MICHIGAN STATE UNIVERSITY

BAE Department of Biosystems and Agricultural Engineering

Waste Biomass Inventory to Support Renewable Energy Development

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Objectives

- Analyze completed inventories in the United States
  - Level of specificity
  - Sources considered
  - Presentation format
- Assist in developing a waste biomass inventory for the state of Michigan

Outline

- Common biomass conversion technologies
- Biomass feedstocks and blending
- Completed biomass inventories
- Potential energy analysis and examples
- Michigan biomass energy tool

Conversion Technologies

Anaerobic Digester

http://www.greenmeadowfarms.com/

Biodiesel Production

http://www.michiganbrewing.com

Gasification Plant

http://www.gobiomass.com/

Combustion

http://www.weis-environmental.com/

Ethanol Production

http://www.andersonsethanol.com/

Biomass Sources

Animal Manure

http://en.wikipedia.org/wiki/Manure

Crop Residues

http://www1.agric.gov.ab.ca/

Food Waste

http://garyhaq.wordpress.com/

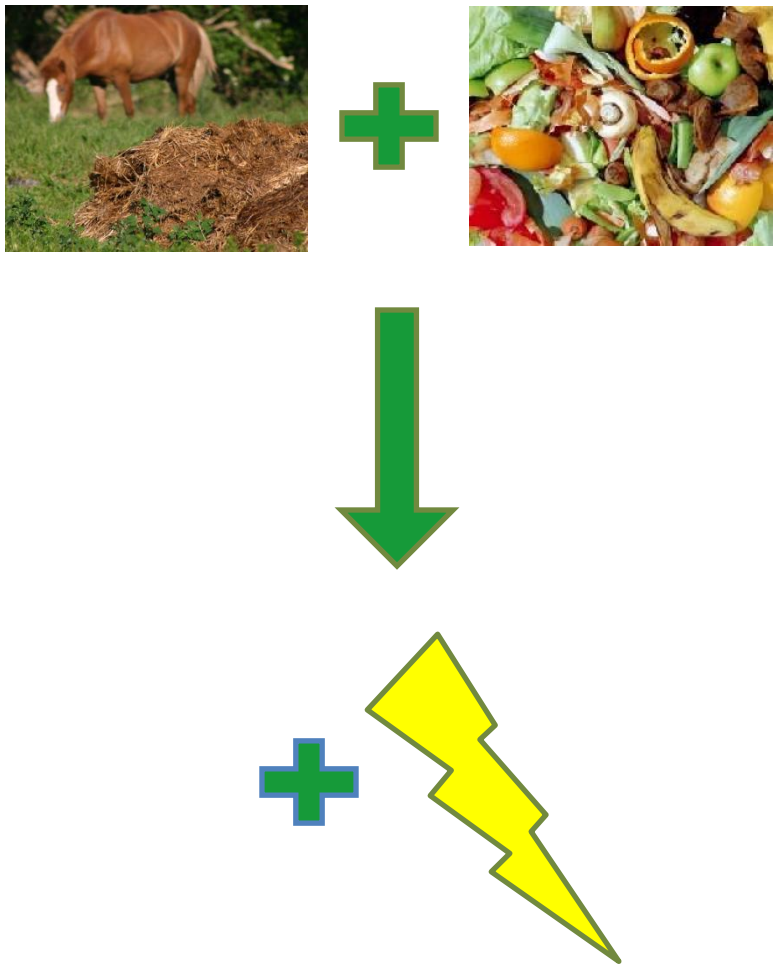
Food Processing Wastewater

http://www.ultraspin.com.au/

WWTP water

http://www.fmu-in.com/fmuweb/

Blending

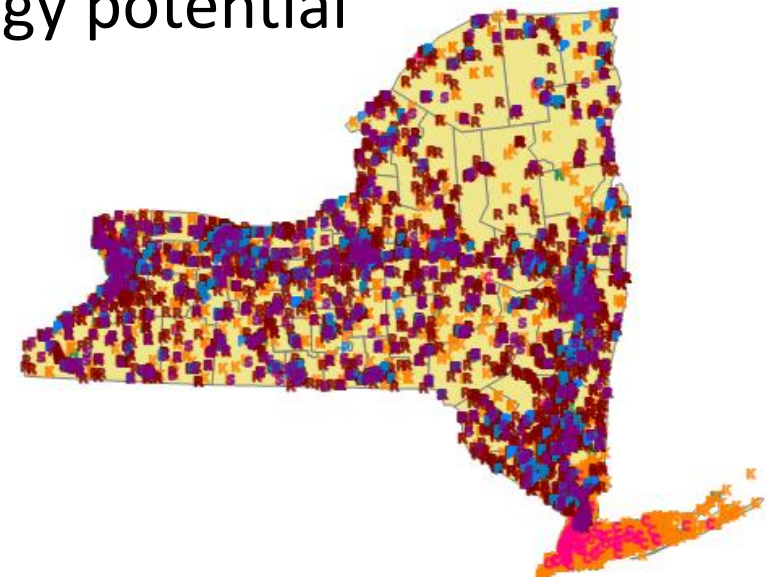


- Must have sufficient feedstock for a facility
- Optimize characteristics of feedstock
- Potential way to manage waste

Regional Biomass Inventories

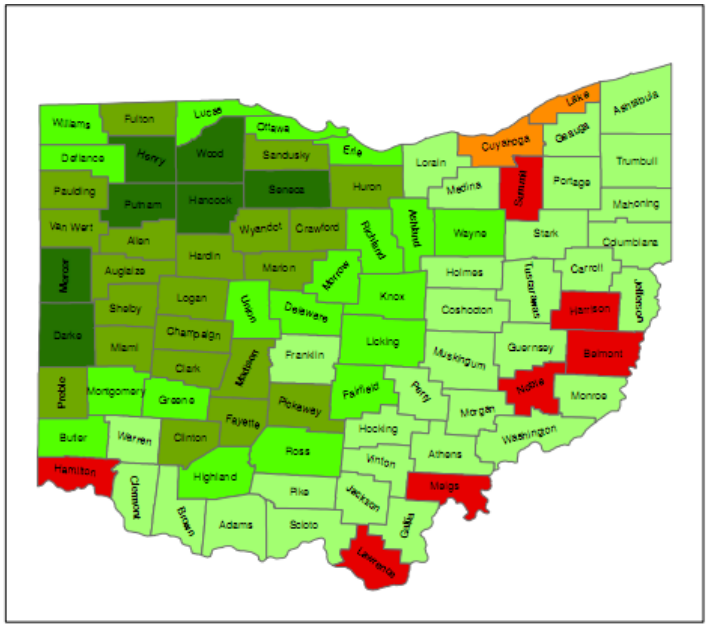
Locate sources of waste biomass and energy potential

- Map locations of biomass using geographic information system (GIS) software
- Understand characteristics
- Estimate energy potential



Turning Waste into Energy. Available at wastetoenergy.bee.cornell.edu/default.htm.

Ohio



Usable Crop Residues (Dry tons)

- Negative
- Data Not Disclosed
- 8 - 20,000
- 26,416 - 60,000
- 63,014 - 100,000
- 102,518 - 135,000

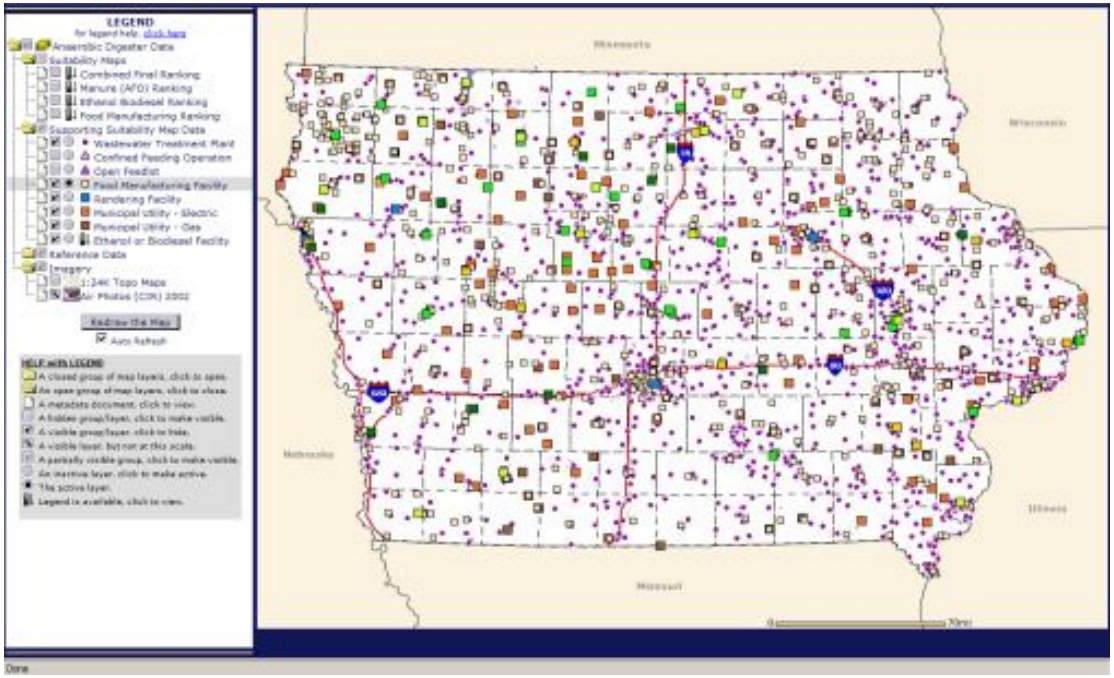
0 12.5 25 50 75 100
Miles

- Mapped crop residues, wood residues, livestock manure and food processing wastes
- Presented gross amounts available by county

Jeanty, P. W., D. Warren, and F. Hitzhusen. 2004. Assessing Ohio's biomass resources for energy potential using GIS.

Iowa

- Mapped wastewater treatment plants, confined animal feeding operations (CAFOs), open feedlots, food manufacturing facilities, and rendering facilities
- Shows exact locations
- Presented in an interactive GIS format online



Iowa Anaerobic Digester Asset Mapping Tool. Des Moines, IA: Department of Natural Resources.

Potential Energy Analysis

Basic analysis

- Gross energy from amount of biomass available
- May not consider energy inputs
- Little or no user interaction/control of variables

Advanced Analysis

- Net energy for many technologies
- Takes into account energy inputs
- Presented in an interactive format, allowing the user to set certain parameters

Wyoming

- Basic analysis of energy available for anaerobic digestion and combustion
- Data reported at the county level
- No user control of variables

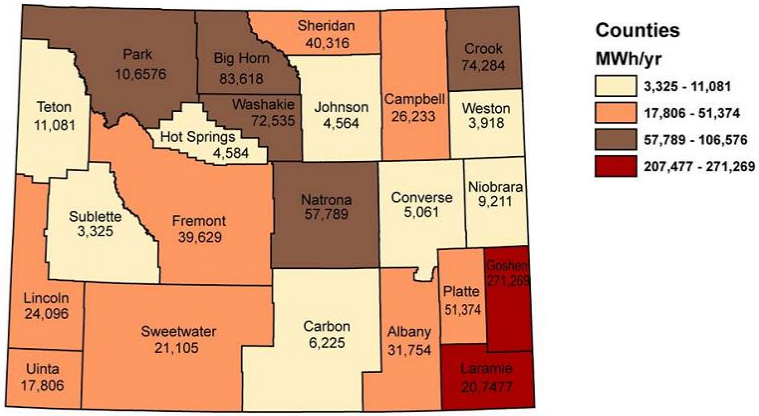


Table VII-1. Higher Heating Value (HHV) for Biomass [A.]

Biomass	HHV (Btu/lb)
Barley	7,441
Corn	7,587
Wheat	7,527
Other Field Crops	7,527
Paper	7,642
Wood Waste	8,304
Yard Waste	6,448
Mill Residue	8,597
Logging Residue	9,027

A. Higher heating value obtained from Frear et al, 2005 and CEC, 2004.

Wyoming Biomass Inventory. 2007. Cheyenne, WY: Wyoming State Forestry Division. Available at slf-web.state.wy.us/forestry.aspx.

New Jersey

- Considers 13 technologies
- Projects energy amounts out to year 2020
- Allows user control of variables

B3 | Direct Combustion-Co-Firing

	A	B	C	D
1				Total
2		Pick from Drop-Down Menu Below:	2007	
3	Choose Technology for Electricity Production:	Direct Combustion-Co-Firing	3,998,357	4,051
4	Choose Technology for Fuel Production:	Ethanol from Starch	24,519,681	24,519
5				
6			Current Gross Quantity (Dry Tons)	Current N Energy Availabl (MMBtu
7	FEEDSTOCK CATEGORIES	FEEDSTOCKS		
8	SUGARS/STARCHES	Energy crops - starch/sugar based		
9		Sorghum	8,410	NA
10		Rye	13,335	NA
11		Corn for Grain	201,376	NA
12		Wheat	42,767	NA
13		Processing Residues (waste sugars)	0	NA
14		*Subtotal*	*265,887*	
15				
16	LIGNOCELLULOSIC BIOMASS	Energy crops - lignocellulosic	0	
17		Agricultual crop residuals		
18		Sweet Corn	7,765	12
19		Rye	38,087	26
20		Corn for Grain	135,728	1,70
21		Corn for Silage	93,418	1,46
22		Alfalfa Hay	95,426	1,48
23		Other Hay	129,549	2,02
24		Wheat	42,752	55
25		Forestry Residues	938,100	7,31
26		Processing Residues (lignocellulosic)	97,193	1,58
27		Yard waste		
28		Brush/Tree Parts	278,765	4,93
29		Grass Clippings	49,003	76
30		Leaves	289,354	4,51

Instructions | Bioenergy Calculator | Bioenergy Production Estimates | Net Usable Assumptions | Energy Content Assumptions | Technology A

Ready

E78

	A	B	C	D	E
1	Energy Content Assumptions				
2	Feedstocks	Energy Content (HHV, Dry Basis)	% Dry Matter (as received)	Unit	Comments
3	Energy crops - starch/sugar based				
4	Sorghum				Not needed for calculations
5	Rye				Not needed for calculations
6	Corn for Grain				Not needed for calculations
7	Wheat				Not needed for calculations
8	Processing Residues (waste sugars)				
9	Energy crops - lignocellulosic	0	50%	Btu/lb	See Lines 64 and 65 for energy content. 50% dry matter per R
10	Agricultual crop residuals				
11	Sweet Corn	7866	85%	Btu/lb	http://www1.eere.energy.gov/biomass/feedstock_databases.html
12	Rye	7800	85%	Btu/lb	Argonne National Lab GREET model (Herbaceous Biomass)
13	Corn for Grain	7866	85%	Btu/lb	http://www1.eere.energy.gov/biomass/feedstock_databases.html
14	Corn for Silage	7866	35%	Btu/lb	http://www1.eere.energy.gov/biomass/feedstock_databases.html
15	Alfalfa Hay	7800	85%	Btu/lb	Argonne National Lab GREET model (Herbaceous Biomass)
16	Other Hay	7800	85%	Btu/lb	Argonne National Lab GREET model (Herbaceous Biomass)
17	Wheat	7481	85%	Btu/lb	http://www1.eere.energy.gov/biomass/feedstock_databases.html
18	Forestry Residues	7800	50%	Btu/lb	See Note (right corner)
19	Processing Residues (lignocellulosic)	8168	90%	Btu/lb	http://www.vt.tuwien.ac.at/biobib/biobib.html. Assumes dried for t
20	Yard waste				
21	Brush/Tree Parts	8850	50%	Btu/lb	Argonne National Lab GREET model (Woody Biomass)
22	Grass Clippings	7800	33%	Btu/lb	Argonne National Lab GREET model (Herbaceous Biomass)
23	Leaves	7800	33%	Btu/lb	Argonne National Lab GREET model (Herbaceous Biomass)
24	Stumps	8850	50%	Btu/lb	Argonne National Lab GREET model (Woody Biomass)
25	Solid wastes - Landfilled				
26	MSW (Landfilled biomass), net of waste paper and foo	7261	50%	Btu/lb	Heat Content and Moisture provided by NJAES and Biobib - http

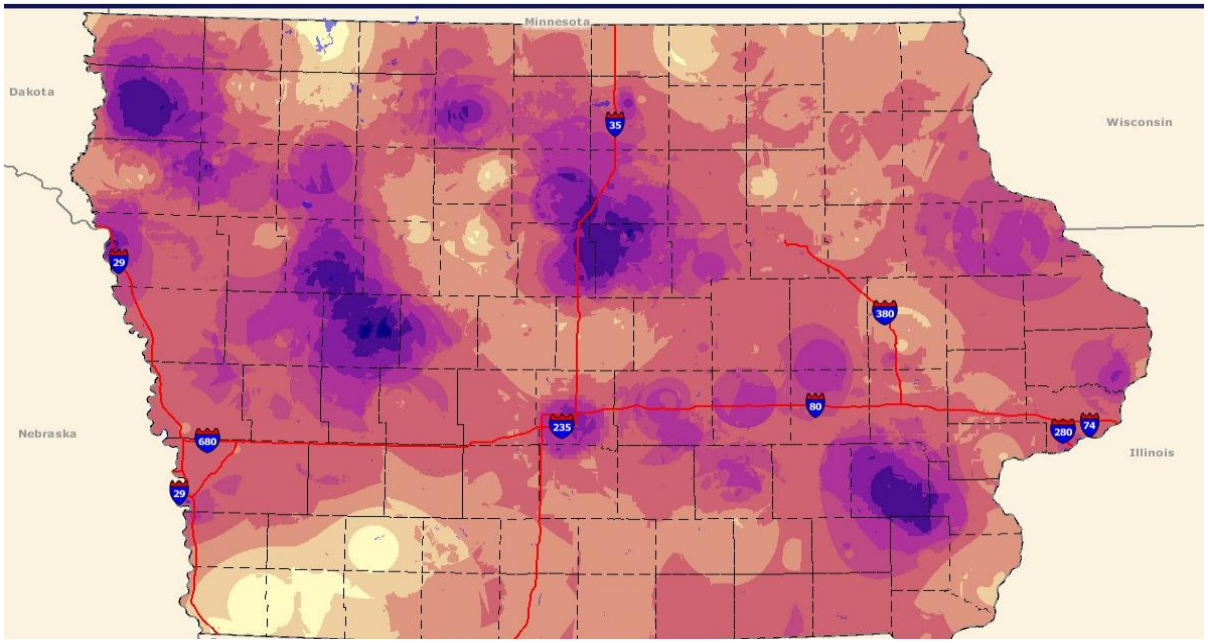
Instructions | Bioenergy Calculator | Bioenergy Production Estimates | Net Usable Assumptions | Energy Content Assumptions | Technology A

Ready

Assessment of biomass energy potential in New Jersey. Available at njaes.rutgers.edu/bioenergy

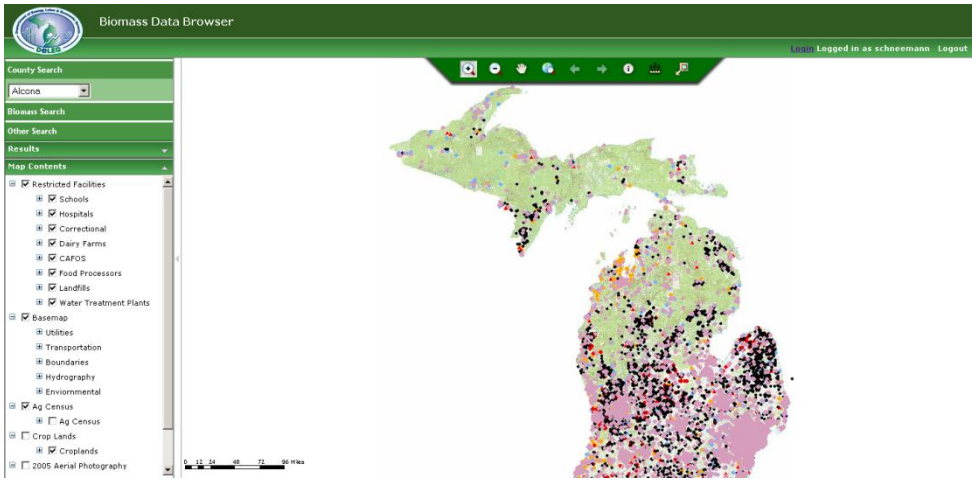
Iowa

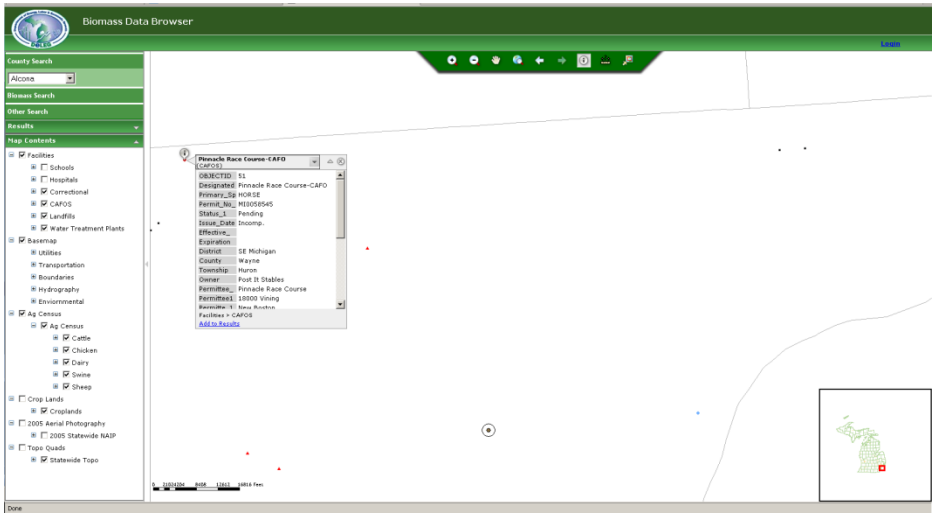
- Presented data as a “suitability layer”
- Good for seeing suitability of a certain site, without specific energy data



Iowa Anaerobic Digester Asset Mapping Tool. Available at www.iowadnr.gov/mapping/maps/digester.html.

Michigan





- Includes GIS layers showing specific locations of biomass
- User-interface shows energy potential at a specific location for each technology
- Considers 5 technologies

Waste Biomass Energy Inventory, MI Department of Labor and Economic Growth

Additional Features

- Factors in energy expended to convert biomass
- “Flags” for constraining features
- Allows the advanced user to specify most variables
- Complete transparency on calculations of energy inputs/outputs, assumptions made, and sources used

Conclusion

- Combining aspects of other studies done, an inventory and online GIS tool is in development by the state of Michigan
- This tool will be useful in high-level assessments of sites for biomass conversion facilities

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