Heating the Midwest with Renewable Biomass: A Vision for 2025

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Working Report

Developed for:
Heating the Midwest with Renewable Biomass
Steering Committee

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Author's Comment

This vision document was prepared with support from the Heating the Midwest with Renewable Biomass Steering Committee through funds generated at the 1st Annual Heating the Midwest Conference and Expo, held April 26-27, 2012 in Eau Claire, Wisconsin. The focus of this vision is to provide an overview for the creation of a vision focused on advancing biomass thermal heating in the Midwest. An economic and resource assessment in support of this vision is presented in the document. The focus of this document is on the following Midwest States: Illinois, Indiana, Iowa, Michigan, Minnesota, North Dakota, Ohio, South Dakota, and Wisconsin. It does not include data for Kansas, Missouri, or Nebraska, which are also considered Midwest States by the US Census Bureau.

Executive Summary[1]

In 2010, the Midwestern United States[2] consumed 15,625 trillion BTU's of energy. Renewables represent 9.26% of all energy consumed in these states for electricity, transportation and thermal needs[3].

Whereas wind, hydro, and solar are electricity generating and ethanol is for transportation, most of the woody biomass goes into thermal and combined heat and power (CHP) applications. About 3.5% of all thermal needs are satisfied by biomass being used as a solid fuel.

Non-renewable and high carbon fossil fuels provided about 97% of the total thermal energy consumed in the Midwestern states' residential sector. This dependence on fossil energy exposes the Midwest to extreme economic vulnerability in the event of fossil fuel price pricing spikes, such as those seen in 2001, 2005 and 2008. It results in significant wealth in the region being exported to support other economies instead of its own regional economic vitality. Further, it exacerbates environmental impacts including the region's contribution to global climate change, air quality and acid rain.

This document outlines a vision to achieve a goal of having 15% of thermal energy for residential and commercial needs provided by renewable energy by 2025, with 10% derived from sustainably produced biomass. This document shows what is attainable and sustainable.

The goal of this effort is to convert a proportion of the state's thermal energy fuel from non-renewable fossil fuels to renewable biomass from forests, wood waste and agricultural sources. It must go hand-in-hand with aggressive efforts to improve building energy efficiency, thus reducing overall energy consumption. While this report and proposed vision focuses on meeting thermal needs with renewable biomass, it is recognized and acknowledged that solar thermal and geothermal are important components in a renewable thermal energy future for the Midwest.

This deployment of the tactics to achieve this vision 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 innovative 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 some western European nations, such as Austria and Sweden, and the Northeastern US, the Midwest will become recognized as a global leader in the advancement of biomass thermal energy.

Achieving this vision will have profound implications for the region's economy, employment levels, 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 homeowners, municipalities, institutions and businesses to understand the opportunity and options available to them. It will require responsible stewardship and sustainable management of the region's

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[1] This design of this report is based on the BTEC 25x25 vision paper produced several years ago for the Northeast. Some of the narrative is, with permission, taken directly from that report. However, this report also contains discussion, data, and analysis specific to the Midwestern states.

[2] Illinois, Indiana, Iowa, Michigan, Minnesota, North Dakota, Ohio, South Dakota, and Wisconsin.

[3] From EIA, Energy Consumption Overview: Estimates by Energy Source and End-Use Sector, 2012

tremendous natural resources of forests and farmlands. This vision sets forth actions that can be taken to move the region toward achieving these ambitious goals.

I. Introduction

The Midwestern United States is a region that is heavily dependent on fossil fuels to provide heat, electricity and transportation. Some of the fossil thermal energy fuel that is consumed in the region is produced in the region. Inexpensive natural gas currently appears to be the lowest cost and most secure thermal energy fuel for the Midwest, but it is not available in many rural locations. Natural gas will remain the dominant member of the thermal energy fuels portfolio but biomass fuels will remain price competitive and are likely to be the lowest cost thermal energy fuel as long as supply and demand remains in equilibrium. See Appendix A that contains a recent analysis of natural gas and the wood-to-energy sector by FutureMetrics.

Energy policy is at the fore of public discourse in the region. In the last decade, many steps have been taken to reduce the over-reliance on fossil energy through such policies that include:

- Regulatory incentives for the development of alternative power generation
- Renewable electricity portfolio standards (RPS)
- State climate action plans
- Efficiency standards in appliances and building codes

Most of these policy 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 electrical generation and transportation sectors. A comprehensive policy that includes thermal is needed.

Heat, or thermal energy, however, represents more than one-third of all energy consumed in our nation, and in the Midwest it is closer to 38%[4]. 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. Specifically, the Northeast Biomass Thermal Working Group (NEBTWG), the Biomass Thermal Energy Council (BTEC) and other partner organizations have worked closely in collaboration with industry, government and others to develop an aggressive vision and support for increasing biomass thermal in the Northeastern United States. Further, Oregon has moved forward with a formal thermal energy program with a specific focus on biomass thermal. The Oregon Department of Energy (ODOE) is leading this thrust and has multiple efforts underway related to thermal energy.

No Midwestern state has adopted specific formal targets addressing the need to reduce the reliance on fossil energy in making heat. Nationally, thermal energy goals receive even less attention, as much of the warmer states in the nation are focused more on cooling (almost entirely through electricity) than on producing heat.

This vision represents an effort to catalyze debate, creative thinking, and entrepreneurial initiative around the challenge of reducing our reliance on non-renewable fossil energy to produce heat in the Midwest.

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[4] Based on EIA state data, 2010.

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Sustainably produced biomass gives us the opportunity to achieve this vision. In presenting this vision, we wish to inform and energize a public discussion. If the Midwestern region is serious about achieving a cleaner, more sustainable energy future, it must focus new and significant attention on thermal energy. Ambitious target and recommended strategy and policy discussions are proposed to accelerate progress toward meeting the target. Actions are set forth that can be taken in the coming year, as well as longer-term actions that are believed 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 new businesses and industries, while helping to revitalize existing companies in the logging, forest products, manufacturing and agriculture sectors. 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.

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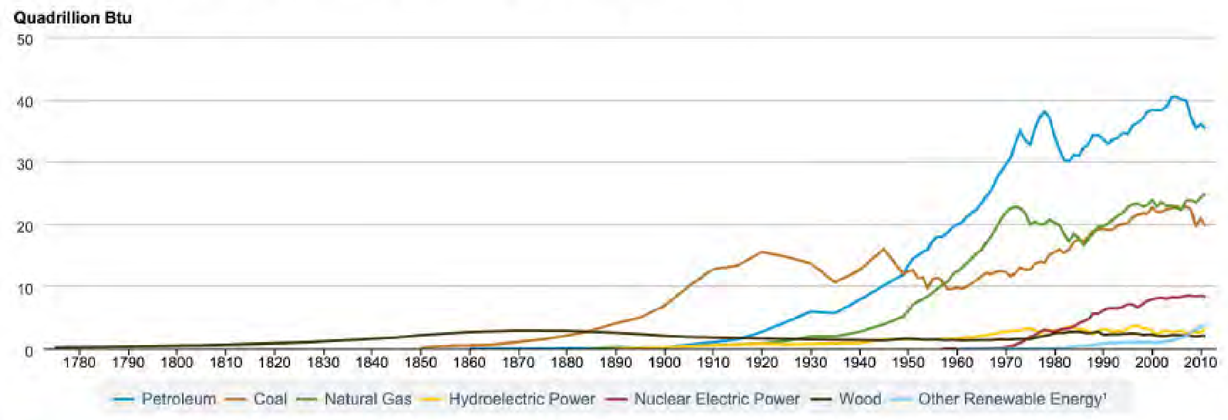
II. Background

The United States has a long history of using biomass for energy. Wood was the predominant fuel before being replaced by coal during the industrial revolution. Coal rose to prominence in the late 1800's. After World War II, oil and electricity began to replace coal to heat buildings and produce industrial process heat. Since the 1960's, natural gas and propane have increased in use, especially in the Midwest, while heating oil has shown decline. The energy crisis of the 1970's and 1980's prompted 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. Between 2000 and 2009 Michigan led the nation in its increase in the use of wood (78.6% increase) for thermal heating. Other Midwestern states also saw increases of between 15% and 52%[5].

U.S. Primary Energy Consumption Estimates by Source, 1775-2011



U.S. Energy Information Administration, *Annual Energy Review*, Tables 1.3, 10.1, and E1.

In 2010, 38% of all energy consumed in the Midwest was used to produce thermal energy, with electricity and transportation fuels representing the remaining 62%. Of all thermal energy consumed, over 97% is provided by fossil fuels, predominantly natural gas, heating oil, and propane. Less than 3% 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. The following tables and figures show this information for the Midwest States of Illinois, Indiana, Iowa, Michigan, Minnesota, North Dakota, Ohio, South Dakota, and Wisconsin.

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[5] US Census data, 2013.

Summary of Residential, Commercial, and Industrial THERMAL usage of fossil fuels (from EIA State Data, 2010)
Trillions of BTU

State	Coal	Natural Gas	Petroleum					Total Energy Use		Proportion of Total for Thermal
			Distillate Fuel Oil	Kerosene	LPG	Residual Fuel Oil	Total			
Illinois	100.0	880.7	42.7	0.3	70.4	0.2	1,094.3	2,944.5		37.2%
Indiana	275.5	497.9	29.8	0.7	24.8	0.5	829.2	2,254.6		36.8%
Iowa	72.0	289.2	38.3	0.1	55.0	0.1	454.7	1,179.9		38.5%
Michigan	71.7	618.2	30.1	0.5	40.9	1.7	763.1	2,056.9		37.1%
Minnesota	25.6	375.1	52.1	0.1	29.9	2.2	485.0	1,384.3		35.0%
North Dakota	97.2	55.6	40.4	-	9.4	0.8	203.4	378.1		53.8%
Ohio	124.4	733.4	61.0	1.2	29.4	2.3	951.7	2,875.1		33.1%
South Dakota	2.9	64.5	12.4	-	7.6	-	87.4	284.5		30.7%
Wisconsin	31.7	128.0	31.5	-	5.1	0.1	196.4	412.4		47.6%
Total	801	3,643	338	2.9	273	7.9	5,065	13,770		36.8%

State	Renewable Fuels for Thermal in Residential						
	Wood	Solar	Geothermal	Total	Proportion of Renewables for Total Thermal	Proportion of Biomass used for Total Energy	Proportion of Biomass used for Total Thermal Energy
Illinois	7.20	2.20	2.00	11.40	1.04%	0.24%	0.66%
Indiana	19.20	0.30	4.40	23.90	2.88%	0.85%	2.32%
Iowa	5.50	0.10	1.10	6.70	1.47%	0.47%	1.21%
Michigan	33.90	0.90	4.90	39.70	5.20%	1.65%	4.44%
Minnesota	12.90	0.40	1.00	14.30	2.95%	0.93%	2.66%
North Dakota	0.50	0.00	0.90	1.40	0.69%	0.13%	0.25%
Ohio	23.90	0.50	3.20	27.60	2.90%	0.83%	2.51%
South Dakota	1.30	0.00	1.70	3.00	3.43%	0.46%	1.49%
Wisconsin	2.20	0.00	0.70	2.90	1.48%	0.53%	1.12%
Total	106.60	4.40	19.90	130.90	2.58%	0.77%	2.10%

The above tables clearly shows that natural gas is the primary heating fuel for Midwest homes, businesses and industry.

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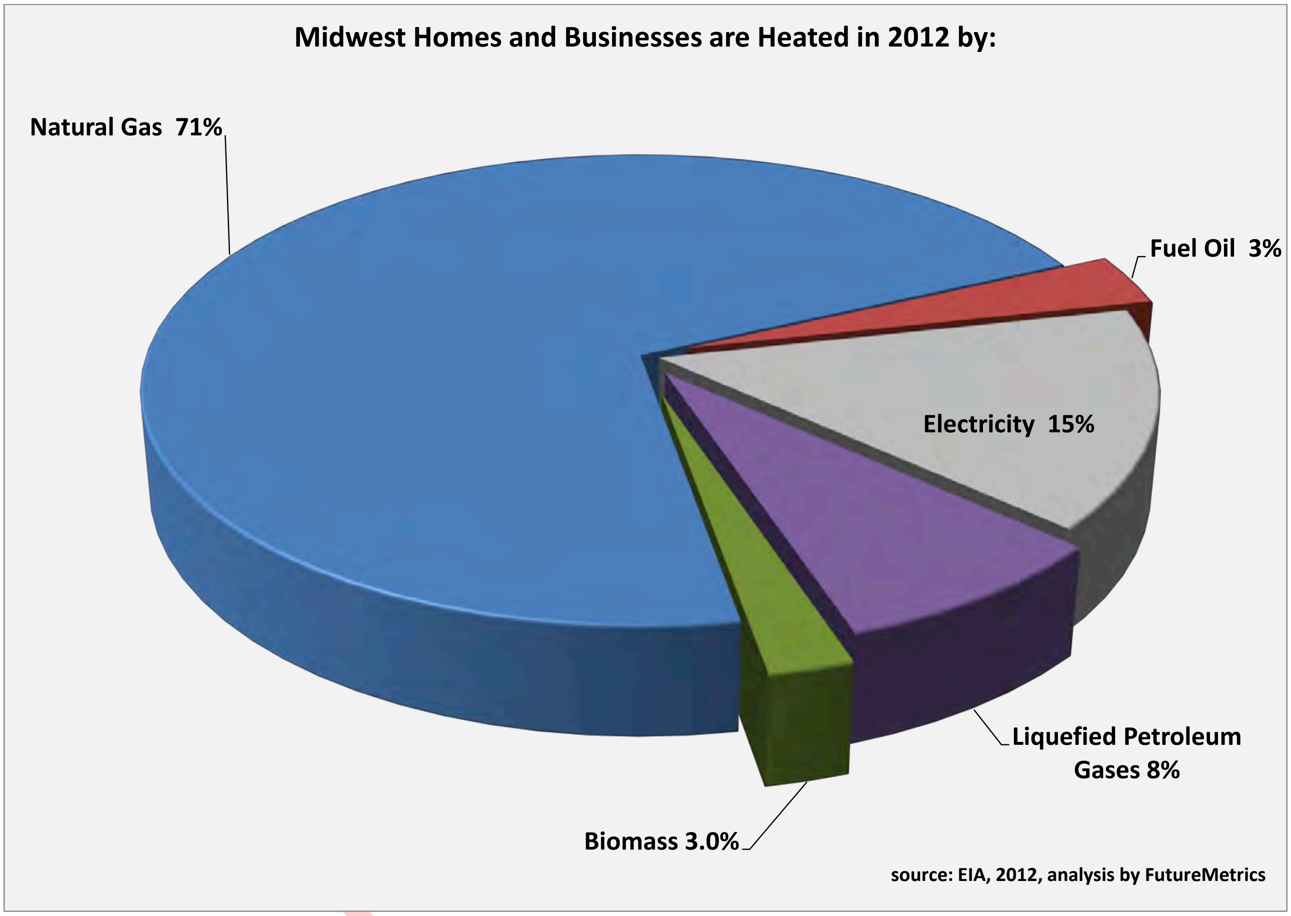
There are many homes, businesses, and other buildings in the Midwest that are not connected to natural gas and many, due to the rural low density of buildings, never will be. The following chart shows this information for the Midwest.



source: EIA, 2012, analysis by FutureMetrics

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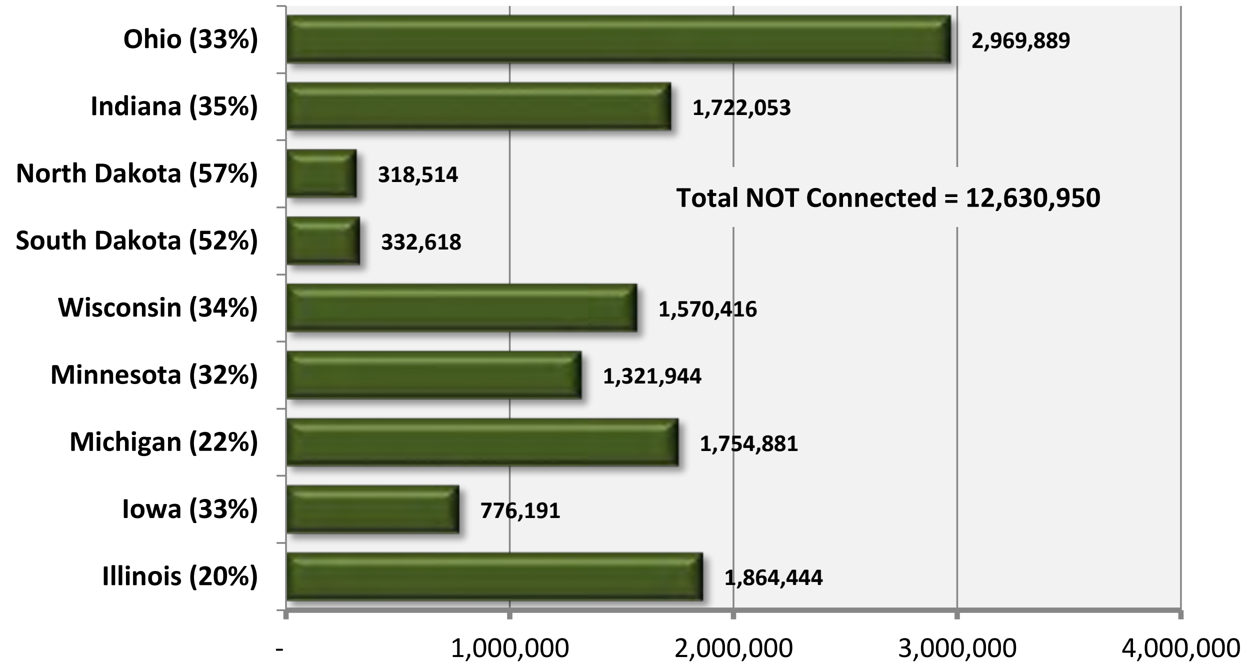

Number of Homes and Businesses NOT connected to Natural Gas
(proportion of total locations NOT connected in parenthesis)

source: US Energy Information Administration, US Census, 2012, analysis by FutureMetrics

Most of those homes not on natural gas use propane, electricity and heating oil, but these fuels are not renewable and not sustainable.

Biomass is renewable and, provided that our forests and our agricultural resources are managed responsibly over time, biomass for fuel is sustainable and carbon-beneficial. It is also indigenous and plentiful in the Midwestern U.S. The Midwest has other renewable thermal resources including solar and geothermal energy. Solar thermal can supplement (not replace) primary heating systems and geothermal is relatively costly to install for homeowners and businesses. Biomass is the Midwest's renewable energy strong point.

The region has productive and resilient forests. The Midwest has extensive agricultural lands and agricultural by-products that can be used for biomass based fuels. The region has 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.

Modern energy conversion technology, such as high efficiency boilers, furnaces and combined heat and power systems, are very efficient and can cleanly utilize the region's biomass resources for thermal energy. European and U.S. chip and pellet combustion technology can produce thermal energy efficiencies and particulate emissions that are comparable to fossil fuel systems. Adoption of pellet-fueled space heating (e.g. stoves and boilers) has grown significantly in the Midwest 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 but increasing number of installations, but there is widespread interest across the region in these technologies.

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Bulk distribution of pellet and chip 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 considered too high and the performance of older units inefficient. However, the Northeast and in particular Maine, New Hampshire, and Vermont have bridged the gap in terms of private capital investment in pellet fuel delivery infrastructure. There are now more than a dozen modern pellet delivery trucks delivering pellet fuel throughout the region[6].

From the standpoint of supportive public policy, the Midwest thermal biomass industry still has a long way to go to give biomass thermal comparable policy treatment to that received by biomass electric generation and production of liquid transportation fuels. However, some states such as New Hampshire have 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. New Hampshire now allows thermal renewable energy credits (RECs) along with the traditional RECs for electricity generated from renewable sources. Many northeast states have utilized the American Recovery and Reinvestment Act of 2009 (ARRA) stimulus funds in support of thermal renewable projects. In New Hampshire, ARRA funds subsidized the installation of more than 125 pellet boiler systems. Maine funded 23 pellet and chip biomass heating plants with ARRA funds. FutureMetrics has initiated a study to quantify the positive economic benefits (jobs, tax revenues, etc.) as a result of the ARRA investment. 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 propose that 15% of all thermal energy in the Midwest come from renewable energy sources with 10% derived from sustainably produced biomass by 2025. The remainder of this energy would come from solar and geothermal sources.

This shift in our sources for thermal energy will produce extraordinary economic, social and environmental benefits for the region both by offsetting the need for fuel produced far away and by supporting existing and creating new jobs to support the biomass fuel supply chain. We call for the renewable energy to come from sustainable forest biomass, wood waste, energy crops and agricultural biomass resources transformed into heat with clean and efficient technology. Today, renewable energy accounts for 3.5% of the total thermal energy sources for the region almost all of which is from forest and agricultural biomass.

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 well-paying 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

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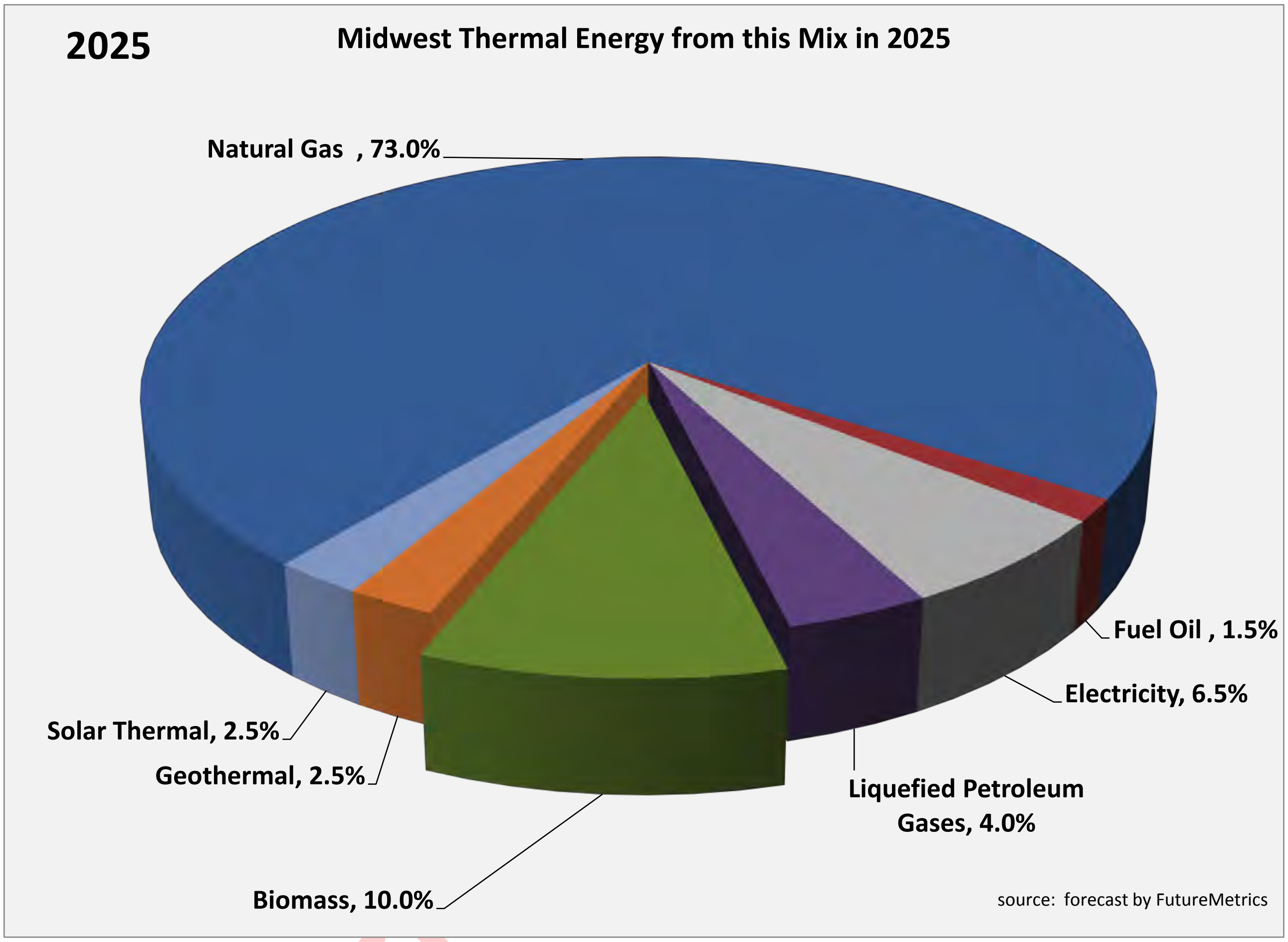
[6] See www.MaineEnergySystems.com for an overview of one company's success in the wood pellet boiler market.

expansion of biomass thermal through favorable tax, regulatory and incentive policies. The Midwest will be recognized as a global leader in the advancement of biomass thermal energy.



source: forecast by FutureMetrics

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IV. Estimates of Sustainable Feedstock Supply for Biomass Thermal

The initiative for conversion of homes, businesses, and buildings in the Midwest 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 agricultural sector, and create robust and resilient renewable 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 and fields.

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. 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 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. In the Midwest, Wisconsin has developed and approved Wisconsin's Forestland Woody Biomass Harvesting Guidelines in 2008, Minnesota developed the Biomass Harvesting Guidelines for Forestlands, Brushlands and Open Lands in 2007, and Michigan produced the Michigan Woody Biomass Harvesting Guidelines in 2008. This sensitivity to consequences needs to also be extended into the agricultural sector so that production and prices of food and feed crops are not distorted by policy. It is recommended that the Heating the Midwest effort identify, access and integrate this information in final execution of the vision.

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[7]. We can conservatively estimate how much biomass from existing forestry operations and existing 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 conservative adjustment of 75% 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

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[6] Such as the "Midwest Biomass Inventory Assessment," by Ripplinger and Katyal, North Dakota State University, April, 2012. http://heatingthemidwest.org/wp-content/uploads//Midwest-Biomass-Inventory-Assessment-April-2012.pdf That report is used in this work as part of the basis for inventory assessment.

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harvesting of biomass must be offset by the aggregate growth of new stock[8], 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 completed for this report was:

1. The region's current and potential supply of feedstock for green wood chips or pellet manufacturing were estimated[9].
2. The demand for heating fuel other than natural gas by homes and businesses was estimated for the region[10]. Homes and businesses that currently use natural gas were excluded from the estimated thermal demands.
3. The demand for heating fuel was converted to an equivalent for wood pellets (larger thermal demands will convert to wood chip fuel but this analysis will assume pellets).
4. The demand for feedstock for thermal energy from wood was 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, 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 Midwestern 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 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[11]. For instance, if the median size home in the Midwest is 2,001 square feet (US Census, 2010), then a biomass district heating plant that serves 100,000 square feet that is equivalent to about 50 homes.

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[8] 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.

[9] 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 that are likely, will be ignored. The analysis also assumes that the stock of forestlands will not change significantly. Agricultural residues will be assumed to be used for power and combined heat and power rather than for pellet manufacturing.

[10] The demand for propane, also a relatively expensive fossil heating fuel will also be included in the analysis.

[11] The median size home in the Midwest is 2,001 square feet (US Census, 2010). If a district heating plant serves 100,000 square feet that is equivalent to about 50 homes.

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

Estimate of Biomass Feedstock Available for Energy

A thorough report, "Midwest Biomass Inventory Assessment" (Ripplinger et al 2012) was developed and this report will use its data (see link in footnote 5). That report, however, does not consider roundwood harvested for the dedicated purpose of being made into fuel chips or pellets. This analysis will add high level estimates of the sustainable annual roundwood supply.

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 again adjusted to 75% of the estimated values. By arbitrarily cutting what is already a conservative estimate we are both acknowledging the potential for 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 three sectors: forest biomass, dedicated woody energy crops, agricultural biomass, and dedicated grass energy crops.

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

1. It begins with the Ripplinger and Katyan and the Billion Ton Study estimates of the current (2012) aggregate stock of merchantable residual biomass in the Midwest.
2. Their analysis is expanded to estimate current (2012) roundwood stocks that are available for pellet manufacturing[12].
3. The 2025 estimates are based on the Ripplinger and Katyan 2025 estimates, Billion Ton Study data, and FutureMetrics' assumptions for improved silviculture.
4. In all cases, the final estimates are adjusted to 75% to reflect the potential for estimation error.

The final values that are suggested as possible in 2025 are based on 2012 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. It is also likely that demand for pulpwood will change.

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[12] This analysis uses pellets as the baseline fuel. Residential and light commercial systems will only use pellets. Wood chips require more capital investment and a full time staff for operating the boilers. However, the quantity of thermal energy derived from the stocks of woody and agricultural biomass can be utilized in either form. Thus the conclusions as to the number homes (or equivalent businesses) and jobs are not significantly changed based on the fuel medium.

The current estimated amounts of agricultural materials and woody materials is shown in the table below.

Estimated Agricultural Biomass 2012

Estimates in 1,000's of Green Tons

Agricultural Biomass	Illinois	Iowa	Michigan	Minnesota	North Dakota	South Dakota	Wisconsin	Indiana	Ohio	Total
Crop Residue										
Barley Straw	0	0	0	43	701	0	0	0	0	744
Corn Stover	9,496	20,777	1,070	6,998	1,366	4,960	1,563	3,703	3,073	53,006
Wheat Straw	862	8	832	420	229	3,009	232	58.8	1501.9	7,153
Oat Straw	0	0	0	0	0	0	0	0	0	0
Total	10,358	20,785	1,902	7,461	2,296	7,969	1,795	0	0	52,566
Hay	2,016	4,319	1,753	4,602	4,286	6,753	5,513	1,764	3,157	34,163
Total	12,374	25,104	3,655	12,063	6,582	14,722	7,308	1,764	3,157	**86,729**
Dedicated Energy Crops										
Perennial grass	0	0	0	0	0	0	0	0	0	0
Woody Energy Crops	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0
Forest Biomass for Pellet Production										
Logging Residue & Thinnings	276	102	898	873	7	68	1,130	609	402	4,365
Other Removal Residue	234	62	294	656	15	14	1,049	94	5	2,423
Sustainable Harvest of Roundwood available for pellet making	1196.5	597.5	3056	1247	77.5	67.5	2,482	1,338	1,240	11,302
Total	1,707	762	4,248	2,776	100	150	4,661	2,041	1,647	**18,089**
Total	**14,081**	**25,866**	**7,903**	**14,839**	**6,682**	**14,872**	**11,969**	**3,805**	**4,804**	**104,818**

source: "Midwest Biomass Inventory Assessment", April, 2012, Billion Ton Study data, USDA FIA Data, analysis by FutureMetrics

Estimated Agricultural Biomass 2025

Estimates in 1,000's of Green Tons

Agricultural Biomass	Illinois	Iowa	Michigan	Minnesota	North Dakota	South Dakota	Wisconsin	Indiana	Ohio	Total
Crop Residue										
Barley Straw	0	0	0	82	1038	0	0	0	0	1,120
Corn Stover	14,621	33,242	1,844	10,579	3,299	8,260	3,306	7,745	6,748	89,644
Wheat Straw	1223	15	1124	1014	1315	3,961	338	91.5	1820	10,902
Oat Straw	0	0	0	0	0	0	0	0	0	0
Total	15,844	33,257	2,968	11,675	5,652	12,221	3,644			85,261
Hay	1,862	3,842	1,621	3,916	3,829	5,662	5,097	1,608	2,960	29,240
Total	17,706	37,099	4,589	15,591	9,481	17,883	8,741	1,608	2,960	**114,501**
Dedicated Energy Crops										
Perennial grass	29	0	0	0	0	583	0	89.3	1990	2691.3
Woody Energy Crops	0	0	1501	936	0	0	1854	161	1492.8	5944.8
Total	29	0	1501	936	0	583	1854	250.3	3482.8	8636.1
Forest Biomass for Pellet Production										
Logging Residue & Thinnings	280	103	915	898	7	76	1,155	624	413	4,471
Other Removal Residue	238	63	298	666	16	14	1,064	96	5	2,459
Sustainable Harvest of Roundwood	1794.75	896.25	4584	1870.5	116.25	101.25	3,723	2,006	1,860	16,952
Total (includes woody energy crops)	2,313	1,062	5,797	3,435	139	191	5,942	2,726	2,278	**29,827**
Total (woody energy crops are not double counted)	**20,048**	**38,161**	**11,887**	**19,962**	**9,620**	**18,657**	**16,537**			**147,020**

source: "Midwest Biomass Inventory Assessment", April, 2012, Billion Ton Study data, USDA FIA Data, analysis by FutureMetrics

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The analysis concludes that, based on very conservative assumptions, by 2025 there is the potential for about 29.8 million green tons per year (forest plus energy crops plus residue) of feedstock available for domestic and commercial (pellets or chips) energy applications. Other materials such as corn stover (an estimated 90 million tons per year in 2025), with today's technology, are best suited for larger scale biomass fueled boilers.

This analysis will not look deeply at the benefits of using the significant quantities of non-woody biomass products. Larger scale CHP and straight heating technologies exist for using these fuels. This 15 by 25 vision report focuses on heating homes, businesses, schools, and many private and public buildings. But the magnitude of the non-woody biomass resource in the Midwest cannot be ignored.

The combined energy in the Midwest states' biomass in 2025 is estimated to be 2,177 trillion BTU.

Estimated Biomass Higher Heating Value (Trillion BTU) 2012

Agricultural Biomass	Illinois	Iowa	Michigan	Minnesota	North Dakota	South Dakota	Wisconsin	Indiana	Ohio	Total
Crop Residue										
Barley Straw	0.0	0.0	0.0	0.6	9.9	0.0	0.0	0.0	0.0	11
Corn Stover	134.1	293.4	15.1	98.8	19.3	70.0	22.1	52.3	43.4	749
Wheat Straw	12.2	0.1	11.7	5.9	3.2	42.5	3.3	8.0	20.4	107
Oat Straw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Total	146.3	293.5	26.9	105.4	32.4	112.5	25.3	60.3	63.8	866
Hay	28.5	61.0	24.8	65.0	60.5	95.4	77.9	25.2	45.1	483
Total	174.7	354.5	51.6	170.4	92.9	207.9	103.2	85.5	108.9	**1,350**
Dedicated Energy Crops										
Perennial grass	0	0	0	0	0	0	0	0	0	0
Woody Energy Crops	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0
Forest Biomass for Pellet Production										
Logging Residue & Thinnings	2.2	0.8	7.2	7.0	0.1	0.5	9.0	4.9	3.2	35
Other Removal Residue	1.9	0.5	2.3	5.2	0.1	0.1	8.4	0.8	0.0	19
Sustainable Harvest of Roundwood available for pellet making (45% moisture content)	9.5	4.8	24.4	9.9	0.6	0.5	19.8	10.7	9.9	90
Total	14	6	34	22	1	1	37	16	13	**144**
Total	**188**	**361**	**85**	**192**	**94**	**209**	**140**			**1,494**

source: "Midwest Biomass Inventory Assessment", April, 2012, Billion Ton Study data, USDA FIA Data, analysis by FutureMetrics

The table below shows the millions of tons of oil equivalent (MTOE) of energy from agricultural residues that could be used for larger industrial scale district heat, process heat or CHP in the region. It also shows the value of the agricultural residue in barrels of petroleum equivalent. Note that 482.5 million barrels per year is about 7% of the entire US consumption of oil. This is a significant amount of potential energy that could be used for industrial scale heat, CHP, and perhaps even for electrical power production.

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In Millions of Tons of Oil Equivalent (MTOE) per Year										
Agricultural Biomass	Illinois	Iowa	Michigan	Minnesota	North Dakota	South Dakota	Wisconsin	Indiana	Ohio	Total
Crop Residue										
Barley Straw	0.00	0.00	0.00	0.03	0.37	0.00	0.00	0.00	0.00	**0.40**
Corn Stover	5.21	11.84	0.66	3.77	1.17	2.94	1.18	2.76	2.40	**31.93**
Wheat Straw	0.44	0.01	0.40	0.36	0.47	1.41	0.12	0.03	0.65	**3.88**
Oat Straw	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Total	5.64	11.84	1.06	4.16	2.01	4.35	1.30	2.79	3.05	**36.21**
Hay	0.66	13.21	1.63	5.55	3.38	6.37	3.11	3.36	4.11	**41.39**
Total	**6.31**	**25.06**	**2.69**	**9.71**	**5.39**	**10.72**	**4.41**	**6.15**	**7.16**	**77.60**

In Millions of Barrels of Oil Equivalent per Year										
Agricultural Biomass	Illinois	Iowa	Michigan	Minnesota	North Dakota	South Dakota	Wisconsin	Indiana	Ohio	
Crop Residue										
Barley Straw	0.00	0.00	0.00	0.18	2.30	0.00	0.00	0.00	0.00	**2.48**
Corn Stover	32.38	73.63	4.08	23.43	7.31	18.29	7.32	17.15	14.95	**198.55**
Wheat Straw	2.71	0.03	2.49	2.25	2.91	8.77	0.75	0.20	4.03	**24.15**
Oat Straw	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Total	35.09	73.66	6.57	25.86	12.52	27.07	8.07	17.36	18.98	**225.17**
Hay	4.12	82.17	10.16	34.53	21.00	39.61	19.36	20.92	25.53	**257.40**
Total	**39.22**	**155.83**	**16.74**	**60.39**	**33.52**	**66.68**	**27.43**	**38.27**	**44.51**	**482.58**
										analysis by FutureMetrics

As noted earlier in this section, this analysis will not attempt to forecast the growth of liquid fuels production or electricity production from biomass.

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V. Economic and Environmental Benefits of Achieving the Vision

Estimate of Proportion of Conversion from Fossil Fuels other than Natural Gas to Biomass and the Economic Impacts of Conversion

The analysis was conducted in two stages. The first stage estimated the number of household equivalents[13] that could be heated using the estimated sustainable feedstock derived above. It must be noted that businesses, government buildings and other facilities are included in the broad term "household equivalent or units." The second stage estimated 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 nine state region was estimated.
2. The total number of those household units that could convert given the potential supply of biomass in 2025 was estimated.
3. The economic effects of having the dollars spent 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.

The following table shows the average fuel use for homes in the nine states. The average household unit in the nine states uses the equivalent of about 877 gallons per year of #2 heating oil, or 1,274 gallons of propane or 35,483kWh of electricity[14]. This analysis will convert that heating demand into dry biomass demand and then back to raw feedstock demand[15]. This analysis will also convert all business heating oil and/or propane demand to the equivalent number of household units.

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[13] That is, the analysis will use the typical square footage of an average Midwestern 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.

[14] From EIA State data and US Census Data, 2012. The energy content of heating oil, propane, electricity, and natural gas is used to estimate the equivalent amount of heating oil that would be needed.

[15] 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.

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Heating Fuel Use for an Average Home

	Average Annual Heating Oil Use (gallons)	Average Annual Propane Use (gallons)	Average Annual Electricity Use (kWh)	Average Equivalent Pellets (tons) at 7800 BTU/lb
Wisconsin	811	1,178	32,809	7.18
Minnesota	1,234	1,792	49,893	10.91
Michigan	738	1,072	29,850	6.53
North Dakota	1,127	1,636	45,564	9.97
South Dakota	765	1,111	30,931	6.77
Iowa	883	1,282	35,695	7.81
Illinois	749	1,088	30,298	6.63
Indiana	780	1,133	31,547	7.17
Ohio	810	1,177	32,761	7.76
Average =>	877	1,274	35,483	7.86

source: EIA State Data, 2010, analysis by FutureMetrics

The average use of heating oil, propane or electricity per year converts into an annual demand for pellets as shown in the chart above (assuming 85% pellet boiler efficiency and 85% oil boiler efficiency).

Many residential and business locations already use pellet stoves/boilers 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 or electricity 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 about 0.5 household equivalents in the measure of the potential.

Using this data and balancing the projected production of biomass in the nine states to the potential demand from households, businesses, schools and other users, the equivalent of 10% of households in the nine states could convert to biomass for thermal needs and comfortably remain within the sustainability boundary conditions[16].

	Occupied Households	Equivalent Number of Businesses, Schools, Buildings	Total Number of Household Equivalents	Percent that Use #2 Heating Oil, Propane, or Electricity	Total Potential Converting (natural gas is excluded)	Actual houshold units at 10.0% of total	**Total Tons of Dry Biomass if 10.0% Convert**	**Total Tons of Green Biomass Required to Heat 10.0% of Total**
Wisconsin	2,624,358	1,994,512	4,618,870	30%	1,385,661	139,000	994,326	1,988,653
Minnesota	2,347,201	1,783,873	4,131,074	28%	1,156,701	116,000	1,262,255	2,524,511
Michigan	4,532,233	3,444,497	7,976,730	20%	1,595,346	160,000	1,041,573	2,083,147
North Dakota	317,498	241,298	558,796	54%	301,750	30,000	300,717	601,434
South Dakota	363,438	276,213	639,651	49%	313,429	31,000	212,037	424,075
Iowa	1,336,417	1,015,677	2,352,094	31%	729,149	73,000	569,257	1,138,515
Illinois	5,296,715	4,025,503	9,322,218	19%	1,761,899	176,000	1,167,560	2,335,119
Indiana	2,795,541	2,124,611	4,920,152	34%	1,672,852	167,000	1,154,268	2,308,535
Ohio	5,113,446	3,886,219	8,999,665	30%	2,690,900	269,000	1,928,133	3,856,266
TOTAL	**24,726,847**	**18,792,404**	**43,519,251**		**11,607,687**	**1,161,000**	**8,630,127**	**17,260,255**

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[16] 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.

The total tons of biomass required for heating in 2025 is balanced exactly with 75% of the total biomass supply estimated in the section above.

This analysis shows that the biomass portion of the goal of 10% biomass 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, **1,161,000 household equivalents in the nine states included in this study can be converted to renewable regionally produced bioenergy.**

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

Switching from propane, electricity or 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 reliance on fuel produced elsewhere is a drain on most of the Midwestern states' economies. For example, most of the dollars spent on propane and heating oil does not remain in the states[17].

Based on the analysis above, a total of about 1,161,000 household equivalents can convert to biomass fuels for thermal needs. The table below shows that every year, those 1,161,000 households "export" more than $2.2 billion dollars out of the states[18]. That money does not circulate in the local and regional economies, does not generate commerce, and does not create or support jobs.

#2 Distillate Fuel and Propane use in Residential, Commercial, and Industrial (not Transportation) in gallons	Average Gallons per year of Heating Oil	Money Exported from Regional Economy at $3.75/gal for oil	Permanent Jobs Lost to Heating Oil Purchases	Average Gallons per Year of Propane	Money Exported from Regional Economy at $1.76/gal for propane	Permanent Jobs Lost to Propane Purchases	TOTAL Money Exported from the Regional Economy	TOTAL Permanent Jobs Lost
Wisconsin	47,475,400	($138,870,000)	-9,300	94,825,864	($130,180,000)	-8,700	($269,050,000)	-18,000
Minnesota	53,661,283	($156,960,000)	-9,400	129,916,791	($178,350,000)	-10,700	($335,310,000)	-20,100
Michigan	31,489,749	($92,110,000)	-5,600	125,793,262	($172,690,000)	-10,500	($264,800,000)	-16,100
North Dakota	12,166,891	($35,590,000)	-2,300	31,420,463	($43,130,000)	-2,800	($78,720,000)	-5,100
South Dakota	5,722,433	($16,740,000)	-1,100	26,125,272	($35,860,000)	-2,300	($52,600,000)	-3,400
Iowa	7,158,436	($20,940,000)	-1,300	83,188,567	($114,200,000)	-6,900	($135,140,000)	-8,200
Illinois	6,278,225	($18,360,000)	-1,000	182,398,956	($250,400,000)	-13,600	($268,760,000)	-14,600
Indiana	32,565,000	($95,250,000)	-5,800	141,914,842	($194,820,000)	-11,900	($290,070,000)	-17,700
Ohio	81,708,750	($239,000,000)	-13,900	197,821,184	($271,570,000)	-15,800	($510,570,000)	-29,700
	278,226,168	($813,820,000)	-49,700	1,013,405,201	($1,391,200,000)	-83,200	($2,205,020,000)	**-132,900**

data from EIA and US Census, 2012,analysis by FutureMetrics

Using the EIA estimates for fuel prices in 2025[19], those 1.16 million households will send $3.6 billion out of the states (about $3000 per household unit).

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[17] North Dakota has become a significant petroleum producer. However, heating oil is refined primarily in the Gulf Coast refineries. A new refinery will be built in ND but will produce diesel fuel.

[18] The amount that does not stay in the states is based on EIA estimates of the components of refined heating fuel costs (heating oil and propane). In 2010 (the most recent data) 62% of the cost of a gallon was from the cost of crude or natural gas 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.

[19] The EIA estimate for heating oil in 2025 with 2.5% inflation is $6.91/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.

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 nine 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 1,161,000 household equivalents convert to regionally produced biomass 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[20].

Jobs Created by Pellet Production (per 100,000 tons per year of wood pellets)	
Chipping Jobs	5
Logging Jobs	8
Pellet Mill Jobs	24
Trucking Jobs (Logs, Chips, and Pellets)	35
TOTAL	72
Indirect and Induced Jobs	81
Total Jobs per 100,000 tons per year of wood pellets	**153**
Other Assumptions	
Tons of Wood to Make a Ton of Pellets	1.9
Tons per Truck Load of Logs and Pellets	30
Average Trips per Day for Logging Trucks	0.5
Average Trips per Day for Pellet Trucks	2
Home Heating Delivery Trucks per 1000 households	3
Other Home Heating Personnel per 1000 households	3.5
Total Home Heating Personnel per 100,000 tons	81
Housholds per 100,000 tons (at 8 tons per household per year)	12,500

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Based on the each state's ability to sustainably produce biomass fuels, the conversion of 1,161,000 household equivalent would generate more than $419 million in new annual income. The table below summarizes the analysis[21].

Assuming 2.5% inflation the price in 2025 dollars is estimated to be $15.64/gallon. Propane is expected to inflate at a slightly lower annual rate of 2.1%

[20] The table data is the result of FutureMetrics' analysis. It closely matches with results from "Economic Impact Analysis of Wisconsin Pellet Plants", published by the State of Wisconsin Department of Natural Resources, August 18, 2010. Note that fuel delivery and home heating jobs are not included. The propane and 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.

[21] 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 $48,445 is from the US Census,

Economic Impact of Producing Heating Fuel Regionally (in 2025 measured in 2013 $)

	Total Biomass for Pellets Production per Year (green tons)	Direct Jobs	Income at $48,445 per Year per job	Indirect and Induced Jobs	Multiplier Income at $48,445 per Year - Tax Rate 35%	Total ANNUAL Income
Wisconsin	1,988,653	716	$ 34,682,000	957	$ 16,230,000	$ 50,912,000
Minnesota	2,524,511	909	$ 44,028,000	1,095	$ 18,559,000	$ 62,587,000
Michigan	2,083,147	750	$ 36,330,000	814	$ 13,799,000	$ 50,129,000
North Dakota	601,434	217	$ 10,489,000	271	$ 4,600,000	$ 15,089,000
South Dakota	424,075	153	$ 7,396,000	209	$ 3,550,000	$ 10,946,000
Iowa	1,138,515	410	$ 19,856,000	483	$ 8,185,000	$ 28,041,000
Illinois	2,335,119	841	$ 40,725,000	813	$ 13,793,000	$ 54,518,000
Indiana	2,308,535	831	$ 40,261,000	805	$ 13,653,000	$ 53,914,000
Ohio	3,856,266	1,388	$ 67,254,000	1,510	$ 25,595,000	$ 92,849,000
TOTAL	17,260,255	6,214	$ 301,021,000	6,957	$ 117,964,000	**$ 418,985,000**

As the table shows, jobs and income are not only produced directly by the fuel production infrastructure but there are also indirect and induced effects. The $301 million 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.

The other effect that also generates economic growth is the 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 and chip fuels have been less expensive than heating oil, propane, and electricity. Green chips are significantly less expensive than all fossil fuels.

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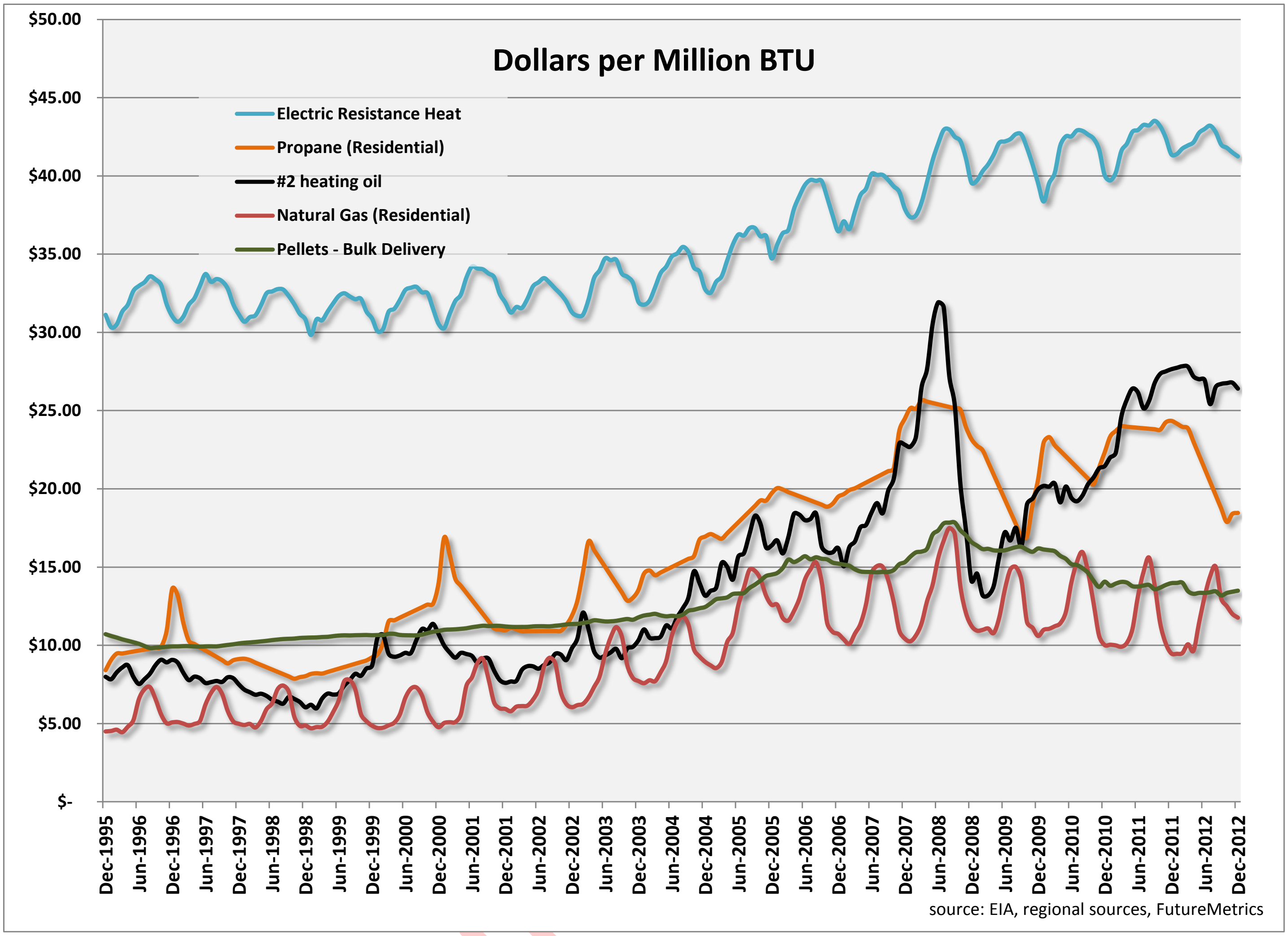
2010. The 35% tax rate is an assumption that includes all taxes that reduce consumption (including but not limited to real estate, sales, income, and excise taxes).



source: EIA, regional sources, FutureMetrics

Work

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 fuels and pellet fuel[22], based on national averages.

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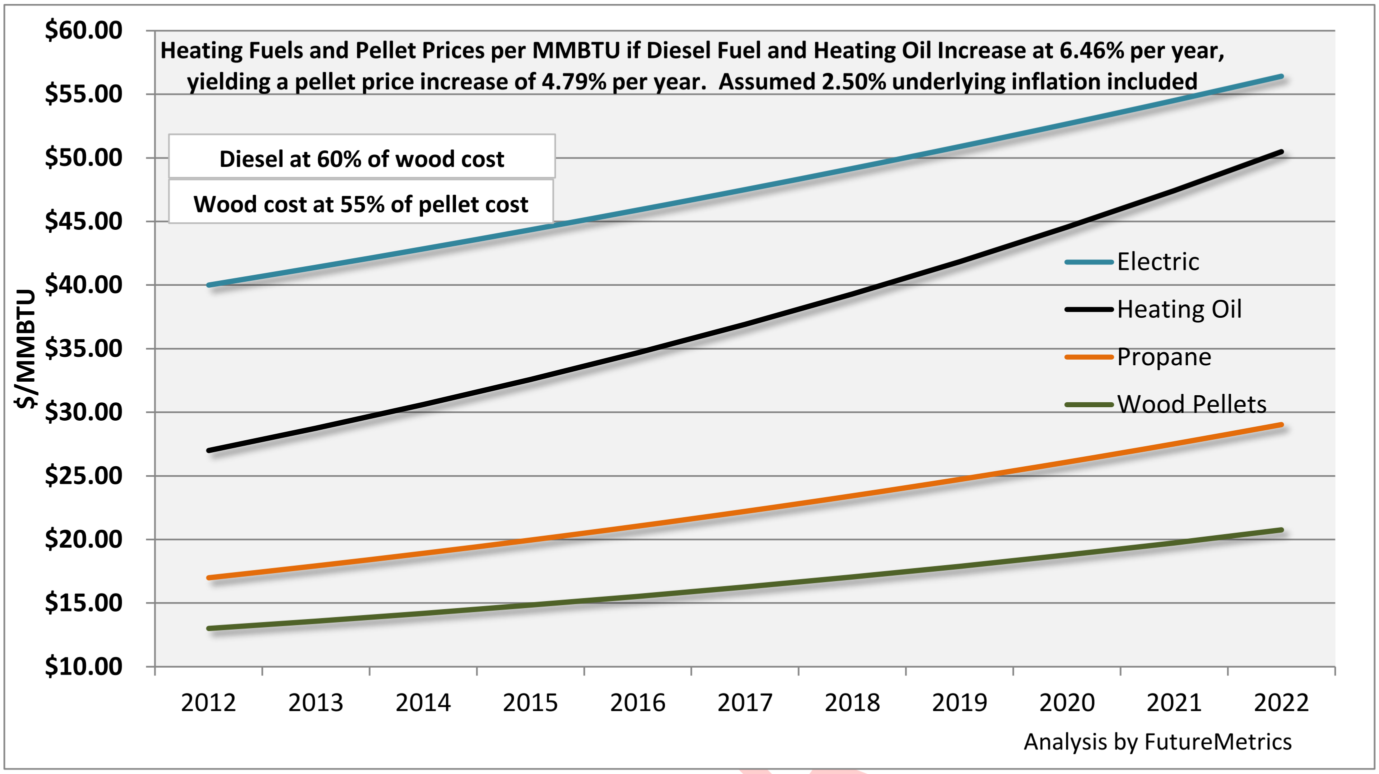
[22] The chip and pellet price forecasts assume that the sustainable supply of biomass that has been estimated is balanced with the demand. The primary contributions to the variable cost of goods in pellet production are wood, labor, and electricity. Wood costs account for about 60% of the cost of goods. Electricity is about 12%. Labor is about 13%. Since biomass costs are about 60% of the cost of pellet manufacturing, a $100/barrel increase in crude oil prices will pass through as about a $25 increase in that component of the cost of manufacturing wood pellets. 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 of heating oil would be expected to increase if oil prices increase. Electricity is expected to increase at about the general inflation rate. Propane, made from crude or natural gas, is expected to rise at a rate between general inflation and crude. (forecasts by FutureMetrics)



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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[23].

	Spending on Propane and Heating Oil by 10.00% of Total Users	Amount that Would be Spent on Biomass Fuel at $235/ton for equivalent heat	Annual Savings	**Total Jobs Due to Heating Cost Savings**	Spending on Heating Oil and Propane at $6.91/gallon and $2.61/gallon	Amount that Would be Spent on Biomass Fuel at $323/ton for equivalent heat	Annual Savings (in 2025 dollars)	**Total Jobs in 2025 Due to Heating Cost Savings**
Wisconsin	$ 345,034,332	$ 234,398,374	$ 110,635,958	5,351	$ 576,045,149	$ 321,778,737	$ 254,266,000	12,299
Minnesota	$ 430,005,505	$ 297,476,139	$ 132,529,366	5,701	$ 710,503,436	$ 408,370,991	$ 302,132,000	12,997
Michigan	$ 339,554,376	$ 245,483,791	$ 94,070,585	4,132	$ 546,414,364	$ 336,996,639	$ 209,418,000	9,199
North Dakota	$ 100,953,551	$ 70,258,597	$ 30,694,953	1,416	$ 166,226,823	$ 96,449,998	$ 69,777,000	3,220
South Dakota	$ 67,452,626	$ 49,283,665	$ 18,168,960	842	$ 107,828,706	$ 67,655,911	$ 40,173,000	1,861
Iowa	$ 173,272,307	$ 133,931,592	$ 39,340,715	1,702	$ 266,849,600	$ 183,859,376	$ 82,990,000	3,590
Illinois	$ 344,579,797	$ 274,080,739	$ 70,499,057	2,751	$ 519,972,918	$ 376,254,121	$ 143,719,000	5,608
Indiana	$ 371,962,995	$ 270,790,500	$ 101,172,495	4,460	$ 595,971,021	$ 371,737,327	$ 224,234,000	9,885
Ohio	$ 654,759,078	$ 452,959,788	$ 201,799,290	8,427	$1,081,866,556	$ 621,816,723	$ 460,050,000	19,212
			$ 798,911,380	**34,783**			**$ 1,786,759,000**	**77,871**

At current prices if all of those establishments that can sustainably switch to biomass fuel did switch, the states would have an annual savings of more than $798 million. In 2025, at the EIA's forecasted prices for heating oil and propane and FutureMetrics' forecasted prices for pellet fuel, the annual savings reach over $1.7 billion.

The expected significant gap between heating fuel prices and pellet fuel prices in 2025, which unlocks and releases millions of dollars into the states' economies, has very significant job effects. The direct,

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[23] 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 that remained in the local economy.

indirect and induced job from those annual savings would create 78,000 permanent new jobs. The fuel supply chain would create another 13,170 jobs. Using regionally produced fuel would also stop the export of 132,900 jobs. The net increase in jobs by 2025 if the 10% goal is reached is 224,000.

Income and Jobs if 10.00% Convert	Total Permanent ANNUAL Income from New Jobs	Total Permanent New Jobs	Total NET Jobs (sum of new jobs and no longer exported jobs)
Wisconsin	$ 328,001,756	14,000	32,000
Minnesota	$ 392,776,637	15,000	35,100
Michigan	$ 282,019,739	10,800	26,900
North Dakota	$ 91,630,371	3,700	8,800
South Dakota	$ 56,026,072	2,200	5,600
Iowa	$ 123,601,729	4,500	12,700
Illinois	$ 222,677,319	7,300	21,900
Indiana	$ 302,317,547	11,500	29,200
Ohio	$ 594,523,036	22,100	51,800
	$ 2,393,574,207	**91,100**	**224,000**

analysis by FutureMetrics

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.

The jobs estimates are for new jobs that will be created both by regional biomass fuel production replacing non-regional propane and 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 propane, heating oil and electricity to pellet fuels takes place, those jobs that already exist for propane and heating oil delivery and the administration of that infrastructure will migrate to doing very similar activities with the pellet fuel.

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.

By 2025, after the full conversion has taken place, the states would have about $2.4 billion dollars per year injected into their economies with a total of 91,100 permanent jobs. Most of the money and jobs will be new, created by the growth of the biomass thermal sector between now and 2025.

Summary of the Economic Benefits

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 income.

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This analysis has shown that a significant proportion of the 15 by 25 thermal goal can be met with biomass produced in the region. It has also shown that there are substantial economic benefits associated with job creation. Non-biomass renewable energy and biomass thermal/CHP have different supply chains.

Clean and renewable bioenergy can and will help the nine states move toward energy independence and fulfill the economic needs of the region by creating significant new income and jobs. Furthermore, the conversion to wood pellet fuel will support the traditional forest products industry as the demand for printed media declines.

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Environmental and Social Benefits of Achieving the Vision

Increased Viability of Forest and Farm Ownership

The health of Midwest forests 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 forestlands have never received in the United States.**

Providing a viable and stable commodity market for agricultural crop residues would help farms of all sizes be more profitable.

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 CO_2 during their growth period and emit it when combusted, biomass can be considered as a carbon efficient fuel, compared to fossil fuels, if it is harvested responsibly and sustainably. CO_2 is currently the biggest contributor of greenhouse gases that are implicated in climate change[24].

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 Midwest. These particles have adverse health and environmental impacts[25].

Due to the high level of sulfur currently found in heating oil, its combustion is a significant source of sulfur dioxide (SO_2) emissions in the region. Oil heating is also a source of particulate matter (PM), oxides of nitrogen (NO_x) 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 and is significant in the Midwest as well.

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[24] See extensive research on this and a summary of other studies at www.FutureMetrics.com.

[25] See "Wood Pellet Heating" by the Massachusetts Division of Energy Resources, P. 14,June 2007.

Heating oil burners emit significant levels of SO_2 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. SO_2 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 engender advances in technology. For example, the projections include a role for biomass energy crops in meeting the challenge of the increase in biomass thermal energy incorporated in this vision. While shrub willow and hybrid poplar produce a chip that is essentially interchangeable with other whole-tree hardwood chips, this is not true in the case of perennial grasses and agricultural residues.

There are a range of material handling, ash generation, and combustion issues that may come into play with grasses and crop residues, depending on species and to some extent harvesting practices. Agricultural biomass was minimally considered in this paper for the broader small scale boiler market due to material handling issues and some concerns over the mineral content of the feedstock and subsequent emissions levels. Those issues are not an impediment to larger scale applications such as power generation and combined heat and power.

The use of this resource in the future would only improve the economic impacts of biomass heating across the Midwest. However, the potential for generating significant energy from these fuel sources will drive R&D into finding ways to cleanly and efficiently use the feedstock in a broader set of applications.

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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 Midwest should broaden its strategy for energy fuels. 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[26], 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.[27]

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 that applies only to transportation fuels, and is considering a Renewable Electricity Standard that 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 <u>outcome-driven energy policy</u> would seek to deliver on the following core clean <u>energy objectives</u>:

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

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[26] Energy Information Association, 2012 data

[27] As reported by the Environmental Law Institute based on 2002-2008 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 Midwest (and other regions of the country). Low-income families in particular are vulnerable to price hikes in oil or propane 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 CO_2 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 that optimize carbon storage, adaptation potential, biomass used for energy, and the harvest of traditional products.

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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 Midwestern States

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

- First, the nine Midwest 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:

- State climate change action plans
- State endorsement of 15x’25 action plans

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- National climate and energy policy legislation; current tax incentive and federal grant and loan programs for thermal energy and biomass applications
- Other state level energy planning, perhaps specific to thermal renewable energy

VII. A Call to Action: Next Steps

This is an ambitious Vision for biomass thermal in the Midwest. Making progress toward this vision will require immediate actions, some of which are identified below. A volunteer working group of industry, government and non-governmental organization leaders has been formed that are committed to increasing biomass thermal in the Midwest. Additional actions will flow from this group, and can include the following:

1. Ongoing engagement and action by Heating the Midwest with Renewable Biomass Steering Committee and Action Teams. This effort currently has representation from across the region, and includes industry, nongovernment organizations (NGOs), university and government officials.

2. Development by the Steering Committee of a "key contacts" list of policy makers, opinion leaders, state and federal officials, community development and industry leaders.

3. Broad dissemination and promotion of the Vision to the key contacts list. This report will be amended following the 2013 Heating the Midwest Conference & Expo to list the key organizations and their websites.

4. Convening the 2013 Heating the Midwest Conference and Expo in April 2013 to present and receive feedback on the Vision. At the completion of the 2013 Conference and Expo, regional meetings with key contact should be conducted to seek input and to refine the vision with particular focus on strategies and policy recommendations.

5. Formation by the working group of a "Midwest regional biomass thermal policy action team", with representation from all nine 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.

What You Can Do Today

- **Get Involved!**
- **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.**

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Appendix A – Natural Gas and Wood Pellets

Cheap Natural Gas will be Good for the Wood-to-Energy Sector!

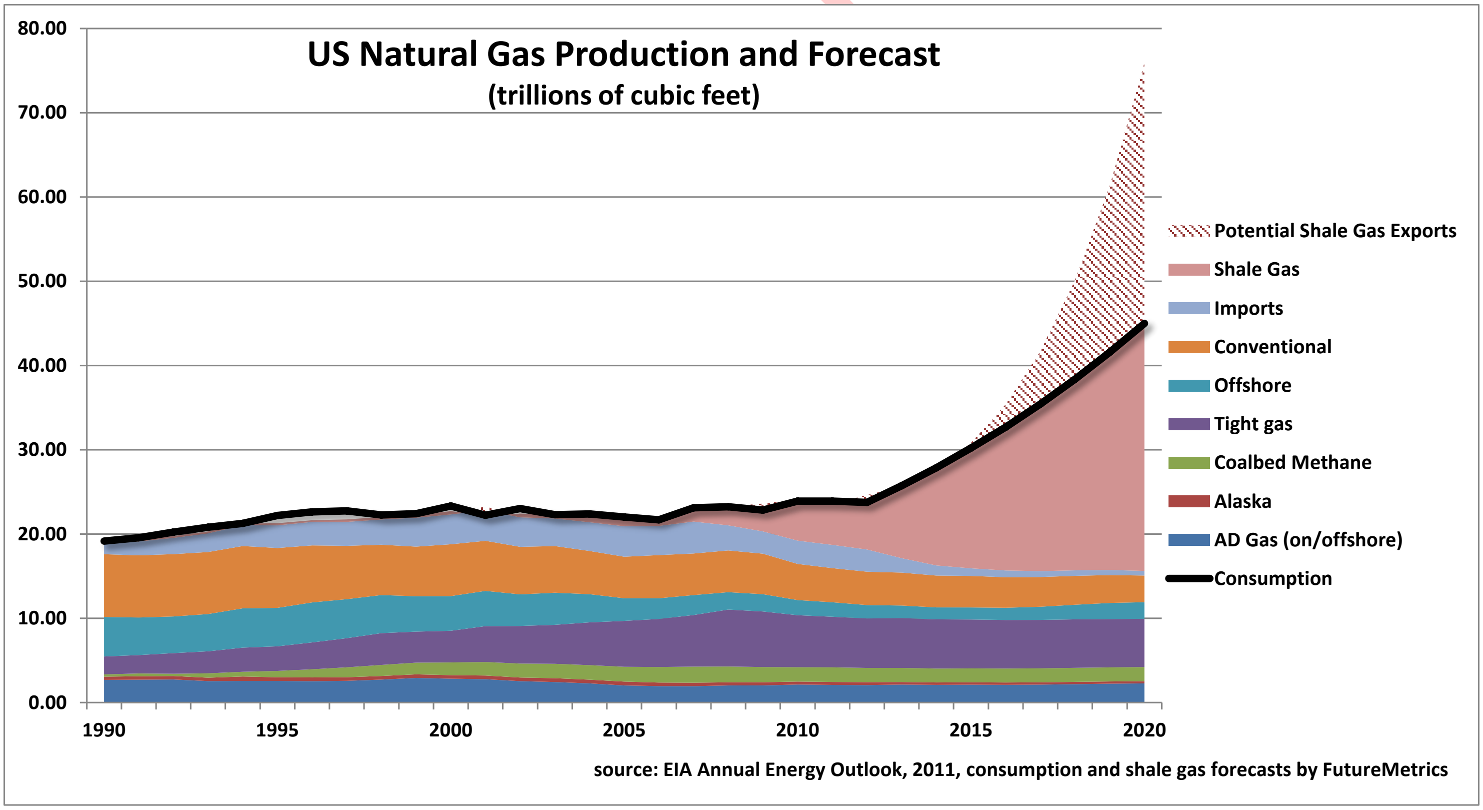
By Dr. William Strauss, FutureMetrics

It is not uncommon to hear that low cost natural gas is a challenge to the growth of the biomass thermal sector. There is no question that cheap natural gas has changed the landscape and has, in a number of locations, caused projects that were considering biomass fuel to go with natural gas.
But, as this brief white paper will show, the wood-to-energy sector will significantly benefit from low cost natural gas.

The pathway is through compressed natural gas (CNG) as a transportation fuel. As this paper will show, we expect a relatively rapid transition into CNG fueled vehicles of all types. The impact of significantly lower operating costs, from harvest to highway transport, on the cost of wood will make biomass fuels cheaper and cost competitive with pipeline natural gas and CNG.

In an earlier FutureMetrics white paper, we forecast natural gas production in the US. The chart below is from that paper. The rapid rise in domestic consumption is in part due to the rapid shift in transportation fuel from gasoline and diesel to CNG.

Report



source: EIA Annual Energy Outlook, 2011, consumption and shale gas forecasts by FutureMetrics

The cost for CNG as a transportation fuel has to include the costs associated with the filling infrastructure. The cost of CNG at a fast filling location or from a truck-to-site system depends on a number of variables[28].

We estimate the all-in cost at today's natural gas rates is about $1.61 per diesel gallon equivalent.

	Unit	Price	BTU/Unit	$/MMBTU	CAPEX Amortization and other Costs[1] ($/MMBTU)	Total Cost per MMBTU	$/Diesel Gallon Equivalent
Natural Gas	MMBTU	$5.50	1,000,000	$5.50	$6.10	$11.60	**$1.61**
Diesel	Gallon	$4.00	139,200	$28.74		$28.74	**$4.00**

source: EIA data, 2013, analysis by FutureMetrics

The cost for new natural gas fueled engines and vehicles is only marginally higher than traditional diesel fueled vehicles and that cost difference will quickly disappear as production volumes increase.

Therefore, our forecast is that CNG fueled vehicles will become the dominant transportation solution in the near future (3 to 7 years). The only bottleneck is filling station infrastructure and that will change rapidly as the market wakes up to the operating cost benefits of CNG over gasoline and diesel fuel. The ease of moving CNG on highway tankers will also transform the in-woods logging industry over the same period.

The effect of lower operating costs on wood prices

A significant proportion of the cost of wood for end users is from the cost of diesel fuel used in harvest and transport. The chart below shows that relationship for wood priced in a specific woodbasket in the northeast[29].

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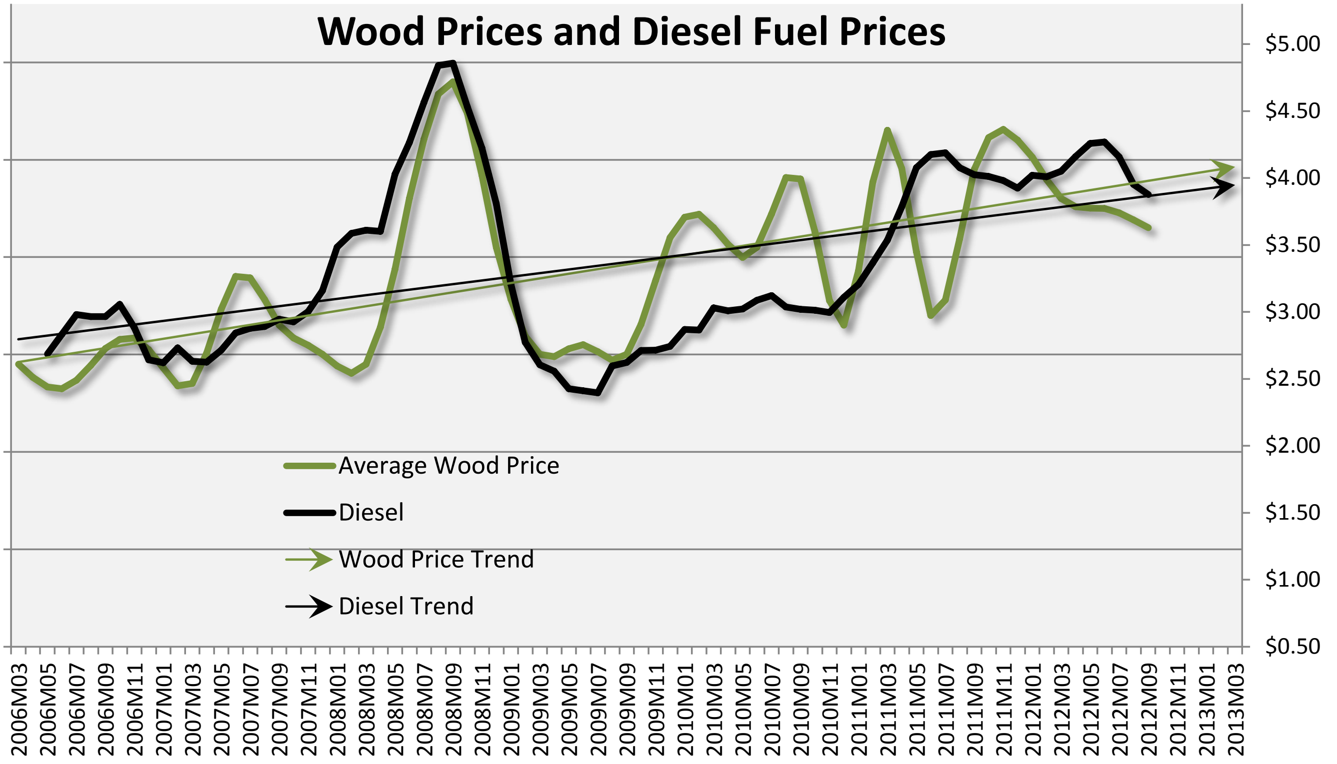
[28] The significant inputs are the cost of the natural gas, the cost of electricity for compression, maintenance and repair costs, capital amortization of the equipment, and state and federal motor fuels taxes (or credits).

[29] The data is from gate prices paid by pulpwood buyers in a closely defined geographical region in the northeast. Each specific location will have different sensitivities to diesel fuel prices.



source: EIA, Innovative Natural Resource Solutions (proprietary wood pricing data), analysis by FutureMetrics

The correlation between a simple average of wood prices for hardwood and pine and diesel fuel is 0.63. It is obvious from the chart that there are other influences on wood prices.

FutureMetrics has worked extensively with Innovative Natural Resource Solutions' consultant Eric Kingsley on a wood price model. That model explains over 90% of the variation by using independent location specific variables[30]. However, for this analysis we will focus only on the contribution that the fuel that powers the harvesting and transportation stock has on wood prices[31].

Below is a scatter plot that illustrates the relationship between wood prices (at a specific wood basket in New England) and diesel fuel.

Working

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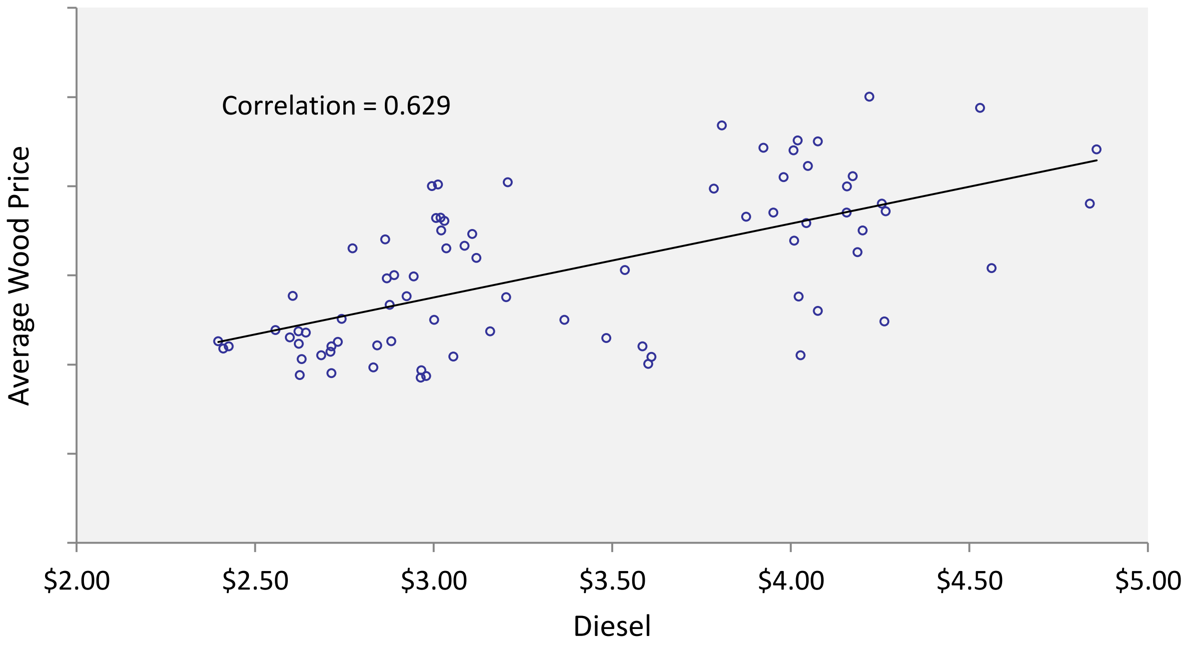
[30] See http://www.palisade.com/cases/futuremetrics.asp for a case study based on that research.

[31] The statistical analysis does incorporate one other dominant input to wood price variability in order to isolate the diesel fuel effect.

Scatterplot of Average Wood Price vs Diesel



source: wood price data from INRS, EIA 2013, analysis by FutureMetrics

Our analysis has determined the following:

For each $1.00 increase in diesel, wood price increases by:	
Average	$4.20
Hardwood	$4.79
Pine	$3.60

We have also estimated wood prices in this location using our pricing model. The inputs to the model going forward are based on an estimated stochastic process that is based on the diesel fuel and the other relevant historical data. The charts below show the diesel fuel forecast and the expected prices for CNG at the pump in diesel gallon equivalent. The confidence intervals are shown as shaded areas. The expected price is the dark line. One sample path is shown in red. To calculate future wood prices and the probability distributions for those prices we run a 5000 iteration simulation that randomly selects from possible future price paths of both diesel fuel and natural gas[32].

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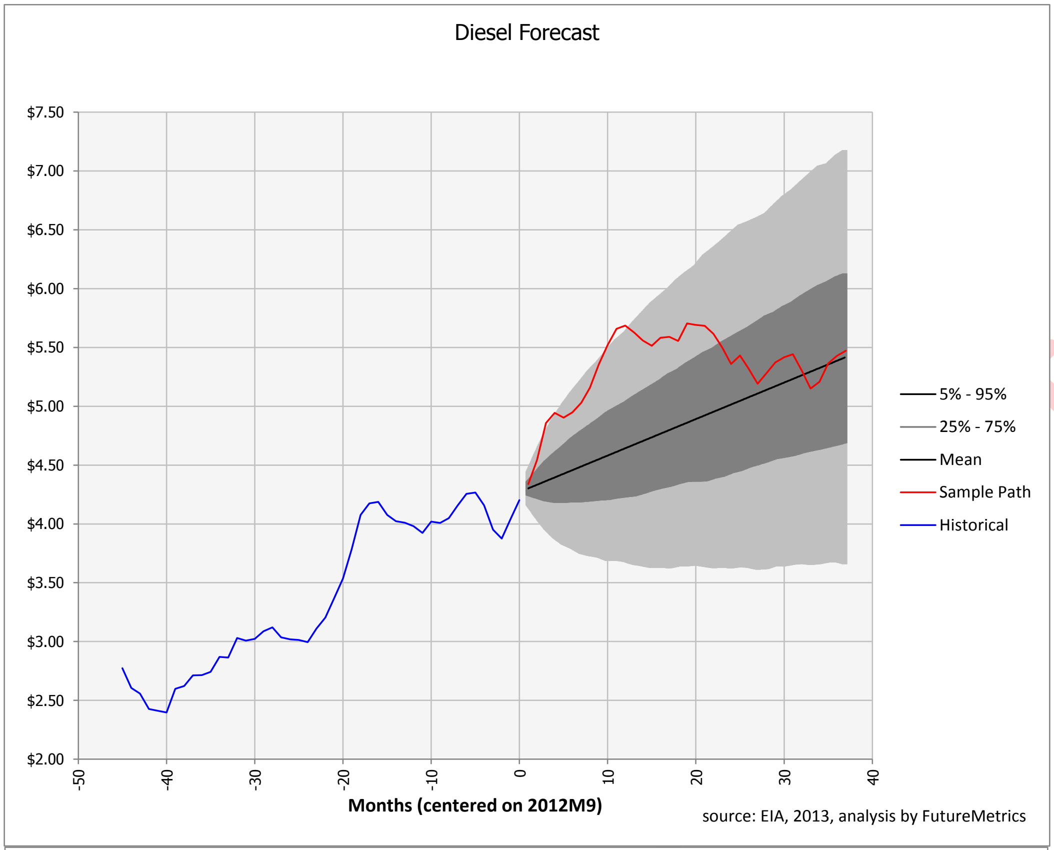
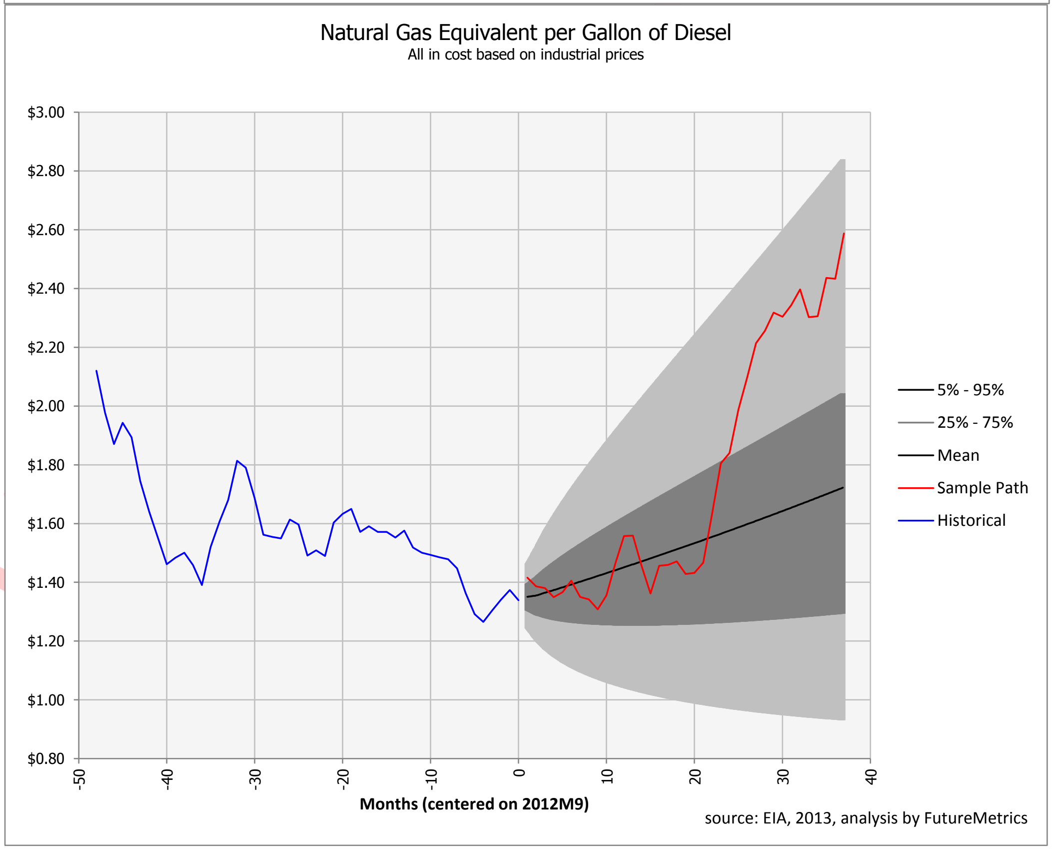
[32] FutureMetrics uses Palisade Corporation's Decision Tools Suite and in particular @RISK for running simulations.



source: EIA, 2013, analysis by FutureMetrics



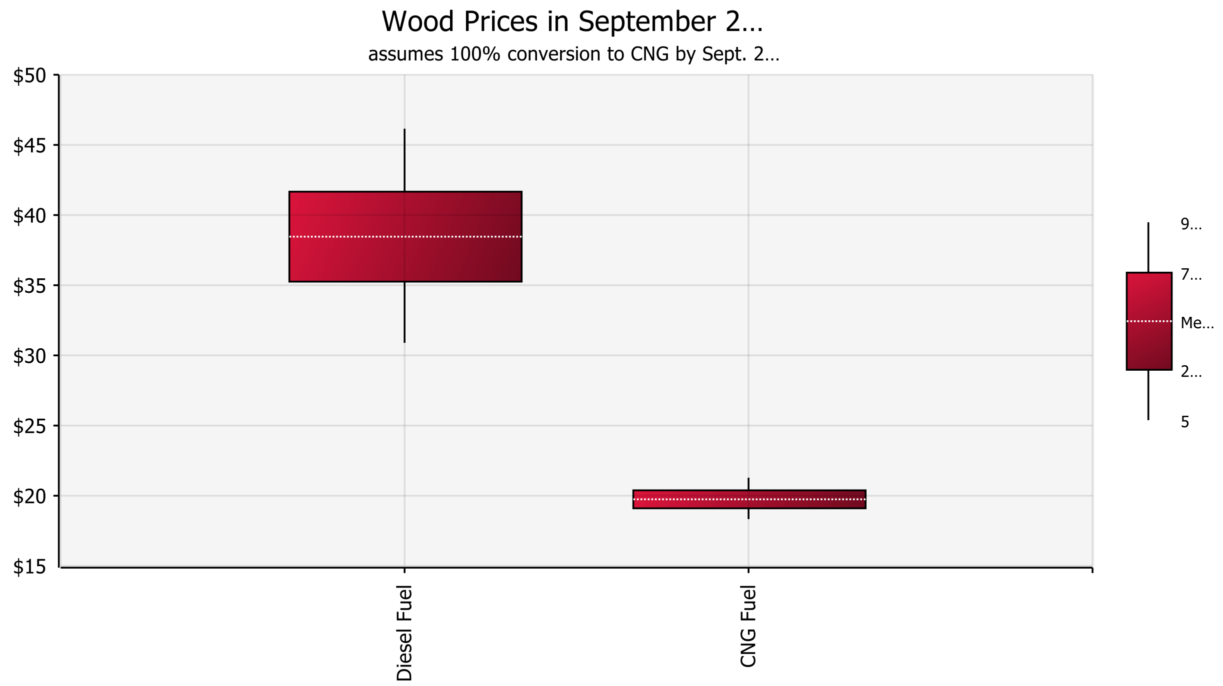
source: EIA, 2013, analysis by FutureMetrics

What follows is based on a hypothetical scenario in which over the next three years (the same 36 months as the forecasts in the charts) transportation fuel converts from 100% diesel to 100% natural gas

(CNG). Of course, that scenario is highly unlikely. However, it will demonstrate the potential effect on wood prices.

Because natural gas converts to a diesel fuel equivalent that is about 40% the cost of diesel at today's prices, the impact on wood prices will be significant. Furthermore, even if the industrial price of natural gas increases, the fixed cost component of the all-in CNG cost will remain relatively constant. In 36 months we forecast that CNG fuel will be 31.8% the cost of diesel on a per gallon equivalent[33].

We also would expect that CNG pricing would be less volatile than diesel fuel since it is not exposed to geopolitical risk. The chart below shows the outcome of our simulation.



The significant drop in operating costs translates, in this woodbasket, into a 49% decrease in wood costs at the gate. In dollar terms, wood would be expected to be about $18.50/green ton less than it would be if diesel is at $5.39/gallon at the end of 2015 (assuming industrial priced natural gas at about $4.60/MMBTU in September, 2015).

The Pellet Export Sector

What would this mean for a pellet export project? The matrix below is based on a detailed capital cost and operating cost model that FutureMetrics has developed for analyzing pellet manufacturing business models.

Work

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[33] That includes an assumption of some price appreciation for natural gas as demand for transportation fuel increases.

250,000 Metric Ton per Year Pellet Export Plant

Sensitivity of Annual After Tax Earnings to Wood Price and Pellet Price (wood price in ST, pellet FOB price in MT)

	$145	$150	$155	$160	$165	$170	$175	$180	$185
$15	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
$16	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
$17	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
$18	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
$19	[redacted]	[redacted]	[redacted]	[redacted]	$8,850,000	[redacted]	[redacted]	[redacted]	[redacted]
$20	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
$21	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
$22	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
$23	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
$24	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
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$37	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
$38	[redacted]	[redacted]	[redacted]	[redacted]	$2,820,000	[redacted]	[redacted]	[redacted]	[redacted]
$39	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
$40	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
$41	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
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$46	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
$47	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

analysis by FutureMetrics

A 50% reduction in wood costs results in 314% increase in the annual after tax cash flow. Furthermore, it takes the project far away from the negative danger zone in the bottom left of the sensitivity matrix. As wood harvest and transport operating costs fall, there is a likelihood that margins for the various entities along the supply chain will broaden and therefore the ultimate feedstock price drop may not be as dramatic as this model suggests.

However, in a competitive market, the impact of low cost domestically produced natural gas and therefore low cost transportation fuel will have a dramatic positive impact on the US's competitiveness in the global wood pellet export markets. As low cost producers such as Brazil come into the markets, the ability to price compete and maintain reasonable margins will be very important. The lower carbon output of CNG versus diesel fuel will also enhance the low carbon footprint of wood pellets and add to their value.

The Domestic Wood Pellet Boiler Sector

The impacts of low cost CNG in the domestic pellet boiler sector are more complex to model. Low cost CNG will compete for market share in the home and commercial heating markets. However, the ability for domestic pellet producers to operate with a lower feedstock cost will allow lower priced pellets. In many locations, even with CNG, pellets will be the lowest cost fuel.

At a wood cost of $38/green ton, a modestly sized domestic pellet mill (80,000 tons per year) can break even[34] with a gate price of about $165/ton (short ton). With transportation costs from the mill, bulk delivery with a fully pneumatic delivery trucks, and modest margins for the fuel delivery firms, the price of fuel to owners of wood pellet fueled central heating systems is expected to be about $220/ton. The table below shows this relationship with natural gas delivered to heating customers as CNG and using the same cost per MMBTU as used above for transportation fuel (also heating oil is shown at the same price as diesel fuel which is consistent with the price histories of those fuels).

	Unit	BTU per Unit	Price per Unit	Efficiency	Price per MM BTU (adjusted for efficiency)
Heating Oil	Gallon	138,000	$ 5.25	87%	$33.10
Propane	Gallon	91,000	$ 3.00	93%	$30.66
Natural Gas as CNG	MMBTU	1,000,000	$ 11.60	93%	$10.79
Wood Pellets	Ton	16,800,000	$ 220.00	87%	$11.39
Electricity	kWh	3,412	$ 0.1208	100%	$35.40

analysis by FutureMetrics

If wood costs drop as shown above and the pellet delivery trucks run on CNG, the cost to the end user is expected to be as follows (break even for the pellet mill drops to about $132/ton).

	Unit	BTU per Unit	Price per Unit	Efficiency	Price per MM BTU (adjusted for efficiency)
Wood Pellets	Ton	16,800,000	$ 185.00	87%	**$9.58**

Pellets will thus remain price competitive with CNG and very competitive with other heating fuels. The primary target markets for domestic pellet boiler systems will continue to be those areas that are not connected to pipeline natural gas infrastructure.

Conclusion

Natural gas will remain very low cost in the US relative to diesel and heating oil. In many locations, it will win the battle for domestic market share over wood pellets. This analysis did not look at larger scale wood chip boilers. However, lower wood costs will benefit all systems that use wood chips or wood pellets.

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[34] We assume break even to be an 8% return on investment.

Low cost domestically produced abundant natural gas will provide the foundation for a much more competitive industrial pellet export sector and for lower cost domestic pellet manufacturing. As CNG replaces diesel, end user wood costs will fall dramatically and the cost of production for both domestic and export pellets will, as this white paper has shown, fall dramatically.

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