Michigan's Position in the U.S. Biofuel and Bioenergy Market

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Michigan State University's Product Center for Agriculture and Natural Resources, under the direction of the MSU Bioeconomy Network, is offering a series entitled, "Status of Michigan's Bioeconomy: Progress & Evolving Potential." The purpose of the series is to better inform decision-makers and bioeconomy stakeholders about a range of issues and opportunities related to the still emerging bioeconomy, especially in Michigan.
The papers in the series include:

- *Advancing the Bioeconomy: Overview of Michigan's Progress*
- *Michigan's Position in the U.S. Biofuel and Bioenergy Market*
- *Potential Future Scenarios of Michigan's Bioeconomy*

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EXECUTIVE SUMMARY

Michigan has a very active bioeconomy, as highlighted in "Advancing the Bioeconomy: Overview of Michigan's Progress." Michigan's legislative support, strong research institutes, and diverse agriculture industry have helped build and support biofuel and bioenergy industries in the state. But how does Michigan compare to the nation and to other states in the region?

A few states consistently are at the top of biofuel and bioenergy market metrics, including California, Illinois, and Iowa. By identifying key metrics and measuring the state's progress against them, decision-makers can help position Michigan to excel in the areas where the state has a competitive advantage.

Michigan is in the top third nationally in terms of total acres of ethanol-eligible crops harvested, biodiesel-eligible crops, and net growth of timberland stock trees. These categories make up the state's bioeconomy feedstock potential.

Michigan is in the top 20 percent of states in terms of ethanol consumption and electricity production from biomass. A strong market for bioeconomy products further encourages increased private investment within the state.

Additionally, Michigan also has a strong renewable portfolio standard (RPS), which supports investment in several renewable energy options, including biomass. While Michigan's RPS is currently competitive with other states in the country, Michigan's 10 percent target will be achieved in 2015; many other states have set higher percentage targets (20 percent or 25 percent) and later target dates (2020 or 2025). So it is important for Michigan to show a continued commitment to developing sources of renewable energy within the state beyond 2015 if there is to be a growing bioeconomy.

Finally, Michigan has had some success securing public funding for biomass research and investments, but the potential for much greater funding exists.

After examining a number of data points across several key metrics, Michigan shows significant strengths in the overall market for biofuels and bioelectricity products. Michigan's diverse crop mix and strong timberland resources puts the state in an excellent position once cellulosic ethanol becomes commercially viable.

INTRODUCTION

This **"Michigan's Position in the U.S. Biofuel and Bioenergy Market"** paper provides an objective comparison of various aspects of bioeconomy potential and activity in Michigan relative to the entire United States and to the Great Lakes Region. More specifically, this paper examines how Michigan compares to other states across a portfolio of bioeconomy metrics:

- biomass feedstock supply
- biobased energy production and consumption
- public policy
- public investments

In addition, an important issue is raised about the lack of available metrics on bioeconomy employment, private investment, and innovation.

As outlined in "Advancing the Bioeconomy: Overview of Michigan's Progress," the Product Center defines the bioeconomy as *any commercial or industrial effort that is based on the conversion of growing, renewable biomaterials into products that replace petrochemical or fossil fuel-based products*. The three main sectors of the bioeconomy include biofuels, bioenergy, and biomaterials, which are all based on feedstock resources. Biofuel and bioenergy are more developed markets and more easily measured than biomaterials; therefore, the metrics identified in this paper are focused on biofuels and bioenergy.

As much as possible, this report draws from the most recent publicly available data from a variety of government agencies, trade associations, and published reports. The report uses quantitative data as available. The data presented represent a sample of select key metrics and are not meant to be comprehensive.

Regionally, Michigan is compared to five other Great Lakes states: Ohio, Indiana, Illinois, Wisconsin, and Minnesota. These states are similar in terms of geographic features and natural resources, economies, commercial and industrial markets, and climate.

BIOMASS FEEDSTOCK SUPPLY

Biomass feedstock supply is primarily a function of the amount of land available to grow feedstocks that can be used in the bioeconomy. The four supply variables considered are:

- acres of ethanol-eligible agricultural crops
- acres of biodiesel-eligible agricultural crops
- acres of woody biomass
- acres of abandoned cropland
- water net recharge rate

Acres of Ethanol-Eligible Agriculture Crops:

Ethanol agriculture crops include corn (for grain and silage), sugarcane, sugar beets, wheat, and forage.[1] These crops can be used for traditional grain ethanol and/or in the production of cellulosic ethanol. These crops have varying levels of efficiency when they're converted to ethanol. Sugar crops have more energy per bushel than corn, which has more energy per bushel than wheat.

In 2007, the top five states in the country in terms of ethanol-eligible agricultural feedstocks harvested are shown below, as is Michigan, which ranked 16th.

Table 1: Top Five States - Total Ethanol-Eligible Acres Harvested

Nationwide Rank	State	2007 Total Ethanol-Eligible Acres Harvested[2]
1st	Kansas	15,008,187
2nd	Iowa	14,997,359
3rd	Illinois	14,580,984
4th	Nebraska	13,765,411
5th	North Dakota	13,547,581
16th	**Michigan**	**4,184,342**

The Great Lakes region as a whole makes up roughly 25 percent of the total U.S. ethanol-eligible acres harvested. Within the region, Michigan ranks sixth largely because corn currently makes up the majority of ethanol crops and Michigan produces less corn than its neighbors.

Table 2: Regional Total Ethanol-Eligible Acres Harvested

Regional Rank	State	2007 Total Ethanol-Eligible Acres Harvested[3]
1st	Illinois	14,580,984
2nd	Minnesota	11,721,909
3rd	Indiana	7,271,911
4th	Wisconsin	6,328,808
5th	Ohio	5,494,875
6th	**Michigan**	**4,184,342**

Looking at acres of cropland is only part of the picture. States have varying yields for any given crop. For example, in 2008 Michigan yielded 138 bushels of corn per acre, which placed it ahead of Wisconsin and Ohio, as shown in the table below.

[1] USDA, National Agriculture Statistics Service, 2007.
[2] USDA, Census of Agriculture, 2007
[3] USDA, Census of Agriculture, 2007

Table 3: Regional Corn Yield per Acre

Regional Rank	State	2008 Yield: Bushels of Corn per Acre[4]
1st	Illinois	179
2nd	Minnesota	164
3rd	Indiana	160
4th	**Michigan**	**138**
5th	Wisconsin	137
6th	Ohio	135

Acres of Biodiesel-Eligible Agricultural Crops:
Biodiesel eligible agricultural crops grown in the United States whose lipids can be recovered for oil are soybeans and canola. There are several other sources of biodiesel raw materials besides these two agriculture crops, including yellow grease, used oils, algae, and jatropha.

Table 4, below, lists the top five biodiesel-eligible crop states and the corresponding total acres of soybeans and canola crops. Michigan ranks 12th nationwide in terms of total soybean and canola crop acres harvested.

Table 4: Top Five States - Total Biodiesel-Eligible Acres Harvested

Nationwide Rank	State	2007 Total Biodiesel-Eligible Crop Acres Harvested[5]
1st	Iowa	8,612,810
2nd	Illinois	8,293,711
3rd	Minnesota	6,303,044
4th	Indiana	4,783,821
5th	Missouri	4,672,738
12th	**Michigan**	**1,715,579**

As with ethanol-eligible crops, the Great Lakes region produces significant amounts of biodiesel-eligible crops. Land well suited to corn production is also generally well suited to soybean production. The canola market is not well developed in this part of the country. Michigan ranks fifth in the region, as shown in the table below:

[4] USDA, Crop Production Summary, 2008
[5] USDA, Census of Agriculture, 2007

Table 5: Regional Total Biodiesel-Eligible Crops

Regional Rank	State	2007 Total Biodiesel-Eligible Crop Acres Harvested[6]
1st	Illinois	8,293,711
2nd	Minnesota	6,303,044
3rd	Indiana	4,783,821
4th	Ohio	4,236,337
5th	**Michigan**	**1,715,579**
6th	Wisconsin	1,365,120

Acres of Woody Biomass Timberland:

While not currently used to make biofuels, timberland (defined as land covered by forests capable of producing 19.72 cubic feet per acre of industrial wood annually and not reserved[7]) represents a substantial future source of biomass feedstock as cellulosic ethanol, gasification, and similar technologies develop commercially. As shown in the table below, Michigan ranks 7th nationally among states that have large timberland acreage. The state could potentially be a significant player in the cellulosic biofuel market.

Table 6: Top Five States Nationally - Total Acres of Timberland

Nationwide Rank	State	2007 Total Timberland (1,000 Acres)[8]
1st	Oregon	24,617
2nd	Georgia	24,247
3rd	Alabama	22,580
4th	Montana	19,790
5th	Mississippi	19,536
7th	**Michigan**	**19,023**

Michigan is ranked first among Great Lakes states in timberland acreage.

Table 7: Regional Total Acres of Timberland

Regional Rank	State	2007 Total Timberland (1,000 Acres)[9]
1st	**Michigan**	**19,023**
2nd	Wisconsin	16,042
3rd	Minnesota	15,113
4th	Ohio	7,644
5th	Indiana	4,533
6th	Illinois	4,363

[6] USDA, Census of Agriculture, 2007
[7] USDA, Forest Services.
[8] USDA Forest Services, "National Assessment - Resources Planning Act (RPA)," 2007.
[9] USDA Forest Services, "National Assessment - Resources Planning Act (RPA)," 2007.

Michigan, Wisconsin, and Minnesota have far more timberland than Ohio, Indiana, and Illinois.

While woody biomass could prove to be a big part of the biofuel and bioenergy markets, it must be harvested sustainably to ensure future feedstock availability. To ensure sustainability, use cannot exceed new growth of growing stock trees. For example, in 2006 forest growth in Michigan exceeded forest harvested by 761,216 cubit feet. Using this metric, Michigan ranks 15th nationally in net new growth of timberlands.

Table 8: Top Five States - Net Growth of Growing Stock Trees

Nationwide Rank	State	2006 Net Annual Growth of Growing Stock Trees (1,000 ft^3/yr)[10]
1st	Georgia	1,927,557
2nd	Oregon	1,701,589
3rd	Washington	1,638,148
4th	California	1,546,868
5th	Alabama	1,512,454
15th	**Michigan**	**761,216**

As with total timberland acreage, Michigan leads the Great Lakes states in net new growth of growing stock trees.

Table 9: Regional Net Growth of Growing Stock Trees

Regional Rank	State	2006 Net Annual Growth of Growing Stock Trees (1,000 ft^3/yr)[11]
1st	**Michigan**	**761,216**
2nd	Wisconsin	603,978
3rd	Minnesota	469,632
4th	Indiana	356,241
5th	Illinois	327,042
6th	Ohio	311,430

All states in the region have increasing forest resources.

Acres of Abandoned Cropland:
Abandoned cropland is a metric of unharvested, available land, which could be used to plant any biomass feedstock. This resource is being evaluated by industry and policy-makers as potential energy crop plantations made up of fast growing timber species and other biomass crops such as switchgrass or miscanthus. This metric has been computed for the Great Lakes states based on historical crop acreage compared to present-day acreage and current population density.

[10] USDA Forest Services, "National Assessment - Resources Planning Act (RPA)," 2006.
[11] USDA Forest Services, "National Assessment - Resources Planning Act (RPA)," 2006.

Data on abandoned cropland are not available for all states, but our comparison of Great Lakes states shows that Michigan is ranked third in the region in abandoned cropland potential for biomass production.

Table 10: Regional Abandoned Cropland

Regional Rank	State	Abandoned Cropland (Acres)
1st	Wisconsin	890,530
2nd	Ohio	884,310
3rd	**Michigan**	**832,333**
4th	Minnesota	539,138
5th	Indiana	473,440
6th	Illinois	338,383

BIOFUEL PRODUCTION AND CONSUMPTION

Biobased energy in the form of biofuels and biobased electrical production are by far the largest components of the current bioeconomy. Biofuels include traditional grain ethanol, cellulosic ethanol, and biodiesel. The federal Renewable Fuel Standards mandate 36 billion gallons of renewable fuels by 2022, including 21 billion gallons of advanced biofuels.[12] Advanced biofuels include cellulosic ethanol and biodiesel, but exclude cornstarch ethanol.

The Product Center and Shepherd Advisors evaluated the production, consumption, and availability of these renewable fuels across the country to compare how Michigan competes in this sector of the bioeconomy.

Biofuel demand was measured by examining the following four variables:

- biofuel production capacity
- ethanol consumption
- E85 consumption
- total petroleum fuel consumption

Biofuel Production Capacity:
Ethanol and biodiesel industry associations track the number of production facilities by state. This paper includes industry associations' estimates of total current production capacity as well as capacity under construction. It is important to note that some major ethanol producers, such as Archer Daniels Midland, do not disclose production capacities for individual plants. For these companies, the total production capacity of the company has been divided and assigned evenly between each of the plants.

[12] EPA, "Renewable Fuels: RFS1 & RFS2 Compliance Help," April 20, 2010.

Twenty-nine states have ethanol production capacity and 44 states have biodiesel production capacity. With ethanol and biodiesel capacity added together, the top five production states are shown below. Within the U.S. market, Michigan ranks 14th in total biofuel production capacity.

Table 11: Top Five States - Biofuel Production Capacity

Nationwide Rank	State	2009 Total Biofuel Production Capacity (Millions of Gallons/Year)[13]
1st	Iowa	3,794
2nd	Nebraska	1,850
3rd	Illinois	1,548
4th	Minnesota	1,409
5th	Indiana	1,204
14th	**Michigan**	**313**

As current biofuel production in the United States draws almost entirely upon corn and soybeans, it is not surprising that biofuel production capacity is located most densely in states with the largest stocks of these biofuel-eligible feedstocks. This pattern is also true in the Great Lakes region, where Michigan ranks sixth.

Table 12: Regional Biofuel Production Capacity

Regional Rank	State	2009 Total Biofuel Production Capacity (Millions of Gallons/Year)[14]
1st	Illinois	1,548
2nd	Minnesota	1,409
3rd	Indiana	1,204
4th	Ohio	649
5th	Wisconsin	534
6th	**Michigan**	**313**

Ethanol Consumption:
Total ethanol consumed includes ethanol used as an oxygenate (a blend of up to 10 percent ethanol with gasoline) and E85. The vast majority of ethanol currently is used as an oxygenate, so total ethanol consumption is tied closely to total gasoline consumption in the states that allow or mandate ethanol blends.

The table of total ethanol consumption below shows Michigan ranks seventh nationally in terms of ethanol consumption.

[13] Renewable Fuels Association, "Biorefinery Locations," April 8, 2010; Biodiesel Magazine, Plant List, October 6, 2009.
[14] Renewable Fuels Association, "Biorefinery Locations," April 8, 2010; Biodiesel Magazine, Plant List, October 6, 2009.

Table 13: Top Five States - Total Ethanol Consumed

Nationwide Rank	State	2007 Total Ethanol Consumed (Trillion Btu)[15]	2007 Total Ethanol Consumed (1,000 gallons)*
1st	California	82.5	1,089,828
2nd	Texas	53.8	710,700
3rd	Illinois	34.1	450,462
4th	New Jersey	32.6	430,647
5th	New York	26.5	350,066
7th	**Michigan**	**22.8**	**301,189**

* Computed using 75,700 Btu/Gal

Within the Great Lakes region, Michigan ranks third in terms of total ethanol consumption.

Table 14: Regional Total Ethanol Consumed

Regional Rank	State	2007 Total Ethanol Consumed (Trillion Btu) [16]	2007 Total Ethanol Consumed (1,000 gallons)*
1st	Illinois	34.1	450,462
2nd	Ohio	25.7	339,498
3rd	**Michigan**	**22.8**	**301,189**
4th	Minnesota	19.9	262,880
5th	Indiana	16.1	212,682
6th	Wisconsin	15.9	210,040

*Computed using 75,700 Btu/Gal

Demand for E85, which is commercially available at some conventional fueling stations, is a useful indicator of consumer biofuel demand. Consumers with "flexible fuel" engines can choose whether to fill their gas tanks with regular gasoline or E85. This choice is driven by many factors, including knowledge about the product, green attitude, price of E85 versus gasoline, convenience of E85 pumps, support for energy independence, and support of agriculture. In terms of E85 consumed, Michigan ranks 10th nationally.

[15] DOE, Energy Information Administration, "State Data for Consumption and Sales," 2007.
[16] DOE, Energy Information Administration, "State Data for Consumption and Sales," 2007.

Table 15: Top Five States - E85 Consumed

Nationwide Rank	State	2007 Ethanol, (E85) Consumed (1,000 Gasoline-Equivalent Gallons)[17]	Number of E85 Stations[18]
1st	California	5,594	44
2nd	Florida	3,918	32
3rd	North Carolina	3,736	21
4th	Texas	2,668	42
5th	Virginia	2,457	9
10th	**Michigan**	**1,508**	**93**

Regionally, Michigan ranks second in E85 consumption. As seen in the two tables, the number of E85 stations does not necessarily coincide with increased ethanol consumption.

Table 16: Regional E85 Consumption

Regional Rank	State	2007 Ethanol, (E85) Consumed (1,000 Gasoline Equivalent Gallons)[19]	Number of E85 Stations[20]
1st	Illinois	2,082	203
2nd	**Michigan**	**1,508**	**93**
3rd	Minnesota	1,271	354
4th	Ohio	1,025	62
5th	Indiana	973	112
6th	Wisconsin	753	126

The table above shows that Michigan consumes approximately 240,000 more gasoline-equivalent gallons than Minnesota, a state with roughly half the number a people. Alternatively, Minnesota consumes approximately 70 percent more E85 per capita than Michigan. This is likely due to Minnesota's strong policy support of biofuels, as illustrated later in the document.

Total Petroleum Fuel Consumption:
Total petroleum fuel consumption is a proxy for the total market potential for biofuels within a state. Using this metric, Michigan ranks ninth in the nation and third in the region. Consumption is closely tied to population.

[17] DOE, Energy Information Administration, "State Data for Consumption and Sales," 2007.
[18] DOE, EERE, "Alternative Fueling Station Total Counts by State and Fuel Type," 04/19/2010
[19] DOE, Energy Information Administration, "State Data for Consumption and Sales," 2007.
[20] DOE, EERE, "Alternative Fueling Station Total Counts by State and Fuel Type," 04/19/2010

Table 17: Top Five States - Total Gasoline Consumption

Nationwide Rank	State	Total Btu of Petroleum Fuel Consumption 2007 (Trillion Btu)[21]
1st	California	3,358.00
2nd	Texas	2,812.60
3rd	Florida	1,602.10
4th	New York	1,047.80
5th	Illinois	1,045.60
9th	**Michigan**	**771.2**

Table 18: Regional Total Motor Gasoline Consumption

Regional Rank	State	Total Btu of Petroleum Fuel Consumption 2007 (Trillion Btu)[22]
1st	Illinois	1,045.60
2nd	Ohio	1,022.50
3rd	**Michigan**	**771.2**
4th	Indiana	639.1
5th	Minnesota	509.8
6th	Wisconsin	443.9

BIOBASED ELECTRICITY PRODUCTION AND CONSUMPTION

Biobased electrical production, primarily through anaerobic digestion, capture of landfill gas, and direct combustion of biomass, is driven increasingly by renewable portfolio standards (RPS) passed by individual states.

Biobased electrical demand was measured by examining the following three variables:

- power generation – woody biomass
- power generation – other biomass
- total electricity consumption

Power Generation - Wood or Wood Derived Fuels:
Biocombustion includes burning woody biomass (paper, pellets, railroad ties, utility poles, wood chips, bark, red liquor, sludge wood, spent sulfite liquor, and black liquor) in traditional electricity generation boilers. Red liquor, spent sulfite liquor, and black liquor are wood waste liquids that are byproducts of the pulp and paper manufacturing processes.

According to 2008 U.S. Department of Energy (DOE) data, Michigan ranks ninth nationally in power generation from wood and wood derived fuels.

[21] DOE, Energy Information Administration, "State Data for Consumption and Sales," 2007.
[22] DOE, Energy Information Administration, "State Data for Consumption and Sales," 2007.

Table 19: Top Five States - Electricity Generation from Wood

Nationwide Rank	State	2008 Generation from Wood and Wood Derived Fuels (Megawatt Hours)[23]
1st	Maine	3,668,569
2nd	California	3,483,555
3rd	Alabama	3,323,616
4th	Georgia	2,660,285
5th	Louisiana	2,638,789
9th	**Michigan**	**1,710,423**

In the Great Lakes region, Michigan is leading its neighbors in power generation from wood and wood derived fuels, generating more than twice as much as any other state in the region.

Table 20: Regional Electricity Generation from Wood

Regional Rank	State	2008 Generation from Wood and Wood Derived Fuels (Megawatt Hours)[24]
1st	**Michigan**	**1,710,423**
2nd	Wisconsin	775,040
3rd	Minnesota	725,220
4th	Ohio	418,117
5th	Illinois	612
6th	Indiana	-

Power Generation - Other Biomass:
Other biomass includes biogenic municipal solid waste, landfill gas, sludge waste, agricultural byproducts, other biomass solids, other biomass liquids, and other biomass gases (including digester gases and methane). Again, according to the most recent DOE data, Michigan ranks ninth nationally for power generation from other biomass sources:

Table 21: Top Five States - Electricity Generation from Other Biomass

Nationwide Rank	State	2008 Generation from Other Biomass(Megawatt Hours)[25]
1st	California	2,361,946
2nd	Florida	2,334,127
3rd	New York	1,512,860
4th	Pennsylvania	1,416,201
5th	Massachusetts	1,129,046
9th	**Michigan**	**739,537**

Regionally, Michigan ranks second, just behind Minnesota, for power generated from other biomass sources.

[23] DOE, EIA, "State Data for Reserves and Supply," 2008.
[24] DOE, EIA, "State Data for Reserves and Supply," 2008.
[25] DOE, EIA, "State Data for Reserves and Supply," 2008.

Table 22: Regional Electricity Generation from Other Biomass

Regional Rank	State	2008 Generation from Other Biomass (Megawatt Hours)[26]
1st	Minnesota	771,042
2nd	**Michigan**	**739,537**
3rd	Illinois	697,370
4th	Wisconsin	491,754
5th	Indiana	273,038
6th	Ohio	190,175

Total Electric Consumption:
Total electric power consumption is a rough indication of total bioenergy market potential within a state. Nationally, Michigan is ranked 12th in terms of total electricity consumption.

Table 23: Top Five States - Electricity Consumption

Nationwide Rank	State	Total Electric Power Consumption, 2007 (Trillion Btu)
1st	Texas	3,628.90
2nd	Pennsylvania	2,269.20
3rd	Illinois	2,073.70
4th	Florida	2,052.40
5th	California	1,975.60
12th	**Michigan**	**1,214.20**

In the region, Michigan ranks fourth.

Table 24: Regional Electricity Consumption

Regional Rank	State	Total Electric Power Consumption, 2007 (Trillion Btu)
1st	Illinois	2,073.70
2nd	Ohio	1,572.40
3rd	Indiana	1,317.60
4th	**Michigan**	**1,214.20**
5th	Wisconsin	647.1
6th	Minnesota	588.7

PUBLIC POLICY

Public policies play a significant role in either supporting or thwarting the bioeconomy – at both the national and state level. Policies that provide tax production credits, renewable energy/renewable fuel mandates, incentives for biofuel stations/pumps, or consumer incentives all can have a significant impact on whether and how fast the bioeconomy grows. The Product Center and Shepherd Advisors compared the Great Lakes states' policy support for growing the bioeconomy to evaluate the relationship between these policies

[26] DOE, EIA, "State Data for Reserves and Supply," 2008.

and strong bioeconomy. This analysis focuses on renewable energy portfolio standards and renewable fuel standards and incentives.

Renewable Portfolio Standards (also known as Renewable Energy Standards):
Currently 24 states have renewable portfolio standards and five other states have non-binding renewable energy goals. Bioenergy is a form of renewable energy that can help meet these renewable energy requirements. The target renewable energy goal and the time period to reach that goal vary by state so it is difficult to directly compare the programs. For the purposes of this comparison, we have estimated the total megawatt hours (MWH) of energy needed to meet the goal based on 2008 retail electricity sales.

Below are the top states based on the criteria outlined above. This includes all forms of renewable energy, not just biobased energy. Based on this calculation, Michigan ranks seventeenth nationwide in terms of total MWH of renewable energy that will be achieved under the renewable portfolio standard mandates.

Table 25: Top Five Sates - Mandated Renewable Energy (RE) Market

Nationwide Rank	State	Target	Year	Estimated Mandated Renewable MWH
1st	California	33 percent	2020	88,491,222
2nd	Ohio	25 percent	2025	39,847,202
3rd	Illinois	25 percent	2025	36,154,979
4th	New York	24 percent	2013	34,572,705
5th	Pennsylvania	18 percent	2020	27,072,106
17th	**Michigan**	**10 percent**	**2015**	**10,578,127**

Regionally, Michigan ranks fourth, but Indiana does not have a renewable portfolio standard enacted.

Table 26: Regional Mandated Renewable Energy (RE) Market

Regional Rank	State	Target	Year	Estimated Mandated Renewable MWH
1st	Ohio	25 percent	2025	39,847,202
2nd	Illinois	25 percent	2025	36,154,979
3rd	Minnesota	25 percent	2025	17,197,904
4th	**Michigan**	**10 percent**	**2015**	**10,578,127**
5th	Wisconsin	10 percent	2015	7,012,183
6th	Indiana	0 percent		-

Renewable Fuel Standards and Incentives:
According to the DOE, 12 states have renewable fuel standards in addition to the federal mandate. However, state policies also support biofuel markets through producer and retailer incentives and state fleet requirements. Similar to the renewable portfolio standards, state-level renewable fuel policies vary vastly among states. Table 27 below provides a summary of some of the types of policies in the Great Lakes region.

Table 27: Regional Biofuel Policies

	Renewable Fuel Policies[27]			
	Producer Incentive/Grant Funds	Retailer/Infrastructure Incentives for Ethanol Blends and E85	State RFS	State Fleet Fuel Purchase/Use Requirement
Illinois		X		
Indiana	X	X		X
Michigan		X		
Minnesota	X	X	X	X
Ohio		X		X
Wisconsin		X		

Minnesota has the strongest policies in the region, which is highlighted by the state's very high, per capita consumption of biofuels.

PUBLIC INVESTMENTS

In recent years, federal funding of bioeconomy-related projects has increased, as agencies such as the the departments of Energy and Agriculture and the National Science Foundation (NSF) have continued to prioritize research, commercialization, and deployment of bioeconomy technologies and programs.

National Science Foundation Funding:
Below is a ranking of states that received the most funding from 2005 to 2009 from the NSF. Michigan ranks ninth nationally for total NSF science and technology funding.

Table 28: Top Five States Receiving NSF Funding – by total NSF Funding from 2005 to 2009

Nationwide Rank	State	NSF Funding from 2005 to 2009[28]	10 year average funding per year
1st	California	$4,446,863,000	$790,842,000
2nd	Virginia	$2,154,624,000	$361,438,800
3rd	New York	$2,128,589,000	$383,958,300
4th	Massachusetts	$2,064,916,000	$371,763,300
5th	Colorado	$1,407,116,000	$254,692,200
9th	**Michigan**	**$886,702,000**	**$157,681,800**

Michigan ranks second in the region for NSF funding.

[27] Renewable Fuels Association, State Programs
[28] National Science Foundation, "Funding by State: 2000-2009."

Table 29: Regional States Receiving NFS Funding – by total NSF Funding from 2005 to 2009

Regional Rank	State	NSF Funding from 2005 to 2009[29]	10 year average funding per year
1st	Illinois	$1,394,800,000	$248,285,100
2nd	**Michigan**	**$886,702,000**	**$157,681,800**
3rd	Wisconsin	$691,702,000	$117,653,500
4th	Indiana	$551,506,000	$93,800,000
5th	Ohio	$549,236,000	$95,529,400
6th	Minnesota	$399,935,000	$70,668,800

USDA Biomass Research and Development Grants:

The tables below list the top recipients of USDA Biomass R&D Grants from 2004 to 2008. Michigan ranks 22nd nationally for USDA Biomass R&D Grant Funding.

Table 30: Top Five States - USDA Biomass R&D Grants by Dollar Amount

National Rank	State	2004-2008: Five Year Total USDA Biomass R&D Grant Program Funding[30]	Number of Awards
1st	California	$5,713,277	6
2nd	Iowa	$5,615,877	3
3rd	North Carolina	$5,243,874	6
4th	Minnesota	$3,985,220	4
5th	Florida	$3,443,101	3
22nd	**Michigan**	**$776,616**	**2**

Regionally, Michigan places fifth with two awards during the time period.

Table 31: Regional USDA Biomass R&D Grants by Dollar Amount

Regional Rank	State	2004-2008: Five Year Total USDA Biomass R&D Grant Program Funding[31]	Number of Awards
1st	Minnesota	$3,985,220	4
2nd	Wisconsin	$2,000,000	1
3rd	Ohio	$1,709,065	2
4th	Illinois	$1,000,000	1
5th	**Michigan**	**$776,616**	**2**
6th	Indiana	$-	0

DOE R&D Funding:

The Department of Energy has invested an average of more than $4 billion annually from 2005 to 2009 in Energy Efficiency and Renewable Energy (EERE) and Office of Science

[29] National Science Foundation, "Funding by State: 2000-2009."
[30] USDA, Rural Development, "Business Programs Activity Report," FY2008.
[31] USDA, Rural Development, "Business Programs Activity Report," FY2008.

research and development programs.[32] The EERE program provides funding for basic and applied research in energy efficiency and renewable energy. The Office of Science is the largest supporter of physical science in the nation and funds basic research, national laboratories, and facilities. DOE funding for these programs is provided in aggregate, but is not published by state.

In 2009, the DOE allocated $16.7 billion of American Recovery and Reinvestment Act (ARRA) funding to EERE projects. Due to increased reporting requirements for the ARRA funds, these data are broken down by classification and by state. Of the $16.7 billion, $800 million was specifically for the biomass program. Below is a ranking of states that received funding in the following four categories:

- bioenergy research center capital equipment
- commercial scale biorefinery projects
- integrated biorefinery research expansion
- modify integrated biorefinery solicitation program for pilot and demonstration scale biorefineries

Table 32: Top Five States Receiving ARRA Biomass Funding

Nationwide Rank	State	Total ARRA Biomass Funding[33]
1st	California	$99,883,790
2nd	Colorado	$88,602,814
3rd	Mississippi	$81,134,686
4th	Florida	$74,344,074
5th	Illinois	$54,907,877
12th	**Michigan**	**$19,620,303**

Table 33: Regional ARRA Biomass Funding

Regional Rank	State	Total ARRA Biomass Funding[34]
1st	Illinois	$54,907,877
2nd	Ohio	$19,620,303
3rd	**Michigan**	**$17,970,187**
4th	Wisconsin	$4,099,000
5th	Minnesota	$12,643
6th	Indiana	$-

THE "MISSING" METRICS

There are three other key metrics that were envisioned to be part of this report -- employment, private investment, and innovation. Developing effective metrics to

[32] NSF, Division of Science Resources Statistics. 2010. Federal Funds for Research and Development: Fiscal Years 2007–09. Detailed Statistical Tables NSF 10-305. Arlington, VA.
[33] DOE, "ARRA Funding Metrics by State," As of April 9, 2010.
[34] DOE, "ARRA Funding Metrics by State," As of April 9, 2010.

accurately assess these three factors and their full economic impact is very difficult. These three factors are the ones about which public and private decision-makers would most like to have detailed information to support effective business and public policy development. Bioeconomy employment, private investment, and innovation are not here due to a lack of adequate data on these measures. The collecting, analyzing, and funding for these metrics needs to be addressed if Michigan's progress in the bioeconomy is to be tracked and encouraged.

Employment:
Job creation is a key driver for both political and societal support of the bioeconomy. Studies to date indicate that the bioeconomy offers broad job growth potential, particularly in rural regional economies. There are many reports available for job creation from clean energy or "green" jobs. Two examples considered for this report include the Renewable Energy Policy Project and The Clean Energy Economy. Neither is comprehensive nor, to our knowledge, specific to the entire bioeconomy, as defined in this report. Another factor not considered in these reports is the number of indirect jobs.

If we use Michigan's corn ethanol industry as an example, we can use IMPLAN, a standard economic impact software package, to generate estimates of direct and indirect employment impacts for an "other basic organic chemical manufacturing" company. This category includes ethanol plants. IMPLAN estimates that the economic impacts of an ethanol plant with $75 million in sales and a workforce of 35 people are $136.2 million in economic activity and a total employment impact of 305 jobs. This is only one industry example and there has been no work to apply this model to the numerous other bioeconomy sectors to get estimates of their economic impact on Michigan. Nor has there been any definitive data collection on actual jobs created throughout Michigan's bioeconomy.

Private Investment:
The amount of money that private investors are willing to invest in an industry or a technology is indicative of growth potential. There are several reports regarding venture capital investment, which generally lumps the bioeconomy in with biotechnology or with energy. Additionally, research and development investment in bioeconomy technologies by public companies is not published. Therefore, it is difficult to discern private investment in the bioeconomy.

Furthermore, private investors currently are wary of the bioeconomy. In the last five years, some investors lost money on investments in biofuels, primarily a result of the recession and low gas prices. Also, biofuels and bioelectricity do not require much intellectual property, a requirement for many investors. Finally, the biofuel markets are still dependent on government incentives. The biodiesel subsidy, for example, expired in February 2010. Since that time, many biodiesel companies have ceased operations.

The development of a confidential way to gather and report the private investment numbers for the state would be most helpful in tracking the industry's growth and assessing its potential contribution to the state's future.

Innovation:
Finally, the key to continued success in the bioeconomy is technological advancements that make biobased products equal to or better than traditional products in both quality and price. Innovation and research and development are critical to this industry. To measure innovation, we looked at both patents and entrepreneurial activity, but again, neither could be broken down specifically enough to indicate activity in the bioeconomy. Additionally, the bioeconomy, unlike other sectors (medical or electronics for example), does not generate many new patents. Furthermore, the innovation necessary to launch rapid growth in the bioeconomy revolves around types of plants, growth of plants, and "bugs," the bacteria required to breakdown cell walls to allow access to the sugars in plants. This knowledge spurs innovation but does not always lead to new patents. As a result, tracking innovation in the bioeconomy is quite difficult, but it needs to be done if effective public and private strategies are to emerge and be encouraged.

The Potential and Limits to Better Measurement:
In addition to the reasons listed above, measuring the economic impacts and employment aspects of the bioeconomy is complicated by the subtle products and interrelated supply chains of the bioeconomy. For example, the Ford Motor Company is increasing its participation in the bioeconomy through initiatives such as:

- Using 40 percent soy polyurethane foam in the seat cushions and setbacks of the 2011 Ford Explorer and using soy polyurethane foam in versions of the Taurus, the Mustang, the F-150, the Focus, the Flex, the Escape, the Expedition, the Econoline van, and the Lincoln MKS and Navigator.

- Using wheat straw reinforced plastic for the third row storage bin in the Flex.

- Developing soy oil products to replace petroleum in rubber compounds for deflector shields and baffles, radiator deflector shields, cup holder inserts, and floor mats.

- Experimenting with the use of grape seed and sunflower oil as raw material in auto components.

From these examples, one can sense the growing economic impacts and potential of the bioeconomy. Yet, quantifying the specific investment, jobs, and rate of innovation of Ford's bioeconomy efforts, let alone the efforts of the larger automotive industry, are daunting and not readily available, particularly when the vast majority of these companies' revenues are from non-bioeconomy businesses.

Access to detailed and accurate information regarding employment, private investment, and innovation is imperative to tracking the progress of the bioeconomy, and public

organizations within government and/or academia must begin to gather, analyze, and make public this information.

CONCLUSIONS

The bioeconomy is very dynamic and will continue to be as it grows. For a state that is committed to succeeding in the bioeconomy, it is important to understand the key metrics and track progress toward growth goals.

In terms of biomass feedstock supply, Michigan is well-positioned to succeed. Currently ethanol comes primarily from corn; however, as the bioeconomy evolves, Michigan's diverse agricultural industry, vast timberland, as well as available cropland, give the state a strong competitive edge for growth in the bioeconomy. Michigan's temperate climate and fertile soil position it well in terms of crop yield and crop diversity.

Michigan's, and the region's, growing timberland stock is a key competitive advantage that positions the region very well. However, success will depend on technological advancements in bioeconomy areas such as woody biomass.

Additionally, the state is in the top quarter of consumers of energy, both in terms of electricity and motor fuel. As bioeconomy alternatives arise, there is great opportunity to substitute bioeconomy alternatives for imported fossil fuels.

Michigan also ranks highly in terms of ethanol consumption and biomass electricity production. Key state regulations and initiatives have greatly increased Michigan's ethanol consumption. In particular, Gov. Granholm strongly supported ethanol pumps and flexible fuel vehicles. Additionally, Michigan was the sixth state to ban MTBE oxygenate, which opened the door for ethanol blends. Continued policy support through actions such as a state fleet fuel requirements, state renewable fuel standards, or producer incentives will continue to drive consumption in Michigan.

As ethanol consumption increases in the state, Michigan could consider building additional capacity to produce more ethanol within the state, rather than importing more fuel into the state. Unlike some large corn-producing states, Michigan did not rush into developing corn ethanol production facilities. This smart production growth has helped the state's ethanol market weather the recent recession.

Michigan currently has a strong renewable portfolio standard through 2015; however most states have mandated growth beyond 2015. To remain competitive, Michigan will need to demonstrate a strong and growing renewable energy market beyond 2015. Michigan also has relatively fewer state incentives for renewable fuel compared to other states in the region.

Finally, investment and innovation are key factors affecting the size and rate of growth in the bioeconomy. Michigan needs a strong commitment to bioeconomy research and development to lead this industry's development.