Biomass Heating Feasibility Guide

PROJECT PARTNERS:

Daniel Friesen, Author

Southern MN Initiative Foundation/SW Clean Energy Resource Team

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From Idea to Reality

At AURI, we believe that implementing innovation takes:

- **good ideas, generated through applied research with our partners and regular meetings with our stakeholders,**
- **hands-on scientific technical assistance, and**
- **a strong resource network.**

In the end, all of these elements work together to generate economic impact by creating jobs and bringing income to the State of Minnesota.

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Why We're Here Today

Today we have some idea-generating research that we want to share with you.

- **Demonstrate opportunity for agricultural and forestry residues**
- **Build awareness of alternatives to fossil fuels**
- **Assist livestock and other agricultural producers to reduce heating costs and improve competitiveness**
- **Provide information to entrepreneurs and businesses to move ideas to reality**

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Why We're Here Today

Purpose-Outcomes

- Assessment of several biomass heating technologies and biomass fuels
- Demonstrate the economic feasibility of replacing high cost heating fuels such as propane with biomass heating systems
- Develop a tool (public domain) to assist those wishing to determine the feasibility of switching to biomass heating systems

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Author

Daniel Lepp Friesen, owner of DLF Consulting, has over 20 years of energy and management consulting experience.

Educational background includes:

- Master of Business Administration
- Bachelor of Science, Renewable Energy Engineering Technology
- Bachelor of Arts, International Development
- Professional Memberships:
  - Manitoba Environmental Industries Association
  - Building Energy Management Manitoba
  - 50by30.org – Energy Policy Initiative

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Executive Summary

- Focus: Greenhouses and Turkey Barns
- Biomass resources – agricultural and forestry
- Biomass fuel suppliers in Minnesota
- Biomass fuel handling examples
- Biomass heating system suppliers and products
- Biomass heating system components (Balance of System)
- Biomass heating system costs and financial implications
- Financial sensitivity analysis

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Executive Summary

	Facility: Greenhouse @ 22K ft2 or Turkey Barn @ 50K ft2					
	Combustor Size: 2 MMBtu/h					
	Fuel Form	**Pellet**	**Pellet**	**Woodchip**	**Bale**	**Bulk**
	Combustor	**Outdoor Air Heater**	**Outdoor Water Heater**	**Outdoor Water Heater**	**Indoor Water Heater**	**Indoor Water Heater**
1	**Fuel Type**	Wood Pellet	Wood Pellet	Woodchip	Baled Straw / Stover	Woodchips / Hogfuel / Biomass (loose stover)
2	**$ / Ton**	$ 175	$ 175	$ 75	$ 60	$ 60
3	**Moisture**	6%	6%	30%	15%	15 - 45%
4	**System Type**	Hot Air	Hot Water	Hot Water	Hot Water	Hot Water
5	**Combustor Cost**	$ 120,000	$ 165,000	$ 165,000	$ 165,000	$ 165,000
6	**Balance of System Cost**	$ 120,000	$ 105,000	$ 105,000	$ 320,000	$ 350,000
7	**Initial Costs**	$ 258,000	$ 290,000	$ 305,000	$ 532,000	$ 564,000
8	**Annual Costs**	$ 47,000	$ 47,000	$ 25,000	$ 28,000	$ 27,000
9	**Annual Savings**	$ 84,000	$ 147,000	$ 84,000	$ 84,000	$ 84,000
10	**Annual Debt**	$ 31,000	$ 35,000	$ 32,000	$ 55,000	$ 57,000
11	**Pre-tax Internal Rate of Return (equity)**	17.1%	13.0%	42.0%	11.1%	11.9%
12	**Net Present Value**	$ 95,000	$ 67,000	$ 280,000	$ 91,000	$ 112,000
13	**Simple Payback (Yr)**	8.2	9.1	5.2	9.6	9.3

	NOTES
1	The fuels listed cover the gamut of feedstocks reviewed in the report
2	Prices vary, however, those listed are based on supplier data from Minnesota in response to the request for proposal
3	Moisture is a key factor of any biomass fuel impacting storage, handling and boiler efficiency.
4	Heat generated can be used in a number of ways, e.g. Air heat can be converted, with efficiency losses to water heat, and vice
5	Costs based on an aggregated review of combustor information provided in response to the request for proposal
6	Costs cover what the rest of the system requires e.g. Pumps, controls, pipes, concrete, buildings etc.
7	Total of the lines 5 and 6 in addition to other expenses (such as 5% contingency cost). IMPORTANT: the bulk and bale systems require manual loading equipment which is not included in this price.
8	Includes fuel, operations and maintenance. For transportation add $2-3 per ton per mile.
9	Calculated based on what will be saved by NOT using propane @ $1.50 per gallon
10	Based on 75% of the project financed @ 6% over 10 years
11	Based on 2% inflation, 2% cost of fuel increase, 6% discount rate, 15 year project life
12	Present value of future discounted cash flows - if NPV is positive, the investment is worth examining
13	Amount of time for the project to pay for itself based on savings paying off the investment

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Biomass

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Biomass – this study

- **Forestry:** sawdust, woodchips, hogfuel, trimmings, cut logs and other industrial wood processing by-products, willows and other fast growing trees.
- **Agriculture:** crop residues, industrial residues, poultry litter, miscanthus and other grass crops.
- **Forms:** pellet, puck, cube, bale, bulk

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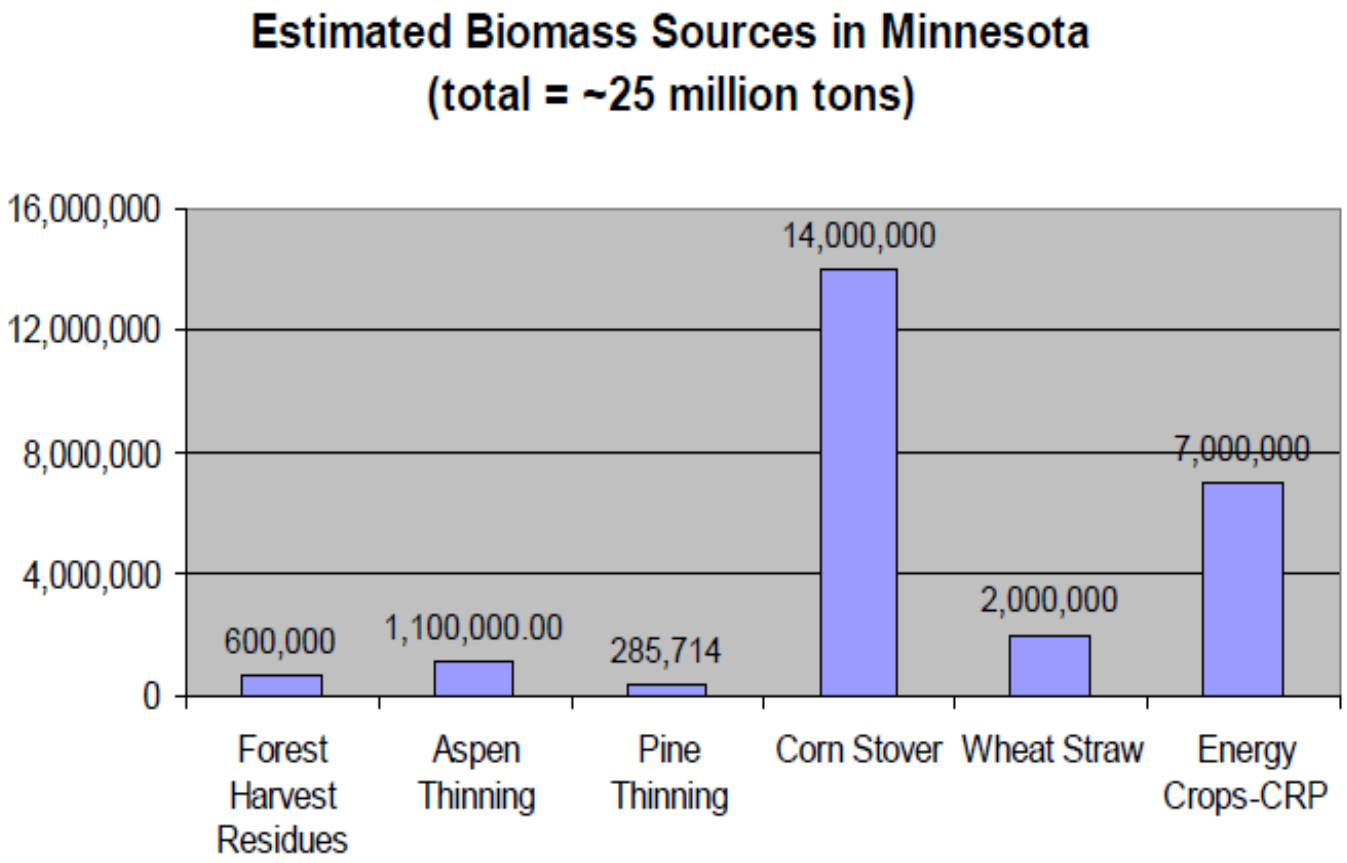
Minnesota Biomass



University of Minnesota Extension

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Minnesota Biomass

Availability of Biomass for Energy Production in Minnesota, Based on ONRL 1999 Study*

Resource	Quantity Available (000 dry tons/year)			Quantity Available Without Ag. Residues (000 dry tons/year)		
	<$30/t	<$40/t	<$50/t	<$30/t	<$40/t	<$50/t
Forest residues	468	682	875	468	682	875
Mill residues (wd)	71	916	1,121	71	916	1,121
Ag. residues	0	11,936	11,936			
Energy crop pot.	0	427	5,783	0	427	5,783
Urban wd waste	1,533	1,533	1,533	1,533	1,533	1,533
Total	2,072	15,494	21,248	2,072	3,558	9,312

*Walsh et al. 1999.

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	Average	Unit	Moisture	Sources
	Fossil Fuels			
Fuel Oil	18,015	Btu/lb	-	2
Coal	10,749	Btu/lb	-	2
Oil	18,355	Btu/lb	-	1
Natural Gas	100,000	Btu/therm	-	1
Propane	91,600	Btu/gal	-	1
Lignite coal	6,578	Btu/lb	-	1
	Wood			
Pellets	7,524	Btu/lb	8	2
Pile Wood	4,084	Btu/lb	-	2
Hardwood wood	8,469	Btu/lb	-	14,18
Softwood wood	8,560	Btu/lb	-	12,13,14,15,16,17
Softwood Chips	4,084	Btu/lb	50	2
Softwood Chips	6,535	Btu/lb	20	2
Forest S. Chips	5,718	Btu/lb	30	2
Forest H. Chips	5,718	Btu/lb	30	2
Sawdust Dry	8,000	Btu/lb	0	3,4
Sawdust Green	4,500	Btu/lb	50	5
	Animal Waste			
Manure	8,500	Btu/lb	0	6
Manure	4,200	Btu/lb	50	6
Poultry Litter	5,000	Btu/lb	25	7,8

	Average	Unit	Moisture	Sources
	Ag Crop Waste			
Straw Chopped	6,234	Btu/lb	15	2
Straw Big Bales	6,234	Btu/lb	15	2
Grass Pellets	6,879	Btu/lb	8	10,11
Corn stalks/stover	7,777	Btu/lb	-	12,13,17
Sugarcane bagasse	7,900	Btu/lb	-	12,13,17
Wheat straw	7,556	Btu/lb	-	12,13,17
Hulls, shells, pruning	7,825	Btu/lb	-	13,14
Fruit pits	9,475	Btu/lb	-	13,14
	Herbaceous Crops			
Miscanthus	8,100	Btu/lb	-	17
Switchgrass	7,994	Btu/lb	-	12,13,17
Switchgrass dry	7,750	Btu/lb	-	9
Other grasses	7,901	Btu/lb	-	17
Bamboo	8,330	Btu/lb	-	17
	Woody Crops			
Black locust	8,496	Btu/lb	-	12,17
Eucalyptus	8,303	Btu/lb	-	12,13,17
Hybrid poplar	8,337	Btu/lb	-	12,14,17
Willow	8,240	Btu/lb	-	13,14,17
	Urban Residues			
MSW	7,093	Btu/lb	-	13,17
Newspaper	9,014	Btu/lb	-	13,17
Corrugated paper	7,684	Btu/lb	-	13,17
Waxed cartons	11,732	Btu/lb	-	13

Greenhouses

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Greenhouses

	Large	Medium	Medium	Small
Total Greenhouse Area (ft2)	65,000 - 80,000	30,000 - 40,000	30,000 - 40,000	1,000 - 3,000
Fuel Production	On-site	Purchased	On-site	Purchased
Heat Storage	Yes	No	No	Yes
Type of Heating System	Fin/tube, under plant beds	Floor Heating, convection direct fire unit	Fin/tube, under plant beds, water/air fan convection	In-floor
Full/Part year Operation	Full Year	Part Year	Full Year	Part year
Heating Fuel (see note)	Biomass Pellets	Natural Gas / Propane	Straw bales	Biomass Pellet
Unit	Ton	Therm / Gal	Ton	Ton
Cost / Unit	$150 - $180	$0.65 / $1.50	$80 - $100	$150 - $200
Heating Cost / yr	$50,000 - $65,000	$30,000 / $100,000	$35,000 - $45,000	$3,000 - $5,000
Cost / ft2	$0.75 - $0.85	$0.65 / $3.00	$1.10 - $1.20	$1.70 - $2.00
MMBtu / yr	8,000 - 9,000	3,500 / 8,000	7,500 - 8,500	800 - 1,200
MMBtu / hr Heating Capacity	4 - 6	3 - 5	3 - 5	.4 - 1

Note: Heating Fuels listed do not include solar contribution.

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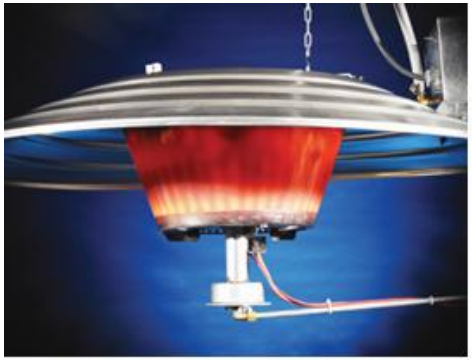
Turkey Barns



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Turkey Barns

	Large	Medium	Small
Barn Size (sf)	175,000 - 225,000	75,000 - 100,000	30,000 - 50,000
No. Barns	4 - 5	3 - 4	1 - 2
Ave Size ea (sf)	45,000 - 55,000	20,000 - 25,000	20,000 - 25,000
No. Turkeys per barn	25,000 - 30,000	20,000 - 25,000	20,000 - 25,000
Operation	Brooders, Hens, Toms	Brooders, Hens	Brooders
Heating Fuel	Propane	Propane	Natural Gas
Unit	Gallon	Gallon	Therm
Cost/Unit	$ 1.50	$ 1.75	$ 0.65
Heating Cost/yr	$150,000 - 175,000	$60,000 - 85,000	$25,000 - 35,000
Cost / ft2	$0.75 - $0.85	$0.80 - $0.95	$0.70 - $0.80
MMBtu / yr	8,000 - 8,500	4,000 - 5,500	1,500 - 3,000
MMBtu/hr Heating Capacity	24 - 28	6 - 10	2 - 4

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Biomass Use

Biomass Heating Fuels	Type of Feedstock	Processing	Handling Equip	Storage	Feed mechanism to Combustor
Pelletted or densified biomass	Forestry and Crop residues, Industrial byproducts	Grinding, Densification	Auger, Conveyor	Bin / Silo	Auger, Conveyor
Bulk biomass feedstock	Wood chips, Flax shives, Sunflower Hulls, Other		Loader	Enclosed barn/shed with loader access	Walking floor, Auger
Baled Feedstock	Corn Stover, Wheat Straw, Bean Straw, Canola Straw, Grasses	Bale Grinder / Slicer	Fork lift/crane	Barn/Shed	Walking floor, Bale conveyor

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Biomass Processing













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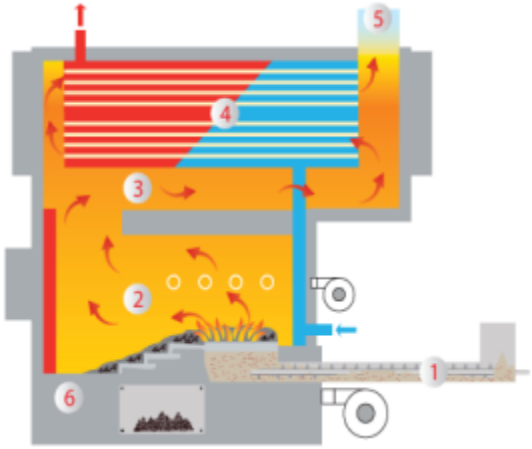
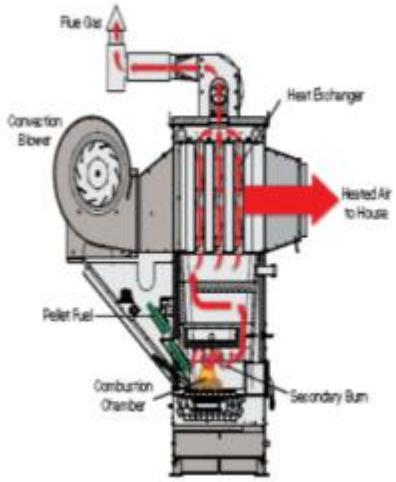
Biomass Heating Technologies



1. Screw Auger
2. Combustion Chamber
3. Post-combustion Chamber
4. Heat Exchanger
5. Flue Gas Exit
6. Ash Extraction



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Biomass Heating Unit Response

Company Name	Location	Contact	Combustor Size
Heartland Energy Systems	Minnesota	David Fiebelkorn	500k
LEI Products	Kentucky	Rick Jones	500k
Itasca Power Co	Minnesota	Dean Sedgewick	Custom; 5M
AFAB-USA: VanerTekno, OsbyParca	Sweden - US Dist	Dave McNertney	500k - 1M
Marth EarthWise / Wood Master	Wisconsin / Minnesota	Danny Gagner	500k - 5M
Blue Flame	Manitoba	Eugene Gala	Custom: 500k - 5M
Biomass Briquette Systems: LINKA	Denmark - US Dist	Dave Schmucker	500k - 5M

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Biomass Heating Units

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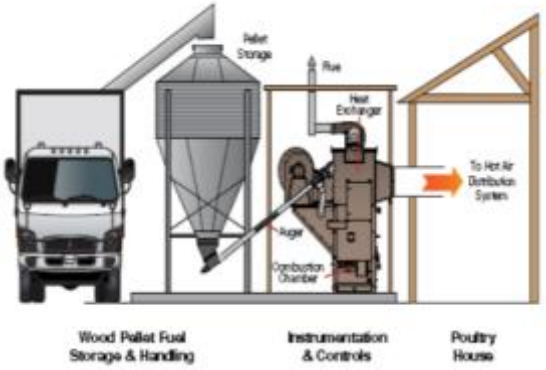
Combustor Unit Size	0 to 500kBtu	500kBtu to 2MMBtu	2MMBtu to 5MMBtu
# Units surveyed	9	7	7
Feedstocks	Wood chips, hog fuel, pellets, corn stover, sawdust, dirty "waste" chips, grass pellets, waxed cardboard, hay, straw, cubes, poultry litter	Wood Pellets, Straw, stover, wood chips, shavings, cubes, pucks, poultry litter	Hog fuel, Wood Pellets, Straw, stover, poutry litter, cubes, chips,
Output	Hot Air, Hot Water,Steam	Hot Air, Hot Water,Steam	Hot Air, Hot Water,Steam
Combustion Efficiencies	75% - 95%	76% - 95%	77% - 94%
Ash Handling Options	Manual or Automatic	Mostly Automatic	All Automatic
Emissions Options	Cyclone/Multi-Cyclone	Cyclone/Multi-Cyclone	Cyclone/Multi-Cyclone
Fire Suppression Options	Some offer automatic shutdown on heat overload	Some offer automatic shutdown on heat overload	Some offer automatic shutdown on heat overload
PC Remote Access	Most Include as Option	Most Include as Option	Most Include as Option
Installation Requirements	Some 3ph power (others require 220V Single Phase), Some require water or compressed air	All require 3ph power, Some require water, Some require compressed air	All require 3ph power, Most require water, Some require compressed air
Pricing: Average / Stnd Deviation*	$56k / $30k	$145k / $48k	$250k / $65k
Price per Btu*	$0.05 - $0.19	$0.05 - $0.09	$0.05 - $0.11
Units Suveyed	Heartland Energy Systems, LEI Products, AFAB-USA, Marth - Earth Wise, Biomass Briquette Systems, Woodmaster	AFAB-USA, Marth - Earth Wise, E-Mission Free, Biomass Briquette Systems, Woodmaster	Itasca Power Co., AFAB-USA, Marth - Earth Wise, Biomass Briquette Systems, Woodmaster
Components Included	Varies	Varies	Varies
* Outliers removed			

Balance of Systems



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Balance of Systems

Feasibility Study
Site Preparation
Engineering
Other legal, permitting fees
Combustor Building (may not be required)
Biomass Storage
    Bin/silo
    Building
Heat distribution
    Trenching
    Pipes
    Insulation
Controls
Intersection with existing heating system
Electrical and water service as required
Ash / Dust handling

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	Fuel Form	Pellet	Pellet	Woodchip	Bale	Bulk
	Combustor	Outdoor Air Heater	Outdoor Water Heater	Outdoor Water Heater	Indoor Water Heater	Indoor Water Heater
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2	$ / Ton	$ 175	$ 175	$ 75	$ 60	$ 60
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Questions:

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