Heating the Northeast with Renewable Biomass
A Vision for 2025

Presented by:
Biomass Thermal Energy Council, Washington DC
Alliance for Green Heat, Takoma Park MD
Maine Pellet Fuels Association, Portland ME
New York Biomass Energy Alliance, Syracuse NY
Pellet Fuels Institute, Arlington VA

April 28, 2010

Contents | **Page**

Acknowledgements

Heating the Northeast with Renewable Biomass: A Vision for 2025 was researched and written by staff and volunteers with the five presenting organizations, including:

- **Charles Niebling**, Chair, Biomass Thermal Energy Council, Washington DC, and General Manager, New England Wood Pellet, Jaffrey NH
- **Lisa Rockefeller**, Chair, Gov't. Affairs Committee, Biomass Thermal Energy Council, and Policy Director, American Biomass Distribution/Woodpellets.com, Goffstown NH
- **John Ackerly**, President, Alliance for Green Heat, Takoma Park MD
- **Dan Conable**, Director, New York Biomass Energy Alliance, Syracuse NY
- **George Soffron**, President, Maine Pellet Fuels Association, Portland ME, and President, Corinth Wood Pellet, Corinth ME
- **Bill Bell**, Executive Director, Maine Pellet Fuels Association, Portland ME
- **Jennifer Hedrick**, Association Manager, Pellet Fuels Institute, Arlington VA

Significant research and data analysis was provided by **Dr. William Strauss**, Principal of FutureMetrics, Bethel ME, and by **Andrea Colnes**, Policy Director, Biomass Energy Resource Center, Montpelier VT

Funding for this initiative was provided by the sponsors and attendees at the 2nd Annual Heating the Northeast with Renewable Biomass conference, held April 27-28, 2010 in Manchester NH. www.heatne.com. We gratefully acknowledge this support.

Important Disclaimer

Limited funding, staff support and time constraints did not permit the preparation of this vision to be exhaustively researched or independently peer reviewed. Data analysis, findings and conclusions are subject to further refinement based on new or better information, and new or different interpretations of this information. **The organizations presenting this vision are doing so to engender discussion on the issues and questions it raises, and reserve the right to agree or disagree with certain of its findings and conclusions.** We welcome detailed comments and critique of the vision document. Comments may be submitted to:

Biomass Thermal Energy Council
Attn: Kyle Gibeault
1211 Connecticut Ave., NW, Suite 600
Washington DC 20036
Phone: 202-596-3974
Email: info@biomassthermal.org
Web: www.biomassthermal.org

Executive Summary

In 2007, the northeastern United States (six New England states and New York) consumed 2.09 quadrillion BTUs of thermal energy for space heating , hot water, and industrial heat, representing 38.7 % of all energy consumed in these states for electricity, transportation and thermal needs. Non-renewable and high carbon fossil fuels provided about 96 % of the total thermal energy consumed, with renewable energy providing less than 5 % from biomass, solar and geothermal resources. This dependence on fossil energy (the northeastern states use 86% of the nation's entire consumption of home heating oil), nearly all of which is produced outside the region and a significant percentage of which is exported from foreign countries, exposes the northeast to extreme economic and social vulnerability in the event of price shocks, such as those seen in 2001, 2005 and 2008. It exacerbates environmental impacts including the region's contribution to global climate change, air quality and acid rain. Further, it results in significant wealth in the region being exported to support other economies instead of our own regional economic vitality.

We, the five proposing organizations, call for an American Revolution to domestically produce the thermal energy consumed in the six New England states and New York. We propose that 25% of all thermal energy requirements in the Northeast are met with renewable energy resources by the year 2025. This shift in our sources for thermal energy will produce extraordinary economic, social and environmental benefits for the region, which currently relies on fossil fuel for 96% of its thermal energy. Furthermore, we call for three quarters of the renewable energy to come from sustainably produced biomass from forest and farm resources transformed into heat with clean and efficient technology, and for solar and geothermal technologies to provide the balance. Today, renewable energy accounts for 4.3% of the total thermal energy sources for the region, and forest biomass (wood) comprises 96% of all renewable thermal energy in the region.

The vision must go hand-in-hand with aggressive efforts to improve building energy efficiency, thus reducing overall energy consumption. A robust market economy will provide long-term employment for tens of thousands of new workers in forest and farm production of diverse biomass feedstocks; sales, installation and service of high efficiency thermal energy combustion and combined heat and power technology; and biomass fuel processing, production and delivery. Leading academic institutions in the region will provide cutting edge research and development for continuous improvement of technology. State and local governments will recognize and support the continued expansion of biomass thermal through targeted tax, regulatory and incentive policies, in partnership with a unified and progressive industry. Along with western European nations, the northeast will be recognized as a global leader in the advancement of biomass thermal energy.

Achieving this vision will have profound implications for the region's economy, environment and quality of life. It will only be possible through the coordinated efforts of advocacy groups, research institutions, industry and government at all levels. It will require private investment in the hundreds of millions of dollars, and bold action. It will require a sustained education and outreach effort to help home owners, municipalities, institutions and businesses to understand the opportunity and options available to them. It will require responsible stewardship and sustainable management of the regions tremendous natural resources of forest and farmlands. The consequences of inaction, and failure to meet this vision, will extract a traumatic cost to our economy and environment. The vision sets forth immediate actions that can be taken to move our region toward achieving these ambitious goals.

I. Introduction

The northeastern United States (defined throughout this report as the six New England States and New York) is a region heavily dependent on fossil fuels to provide heat, electricity and transportation. Yet we produce virtually none of the fossil energy we consume, making our economy and quality of life highly vulnerable to supply disruptions and price shocks with these non-renewable resources. We are also a densely populated region, with long-standing sensitivity to the environmental impacts of growth and energy consumption on air and water quality, and the health of wildlife and natural ecosystems.

For these and many other reasons, energy policy is at the fore of public discourse in our region. In the last 10 years, significant steps have been taken to reduce our over-reliance on fossil energy through such policies as: regulatory incentives for the development of alternative power generation, renewable electricity portfolio standards, the Regional Greenhouse Gas Initiative to reduce emissions from power generation, state climate action plans, efficiency standards in appliances and building codes, etc. Most initiatives have been focused on electricity. Combined with federal policy establishing a renewable fuels standard and alternative transportation fuel mandates, vehicle fuel efficiency requirements, extensive production and investment tax credits, and heavy subsidies for mass transportation, it is clear that most state and federal energy policy has been focused on the electric and transportation sectors.

Heat, or thermal energy, however, represents more than one-third of all energy consumed in our nation, and in the northeast, it is closer to 40%. Historically, thermal energy has received very little policy attention, perhaps because it is largely unregulated and highly decentralized. It has only been in the last few years that policy leaders have recognized the necessity of focusing attention on thermal energy.

Some northeastern states, such as New Hampshire and Vermont, have formally adopted policy objectives such as 25 x ’25, which requires attention on thermal. Other states such as New York have recognized that broad greenhouse gas emissions targets cannot be achieved without greatly reducing thermal energy consumption in buildings and industrial processes, or by displacing high carbon intensity fuels such as heating oil with lower carbon intensity fuels such as biomass.

With exception of Maine, which has legislatively set a goal of reducing oil for heating by 20% by 2020, no northeastern state has adopted specific formal targets addressing the need to reduce our reliance on fossil energy in making heat. Nationally, thermal energy goals receive even less attention, as much of the nation is focused less on heat than on cooling (almost entirely through electricity).

<u>If there is to be an American Revolution in how we produce thermal energy sustainably, it should appropriately begin in the northeastern United States.</u> Today we are threatened by economic uncertainty by foreign powers similarly as we were in 1776 due to our over-dependence on oil, especially in the Northeast.

This vision represents an effort by a group of six organizations to catalyze debate, creative thinking and entrepreneurial initiative around the challenge of reducing our reliance on non-renewable fossil energy to make heat in the northeast. Sustainably produced biomass gives us the opportunity to achieve this vision. In presenting this vision, we wish only to inform and energize a public discussion. We do not presume to know all the solutions, and in fact, this vision will probably prompt more questions than it provides answers. <u>But if our region is serious about achieving a cleaner, more sustainable energy future, it must focus serious attention on thermal energy</u>. We offer an ambitious target and recommend strategies and policies to accelerate progress toward meeting the target. We set forth immediate actions that can be taken in the coming year, as well as longer term actions that are more speculative but we believe to be necessary.

This is the beginning of a dialogue to transform an important sector of our energy economy in line with consensus national and global goals to shift to renewable, sustainable sources of energy. This transformation will create tremendous growth and profit opportunity for whole new industries. We offer this vision only to challenge the status quo and engage the people of our region in a process of change that, we believe, will be more sustainable and beneficial to our region in the long run.

II. Background

The United States, and especially the Northeast, has a long history of using biomass to make heat (Figure 1). Wood was the predominant fuel before being replaced by coal during and following the industrial revolution. Coal rose to prominence in the early 1900's. After World War II, oil and electricity began to replace coal in heating buildings and industrial process heat. Since the 1960's, natural gas and propane have increased in use, while heating oil has shown some decline. The energy crisis of the 1970's and 1980's prompted some resurgence in the use of wood for residential heating, but this use has declined since it peaked in the 1980's. Since 2001, there has been some increase in the use of wood and wood pellets in response to increasing cost and price volatility of oil and gas.

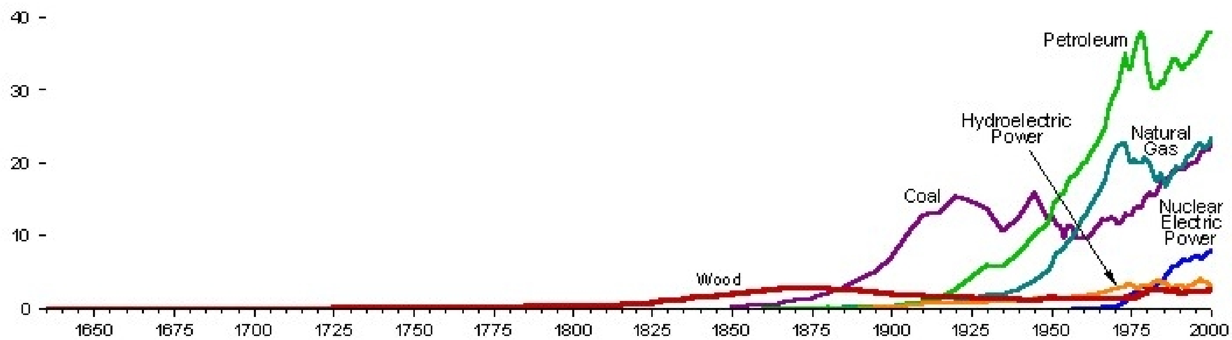


Figure 1. History of energy use in the United States, 1840-present. Source: USDOE Energy Information Administration

In 2007, 38.7% of all energy consumed in New England and New York took the form of thermal energy, with electricity and transportation fuels representing the remaining 61.3% (Table 1). Of all thermal energy consumed, over 95 % is provided by fossil fuels, predominantly natural gas, heating oil, and propane. Less than 5% is provided by renewable fuels such as biomass (wood), solar and geothermal, with the latter two renewables representing a very small fraction of the total.

Summary of Residential, Commercial, and Industrial THERMAL usage of fossil fuels (from EIA State Data, 2007)
Trillions of BTU

State	Coal	Natural Gas	Petroleum: Distillate Fuel Oil	Petroleum: Kerosene	Petroleum: LPG	Petroleum: Residual Fuel Oil	Petroleum: Total	Total Energy Use	Proportion of Total for Thermal	Renewable Fuels for Thermal: Wood	Renewable Fuels for Thermal: Solar PV	Renewable Fuels for Thermal: GeoThermal	Renewable Fuels for Thermal: Total	Proportion of Renewable for Total Thermal
Connecticut	0.1	105.1	96.3	0.9	12.1	3.7	218.2	610.2	35.8%	5.30	1.00	0.00	6.30	2.89%
Maine	3.0	11.2	64.8	6.1	10.1	20.0	115.2	329.0	35.0%	4.30	0.20	0.00	4.50	3.91%
Massachusetts	2.8	224.9	119.3	1.0	12.0	11.4	371.4	1,022.7	36.3%	11.20	0.30	0.50	12.00	3.23%
New Hampshire	0.1	23.4	33.1	1.9	11.9	5.4	75.8	207.2	36.6%	2.20	0.10	0.00	2.30	3.03%
New York	36.9	785.9	281.5	8.9	26.3	64.0	1,203.5	2,963.8	40.6%	61.00	1.40	0.80	63.20	5.25%
Rhode Island	-	37.1	22.3	0.1	1.5	2.6	63.6	153.0	41.6%	1.70	0.00	0.00	1.70	2.67%
Vermont	-	8.8	19.4	1.6	7.7	1.5	39.0	108.1	36.1%	1.20	0.10	0.00	1.30	3.33%
Total	42.9	1,196.4	636.7	20.5	81.6	108.6	2,086.7	5,394.0	38.7%	86.90	3.10	1.30	90.00	4.31%

Table 1. Summary of residential, commercial, and industrial thermal energy usage of fossil and renewable fuels, 2007. Source: USDOE Energy Information Administration.

In some northeastern states (Maine, New Hampshire, Vermont) , distillate oil is the predominant heating fuel. The Northeastern U.S. is one of the world's largest markets for heating oil: approximately 4 billion gallons of heating oil are burned annually in residential furnaces and approximately 1billion gallons are burned in commercial furnaces. Heating oil represents 54 percent of total demand for #2 distillate oil in the Northeast, compared to 38 percent for highway diesel. We are the only region in the U.S. and one of the few regions in the world that depends so heavily on oil: the northeast consumes 86% of all distillate oil used for heating purposes in the United States (USDOE EIA).

The heating oil industry is a mature and successful industry. It has well-developed inventory storage and distribution infrastructure and provides many thousands of good jobs. It has a customer base of 5.7 million household equivalents in the seven northeastern states, and many thousands of institutions, businesses and industries[1]. Significant improvements in boiler and furnace efficiency have reduced overall oil consumption per capita. New appliance standards and a proposed low sulfur heating oil mandate promise even greater efficiency gains with reduced environmental impacts.

But oil is not renewable, and not sustainable. Much heating oil is derived from crude oil produced in countries with which the U.S. has not always enjoyed constructive relationships, e.g. Venezuela. The geopolitics of world petroleum supply and demand have resulted in significant supply and price volatility in recent years. Because of our heavy reliance on heating oil in the northeast, a major global conflict or catastrophic weather event in the Gulf of Mexico where most northeast distillate heating oil is refined could have severe consequences to the economy and well-being of our region. We saw this when heating oil approached a retail delivered price of $5/gallon in some states in 2008. With $0.78 of every $1.00 spent on oil leaving our northeastern economy, the price spike resulted in an outflow of wealth exceeding $17 billion in total, and more than $7 billion relative to the previous year[2].

Biomass is renewable and -- provided our forests and our agricultural resources are managed responsibly over time – biomass is sustainable and carbon-beneficial. It is also indigenous and plentiful in the northeastern U.S. We have other renewable thermal resources too, such as solar and geothermal energy – but not as much available to be tapped economically relative to other regions of the country, such as the southwest (solar), and northwest (geothermal). Biomass is our strength. We have productive and resilient forests, although our long history of management and utilization is mixed. We can do it better, and more sustainably. We have extensive agricultural lands, and in some areas such as New York, these lands are underutilized and hold enormous potential to produce woody and herbaceous energy crops. We have significant underutilized biomass waste streams, such as urban landscape wood, and wood manufacturing residuals that if clean and free of non-biomass contaminants can contribute to the available supply of biomass for energy that are underutilized. While this is an abundant resource, it is finite and should be prioritized for efficient uses.

<u>New energy conversion technology, such as high efficiency boilers, furnaces and combined heat & power systems, offer tremendous promise in utilizing our region's biomass resources for thermal energy</u>. European and American chip, pellet and briquette combustion technology is advancing rapidly to produce thermal energy efficiencies and particulate emissions that are comparable to modern heating oil and natural gas systems. Adoption of pellet-fueled space heating (e.g. stoves) has grown significantly in the northeast since the early 2000's, and is now a widely recognized and accepted alternative. Wood chip boilers have gained broad acceptance in heating larger commercial and public buildings, such as schools. District heating and biomass CHP exist in a small number of installations, but there is widespread interest across the region in these technologies. Bulk distribution of pellet and chip

[1] USDOE Energy Information Administration, 2007 data
[2] USDOE Energy Information Administration, 2007 data

fuels is still in its early stages, as both require broad market adoption to attract capital investment in expensive storage and transport equipment. Firewood remains by far the most common means of utilizing biomass to make heat, but its emissions are still too high, and new EPA regulations will significantly reduce emission levels in future units. Much work remains to be done to replace the inventory of relatively inefficient firewood stoves and furnaces with clean, high-efficiency equipment which is now coming into the market in the United States.

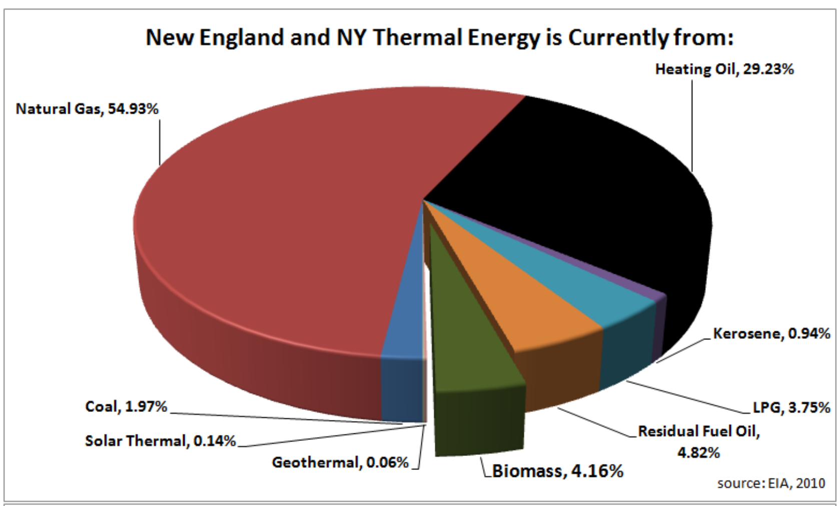
From the standpoint of supportive public policy, the northeast leads the nation in recognition of thermal renewable energy, but still has a long way to go to accord thermal comparable treatment to that received by biomass electric generation and production of liquid transportation fuels. Some states like NH have undertaken legislative studies of thermal renewable technologies. NH has also recognized thermal renewables among the technologies that can be supported with revenues from the state's Electricity Renewable Portfolio Standard, and the Regional Greenhouse Gas Initiative. Other states, such as ME, VT and MA, have utilized federal stimulus (ARRA) funds in support of thermal renewable projects. MA has also authorized use of utility electric efficiency funds to be used for "fuel/technology neutral" programs other than just electric efficiency. Still, the suite of incentives and supportive policies still falls well short of what is provided to encourage biomass electric generation.

III. The Vision

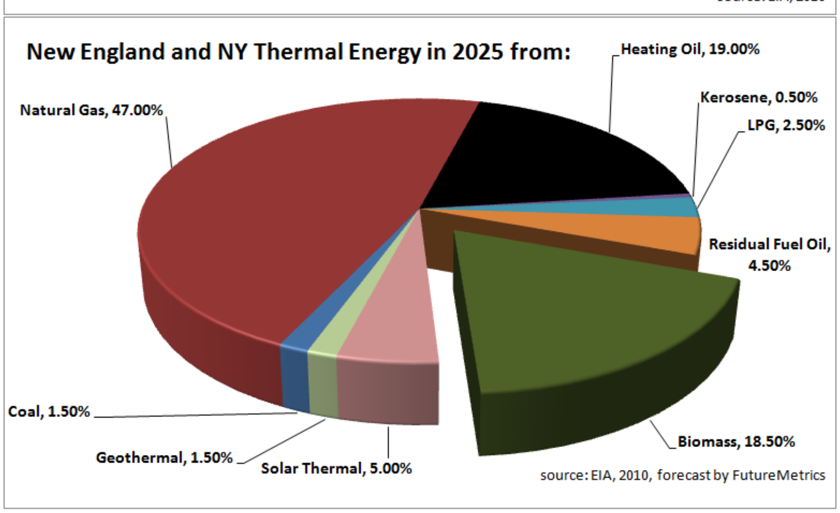
We, the five proposing organizations, call for an American Revolution to domestically produce the thermal energy consumed in the six New England states and New York. We propose that 25% of all thermal energy requirements in the Northeast are met with renewable energy resources by the year 2025. This shift in our sources for thermal energy will produce extraordinary economic, social and environmental benefits for the region, which currently relies on fossil fuel for 96% of its thermal energy. Furthermore, we call for three quarters of the renewable energy to come from sustainably produced biomass from forest and farm resources transformed into heat with clean and efficient technology, and for solar and geothermal technologies to provide the balance. Today, renewable energy accounts for 4.3% of the total thermal energy sources for the region, and forest biomass comprises 96% of all renewable thermal energy in the region.

This vision is consistent with consensus national and regional goals to reduce reliance on non-renewable fossil energy. A robust market economy will provide tens of thousands of new jobs in forest and farm production of biomass feedstocks, manufacturing, distribution and maintenance of clean, high efficiency thermal energy combustion systems, along with fuel processing, production and delivery. Leading academic institutions in the region will provide cutting edge research and development for continuous improvement of technology. State and local governments will recognize and support the continued expansion of biomass thermal through favorable tax, regulatory and incentive policies. The northeast will be recognized as a global leader in the advancement of biomass thermal energy.

TODAY



2025



IV. Estimates of Sustainable Feedstock Supply for Biomass Thermal

The initiative for conversion of homes, businesses, and buildings in the seven states to renewable biomass derived fuels must be delineated within the constraints of the ability of the region to provide the feedstock on a continuous basis, sustain the health of the region's forests, and create robust and resilient energy economies. All of the expected positive economic and environmental outcomes of the implementation of this initiative are only possible if the fuel is renewable– that is, the energy derived from the stock of biomass now does not diminish future energy stocks or the long term health of the region's forests.

Sustainability of the biomass resource depends on wood and agricultural supplies on a macro level as well as harvesting methods and infrastructure. It must also be advanced in the context of air quality and carbon reduction objectives. In terms of wood supply, sustainable development of the region's biomass resources depends on understanding the capacity of our forests and agricultural lands to supply biomass while preventing over-harvesting and associated ecological and economic consequences. Providing an accurate and ongoing assessment of the amount of low-quality woody biomass available from forests for energy on a sustainable basis that supports long-term forest health, soil productivity, water quality, wildlife habitat and biodiversity is essential.

In addition, in many instances, previously developed best management practices did not anticipate the increased removal of biomass associated with an expanded biomass energy industry. To help ensure long-term forest health and productivity, a review and update of harvesting standards and consideration of biomass fuel procurement guidelines are important.

Given the complexity of economic and social forces that influence resource availability and allocation among alternative uses, the adequacy of future feedstock supplies can be the subject of extensive, in-depth study[3]. We can conservatively estimate how much biomass from existing forestry operations and potential biomass from dedicated crops is possible for the region based on generalized data described below. To minimize the possibility of crossing below a sustainability threshold, a very conservative adjustment of 50% of the estimated amount biomass is used to determine what percentage of regional homes, businesses and buildings can be converted.

Defining what qualifies as renewable is also important. For purposes of this analysis, we will impose a sustainability constraint that is of a broad stroke. The supply of feedstock will be considered sustainable as long as the net annual growth to harvest ratio is one or greater. At a landscape scale, the aggregate

---

[3]One such analysis, "Renewable Fuels Roadmap and Sustainable Biomass Feedstock Supply Study for New York" has been undertaken by the New York Energy Research and Development Authority (NYSERDA), in collaboration with the New York State Department of Agriculture and Markets and the New York State Department of Environmental Conservation (NYSDEC). This study is expected to be released within the next few weeks. . The state of Massachusetts' Department of Energy Resources in association with the Manomet Center for Conservation Services will be completing a biomass study in May, 2010. The Northeast State Foresters Association is undertaking a major regional study entitled, "**Wood to Energy and Landscape Sustainability in the NEFA region",** which will evaluate biomass sustainability across NY, VT, NH and ME**.** This project will determine if there is enough wood across the 4-state region to fuel all of these new efforts sustainably in the coming years and how to increase supplies (growth) through better silvicultural techniques.

harvesting of biomass must be offset by the aggregate growth of new stock[4], considering only land that is not in parks, forest preserves, or other land protected by covenants and other restrictions that preclude timber harvesting. At a woodlot scale, sustainable harvesting practices must be directed by best management practices based on the best available understanding of forest systems.

The analysis will proceed as follows: The region's current and potential supply of feedstock for green chips or pellet manufacturing will be estimated[5]. Then the demand for heating oil by homes and businesses will be estimated for the region[6]. Homes and businesses that currently use natural gas will be excluded from the estimated thermal demands. The demand for heating oil will be converted to an equivalent for wood pellets (larger thermal demands will convert to wood chip fuel but the analysis will assume pellets). Then the demand for feedstock for thermal energy from wood will be balanced with the demand for energy by homes and businesses in order to determine the percentage of homes and businesses that can convert by 2025 without violating the sustainability constraint.

Recognizing that biomass thermal will not be the only sector using biomass is also important. The potential for the development of lignocellulosic ethanol production, as well as the potential continued development of biomass to electricity generation may also demand feedstock. Current technology would suggest that the most efficient use of biomass feedstock is for direct thermal applications, although there is more to the economics of energy production than technical efficiency alone, and the relative efficiency of different pathways can shift with the development of new technologies.
This report is about the *potential* for the use of biomass in the seven states for thermal needs. Rather than speculate on whether or not the production of lignocellulosic ethanol and continued growth of electricity generation from biomass will be a wise use of the region's biomass resource, this report will avoid forecasting how much biomass market forces will allocate to those technologies. The Vision Report will show the economic benefits of conversion from fossil fuel for heating to biomass for heating based on the estimates of the current sustainable biomass supply.

The probable growth of biomass fueled combined heat and power (CHP) facilities and biomass fueled district heating systems, along with residential and commercial heating systems, also needs to be recognized. In this analysis, all demand for heating will be converted to the equivalent average household[7].

The analysis will then proceed to estimate the economic impacts of converting within the sustainability constraint from fossil fuel to biomass.

---

[4] A common analogy is that of having sufficient money in the bank to live off of the interest without lowering the principal. The interest in this case is the annual harvest. This oversimplifies the case for forests, since poor forest health may actually call for harvest for some period of time that exceeds the rate of growth in order to achieve important forest management objectives like removing diseased trees or achieving a more desirable species composition over the long term.

[5] The analysis will use the current estimated sustainable biomass flow as the basis for estimating the role that bioenergy will play by 2025. That means that any potential improvements in silvicultural techniques that would improve the sustainable yield per acre of forest products, improvement which are likely, will be ignored. The analysis also assumes that the stock of forest lands will not change significantly.

[6] The demand for propane, also a relatively expensive fossil heating fuel will also be included in the analysis. The demand will be converted to gallons of heating oil equivalent to simplify the analysis. Propane use in the seven states as a percent of heating fuel is as follows: CT, 2%; ME, 5%; MA, 3%; NH, 11%; NY, 3%; RI, 3%; VT, 14% (data from the EIA state profiles),

[7] The median size home in the northeast is 2312 square feet (US Census). If a district heating plant serves 100,000 square feet that is equivalent to 43.25 homes.

A. Estimate of Biomass Feedstock Available for Energy

The complete analysis is detailed in Appendix A. It is not based on detailed studies. The analysis works backwards from high level data to estimate the potential biomass supply in 2025 given broad assumptions. Any of the assumptions can be questioned; but at every decision point at which an assumption is applied, the analysis follows a very conservative path so that the errors which are inevitable in any forecasting exercise are errors biased toward an estimate that is too low rather than too high. After following the logic to the conclusion, the resulting estimates are cut that in half. By arbitrarily cutting what is already a conservative estimate in half we are both acknowledging the potential for large errors in our high level analysis, and we are greatly increasing the probability that the actual numbers in 2025 will be higher than those derived in this work.

The goal of this analysis is to determine a value for the potential biomass supply available for energy in 2025 that has a very high probability of being attained. This is an exercise in broadly defining what is possible. It is not a bottom up biometric analysis and it will not define the expected future stock of feedstock. Its purpose is to set a likely lower limit to what is possible.

The estimates are derived from two sectors: forest-based biomass and dedicated energy crops.
The analysis of the potential forest biomass available in 2025 is broadly based on the following steps:

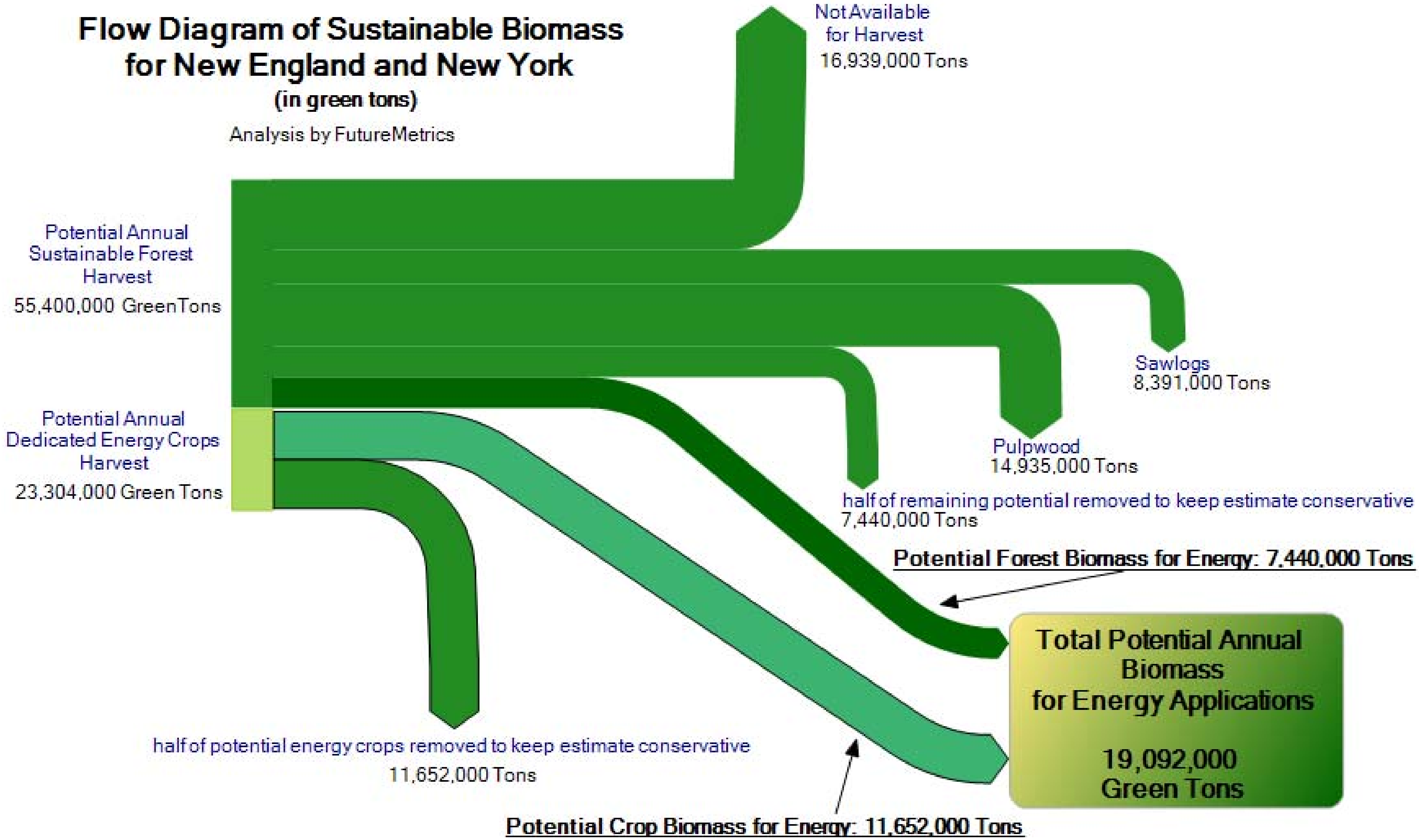
1. It begins with the US Forest Service's estimates of the aggregate stock of merchantable biomass in the seven states.
2. Then the total potential annual sustainable harvest from that stock of biomass is estimated based on net annual growth rate.
3. Then the actual total annual harvest is estimated as a proportion of the potential harvest. The difference between potential and actual varies widely among the states due to land ownership patterns, conservation lands, and parks.
4. Then the proportion of the estimated actual annual sustainable harvest that is used for pulp, chips, and firewood is estimated. The pulp, chips, and firewood stock is culled from the total as the segment that could be biomass thermal fuel feedstock.
5. Then the proportion of that total that is used for pulp production is estimated. The wood that is feeding pulp mills is therefore not considered as potential biomass thermal fuel feedstock.
6. The final estimate of the potential forest biomass available in 2025 is then halved.

The final values that are suggested as possible in 2025 are based on 2010 land use and forestry methods. It is likely that by 2025, as the significant positive economic and environmental effects of converting from fossil fuels to low carbon regionally renewable biomass thermal fuels become ingrained in our energy mix, that land use and forestry methods will be optimized for production, ecological balance, and environmental protection.

The second part of the analysis, also detailed in appendix A, estimates the potential supply of biomass feedstock from dedicated crops. That exercise is more straightforward. It is based on current data on the number of acres of land that are currently not cultivated which could be brought into production without limiting food crops or animal grazing lands. For this analysis, 25% of that potential land is used for energy crops by 2025. The results of that analysis are also halved.

The analysis concludes that, based on very conservative assumptions, by 2025 there is the potential for about 19 million green tons (forest plus dedicated energy crops) of feedstock available for energy applications.

As noted earlier in this section, this analysis will not attempt to forecast the growth of liquid fuels production or electricity production from biomass. It should be noted that the biomass for energy that is shown in the diagram below is the same stock from which those uses would derive supply.
A flow diagram of the estimation logic and the outcomes is shown on the next page.


Flow Diagram of Sustainable Biomass
for New England and New York
(in green tons)
Analysis by FutureMetrics
Not Available
for Harvest
16,939,000 Tons
Potential Annual
Sustainable Forest
Harvest
55,400,000 GreenTons
Sawlogs
8,391,000 Tons
Pulpwood
14,935,000 Tons
half of remaining potential removed to keep estimate conservative
7,440,000 Tons
Potential Forest Biomass for Energy: 7,440,000 Tons
Potential Annual
Dedicated Energy Crops
Harvest
23,304,000 Green Tons
Total Potential Annual
Biomass
for Energy Applications
19,092,000
Green Tons
half of potential energy crops removed to keep estimate conservative
11,652,000 Tons
Potential Crop Biomass for Energy: 11,652,000 Tons

V. Economic and Environmental Benefits of Achieving the Vision

A. Estimate of Proportion of Conversion from Heating Oil and other Fossil Fuels to Biomass and the Economic Impacts of Conversion

The details of this analysis are contained in Appendix B. The analysis is in two stages. The first stage estimates the number of household equivalents[8] that could be heated using the estimated sustainable feedstock derived above. The second stage estimates the economic impact of the conversion.
The estimate of the number of household equivalents and the economic impact broadly follows these steps:

1. The total number of household equivalents in the seven state region is estimated.
2. The total number of those household units that could convert given the potential supply of biomass in 2025 is estimated.
3. The economic effects of having the dollars spent by on heating fuel by those that could convert stay in the region rather than being exported out of the region are estimated.
4. The economic effects of increased disposable income due to lower heating costs to those that convert are estimated.

Table 2 below[9] summarizes the outcome of the exercise that is detailed in Appendix B.

	Total Permanent ANNUAL Biomass Thermal Created Income with annual pay at $53,587	Total Permanent Biomass Thermal Jobs in 2025
CT	$ 324,020,541	10,349
MA	$ 462,336,713	15,725
ME	$ 625,867,221	19,780
NH	$ 215,766,274	7,420
NY	$ 2,528,033,543	75,740
RI	$ 88,498,019	2,879
VT	$ 257,767,868	8,322
	$ 4,502,290,180	**140,216**

Table 2. Estimates of total annual income created and retained in Northeast region if Vision goal of 18.5% of all thermal energy is provided by biomass, and estimate of total jobs created by achievement of Vision goal, by 2025.

[8] That is, the analysis will use the typical square footage of an average New England home as the unit of measurement. One large building will be equivalent to many "household" units. This use of a single unit simplifies the analysis. In the end, the total number of household units that can be heated with biomass can be deconstructed into equivalent homes, business, schools, etc.
[9] The annual pay in 2025 is based on the current median annual pay in northeastern states adjusted for an assumed annual 2.5% inflation.

The jobs estimates are for new jobs that will be created both by regional biofuel production replacing non-regional oil production, and by the increased disposable income that will create new commerce and investment. However, the jobs estimates assume that no new jobs will be created at the delivery end of the supply chain. The estimates assume that as the transition from heating oil to biofuels takes place, those jobs that already exist for heating oil delivery and the administration of that infrastructure will migrate to doing very similar activities with the biofuels.

This analysis does not include an estimate of the new tax revenues that the states would accrue. The addition to the states' treasuries would, however, be substantial.

Switching cannot happen immediately of course. The growth of the supply infrastructure must be such so that the supply of fuel is equal to or greater than the demand. The process of switching will occur over a number of years with the pace of conversions increasing as the infrastructure and the gap between fuel prices grows.

One possible growth scenario is shown in the chart below (Figure 2) in which the rate of conversion increases slowly in the early years and more rapidly as the infrastructure for both biomass heating systems and fuel supply develops. Currently, about 4.16% of the total thermal energy in the seven states is produced from biomass. The chart below shows a potential growth path from the current estimated 265,000 household equivalents to the total estimated sustainable total of 1,385,000.

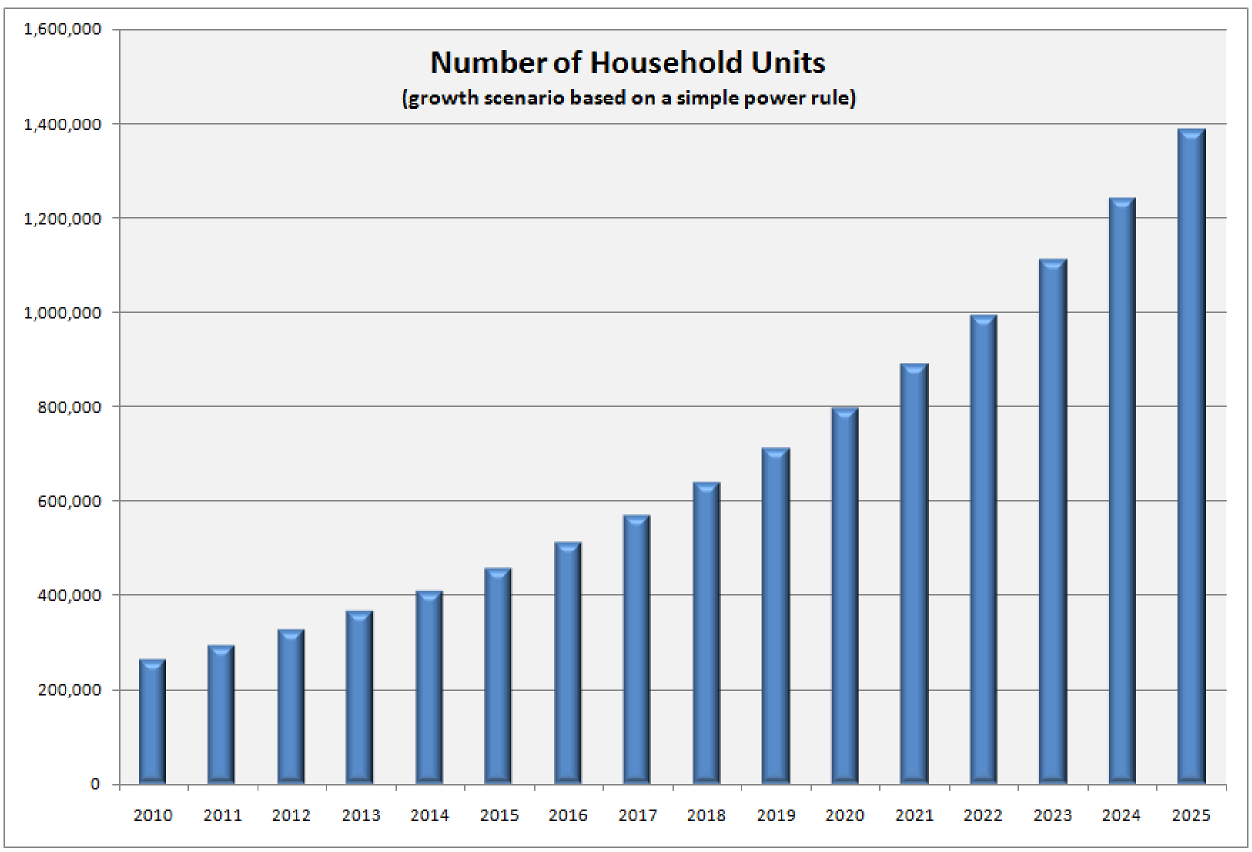


Figure 2. Annual projection of growth in total number of household units that must convert to biomass thermal to achieve Vision goal by 2025.

By 2025 after the full conversion has taken place the states would have more than $4.5 billion dollars per year injected into their economies with a total of 140,200 permanent jobs. Most of the money and jobs will be new, created by the growth of the biomass thermal sector between now and 2025.

Conclusion

The economic benefits of no longer exporting money are substantial. Those benefits are further supported by lowering the cost of heating fuel and unlocking that otherwise captive capital.

This analysis has shown that a significant proportion of the 25 by '25 thermal goal can be met with biomass fuel produced in the region. It has also shown that there are substantial economic benefits associated with job creation. Non-biomass renewable energy sources do not require the supply chain and infrastructure that biomass thermal technology does. Clean and renewable bioenergy can and will help the seven states move toward energy independence and fulfill the economic needs of the region by creating significant new income and jobs.

C. Environmental and Social Benefits of Achieving the Vision

<u>Increased Viability of Forest and Farm Ownership</u>

Open space plans in New York and New England recognize that the primary threat to working forests and farmland is not conversion to a radically different use – forest clearing for other land uses, or industrial development on agricultural land, for example. The primary threat is residential subdivision, usually driven by the lack of any economic use for the land sufficient to cover the carrying cost of the property, in particular land taxes.

The health of Northeastern forests, outside the areas managed largely for pulpwood production in Maine and northern New York, has been compromised by the predominant harvesting pattern, usually referred to as "high-grading". This harvesting pattern has emphasized taking all the salable stems of commercial tree species, with little regard for the stand thinning and other silvicultural practices that would produce healthier forests and better timber stands over the long run. The reason has been simple economics. The value of thinning and culls has not been equal to the cost of their selective removal. While larger landowners increasingly operate with forest management plans and a view to good stewardship of their forest resources for the long term, smaller landowners – the owners of farm woodlots, vacation homes, hunting areas, and so on – have not had the resources to "go in the hole" for good forest management. **Finding a value for biomass, harvested according to good management practices defined in local terms, would permit the kind of careful management that small private forest lands have never received in the United States.**

A large proportion of agricultural land in the Northeast is owned by non-farmers. While most non-farmers would like to rent their open land to a farmer in the neighborhood, as the agricultural industry has contracted, with fewer farmers managing more intensive and geographically concentrated enterprises, millions of acres have been abandoned or practically abandoned, producing only a single grass hay crop a year, or simply being mowed to keep them from becoming overgrown with brush. Perennial biomass crops like hybrid willow or switchgrass could be very attractive options for owners of this land area, and their wider cultivation would be a significant shot in the arm for many regions that have suffered serious economic decline along with a contracting agricultural industry. A market for woody and herbaceous biomass crops would serve both to keep this agricultural land from being chopped up and contributing to “sprawl”, and would provide both rural employment and a broader base of customers for businesses such as equipment dealers than have struggled with a shrinking customer base.

Climate Change, Air Quality and Acid Rain

A significant shift to carbon advantageous biomass fuels for thermal energy has significant climate benefits. As trees sequester CO2 during their growth period and emit it when combusted, wood can be considered as a carbon efficient fuel, compared to fossil fuels, if it is harvested responsibly and sustainably. CO2 is currently the biggest contributor of greenhouse gases that are implicated in climate change.

Sulfur Dioxide and Acid Rain, and Mercury

The combustion of heating oil containing sulfur levels on the order of 2,500 parts per million (ppm) contributes to ambient concentrations of fine particles found in the Northeast. These particles have adverse health and environmental impacts.

Due to the high level of sulfur currently found in heating oil, its combustion is a significant source of sulfur dioxide (SO2) emissions in the region – second only to electric power plants. Regionally, the burning of high sulfur heating oil generates approximately 100,000 tons of SO2 annually – an amount equivalent to the emissions from two average sized coal-burning power plants. Oil heating is also a source of particulate matter (PM), oxides of nitrogen (NOx) and carbon monoxide (CO). While data are limited and uncertain, residential heating with fuel oil is estimated to produce almost 25 percent of mercury emissions in the six New England states.

Heating oil burners emit significant levels of SO2 and mercury. Biomass, by contrast, has only trace amounts of sulfur or mercury. A significant transition to biomass combustion in thermal applications can reduce acid rain-causing sulfur dioxide emissions as well as mercury emissions. SO2 causes acid rain and has a detrimental effect on plants, sea life and other life forms. Mercury is a potent neurotoxin that can make fish inedible and unsafe in high concentrations.

Technology Advancement

Progress toward achieving the Vision goal will necessitate major advances in technology. For example, our projections point to a very substantial role to cropped biomass in meeting the challenge of the large increase in biomass thermal energy incorporated in our vision. While shrub willow and hybrid poplar produce a chip which is essentially interchangeable with other whole-tree hardwood chips, this is not true in the case of perennial grasses. There are a range of combustion issues (VOCs, chlorine compounds, NOX) that may come into play with grasses, depending on species and to some extent harvesting practices. Higher ash levels for pellets made from chips with bark, and for some of the grasses, present a consumer acceptance issue in the residential market, and relatively high silica levels in grass present engineering issues in some appliances. All of these issues are the subject of ongoing research and technological development. A strong market demand for biomass thermal technologies will provide incentives for entrepreneurial initiative, investment in research and development, recognition of the need for R&D support by government, and acceleration in the development of new technologies. This will all be beneficial to our economy and in the achievement of other societal goals.

VI. Strategies and Policies to Achieve the Vision

Policy Overview

If we are to realize broadly held national goals of increasing energy efficiency, addressing climate change, reducing reliance on foreign oil and related national security threats and providing long-term energy affordability, the nation and the northeast must reach for a new energy policy and practice. Effectively applying the potential of biomass energy to help address these issues requires addressing all three major sectors of energy consumption: electric generation, transportation fuels and thermal energy. While US energy consumption is roughly divided into thirds across these sectors[10], existing public policy has focused almost exclusively on the transportation and electric sectors, recognizing the dependency of transportation on petroleum and the electric sector on coal. Billions of dollars in renewable energy subsidies currently flow to the transportation and electricity sectors, while the very substantial dependence of the thermal energy sector on the same problematic fossil fuels has not received comparable support either in the form of direct and indirect subsidies, or support for R&D. [11]

Failure to invest in renewable thermal energy would come at an enormous cost: to our citizens, our environment, our economy and our nation's security. Action is needed at the national, state and regional level to catalyze real change in how we heat and cool our buildings. Comprehensive, innovative public policy has an important role to play in reducing our dependence on foreign oil in the heating sector.

An Outcome-Driven Approach

Existing and emerging energy policy have offered economic signals to consumers by incentivizing specific technologies, rather than rewarding the desired outcomes. For example, the federal government has established a Renewable Fuels Standard which applies only to transportation fuels, and is considering a Renewable Electricity Standard which applies only to electricity production. By shifting to an outcome-driven approach, the government can level the playing field for all technologies and allow solutions to compete based on their outcome, not their energy source. If our goal is to shift to renewable energy and a low carbon economy, then all technologies across the energy sector should be allowed to compete against a uniform set of metrics and goals. By leveling the playing field, public policy can incentivize the highest return activities, whether they come from mature industries or emerging technologies.

An outcome-driven energy policy would seek to deliver on the following core clean energy objectives:

1) **Efficiency:** Public policy should support technologies that result in efficient conversion of a renewable resource to energy. Using biomass fuel to generate thermal energy or combined heat and electric power in the highly-efficient conversion systems now available is a sound use of resources. Used for heat or heat-led Combined Heat and Power (CHP), biomass energy is

[10] Energy Information Association, 2006 data

[11] As reported by the Environmental Law Institute based on 2002-1008 data, of the $29 billion in federal renewable energy subsidies provided during this time period, $16 billion were for transportation fuels, $6 billion for renewable electricity generation and no significant subsidy for renewable thermal energy.

approximately 75-80% efficient, a level which no other conversion systems, either for power or transportation fuel, can achieve.

2) **Affordability:** To empower rapid adoption of clean energy technologies, consumers must find these technologies accessible and affordable. Limited public funds should be focused on catalyzing market penetration and moving new technologies to economies of scale, with an eye towards building long-term, independent market momentum and viability. Given the likelihood of increasing fossil fuel energy prices and declining global supplies, incentivizing affordable renewable technologies such as biomass thermal are an important investment if providing affordable heating, cooling and combined heat and power resources to residents across the northeast (and other regions of the country). Low income families in particular are vulnerable to price hikes in oil and biomass heat will help them make ends meet.

3) Sustainability: Sustainability of the biomass resource depends on wood and agricultural supplies on a macro level as well as harvesting methods and infrastructure. It also must be advanced in the context of air quality and climate change objectives. Sustainable development of the country's woody biomass resource for energy depends on understanding the capacity of our forests to supply biomass while preventing over-harvesting and its associated ecological and economic consequences. In addition, previously developed best management practices did not anticipate the increased removal of biomass associated with the expanded biomass energy industry and offer mixed guidance on the amount of removal that is consistent with long-term forest health and productivity. A review and update of harvesting standards (and/or procurement guidelines) is important to ensure long-term forest health and ecological function.

4) **Security:** Public policy should support a shift in sourcing our energy from domestic resources where end users are exposed to few disruptions, enjoy relative price stability, and can have confidence in local supply will be critical to stabilizing our country's energy profile and economic growth and capacity.

5) **Clean Emissions** – Energy derived from biomass energy must minimize emissions and meet or surpass stringent public health and air quality standards. Biomass energy projects should implement efficient combustion technologies and best management practices for emission control technologies, fuel quality, and operating conditions.

6) Climate Change Mitigation – Use of biomass for energy efficient and appropriately scaled applications has tremendous potential to displace fossil fuels and over the long term lower atmospheric CO2 emissions. Biomass energy used in this manner is a "low-carbon fuel," and integrated with the sustainable fuel supply has the potential to be a net carbon sequestering option, even when considering the fossil fuels used in production and transportation of wood fuel and agricultural production. The degree to which biomass energy systems can reduce carbon emissions compared to fossil fuels is directly related to establishment and management of harvesting regimes, forest types, fuel transport, and efficiency. National carbon sequestration and reduction policies such as carbon cap and trade regulations and voluntary carbon standards will also have an impact on forest management and agricultural decisions regarding carbon storage, forest adaptation, production of biomass for energy, and harvesting of traditional wood products. Policies must be put in place which optimize carbon storage, adaptation potential, biomass used for energy, and the harvest of traditional products.

Critical Public Policy Elements:

Public policy measures to support efficient, clean, sustainable biomass energy:

1. Develop a National Thermal Energy Policy that includes the following elements:
   - A Renewable Thermal Standard (comparable to the existing Renewable Fuels Standard and proposed Renewable Electricity Standard);
   - National and state carbon policies and greenhouse gas emissions programs that support the most efficient thermal uses of biomass;
   - Federal and state incentives, grants and loans to advance the utilization of high efficiency biomass thermal systems; and
   - Renewable Portfolio Standards that include thermal energy and provision of renewable energy credits for thermal applications and which promote efficient use of biomass.

2. Fund and conduct accurate and ongoing assessments of sustainable biomass energy supply.

3. Support biomass harvesting standards, sustainable forest management, and procurement guidelines to ensure a sustainable supply chain for timber and other biomass harvesting activities.

4. Support harvesting and management infrastructure, including policies that encourage and promote the long-term *economic* viability of the supply chain to ensure forestry and logging capacity, and sound land stewardship and management practices necessary to ensure low grade wood resource availability for sustained biomass energy use over the long term.

5. Establish consistent federal and state air emission standards and regulations for biomass energy to minimize emissions and meet stringent public health and air quality standards.

6. To support the ability of biomass energy to help reduce climate change, support forest conservation efforts, provide offset credits and other incentives for increased carbon sequestration and storage, and address forest adaptation due to changing climate.

Action and Opportunity in Northeastern States

To achieve this vision for biomass thermal, three key actions are required.

- First, the seven northeastern states must incorporate thermal energy into emerging energy policy and include goals for clean, efficient, sustainable and affordable biomass thermal energy in the mix.
- Second, establish and fund necessary policies to accomplish the goal working at the state level and collaboratively at the regional and national levels.
- Third, initiate and support a public education campaign commensurate with the vision and build effective partnerships and alliances to carry biomass thermal energy vision forward.

Important state, regional and national policy opportunities for incorporating an effective biomass thermal vision into national, regional and state level policy planning include the following:

- Conference of New England Governors and Eastern Canadian Premiers resolution
- State climate change action plans

- State endorsement of 25x’25 action plans
- National climate and energy policy legislation; current tax incentive and federal grant and loan programs for thermal energy and biomass applications; the reauthorization of federal legislation known as the Farm Bill; and other opportunities
- Other state level energy planning, perhaps specific to thermal renewable energy

VII. A Call to Action: Next Steps

We have presented an ambitious Vision for biomass thermal in the Northeast. Making progress toward this vision will require immediate actions, some of which are identified below. A first step is forming a volunteer working group of industry, government and non-governmental organization leaders committed to the vision. Additional actions will flow from this group, and can include the following:

1. Formation of the "Northeast Biomass Thermal Working Group." The working group would have representation from across the region, and include industry, NGO and government officials.

2. Development by the working group of a "key contacts" list of policy makers, opinion leaders, state and federal officials, and industry leaders.

3. Broad dissemination and promotion of the Vision to the key contacts list.

4. Convening of regional dinners over the next 6-9 months to present and receive feedback on the Vision to invited key contacts: perhaps four meetings in NY, NH/VT, ME, MA/CT/RI. The purpose is to seek input, continue to refine vision with particular focus on strategies and policy recommendations.

5. Formation by the working group of a "northeast regional biomass thermal policy action team", with representation from all seven states, to monitor and influence state and local legislation, regulation and other policy matters that will impact the advancement of the Vision. Also, develop model legislation for consideration at the state level, and coordinate regional response to federal policy initiatives.

<u>What You Can Do Today</u>

- **Contact BTEC to offer feedback, criticism and ideas to improve this Vision:**
  Biomass Thermal Energy Council (BTEC)
  1211 Connecticut Ave., NW, Suite 600
  Washington DC 20036
  Phone: 202-596-3974
  Email: info@biomassthermal.org
  Web: www.biomassthermal.org

- **Share the Vision document with anyone who may be interested. Invite their feedback.**

- **Raise these issues with your governor, state and federal officials, and state legislators.**

- **Join and financially support one or more of the organizations that have presented this Vision.**

Appendix A – Methodology for Estimating Biomass Feedstocks

The analysis that follows is not based on detailed studies. The analysis works backwards from high level data to estimate the potential biomass supply in 2025 given broad assumptions. Any of the assumptions can be questioned; but at every decision point at which an assumption is applied, the analysis follows a very conservative path so that the errors which are inevitable in any forecasting exercise are errors biased toward an estimate that is too low rather than too large. Then, after following the logic to the conclusion, the resulting estimates are cut that in half.

The goal of this analysis is to determine a value for the potential biomass supply available for thermal fuels in 2025 that has a very high probability of being attained. This is an exercise in broadly defining what is possible. It is not a bottom up biometric analysis and it will not define the future stock of feedstock. It will, however, likely set a lower limit to what is possible.

The analysis of the potential forest biomass available in 2025 is broadly based on the following steps:

1. It begins with the US Forest Service's estimates of the aggregate stock of merchantable biomass in the seven states.
2. Then the total <u>potential</u> annual sustainable harvest from that stock of biomass is estimated.
3. Then the <u>actual</u> total annual harvest is estimated as a proportion of the potential harvest. The difference between potential and actual varies widely among the states due to land ownership patterns, conservation lands, and parks.
4. Then the proportion of the estimated actual annual sustainable harvest that is used for pulp, chips, and firewood is estimated. The pulp, chips, and firewood stock is culled from the total as the segment that could be biomass thermal fuel feedstock.
5. Then the proportion of that total that is used for pulp production is estimated. The wood that is feeding pulp mills is therefore not considered as potential biomass thermal fuel feedstock.
6. The final estimate of the potential forest biomass available in 2025 is then halved.

The second part of the analysis estimates the potential supply of biomass thermal fuel feedstock from dedicated crops. That exercise is more straightforward. It is based on current data on the number of acres of land that are currently not cultivated which could be brought into production without limiting food crops. For this analysis, 25% of that potential land is used for energy crops by 2025.

As a starting point, the total merchantable biomass available in the seven states is as follows[12]:

[12] from http://fiatools.fs.fed.us/Evalidator401/tmattribute.jsp. Note that this is an estimate of only the merchantable stock. Tops, limbs, stumps and roots are not included in the potential harvest.

Current Green Tons of All Forest Fiber that is Merchantable*	
State	Total
CT	158,593,763
MA	264,062,750
ME	736,786,431
NH	344,166,134
NY	1,126,890,756
RI	28,327,243
VT	346,682,444
Total	**3,005,509,522**

*Estimate for merchantable biomass on forestland (green tons). Merchantable biomass is the main stem of all species > 5" d.b.h. between a 1-foot stump height and a 4" top diameter (outside the bark), including rough and rotten culls.

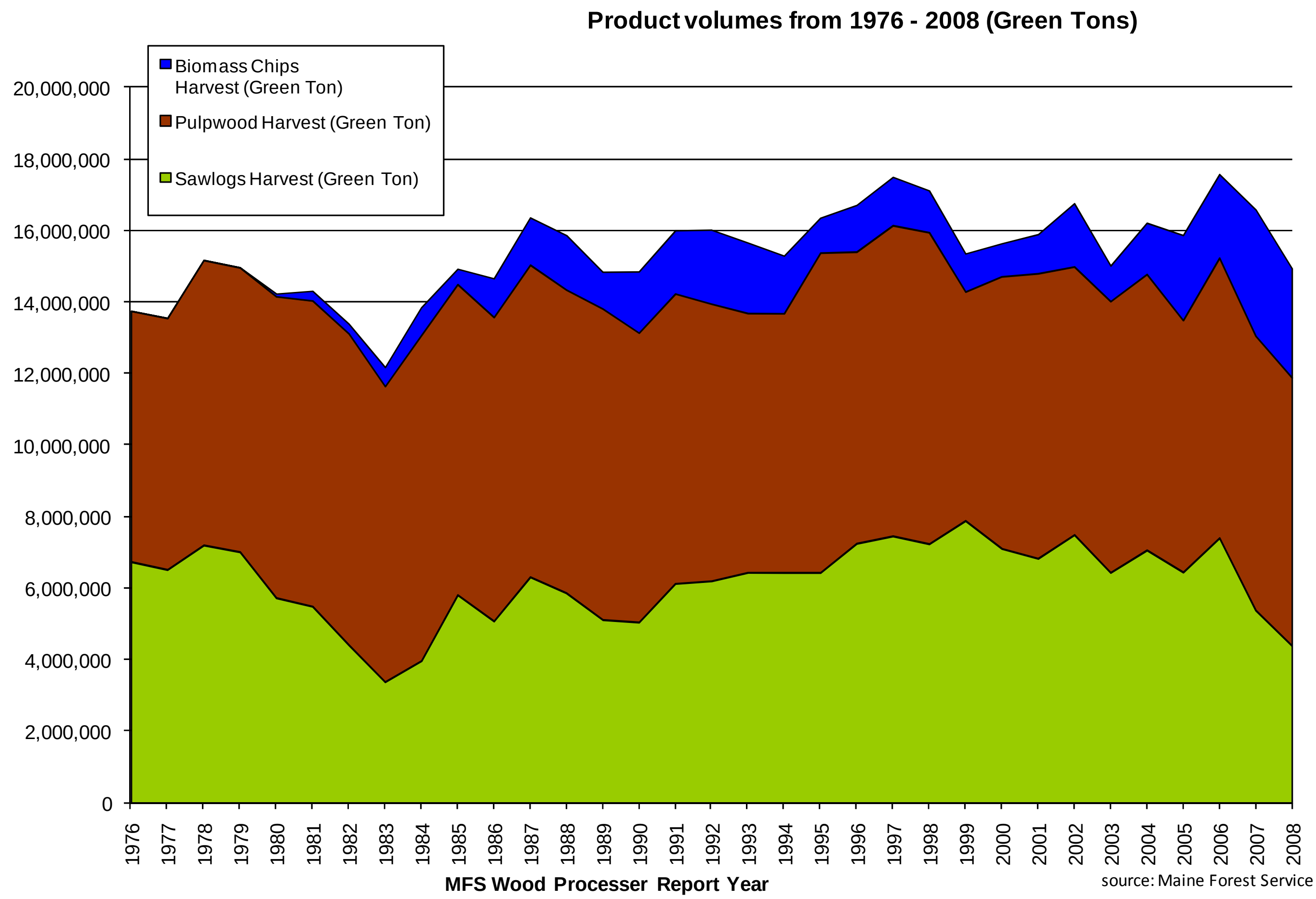
The next step is to calculate the potential sustainable harvest[13] based on growth cycle assumptions and assumptions.

The "potential" annual harvest is not the same as what can actually be harvested. A proportion of the aggregate stock of biomass in the seven states is on lands that do not have expectations of engaging in managed forestry. Conservation lands and other areas, while in the total "potential" will not be a part biomass available for bioenergy in the analysis that follows. Thus the next stage in this analysis is to estimate what proportion of lands are off-limits to managed forestry.

Maine has the most intensively used forest resource of the seven states. Maine harvested about 14.9 million tons in 2008 out of a current potential of about 16.5 million tons per year. The chart below shows that Maine has had an average harvest of 16.4 million tons per year since the mid 1980s. Maine's forests grow at a rate that is sufficient to sustain its average harvest levels[14]. Taking a 5 year rolling average, in Maine the ratio of the actual harvest versus potential is about 0.98.

[13] The calculation of the sustainable harvest is based on the total stock with a growth cycle of between 56.5 and 43.28 years. This is an average of between 1.77% and 2.31% of the total stock every year. The growth cycle is based on data from all species from the Maine Forest Service Wood Processors Reports, 2004-2008, and the "Renewable Fuels Roadmap and Sustainable Biomass Feedstock Supply Study for New York" produced by the New York Energy Research and Development Authority. The estimates are all rounded down to the nearest 100,000.

[14] "Maine Forest Service Assessment of Sustainable Biomass Availability." Maine Forest Service, July 7, 2008 p, 2.



New York harvested 4.70 million green tons of wood in 2008[15]. Of that, 1.05 million tons was chips and 1.05 million tons was pulpwood. When compared to the potential sustainable harvest this number is quite low. This shows that some of New York's forests are not available for forest products. However, it also indicates that New York's potentially harvestable forest biomass stock is growing more rapidly than it is being harvested. New York has an estimated sustainable harvest of about 9 million dry tons per year, for all uses. The estimate used in this analysis lowers this figure to assume 15 million green tons per year (equivalent to 7.5 million dry tons), to err on the side of caution..

The ratios of the actual harvests to the potential harvests used in this analysis are shown in the table below.

[15] New York Department of Environmental Conservation, Industrial Timber Harvest Production and Consumption Report, 2008. (using the Doyle log rule to convert every 1000 board feet of sawtimber to 8 tons)

State	actual harvest to potential harvest ratio
CT	0.30
MA	0.25
ME	0.98
NH	0.42
NY	0.76
RI	0.30
VT	0.50

The estimated annual sustainable harvest of all forest biomass that is derived from the growth cycle assumptions and the ratio of actual harvesting to potential is shown in the table below.

State	**Annual Sustainable Harvest based on Growth Cycle and Off-Limits Lands**
CT	810,000
MA	1,125,000
ME	16,170,000
NH	2,520,000
NY	14,516,000
RI	120,000
VT	3,000,000
Total	**38,261,000**

The next step in this analysis is to identify the proportion of the total actual harvest that could be used for biomass energy feedstock. In all of the seven states, a proportion of the total harvest is pulpwood, biomass chips, and firewood. Pulpwood, biomass chips, and firewood (all of which are appropriate feedstock for biomass thermal fuels) make up about 92% of the total estimated biomass harvest in New York and about 79% of the actual total harvest in Maine[16].

A more detailed study, or data from forthcoming studies, will quantify in detail the ratios for the other five states. This will be necessary to derive accurate data and forecasts for a more in depth analysis. In all cases in the table below, the estimates, if uncertain, have been lowered by 20%. This analysis uses the following assumptions for the ratio of the quantity of pulp, chips, and firewood to the total of the forest products harvested.

[16] These values are from actual data in Maine and are estimated from the values presented in the NY Roadmap study.

State	pulp, chips, firewood as proportion of total
CT	0.50
MA	0.40
ME	0.79
NH	0.65
NY	0.92
RI	0.40
VT	0.40

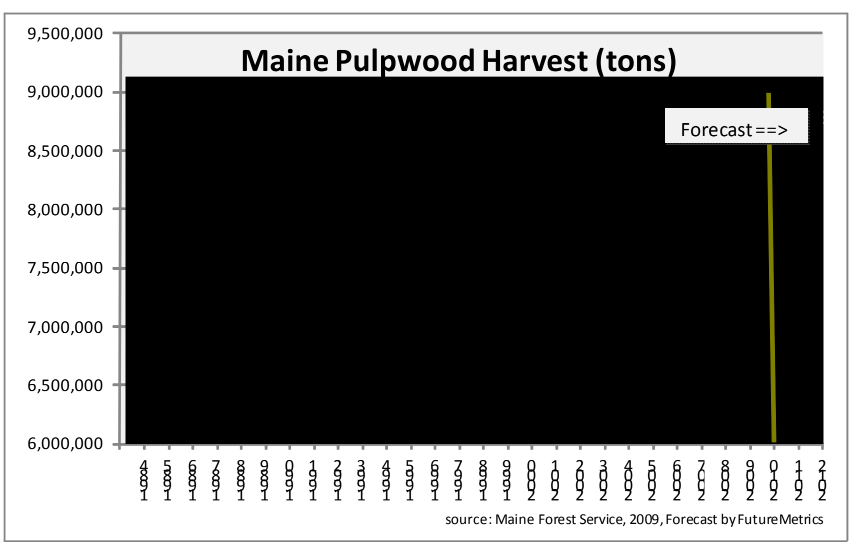
These assumptions are conservative since the scope of this analysis is for the conversions to take place by 2025. Over the next 15 years it is likely that improved silvicultural techniques will improve the sustainable forest yields[17].

From the starting values for the aggregate biomass available, the analysis has thus far adjusted for what the potential sustainable harvest could be, then for the actual potential harvests considering current practices, and then the analysis has culled out the biomass that could be dedicated for energy applications. The last step in this analysis is to remove wood that is used for pulp and paper production from this inventory for potential biomass energy feedstock.

If we assume that the demand for pulpwood for papermaking declines only modestly[18] and we use the average pulpwood harvest as a proportion of the total of chips and pulpwood[19] we conclude that about 14,900,000 tons per year will be available for biomass energy feedstock in 2025.

[17] For example, see "Maine Forest Service Assessment of Sustainable Biomass Availability," July, 2008 in which it is forecast that improved management and harvesting methods can increase the sustainable yield by 20% to 60% over current levels. Also,

[18] The trend over the last decade does not suggest that the demand will remain at current levels. For example in Maine, the trend and forecast are shown in the chart below.



Estimated Annual Sustainable Production of Bioenergy Feedstock	
State	Total
CT	203,000
MA	225,000
ME	6,387,000
NH	819,000
NY	6,678,000
RI	24,000
VT	600,000
Total	**14,935,000**

This value is then cut in half for use in estimating the potential number of current users of fossil fuel that can be converted to sustainable regionally produced bioenergy fuels. The table below shows the end result of this exercise (in green tons).

Estimated Annual Sustainable Production of Bioenergy Feedstock (*50% of final estimate*)	
State	Total
CT	100,000
MA	110,000
ME	3,190,000
NH	400,000
NY	3,330,000
RI	10,000
VT	300,000
Total	**7,440,000**

The numbers are very modest and should be viewed as a lower tail estimate of what is possible in 2025[20]. However, based on these numbers and the estimates for dedicated crops that follow, biomass thermal can still play a very significant role in replacing fossil fuels for heating needs.

It is also likely that as the conversion from heating oil to bioenergy occurs, a significant percentage of the large area of idle and under-utilized farmland will be brought into production with dedicated energy crops. The following table shows the area of uncultivated cropland[21] and pasture in the seven states[22].

---

[19] Maine and NY reports show that 71% and 50% respectively of the non-sawlog harvest that is not firewood goes to pulpwood. For this analysis we will assume a modest decline in pulpwood demand by pulp mills so that the average for all states in 2025 is 50%.

[20] For example, in 2008 Maine harvested 2.54 million tons of biomass chips for direct thermal use and also produced about 310,000 tons of wood pellets using about 620,000 tons of pulp grade wood. Maine was already achieving the 2025 benchmark in 2008. (Maine Forest Service and pellet production data from FutureMetrics)

(acres)	cultivated cropland	non-cultivated	pasture
CT	63,900	108,300	128,700
MA	54,900	196,800	135,900
ME	123,700	260,800	37,400
NH	18,800	105,800	89,300
NY	2,097,800	3,261,100	2,584,100
RI	3,800	16,500	89,300
VT	143,300	443,200	314,400
Total	2,506,200	4,392,500	3,379,100

While an important share of the non-cultivated cropland produces hay that is important to livestock agriculture, and some of the pasture supports pasture-based beef and dairy production, as well as the equine industry, a significant part of both these land categories is used only lightly, frequently only mowed every year or two to keep it open. Assuming that 25% the non-cultivated cropland and pasture is converted to energy crops, and assuming that the average yield per acre by the year 2025 has reached 6 dry tons/year, compared to current yields in the vicinity of 4 dry tons per year[23] the table below shows the potential for additional feedstock (assuming 50% moisture to convert dry to green tons)[24].

(acres)	cultivated cropland	non-cultivated	pasture	Acres for Dedicated Energy Crops	Annual "Green" Tons Equivalent
CT	63,900	108,300	128,700	59,000	708,000
MA	54,900	196,800	135,900	83,000	996,000
ME	123,700	260,800	37,400	75,000	900,000
NH	18,800	105,800	89,300	49,000	588,000
NY	2,097,800	3,261,100	2,584,100	1,461,000	17,532,000
RI	3,800	16,500	89,300	26,000	312,000
VT	143,300	443,200	314,400	189,000	2,268,000
Total	2,506,200	4,392,500	3,379,100	1,942,000	23,304,000

---

[21] This is open land that is not being planted to row crops; it may either be idle land (weed cover or small brush), permanent hay cover, or fruit crops. Orchard land is obviously not a candidate for biomass crop production, but this is a relatively minor land use category by area, although the value of output is very high.

[22] Data is from the National Resources Inventory, managed by USDA's Natural Resource Conservation Service. Data is derived from a statistical sample of plots of land, based on observation of land cover from satellite and ground data. NRI data has a fairly wide margin of error (sometimes as much as 10% either way).

[23] Based on aggregated data in "Biomass Energy Crops: Massachusetts' Potential", MA Division of Energy Resources and MA Dept. of Conservation and Recreation, January, 2008.

[24] This arbitrary adjustment is intended to make biomass crop totals equivalent to green ton estimates for forest biomass; short rotation woody biomass crops like willow do have harvest moisture levels similar to forest wood; grasses are more likely to be harvested after field drying at 15-18% moisture, which results in efficiency gains in some conversion systems.

This estimate is also cut in half, recognizing that some of the cropped biomass supply move to other energy uses such as cellulosic ethanol or fuel produced through thermo-chemical transformation.

	Annual Potential "Green" Tons Equivalent *(50% of final estimate)*
CT	354,000
MA	498,000
ME	450,000
NH	294,000
NY	8,766,000
RI	156,000
VT	1,134,000
Total	11,652,000

Thus the total forest and cropland biomass that this exercise carries into the economic analysis portion of the study, over 19 million green tons, is shown in this final table.

Sustainable Biomass for 2025 Economic Analysis			
State	Forest	Crop	Total
CT	100,000	354,000	454,000
MA	110,000	498,000	608,000
ME	3,190,000	450,000	3,640,000
NH	400,000	294,000	694,000
NY	3,330,000	8,766,000	12,096,000
RI	10,000	156,000	166,000
VT	300,000	1,134,000	1,434,000
Total	7,440,000	11,652,000	**19,092,000**

Appendix B – Methodology for Estimating Economic Impacts

The number of households that use heating oil or propane in the seven states can be estimated directly from government data. However the number of business and buildings that use heating oil or other petroleum derived fuels (residual oil for example) cannot be directly delineated from the EIA and Census data. However, data from the EIA does show heating oil deliveries to residential and commercial establishments. In recent history, of total #2 heating oil delivered, about 19.8% is delivered to commercial establishments. Industrial locations that use petroleum derived fuel for thermal needs typically use residual oil. For this analysis, all thermal demand will be converted to household equivalents[25]. Although the estimates will be missing process needs, the analysis will assume that industrial needs such as central heating plants will serve some proportion of the square footage that requires heating in the seven states.

The average household unit in the seven states uses about 830 gallons per year of #2 heating oil[26]. This analysis will convert that heating oil demand into dry biomass demand and then back to raw feedstock demand[27]. This analysis will also convert all business heating oil demand to the equivalent number of household units.

It should be noted that schools and other buildings as well as some district heating systems have and will continue to convert to biomass fuel. Most of those conversions will not use pellets but will use chips. However their impact on the supply and demand balance will be accounted for in pellet equivalents.

The average use of 830 gallons per year converts into a demand for 14 tons per year of green chips (or 7 tons per year of pellet fuel) (assuming 85% pellet boiler efficiency and 85% oil boiler efficiency).

Many residential locations already use pellet stoves and some will add those appliances to their heating mix in the future. The analysis will focus on the *potential* to convert household equivalent units from fossil fuel to biomass derived fuels on a dry ton basis. So the average pellet stove user that uses 3.5 tons per year of pellet fuel is equivalent to 0.5 household equivalents in the measure of the potential.

Using this data and balancing the projected production of biomass in the seven states derived in the appendix to the potential demand from households, businesses, schools and other users, the equivalent of 18.5% of households in the seven states could convert to biomass for thermal needs[28].

---

[25] That is, the analysis will use the typical square footage of an average New England home as the unit of measurement. One large building will be equivalent to many "household" units. This use of a single unit simplifies the analysis. In the end, the total number of household units that can be heated with biomass can be deconstructed into equivalent homes, business, schools, etc.
[26] From EIA State data and US Census Data, 2010
[27] The conversion from green biomass (chips) to dry biomass is modeled in this paper by using pellets as a proxy for dry chips. It is assumed to require two tons of biomass to produce one ton of pellets. The actual increase in density is slightly less but some of the two tons on biomass is typically used in the drying process.
[28] Note that the total biomass produced in each state may or may not be sufficient for that state. This analysis assumes that fuel will flow across state lines.

	Occupied Households	Equivalent Number of Businesses and Other	Total Number of Household Equivalents	Percent that Use #2 Heating Oil or Propane	Total Potential Converting	Actual houshold units at 18.5%of total
Connecticut	1,323,000	394,651	1,717,651	54%	927,531	172,000
Maine	542,000	161,679	703,679	85%	598,127	111,000
Massachusetts	2,449,000	730,537	3,179,537	42%	1,335,405	247,000
New Hampshire	501,000	149,448	650,448	69%	448,809	83,000
New York	7,907,420	2,358,783	10,266,203	36%	3,695,833	684,000
Rhode Island	405,000	120,812	525,812	45%	236,615	44,000
Vermont	251,000	74,873	325,873	73%	237,888	44,000
TOTAL	**13,378,420**	**3,990,783**	**17,369,203**		**7,480,209**	**1,385,000**

The total tons of biomass required for heating in 2025 is balanced exactly with the total biomass supply estimated in the section above.

	Total Tons of Dry Biomass if 18.5% Convert	**Total Tons of Green Biomass Required to Heat the Household Units**
Connecticut	1,183,686	2,367,371
Maine	763,310	1,526,620
Massachusetts	1,704,201	3,408,402
New Hampshire	572,756	1,145,512
New York	4,716,502	9,433,005
Rhode Island	301,961	603,921
Vermont	303,584	607,169
TOTAL	9,546,000	19,092,000

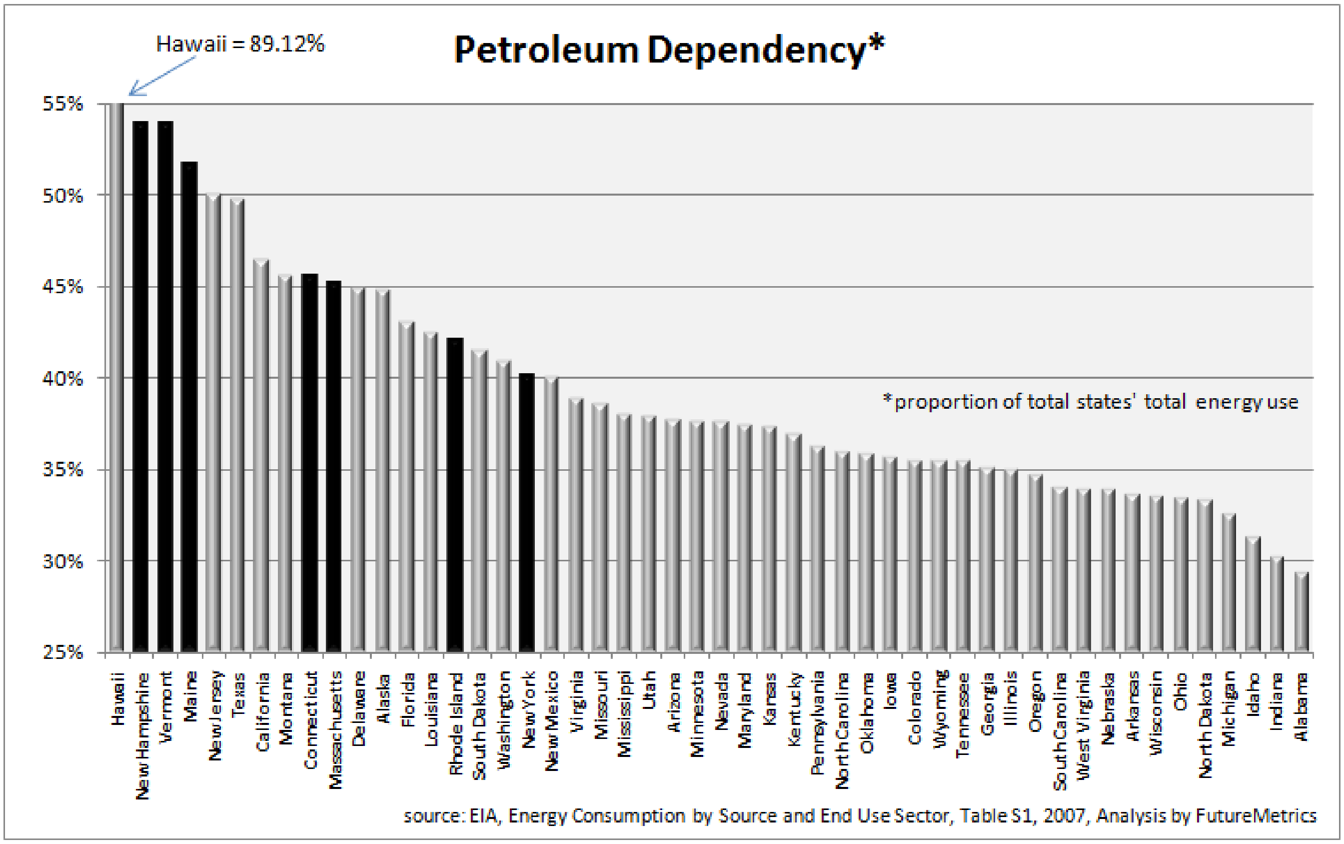
A more detailed analysis could breakout the forecast numbers of expected households, businesses, and other users.

However, this analysis does show that the biomass portion of the goal of 25% renewables for thermal uses by 2025 is a significant proportion of the total role played by biomass, solar thermal, and geothermal. Based on the assumptions and analysis above, 1,385,000 household equivalents in the seven states included in this study can be converted to renewable regionally produced bioenergy.

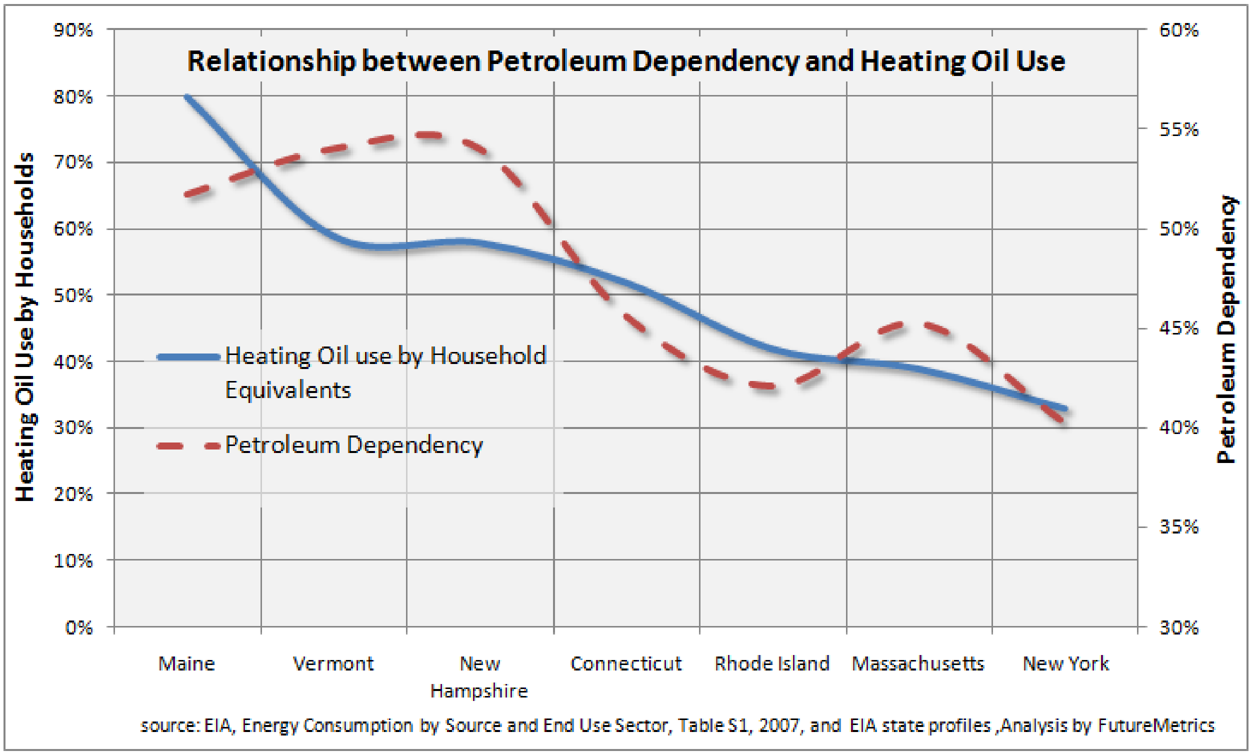
The Economic Impacts Switching from Heating Oil to Biomass for Thermal Applications

Switching from heating oil to regionally produced biomass fuels must make economic sense. This section of the analysis will illustrate the dramatic positive economic effects that accrue from fuel switching.

The seven states included in this analysis are heavily dependent on petroleum based fuel. Excluding Hawaii, three of the seven states are the most petroleum dependent states in the US and all are above the US median of 37.54%.



This dependency is strongly driven by the states' disproportionally high use of heating oil. The chart below shows the relationship between degree of petroleum dependency and the states' use of heating oil.



The heavy reliance on heating oil is a drain on the regional economy. Most of the dollars spent on heating oil (and most petroleum fuels) does not remain in the states.

Based on the analysis above, a total of about 1,385,000 household equivalents can convert to biomass fuels for thermal needs. The table below shows that every year, if heating oil is $2.75/gallon, those 1.385 million households "export" more than $2.55 billion dollars out of the states[29]. That money does not circulate in the local and regional economies, does not generate commerce, and does not create or support jobs.

[29] The amount that does not stay in the states is based on EIA estimates of the components of heating oil costs. In 2007 (the most recent data) 62% of the cost of a gallon was from the cost of crude and 16% of the cost was from refining. The remaining 22% is for regional and local distribution costs and profits. Thus 78% of every dollar spent on heating oil leaves the states.

	Number of Household Equivalents that Convert	Average Gallons or Gallon Equivalents Used per Year by those Homes	Average Total Expenditure Per Year (#2 at $2.75/gal)	**Amount that Does <u>not</u> Stay in the States (EXPORTED)**
Connecticut	172,000	147,920,000	$ 406,780,000	$ 317,288,000
Maine	111,000	95,460,000	$ 262,515,000	$ 204,762,000
Massachusetts	247,000	212,420,000	$ 584,155,000	$ 455,641,000
New Hampshire	83,000	71,380,000	$ 196,295,000	$ 153,110,000
New York	684,000	588,240,000	$ 1,617,660,000	1,261,775,000
Rhode Island	44,000	37,840,000	$ 104,060,000	81,167,000
Vermont	44,000	37,840,000	$ 104,060,000	$ 81,167,000
Total	**1,385,000**	**1,191,100,000**	**$ 3,275,525,000**	**$ 2,554,910,000**

Using the EIA estimates for heating oil prices in 2025[30] and assuming 2.5% annual inflation, those 1.385 million households will send $5.04 billion out of the states.

There are two primary effects of fuel switching that have very strong positive economic effects. The first to be discussed below are the direct effects of creating the fuel within the seven states. The second effect is the consequence of biomass fuels being less costly than heating oil thus freeing up money that was spent on heating for consumption and investment.

If a total of 1.385 million household equivalents convert to regionally produced fuels, those establishments will be supporting the infrastructure and the associated jobs that would create and supply the fuel.

The tables below are based on the following assumptions regarding the production of biomass fuels[31].

[30] The EIA estimate for heating oil in 2025 with 2.5% inflation is $5.43/gallon. Many analysts believe that this estimate is extremely low. FutureMetrics estimates that heating oil in 2025, in 2010 dollars, will be $10.80/gallon. Assuming 2.5% inflation the price in 2025 dollars is estimated to be $15.64/gallon.

[31] Note that fuel delivery and home heating jobs are not included. The heating oil truck jobs will be displaced by the biomass fuel truck jobs and the assumption is that there will be no net change in jobs or income. Note that logging and cultivation jobs are based on 60 thirty ton truck loads per year per logger for 40 weeks of the year; and with expectations for intensive management of dedicated energy crops.

Assumptions	
Jobs Created by Biomass Fuel Production (per 100,000 tons per year of pellets equivalent or 200,000 tpy of biomass)	
Chipping and Grinding Jobs	16
Pellet Mill Jobs	24
Logging and Cultivation Jobs	222
Trucking Jobs (Logs and Chips)	76
Trucking Jobs (Pellets to Retailer)	4
Total Direct Jobs	342
Other Assumptions	
Tons of Biomass to Make a Ton of Pellets	2
Tons per Truck Load of Biomass and Pellets	30
Annual Tons of Wood per Logger	1,800
Trucks per day (365 days/yr) to Move Pellets from Mill	10
Average Trips per Day for Logging Trucks	0.5

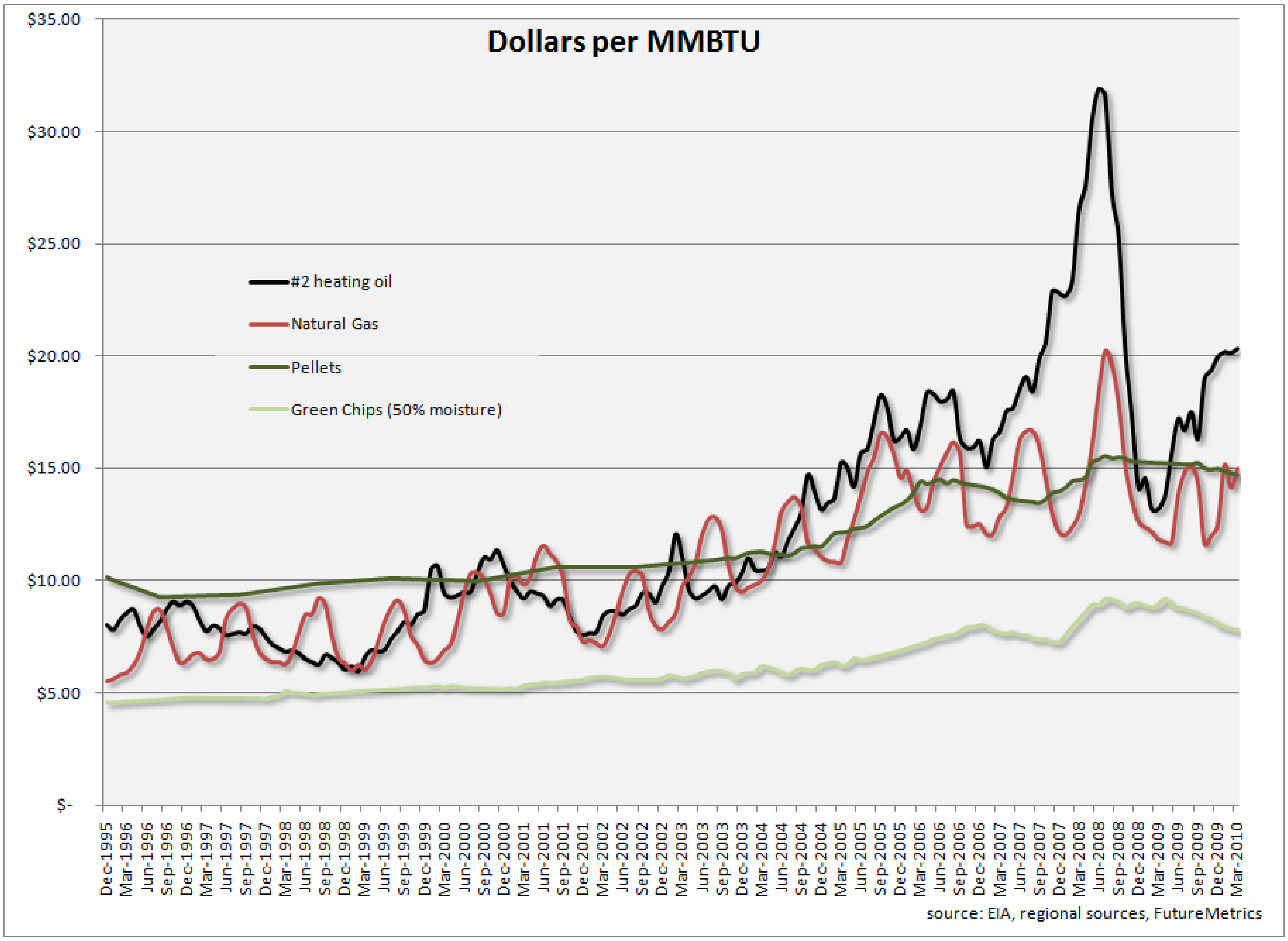
Based on the each state's ability to sustainably produce biomass fuels, the conversion of 1.385 million household equivalent would generate more than $1.6 billion in annual income. The table below summarizes the analysis[32].

Economic Impact of Producing Heating Fuel Regionally									
	Forest Biomass Production per Year	Crop Biomass Production per Year	Total Biomass Production per Year	Direct Jobs	Income at $37,000 per Year per job	Indirect and Induced Job Multipliers per $1,000,000 Increase in Final Demand	Indirect and Induced Jobs	Multiplier Income at $37,000 per Year - Tax Rate 35%	Total ANNUAL Income
CT	100,000	354,000	454,000	776	$ 28,725,000	21.20	609	$ 7,888,000	$ 36,613,000
MA	110,000	498,000	608,000	1,040	$ 38,468,000	24.20	931	$ 12,058,000	$ 50,526,000
ME	3,190,000	450,000	3,640,000	6,224	$ 230,303,000	27.19	6,261	$ 81,084,000	$ 311,387,000
NH	400,000	294,000	694,000	1,187	$ 43,909,000	25.99	1,141	$ 14,778,000	$ 58,687,000
NY	3,330,000	8,766,000	12,096,000	20,684	$ 765,314,000	23.82	18,232	$ 236,110,000	$ 1,001,424,000
RI	10,000	156,000	166,000	284	$ 10,503,000	20.12	211	$ 2,736,000	$ 13,239,000
VT	300,000	1,134,000	1,434,000	2,452	$ 90,729,000	33.52	3,041	$ 39,385,000	$ 130,114,000
TOTAL	7,440,000	11,652,000	19,092,000	32,647	$1,207,951,000		30,428	$ 394,039,000	**$ 1,601,990,000**

As the table shows, jobs and income are not only produced directly by the fuel production infrastructure but also there are also indirect and induced effects. The $1.2 billion of direct jobs money (it was once part of the exported money) stays in the local economies and circulates within the towns and cities of the states. That money spent or invested locally in turn creates demand for products and services and therefore jobs and more local income.

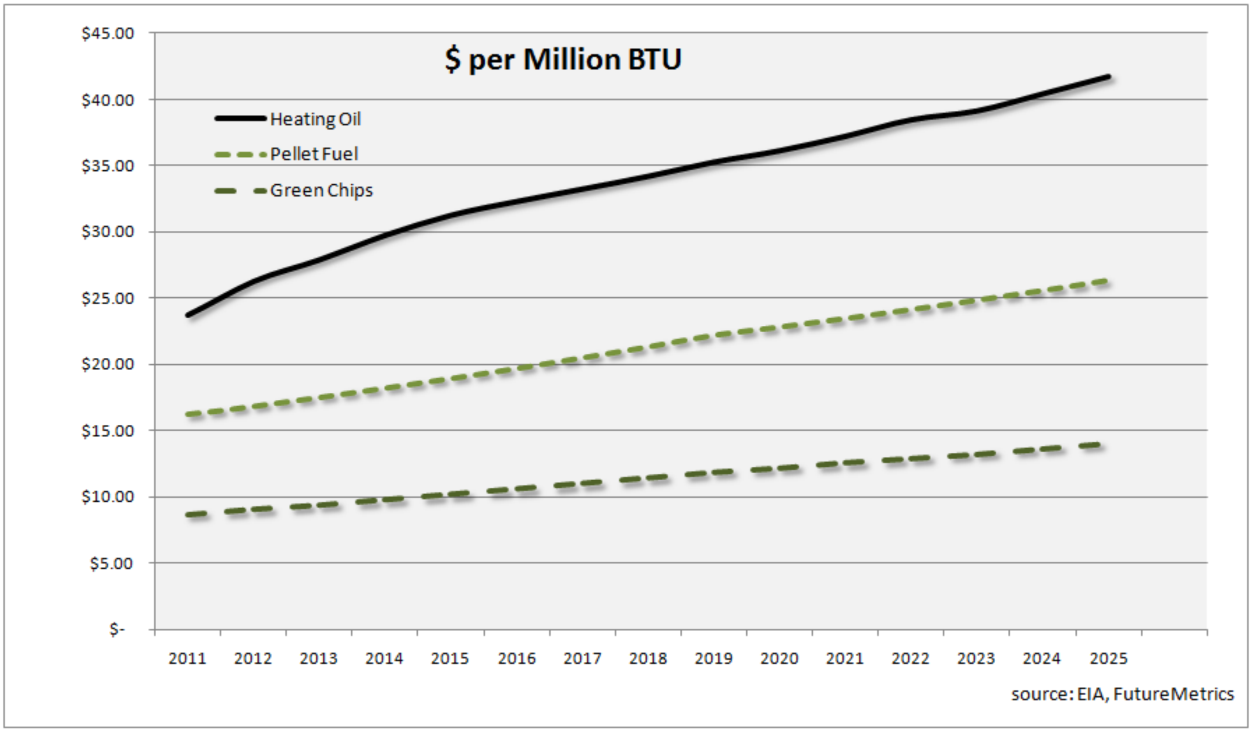
[32] Job multipliers are based on detailed multiplier tables, by state, from the National Renewable Energy Laboratory, The Jobs and Economic Development Impact (JEDI) Model, revised in 2009. The multipliers' aggregate increase in final demand is also modified by an assumed 35% tax rate. The median income of $37,000 is from the US Census, 2008. The 35% tax rate is an assumption that includes all taxes that reduce consumption (including but not limited to real estate, sales, income, and excise taxes).

The other effect that also generates economic growth is result of the lower cost of heating. The chart below shows the prices per million BTU of biomass versus heating fuels. Since 2004, with the exception of the crash in fossil fuel prices at the height of the recession in early 2009, wood pellet fuel has been less expensive that heating oil. Green chips are significantly less expensive than all fossil fuels.



The difference in heating oil prices and biomass fuel prices is expected to grow between now and 2025. The chart below shows the forecast prices per million BTU of heating oil, green chips, and dry biomass (pellet fuel)[33].

[33] The chip and pellet price forecasts assume that the sustainable supply of biomass that has been estimated is balanced with the demand. FutureMetrics has estimated that for every $1.00 increase in crude oil prices the average price of non-sawlog wood is expected to increase by $0.43. This is due to the cost of running the harvesting equipment and the trucking costs. So if crude is up by $100 dollars wood prices are expected to rise by $43. The primary contributions to the variable cost of goods in pellet production are wood, labor, and electricity. Wood costs account for about 60% of the cost of goods. Electricity is about 12%. Labor is about 13%. Since biomass costs are about 60% of the cost of pellet manufacturing, a $100 increase in crude oil prices will pass through as about a $25 increase in that component of the cost of manufacturing wood pellets (this assumes an average delivery distance of about 100 miles). The cost of electricity increasing as a result of higher natural gas or coal prices passes through as 12% of the cost of the increase in pellet costs. For example, if there were a 100%



The gap in prices unlocks financial resources that would otherwise have been spent on heating. The effects of freeing up income for spending within the states is summarized in the following table[34].

	Current Prices					2025 Prices			
	Spending on Heating Oil and Propane Equivalent at $2.75/gallon	Amount that Would be Spent on Pellet Fuel at $265/ton for equivalent heat	Annual Savings	Job Multipliers per $1,000,000 Increase in Final Demand	**Total Jobs Due to Heating Cost Savings**	Spending on Heating Oil and Propane Equivalent at $5.43/gallon	Amount that Would be Spent on Pellet Fuel at $459/ton for equivalent heat	Annual Savings (in 2025 dollars)	**Total Jobs in 2025 Due to Heating Cost Savings**
CT	$ 406,780,000	$ 314,502,000	$ 92,278,000	45.94	3,052	$ 803,273,711	$ 532,279,800	$ 270,994,000	8,964
MA	$ 584,155,000	$ 451,639,500	$ 132,515,500	49.09	4,684	$ 1,153,538,411	$ 764,378,550	$ 389,160,000	13,754
ME	$ 262,515,000	$ 202,963,500	$ 59,551,500	57.93	2,484	$ 518,391,756	$ 343,506,150	$ 174,886,000	7,295
NH	$ 196,295,000	$ 151,765,500	$ 44,529,500	54.08	1,734	$ 387,626,268	$ 256,855,950	$ 130,770,000	5,092
NY	$ 1,617,660,000	$ 1,250,694,000	$ 366,966,000	47.46	12,539	$ 3,194,414,062	$ 2,116,740,600	$ 1,077,673,000	36,823
RI	$ 104,060,000	$ 80,454,000	$ 23,606,000	47.76	812	$ 205,488,624	$ 136,164,600	$ 69,324,000	2,384
VT	$ 104,060,000	$ 80,454,000	$ 23,606,000	56.68	963	$ 205,488,624	$ 136,164,600	$ 69,324,000	2,829
			$ 743,052,500		**26,268**			**$ 2,182,131,000**	**77,141**

At current prices if all of those establishments that can sustainably switch to biomass did switch, the states would have an annual savings of more than $743 million. In 2025, at the EIA's forecasted prices

increase in electricity costs, the cost of pellet manufacturing would increase by 12%. Comparatively, the cost of crude is about 62% of the cost of home heating oil and therefore a $100 increase in crude will increase heating oil by at least $62 (this does not include the increased cost of transport). Thus, the gap in dollars per equivalent BTU would be expected to increase if oil prices increase.

[34] The jobs generated by the savings recognize and adjust for the loss of the jobs that were created by the 22% of every dollar spent on heating oil which remained in the local economy.

for heating oil and FutureMetrics' forecasted prices for pellet fuel, the annual savings reach over $2.18 billion. The expected significant gap between oil prices and pellet fuel prices in 2025, which unlocks and releases billions of dollars in to the states' economies, has very significant job effects. The direct, indirect and induced job from those annual savings would create 77,141 permanent new jobs.

	Total Permanent ANNUAL Biomass Thermal Created Income with annual pay at $53,587	Total Permanent Biomass Thermal Jobs in 2025
CT	$ 324,020,541	10,349
MA	$ 462,336,713	15,725
ME	$ 625,867,221	19,780
NH	$ 215,766,274	7,420
NY	$ 2,528,033,543	75,740
RI	$ 88,498,019	2,879
VT	$ 257,767,868	8,322
	$ 4,502,290,180	**140,216**

This analysis does not include an estimate of the new tax revenues that the states would accrue. However the addition to the states' treasuries would be substantial.