Biomass Heating Feasibility Guide

Minnesota Renewable Energy Roundtable – Bemidji, MN

July 24, 2012

Project Partners: Southern MN Initiative Foundation, and SW Clean Energy Resource Team

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Biomass Heating Feasibility Guide

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Research 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 (energy prices)

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Analysis

Ag Biomass

Risk testing

Biomass Prices

Forestry Biomass

Greenhouses

Heating System Sizes

Heating System Types

Underground Pipes

Biomass Forms

Turkey Barns

Water heat

Air Heat

Financial Variables

System Components (Barns)

Inflation, Interest rates

	Facility: Greenhouse @ 22K ft2 or Turkey Barn @ 50K ft2					
	Combustor Size: 2 MMBtu/h					
	Fuel Form	**Pellet**	**Pellet**	**Woodchip**	**Bale**	**Bulk**
	Combustor	**Indoor 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	$ 84,000	$ 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
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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 versa
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
8	Includes fuel, operations and maintenance. For transportation add $2-3 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
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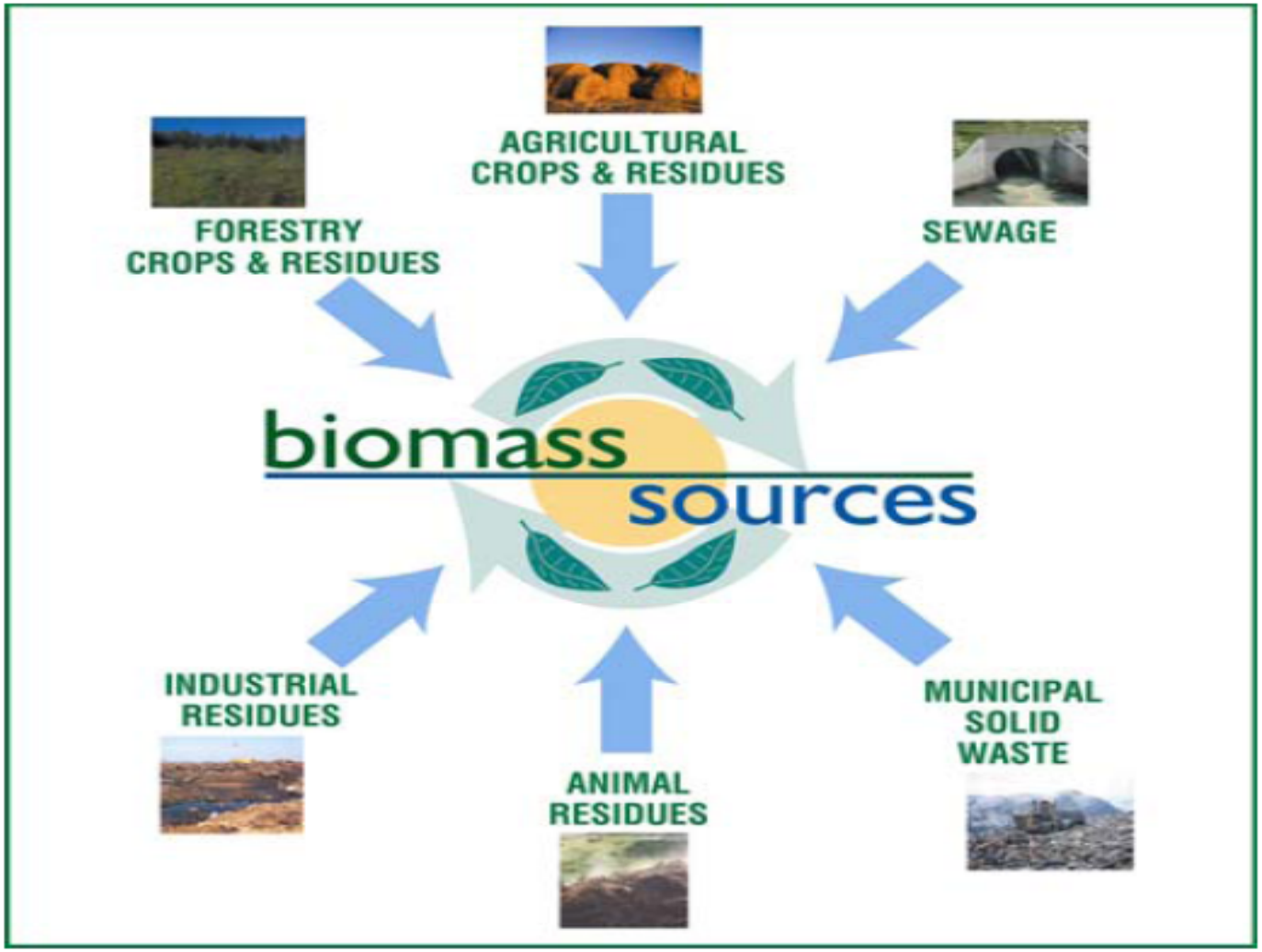
Biomass



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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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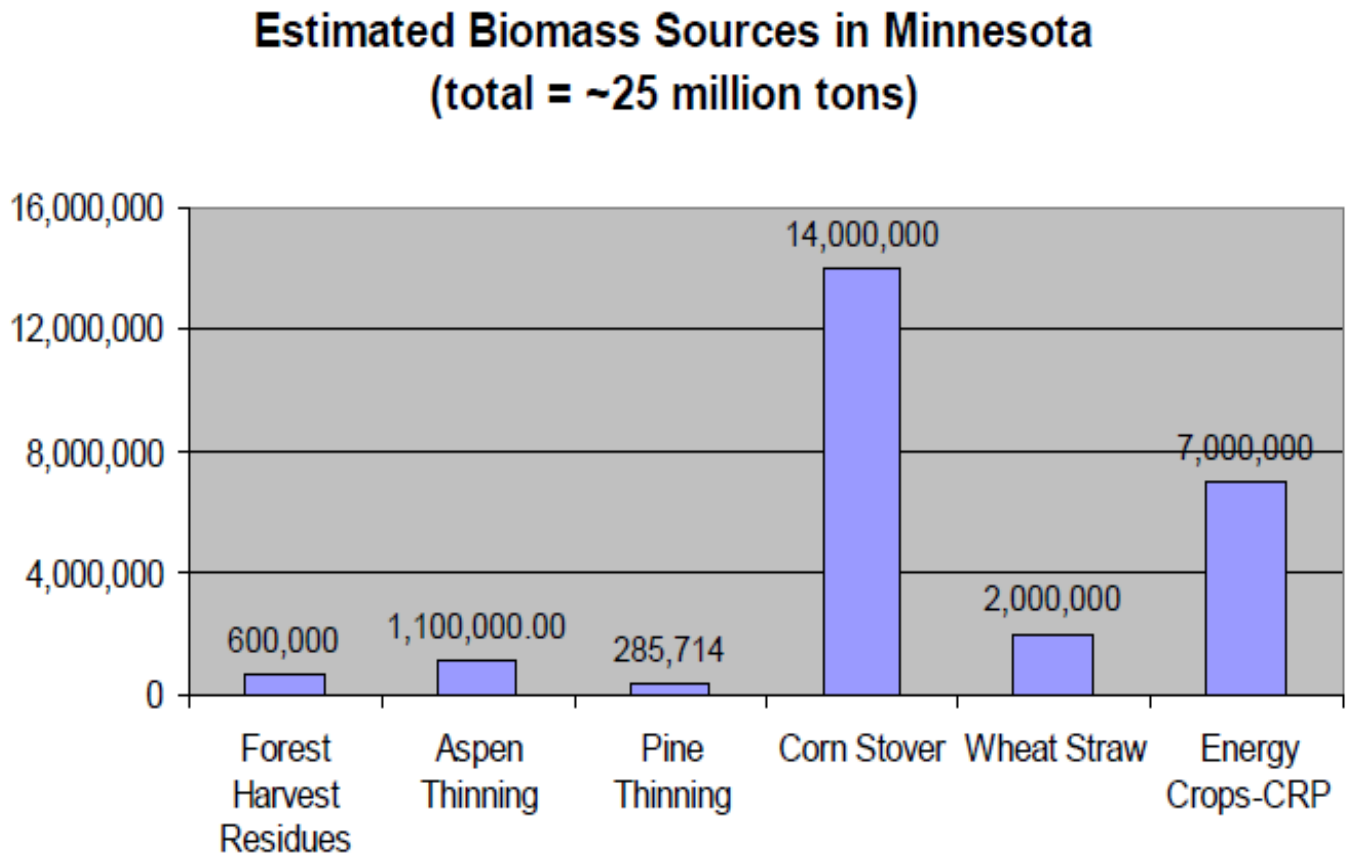
Minnesota Biomass



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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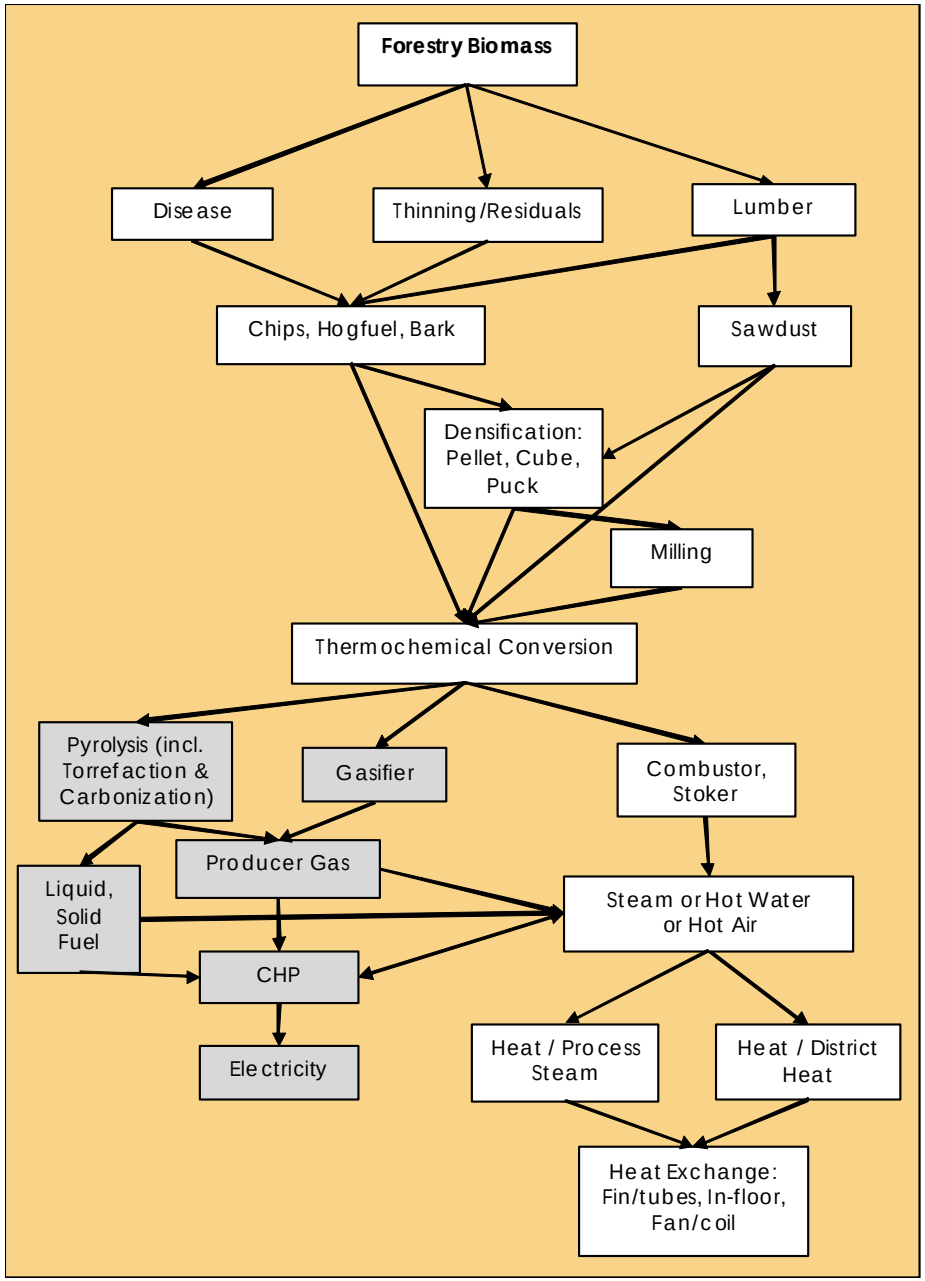

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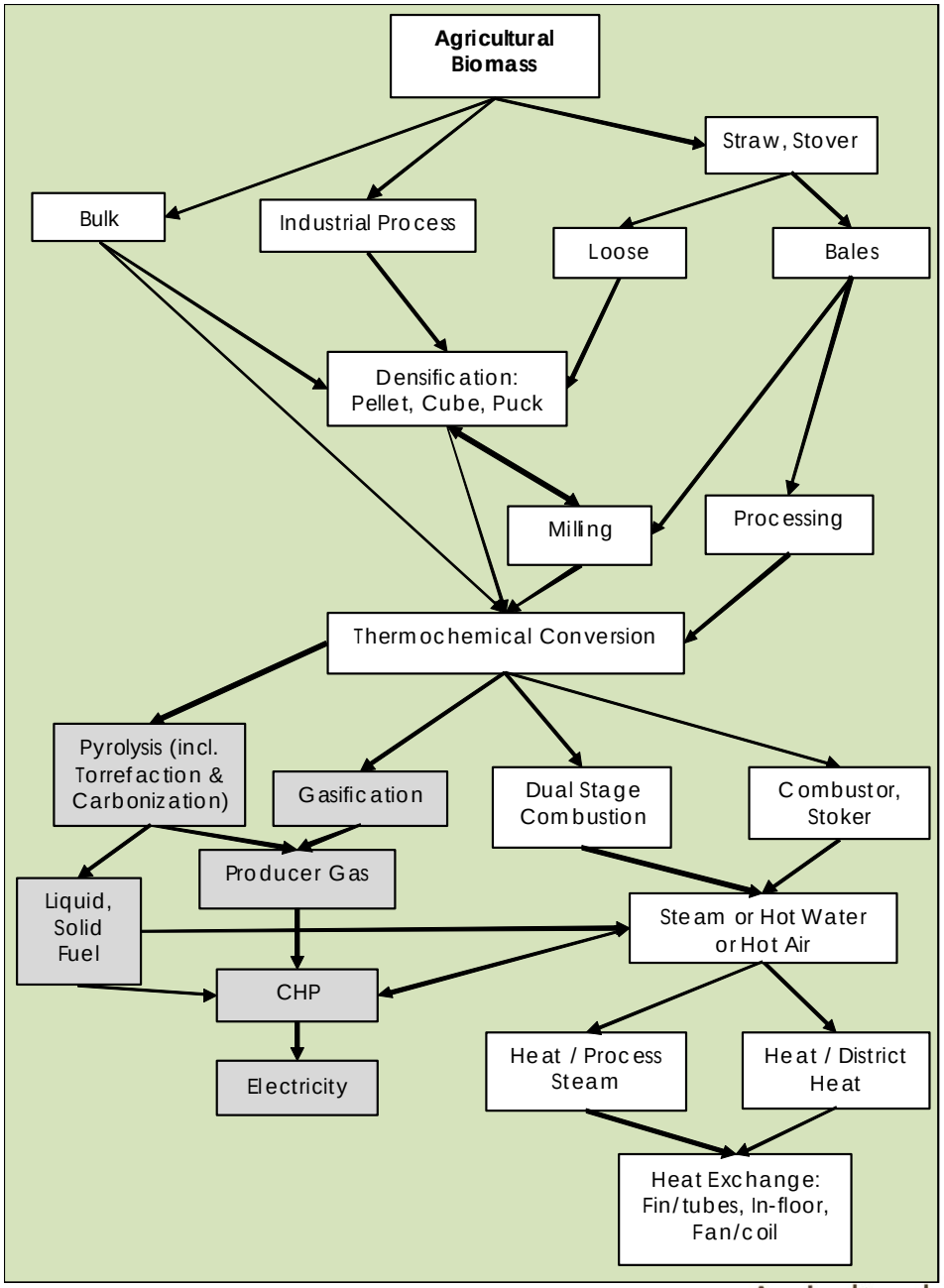

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	Average	Unit	Moisture	Sources		Average	Unit	Moisture	Sources
	Fossil Fuels					**Ag Crop Waste**			
Fuel Oil	18,015	Btu/lb	-	2	Straw Chopped	6,234	Btu/lb	15	2
Coal	10,749	Btu/lb	-	2	Straw Big Bales	6,234	Btu/lb	15	2
Oil	18,355	Btu/lb	-	1	Grass Pellets	6,879	Btu/lb	8	10,11
Natural Gas	100,000	Btu/therm	-	1	Corn stalks/stover	7,777	Btu/lb	-	12,13,17
Propane	91,600	Btu/gal	-	1	Sugarcane bagasse	7,900	Btu/lb	-	12,13,17
Lignite coal	6,578	Btu/lb	-	1	Wheat straw	7,556	Btu/lb	-	12,13,17
	Wood				Hulls, shells, pruning	7,825	Btu/lb	-	13,14
Pellets	7,524	Btu/lb	8	2	Fruit pits	9,475	Btu/lb	-	13,14
Pile Wood	4,084	Btu/lb	-	2		**Herbaceous Crops**			
Hardwood wood	8,469	Btu/lb	-	14,18	Miscanthus	8,100	Btu/lb	-	17
Softwood wood	8,560	Btu/lb	-	12,13,14,15,16,17	Switchgrass	7,994	Btu/lb	-	12,13,17
Softwood Chips	4,084	Btu/lb	50	2	Switchgrass dry	7,750	Btu/lb	-	9
Softwood Chips	6,535	Btu/lb	20	2	Other grasses	7,901	Btu/lb	-	17
Forest S. Chips	5,718	Btu/lb	30	2	Bamboo	8,330	Btu/lb	-	17
Forest H. Chips	5,718	Btu/lb	30	2		**Woody Crops**			
Sawdust Dry	8,000	Btu/lb	0	3,4	Black locust	8,496	Btu/lb	-	12,17
Sawdust Green	4,500	Btu/lb	50	5	Eucalyptus	8,303	Btu/lb	-	12,13,17
	Animal Waste				Hybrid poplar	8,337	Btu/lb	-	12,14,17
Manure	8,500	Btu/lb	0	6	Willow	8,240	Btu/lb	-	13,14,17
Manure	4,200	Btu/lb	50	6		**Urban Residues**			
Poultry Litter	5,000	Btu/lb	25	7,8	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

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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 Suppliers

Fuel Supplier	Location	Type of Fuel	Price per ton
Ever-Green Energy	Minneapolis	Woodchips	Sold only to St. Paul Dist Energy
MARTH	Marathon	Wood Pellets	$135 - 145
		Debarked woodchips	$55 - 65
Great Lakes Renewable Energy	Hayward	Wood Pellets	$145
Pork and Plant	Altura	Biomass Pellets	$150
Hedstrom Lumber	Grand Marais	Woodchips	$50
		Hogfuel	$20
Kotter & Smith	Deer River	Pellets	$165
		Woodchips - wet	$30-40
		Woodchips - dry	$50
		Hogfuel - wet	$25
Farmer supplied		Corn Stover bales	$70-80

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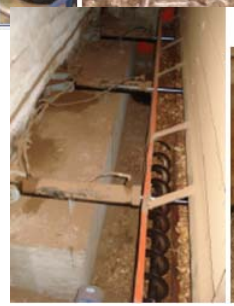
Biomass Processing







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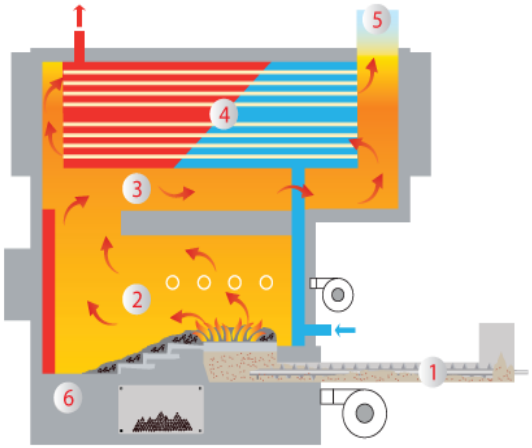
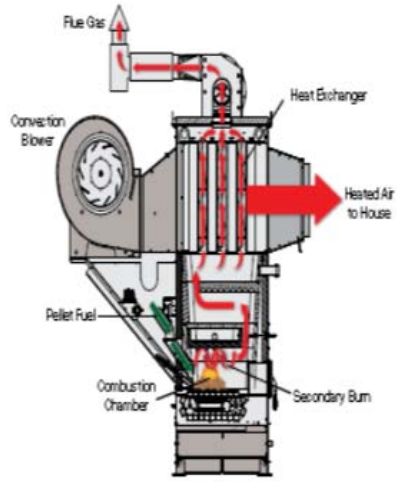
Biomass Heating Technologies



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

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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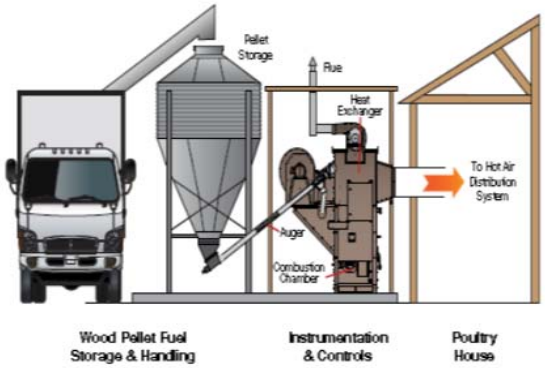
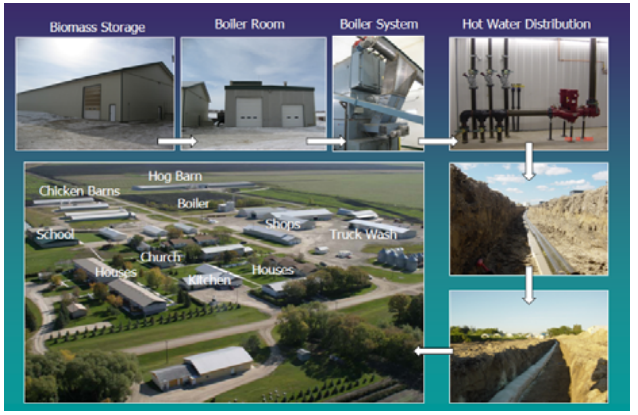
	Fuel Type	Propane - BASE CASE	Pellets		Woodchips	Bales	Bulk Biomass
	System		1	2	3	4	5
1	System Type	Forced Air, Radiant heat, Hot Water	Direct Air Heat	Hot Water (Air)	Hot Water (Air)	Hot Water (Air)	Hot Water (Air)
2	Fuel Production	Offsite	Offsite	Offsite	Offsite	Onsite	Offsite
3	Transportation	Long Distance	Long Distance	Long Distance	Long Distance	Short Distance	Long Distance
4	Fuel Storage	Tank	Bin / Silo	Bin / Silo	Bin / Silo	Building	Building
5	Combustor Building	Yes - small	No	No	No	Yes	Yes
6	Fuel Conveyance	Underground Pipes	Auger	Auger	Auger	Loading Required onto Bale Conveyor	Loading Required onto Walking Floor
7	Fuel Processing direcly prior to combustion	None	None	None	None	Slicing / Grinding, Rock / Metal detection	Rock / Metal detection
8	Heat Storage	None	None	Yes	Yes	Yes	Yes
9	Heat Conveyance	None - heat produced at place and time of need	Air ducting	Underground, Insulated Water Pipes	Underground, Insulated Water Pipes	Underground, Insulated Water Pipes	Underground, Insulated Water Pipes
10	Utilities	Electricity	Electricity	Electricity, Water, Air	Electricity, Water, Air	Electricity, Water, Air	Electricity, Water, Air
11	Ash / Dust storage	None	Limited	Cyclone/Auto/Bin	Cyclone/Auto/Bin	Cyclone/Auto/Bin	Cyclone/Auto/Bin
12	Additional Equipment Req	No	No	No	No	Yes - Fork Lift	Yes - Front End Loader

Balance of Systems





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Research Summary

- Minnesota has a wealth of biomass (>25M tons pa) and biomass heating experience
- Heating needs of agricultural industry can be supplied using biomass
- Minnesota has biomass handling and combustion manufacturing capacity
- Biomass system feasibility driven by costs and financing – challenged with low fossil fuel costs

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Research Summary (2)

- Economic benefit to Minnesota using local biomass resource and related industry
- Policy drivers and targets to encourage biomass heating would assist growth
- Biomass sustainability issues should be addressed
- Animal health considerations may play an important role in moving to biomass heat

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