. This could result in greater lifecycle GHG emission savings to the extent that this results in higher use of residue-based fuel sources. Yard waste is not a typical fuel source for large scale woody biomass energy generation units, so its removal as an eligible source is not likely to have a notable impact on GHG emissions. Bioenergy generation units currently utilize wood from Land Use Change – Non-agricultural. The GHG emission impact of its removal as an eligible fuel source is uncertain because it is unknown what eligible feedstock would replace it. If a residue is used, there would be no impact on the emissions associated with the energy generation, while if a thinning feedstock is used there would be an increase in GHG emission impact. The addition of post-consumer wood products from clean wood and agricultural waste wood as eligible non-forest derived residues is likely to reduce lifecycle GHG emissions as it may displace other higher emission sources.

[33] GHG impacts associated with the MA RPS are only relevant to the extent that facilities participate in the MA RPS.

Current Regulation	Proposed Regulation	Qualitative GHG Emissions Impact
NET EFFICIENCY REQUIREMENTS *225 CMR 14.05(7)(f)(ii) {pg 11}* Generation Units using eligible biomass fuel are required all to have an overall efficiency of at least 50% on quarterly basis (40% for Advancement of Biomass Conversion Generation Units)	NET EFFICIENCY REQUIREMENTS *225 CMR 14.05(7)(c) {pg 15}* A Generation Unit using 5% or more of its fuel sourced from Forest-Derived Residues and Forest Derived Thinnings must achieve an overall efficiency of at least 50% on a quarterly basis. A Generation Unit using more than 95% of its fuel sourced from Forest Salvage and Non-Forest Derived Residues on a quarterly basis does not have an overall efficiency requirement.	The 50% efficiency threshold is a significant barrier to bioenergy generation units participating in the MA RPS market and effectively eliminates the eligibility of biomass electric power-only generation units. The proposed change to waive the overall efficiency requirement for generation units using forest salvage and non-forest derived residues has the potential to increase the reduction of lifecycle GHG emissions because a facility could not use a significant amount of thinnings, a feedstock with less lifecycle GHG emission benefits, and remain eligible.
GHG REDUCTION REQUIREMENTS *225 CMR 14.05(7)(f)(iii) {pg 12}* At least a 50% reduction of life-cycle GHG emissions over **20 years** compared to a new efficient natural gas fired facility (as specified)	GHG REDUCTION REQUIREMENTS *225 CMR 14.05(7)(d) {pg 15}* At least a 50% reduction of life-cycle GHG emissions over **30 years** compared to a new efficient natural gas fired facility (as specified)	Taken in isolation, the longer period to meet the 50% reduction in the proposed policy change results in a lower threshold for a facility to meet. As such, this change could lead to a net increase in overall lifecycle GHG emissions, to the extent that a lower percentage of residues are used.

Current Regulation	Proposed Regulation	Qualitative GHG Emissions Impact
PROBATIONARY STATUS & MAKEUP OFFSET *Section 225 CMR 14.05(8)(d)(3) {pg 21}* Generation units that don't meet the minimum threshold for lifecycle GHG reduction on an annual basis are put on probationary status. Term: Probationary status for **5 years**. SOQ to be revoked 5 years after the undercompliance was first reported. In order to maintain compliance & revoke probationary status, need to either: (1) demonstrate that Unit is complying with GHG requirements for any 3 years of probationary period, or (2) accumulated percent under-compliance is offset by any net over-compliance. Under-compliance payment is required for any year in which the Unit reports under-compliance. Funds intended to be used to support carbon sequestration activities or forest derived residues supply chain. Also requires annual fuel supply plans that show ratcheting up % of non-forest and forest derived residues under contract with fuel supplier (from 0 to 100% in specific increments).	PROBATIONARY STATUS & MAKEUP OFFSET *Section 225 CMR 14.05(8)(f) {pg 25}* Generation units that don't meet the minimum threshold for lifecycle GHG reduction on an annual basis are put on probationary status. Term: Probationary status for **1 year**. SOQ to be revoked 1 year after the undercompliance was first reported. In order to maintain compliance & revoke probationary status, need to change fuel supply plan for corrective action, and need to make up the accumulated under-compliance by over-complying for the next year. No under-compliance mechanism or payments No prescriptive contracting requirements. However, the revised fuel supply plan must be approved by DOER.	For an individual facility that elects to meet the requirements to get out of probationary status to maintain SOQ, the proposed changes are likely to result in overall decrease in life-cycle GHG emissions, or no change. At a broad level, the removal of the option to pay for under compliance for GHG emission reductions would yield positive reduction in GHG emissions because GHG emissions would have to be actually realized, versus paying for reductions. This is especially true because it is uncertain how such payments may be used to reduce GHG emissions and in all cases, the GHG reductions would be in future years from when the actual GHG emission was released from the biomass generation unit.
SUSTAINABLE FORESTRY MANAGEMENT *225 CMR 14.05* Eligible Forest Biomass Tonnage report requires reliance on management plan prepared by professional forester unit certifying compliance with eligibility requirements that may include evidence of forest land certification under FSC, SFI or other certification programs outlined in regulation. Also included in the requirements is compliance with the Biomass Eligibility and Certificate Guideline, which includes but is not limited to restrictions based on soil type and requirement for amount of wood retained in the forest.	SUSTAINABLE FORESTRY MANAGEMENT *225 CMR 14.05 – definitions {pg 11}* Includes explicit definition for Sustainable Forestry Management Practices. Requires a licensed forester attestation, approval from state forester, or independent verification that forest derived residues and forest-derived thinnings are sourced from forests meeting that definition.	Explicit definition of sustainability criteria and independent verification requirement for forest-derived residues and thinnings are likely to result in improvements in sustainability of biomass supply chains for biomass energy generation units. To the extent that generation units rely on these fuels, changes are likely to result in a net reduction in lifecycle GHG emissions overall. Site specific impacts will vary based on management practices.

A quantitative analysis of lifecycle GHG emissions reductions was undertaken by DOER, with inputs provided by the Consulting Team. The full description of the analysis is provided in Appendix B. In summary, the analysis utilized the underlying principles of the *Biomass Sustainability and Carbon Policy Study*[34], often referred to as the Manomet Study. This study maintains that a carbon debt is created when biomass is used to produce energy and that over time, the carbon debt can turn into a dividend through the sequestration of carbon in forests that are managed sustainably. Following several years of stakeholder engagement, DOER developed the *Overall Efficiency and Greenhous Gas Analysis Guideline* which implements the principles of the Manomet study and serves as a regulatory tool to account for lifecycle GHG emissions reductions.

Utilizing this approach, the analysis concluded that under the proposed policy changes, there will be a reduction in lifecycle greenhouse gas emissions. In all cases assessed, lifecycle GHG emissions were reduced by more than 50% for 20 year and 30 year timeframes compared to a base case predicated on maintenance of 2013 RPS guidelines for biomass eligibility. The greenhouse gas emissions reductions were primarily driven by the preference for non-forest derived residues. Additionally, when assessing Generation Units that meet the minimum requirements under the existing 2012 regulations and the proposed 2019 regulations, there is an additional 11.7% reduction in lifecycle GHG emissions over a 20year timeframe. Therefore, the proposed policy changes are providing additional lifecycle GHG reductions by expanding the inclusion of Generation Units that utilize Eligible Biomass Woody Fuel that are Non-Forest Derived Residues.

6 Conclusions

DOER's primary objective in commissioning this report was to understand the degree to which its proposed policy changes could impact greenhouse gas emissions through operational changes for existing biomass generation units – a function of fuel use (directly proportional to energy production) and fuel mix – or through the development of new non-CHP biomass generation units with efficiencies below the 50% threshold that could be eligible if using more than 95% forest salvage or non-forest derived residues.

With respect to existing biomass generation units, the focus of this report was on an analysis of the potential operation of biomass generation units in response to the proposed changes. This analysis assessed the likelihood and magnitude of any change in operating behavior, that is, annual energy production. Emissions are also a function of the fuel mix, which is the subject of a distinct analysis that flows from this effort, see Appendix B. Importantly, an increase in production from zero to greater than zero would, under DOER's greenhouse gas accounting methods, show an increase in greenhouse gas emissions in early years, while an increase in annual energy production may or may not increase lifecycle greenhouse gas emissions under DOER's greenhouse gas accounting methods, as the improved carbon payback profile of forest salvage and non-forest derived residues in some cases could offset the impact of increased fuel use.

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[34] Manomet Center for Conservation Sciences. (2010). *Biomass Sustainability and Carbon Policy Study*. Prepared for Commonwealth of Massachusetts Department of Energy Resources. Retrieved from https://www.manomet.org/wp-content/uploads/2018/03/Manomet_Biomass_Report_Full_June2010.pdf

6.1 Key Findings

6.1.1 Existing Biomass Fleet

With respect to existing biomass generation units, we can make the following findings:

- Currently, Biomass generation units are facing challenging economics in the northeast, with reduced energy and capacity revenues and a recent crash in REC revenues only partially offset by reduced fuel costs.
- Constraining the fuel mix to eligible forest salvage and non-forest derived residues, will result in increased cost for fuel supply. This is partly because more limited fuel supplies will require a much larger fuel shed, leading to greater transportation costs and more complicated procurement logistics.
- The increased cost associated with eligible forest salvage and non-forest derived residues reduce the likelihood that existing generation units would change their operational profiles in response to the adoption of the proposed policy changes.[35]
- Biomass generation units are eligible for use in compliance with RPS policies in multiple states, and individual generation units in the existing fleet have distinct eligibilities, qualifying in some states and not others. All existing biomass generation units not already eligible in Massachusetts are eligible for some other state's RPS, and the response of biomass generation units to proposed policy changes must be taken in light of competing market outlets for their RECs. In short, a facility will not participate in the MA RPS market if it can earn more revenues through its participation in another RPS market.
- Regional REC prices are expected to rise in the next few years, but then drop in the early/mid 2020s in response to an influx of new policy-driven clean energy supply in the region (offshore wind, solar, imported hydro) in excess of statutory target increases.
- Of the regional biomass fleet, we found only six existing biomass generation units likely to be influenced by the proposed policy changes. The potential impact of the proposed policy changes is limited by the unchanged application of the two requirements within the existing Massachusetts RPS:
    - <u>Vintage Eligibility Requirements:</u> Few projects meet the vintage requirements for Class I (commercial operation after 1997), meaning that most generation units would face Class II revenues that are often lower than available in other RPS markets prior to adoption of any Massachusetts change. For these generation units, unless the Massachusetts Class II market price (which has historically been near its ACP, which is projected to cap out at $35/MWH by 2028-29) exceeds their alternative REC revenue outlet, the change would create no additional revenue. As a result, many generation units would face a combination of increased fuel costs without commensurate revenue increases, which would not motive any change in operations.
    - <u>Emissions Eligibility Requirements:</u> the Massachusetts RPS has strict emission limits which many operating biomass generation units would be unable to meet without making major investments in emission control systems. Given anticipated revenues, it is unlikely the biomass generation units would support making these changes without a sufficiently long-term revenue guarantee to support the investment.
- Additional screening criteria – including project size, location, current eligibility, and long-term contracting status – eliminated the remaining plants in the region from a likely response to the

[35] The cheapest of the eligible fuels will be subject to the greatest competitive market pressures. While the directionality of increased costs is not in question, drops in regional biomass fuel prices since a peak in 2015 mean that the higher fuel costs are not necessarily out of line with peak biomass fuel costs experienced several years earlier (although those occurred during times of higher energy, capacity and REC revenue than biomass plants are facing looking forward).

proposed changes. Under base case assumptions, only one generation unit would be expected to increase its production in 2025, when growth in the combination MA RPS Class II ACP and electricity market prices eventually provides sufficient revenues to support increased annual energy production using eligible forest salvage and non-forest derived residues. Under the low cost assumption, only two generation units – one for a single year and another for two years – would be expected to increase production. In total, over the course of a 6-year analysis period, increased production was projected to be 247,907 MWh for the low cost assumption and 800,186 MWh for the base case assumption.

6.1.2 New Biomass Facility

With respect to new generation units, we make the following findings:

- To date, few renewable energy generation units have been driven by RPS policies alone. Rather, the vast majority of new renewable energy generation units have required long-term revenue hedges or other co-incentives primarily offered by distinct policy-driven procurement, and biomass generation units have been no exception[36]. Since the proposed changes would not make the Massachusetts RPS more attractive than other New England state RPS policies in Rhode Island, New Hampshire or Maine – generation units would need to buy a scarcer fuel mix, that is more expensive, to access the same or similar revenues – there is limited reason to expect a new generation unit that would not otherwise be financeable to become so due to the proposed change. The analysis suggests that a sustained REC price of approximately $95 per MWH (in the Base Case) would be required, which (in the presence of a $70 Class I ACP) would not be possible without material supplemental revenue streams.
- It is extremely unlikely that the proposed policy changes would result in a new non-CHP biomass to electricity generation unit being built because the levelized REC revenue need would exceed the Class I price cap established by the ACP. Even under extremely aggressive assumptions of low costs, sub-market fuel cost, and high capacity factor, a new generation unit would require sustained REC prices at a 20-year levelized level approximately three times the Reference Case REC price projection.

The systemic surplus of regional supply over demand driven by policy-driven contracting or incentives for other renewables such as offshore wind and solar imply a low likelihood of more attractive conditions for biomass that would suggest an increase in biomass production beyond the analysis period.

Lifecycle GHG Emissions

- **Lifecycle GHG Emission reductions are above 50%:** The adoption of the proposed amendments to the RPS regulations will lead to the reduction of lifecycle GHG emissions, with a more than 50% lifecycle GHG reduction over 20- and 30-year timeframes compared to a base case predicated on maintenance of 2013 RPS guidelines for biomass eligibility.

- **Characteristic of Feedstock drives lifecycle GHG emission reductions:** While extending the timeframe of the lifecycle greenhouse gas analysis to 30 years does increase the amount of greenhouse gas emissions reductions that occur, the restriction of Forest Derived Thinnings to no more than 5% in order to

[36] One might argue that the Schiller biomass repowering project was developed without such a hedge or co-policy, it was developed by a regulated utility (PSNH) with regulatory approval for cost recovery, which had an equivalent impact of de-risking investment.

waive the overall efficiency requirement is more impactful on the total amount of greenhouse gas emissions reduced.

- Opportunity to realize lifecycle GHG emission reductions: If the proposed changes to the regulations are not implemented, there is a lost opportunity to reduce lifecycle greenhouse gas emissions.

6.2 Limitations of This Analysis

6.2.1 Data Sources

This analysis relies heavily on public data sources, as complemented by the authors' years of experience and past analysis. Public data sources on costs and operating characteristics of the existing biomass fleet suffer from limited availability or comprehensiveness, inconsistent or incomplete labeling (for example in use of gross versus net MW or lower versus higher heating value), or other quality concerns.

6.2.2 Future Revenues

With respect to SEA's New England REMO projections of Class I REC prices as well as energy and capacity revenues, the market and policy landscapes and supply responses to those landscape are constantly shifting. As a result, assumptions underlying the Reference Case REC prices (and energy and capacity price outlook) that serve as the basis for this analysis are likely to evolve over time and could result on higher or lower revenues. Sustainable Energy Advantage regularly runs sensitivity analysis and considers a range of alternative futures. While not explicitly incorporated into this analysis, recent scenario and sensitivity analyses reveal a range of REC price futures, and qualitatively, the authors believe that most futures would lead to similar conclusions. However, less likely scenarios with a sustained increase in demand relative to supply, could yield different conclusions. Likewise, any new products or services that may be adopted which biomass plants could monetize could also yield different conclusions.

Appendix A: Biomass Feedstock Analysis

See Attached Report

Appendix B: Lifecycle Greenhouse Gas Emissions Analysis

See Attached Report