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Factors to Consider when Selecting a Wood Burning Appliance

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Objective

- Types of wood fuels
- Types of Wood Burning Appliances
- Comparison of fuel/appliance types
- Firebox Management
- Resources

Wood Heating Appliances for Homes and Businesses

— Scott A. Sanford, David S. Lieb

Choosing the Right Equipment

January, 2014



Using wood as a heating fuel is ancient technology that is seeing increased popularity with the advent of modern wood heating appliances. Many people opt for wood, wood pellets and grains as low-cost alternative energy sources, especially during periods when energy prices rise.

The transition to wood appears higher for folks with access to woodlots. Using wood may be low-cost but it isn't free! It requires equipment such as chainsaws, splitters, trucks or trailers, and something very precious – time (see: Economics of Wood-burning Appliances, pg 10). Equipment cost, energy efficiency, and air quality health impacts are important factors in deciding whether or not, and how, to heat with wood.



This fact sheet describes what you should consider when contemplating using wood as a primary or secondary heating fuel for your home or business.

CONTENTS

Wood as Fuel	2
Types of Wood Fuels	3
Is My Wood Dry Enough?	3
Heat Potential of Different Fuels	5
Types of Wood-burning Appliances	6
Economics of Wood-burning Appliances	10
Smoke Impacts to Neighbors and Communities	13
Glossary of Terms	14
References and Links	15
Fuel Switching Work Sheet	16

Energy conservation first

Before making the switch to an alternative fuel, it may be wise to consider adopting or installing energy efficiency measures and practices in your home or business. These might include updating to a high-efficiency furnace or boiler (90 percent efficiency or greater), increasing attic and wall insulation, replacing single pane windows, and weatherizing to reduce air infiltration. These things will often give a better return on investment than heating with wood.

Who's heating with wood?

Approximately 200,000 (9 percent) of Wisconsin homes burn about 1.2 million cords of wood every year as either a primary or secondary fuel source (U.S. Energy Information Administration, <http://www.eia.gov>). While many combustion appliances are EPA-approved reduced-emission wood stoves, a substantial number are unregulated high-emission units, either because they pre-date regulation or are unregulated (e.g., outdoor wood boilers).

UWEX Fact Sheet

- 16 pages
- Available for FREE (PDF)
- <http://learningstore.uwex.edu/Assets/pdfs/GWQ066.pdf>

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Cord wood

- “Low cost” ???
- Labor intensive
 - Handle 3 to 6 times
- Harvesting
 - Cut, transport, split, pile/stack
- Air dry - Minimum 1 summer / 2 better
 - Plan requirements 1-2 yrs ahead
 - Less than 20% moisture to burn
- Refueling labor
- Ash disposal
- Energy content depends on species
 - All wood ~ 8000 Btu/lb. dry basis – Density varies
- High emissions – new regulations



Credit: JoAnn Sandberg

Burning Characteristics of Select Wood Species

Wood Species	Weight (lbs/cord)		Energy per dry cord (Million Btus)	Relative smoke emissions
	Green	Air dried		
Green Ash	4184	2880	20.0	Low
Birch	4312	2992	20.8	Medium
Boxelder	3589	2632	18.3	Medium
Cottonwood	4640	2272	15.8	Medium
American Elm	4456	2872	20.0	Medium
Black Locust	4616	4016	27.9	Low
Sugar/Rock Maple	4685	3680	25.5	Low
Silver Maple	3904	2752	19.0	Low
Bur Oak	4960	3768	26.2	Low
White Oak	5573	4200	29.1	Low
White Fir	3585	2104	14.6	Medium

Source: M. Kuhns & T. Schmidt, Heating with Wood, University of Nebraska-Extension

Wood Chips

- **For use in Wood Chip Boilers**
 - Chips metered into boiler to meet demand
- **Local availability**
 - Low cost
- **Moisture Content**
 - Green ~ 50% moisture
 - Lower energy content
 - 4500 Btu/lb
- **Bulk handling**
 - Auto Stoking
 - Conveyors / Loaders
- **Storage**
 - Outside pile, Bunker / covered



Source: NREL

Pellets / Briquettes

- Use of by-products / low value materials
 - Sawdust, wood chips, waste wood
- Uniform product
- Automatic stoking
- Low emissions / low smoke
- Reduces transportation costs
- Higher thermal efficiency – 80% to 90+%
- Bulk Handling – grain handling equipment & bins
- Higher cost / higher energy input



Pellets

- Unit of measure
 - Bulk in tons or 40-50 pound bags
- Moisture
 - 6 to 10% depending on grade
- Energy content
 - Average – 8000 Btu / lb
- Grades (Pellet Fuels Institute)
 - Utility, standard, premium, super premium
 - Difference is mainly ash content 6%, 2%, 1%, 0.5%
- Uniform product
 - 1/4” to 5/16” diameter x 1” to 1-1/2” long



Boilers (hydronic heater)

- One boiler to heat multiple locations
 - Pump heating fluid to needed location
- One system for floor heating and air heating
- Multiple boilers can be in central location
 - One fuel storage system
- Can be located outside
- Store heat - insulated tank
 - To meet peak needs
 - Allow continuous burn



Source: www.renewenergies.com

Furnaces

- Heats air directly
 - Reduces heat exchange losses
 - Air blown thru ducts to point of use
 - No water leaks to worry about
- Located in or adjacent to building
- May need multiple furnaces per building
 - Lower capacity
- Multiple furnaces → Multiple fuel storage bins
 - More labor to fill fuel hoppers



Source: www.tractorbynet.com

Outdoor Wood-Fired Boilers

- “Cheaper” Fuel? – What is the true cost?
 - Labor to re-fuel
- High Smoke emissions rate
- OWB types
 - Uncertified - efficiency range: 20 to 50% (40%)
 - EPA White tag – Efficiency 40 to 78% (64%)
- Fuel: cord wood, wood scrape materials, pallets
- Fuel with scrap materials?
 - NO Glue, NO paint, NO Chemical contamination
 - NO Pressure-Treated wood
- Increasing regulation due to smoke emissions
 - <http://www2.epa.gov/residential-wood-heaters/proposed-new-source-performance-standards-residential-wood-heaters>



Outdoor Wood Boiler Emissions

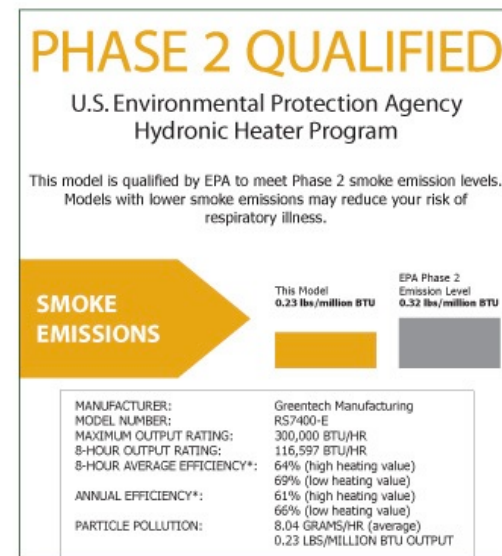


EPA Certified Outdoor Boilers

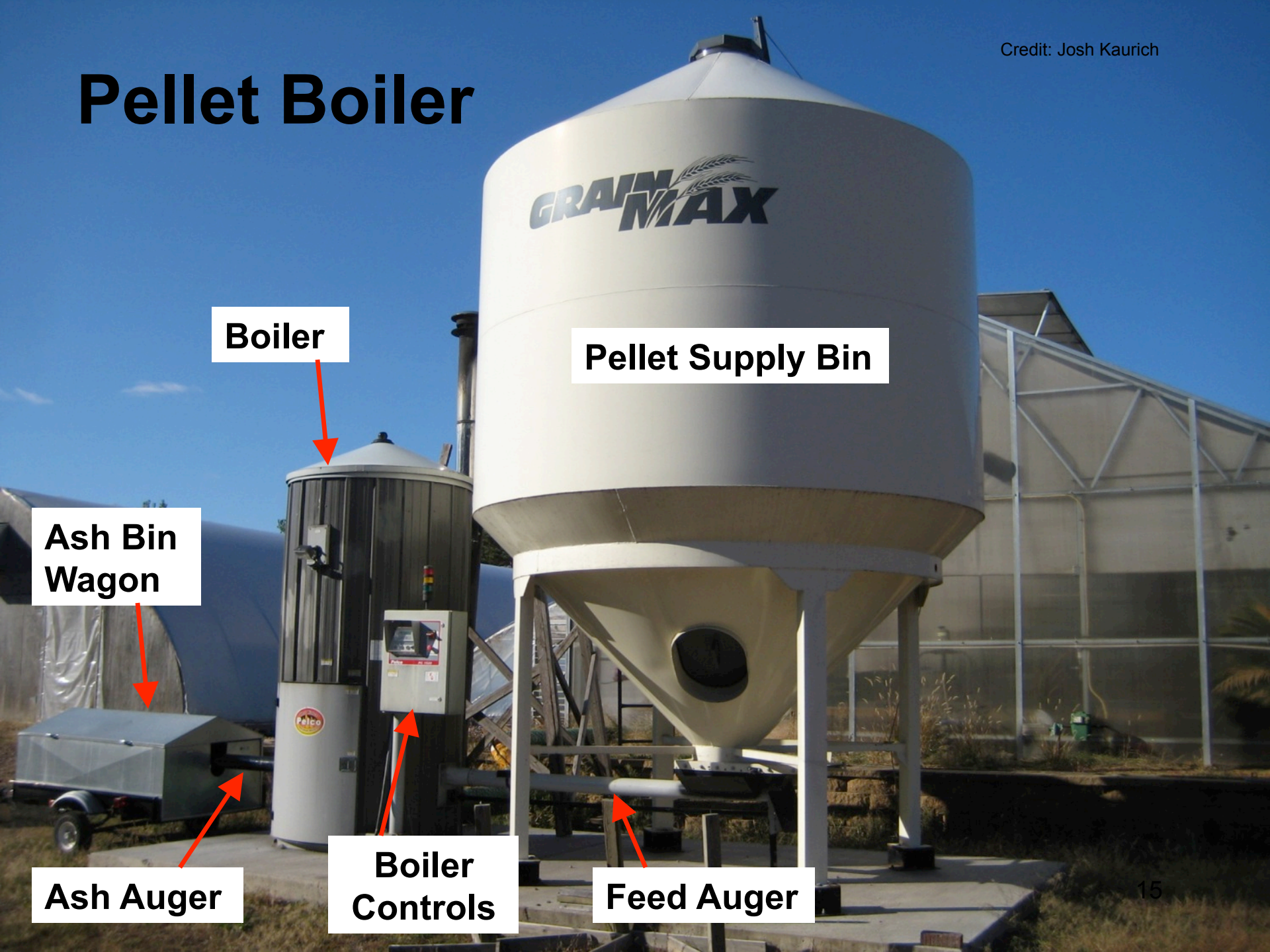
- EPA Voluntary Emissions Reduction Program
 - 90% lower emissions - < 0.32 lb/MBtu
- Low emissions \rightarrow higher efficiency
 - Average efficiency of qualifying cord wood boilers - $\sim 64\%$
- Some states restricted sales - EPA certified models
 - White tag / Phase 2
- EPA information
 - <http://www.epa.gov/burnwise/>

List of qualifying outdoor wood stoves

 - <http://www.epa.gov/burnwise/owhhlist.html>
- New EPA proposal
 - Emission from 0.32 to 0.06 lb/MBtu (2015)



Pellet Boiler



Boiler

Pellet Supply Bin

Ash Bin Wagon

Ash Auger

Boiler Controls

Feed Auger



Pellet furnace/boiler ~165,000 Btu

Wood Chip Boiler

- Suited for larger applications
- Higher capital investment
- Higher maintenance
- More moving parts
- Uses low cost fuel
- Labor to re-fill charge hoppers required daily
- Wood chips – 25 to 50% moisture
- Need storage for tractor trailer load++ of chips
- Availability of supply??
- Capacities ~ 300,000 Btu and greater



Source: www.danvillek12vt.org

Wood Chip Feed System

Storage bin with walking floor



Barron High School,
Barron, WI



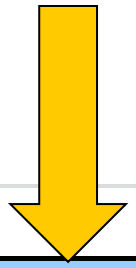
Stand Alone Stoves / Fireplace

- Advantage
 - Lower cost
 - Easy to install
 - Efficiency 63% - wood / 78% - pellet
 - Low smoke***
 - Supplemental heating
- Features to consider
 - Log length / hopper size (pellets)
 - Thermostatically controlled – prevent overheating (pellets)
 - Area to heat versus heat output
 - 10,000 to 70,000 Btu/hr
- Disadvantage
 - Heat distribution not optimal



List of EPA Certified stoves at
www.epa.gov/burnwise

Fuel Comparison



Fuel Type comparison - in order of cost (2013)					
Fuel Type	Energy content	Seasonal Efficiency (2)	Unit cost USD (4)	units	Cost per 1,000,000 Btu
Natural Gas	100000/therm	70-94% (90%)	0.80	Therm	\$8.89
Wood Chips	3780 (50%) - 6190 (25%) / lb	50 - 75% (70%)	50	ton (50%)	\$9.45
Wood Pellets	15400000 per ton	70-85% (80%)	190	ton	\$15.42
OWB EPA Phase 2 (1)	22,000,000 per cord (3)	64%	225	cord	\$15.98
Propane	92000	70-94% (90%)	2.10	gallon	\$25.36
OWB - uncertified (5)	22,000,000 per cord (3)	40%	225	cord	\$25.57
Corn	380,000 per bushel (@ 15% moisture)	70-85% (80%)	9.00	50#	\$29.61
Heating Oil	138000	70-85% (75%)	3.60	gallon	\$34.78
Electricity	3413 / kWh	100%	0.12	kWh	\$35.16

- 1) Meets EPA Phase 2 emissions requirement
- 2) (XX%) Efficiency value used to calculate "Cost per 1,000,000 Btu"
- 3) 6500 Btu/pound (20% moisture)
- 4) Fuel costs in Madison, WI for 2013-2014 heating season delivered to point of use. Does not include any storage costs
- 5) Uncertified outdoor wood-fired boiler (Does not meet EPA Phase 2 requirement)

Firebox Management

- **Only burn dry, seasoned firewood**
 - 20% moisture or less
 - Wet wood is a waste!
 - Smoke
 - Requires more wood
 - Lower firebox temperatures
 - Creosote Formation
 - 6" wedge or smaller
 - Don't burn trash, painted or treated wood
 - Foul odors / Toxic air pollutants

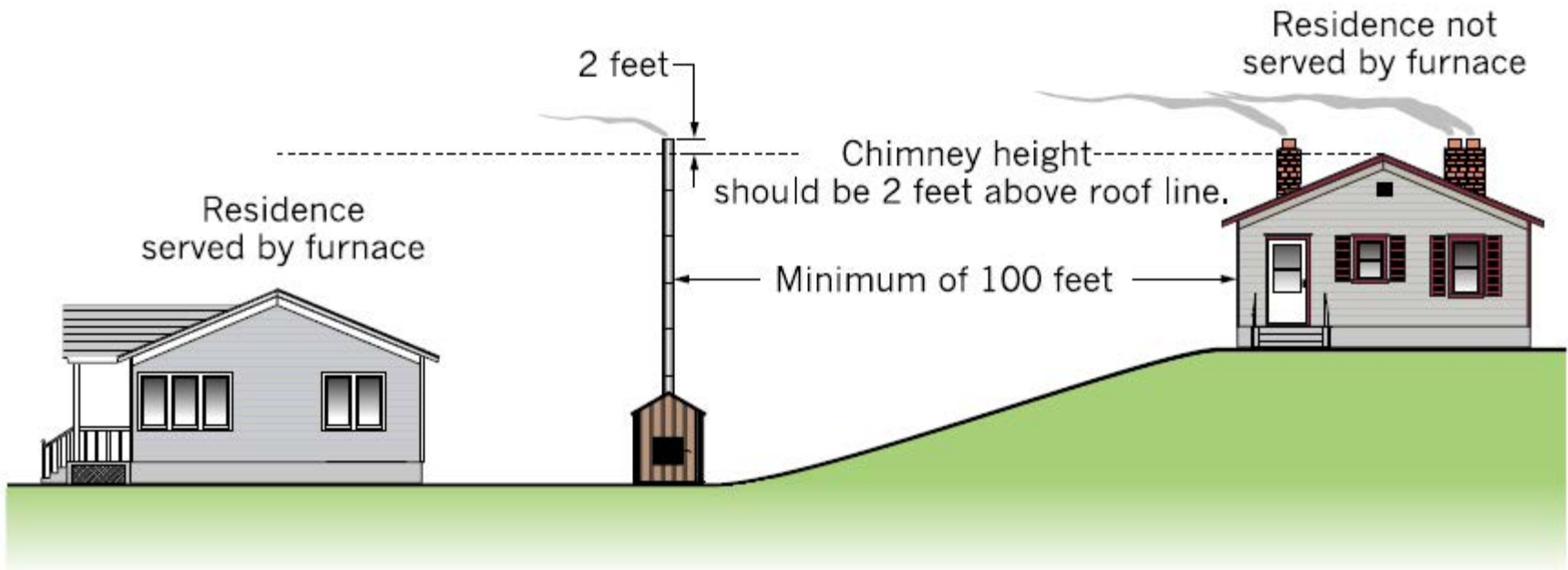


Firebox Management

- Don't overload firebox
 - Only enough for next 8-12 hours or less (OWB)
 - Smaller amounts reduces smoke potential
- Don't let fire smolder
 - Heat not needed – put out fire
- Clean ash pan regularly
 - Ash can obstruct air intake vents
 - Use metal containers for storing or transporting ash
- Clean chimney regularly
 - Reduce risk of chimney fires

Firebox Management

- Chimney height
 - 2 feet higher than highest building within 300 feet
 - Higher chimney – better draw – faster re-light



Summary

- Energy efficiency options First!
 - High Efficiency Furnace, insulation, windows
 - Better return on investment
- Purchase Efficient Appliances > 70%
- Look at complete economics of all options
 - Include labor, ownership, maintenance costs
 - Higher efficiency appliances sometimes cost more
- Firebox management – No/low smoke
- Burning wet wood is a waste! Don't use it.

Resources

- U of Wisconsin Extension Bulletins
 - Wood Heating Appliances for Home and Businesses, GWO066
 - Biomass Energy for Heating Greenhouses, A3907-04
 - Biomass Heating in Greenhouses: Case Studies, A3907-05
 - <http://learningstore.uwex.edu/Energy-Conservation-C29.aspx>
- Burn Wise program (EPA) - <http://www.epa.gov/burnwise/>
- Pellet Fuels Institute – www.pelletheat.org
 - Educational material, pellet manufacturers list
- Wood-Chip Heating Systems, T.M. Maker, Biomass Energy Resource Center, Montpelier, VT 2004.
 - <http://www.biomasscenter.org/pdfs/Wood-Chip-Heating-Guide.pdf>
- Biomass for combustion calculator
 - www.ruralenergy.wisc.edu/esa

Questions

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