

The Problems with Outdoor Wood-Fired Boilers (OWBs)

by

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Why are people concerned?

- ◆ Nuisance
- ◆ Health effects
- ◆ Local officials are reluctant to act without regulations



What is it we see there?

- ◆ Short stacks
- ◆ Visible emissions
- ◆ Nearby neighbors
- ◆ Questionable burning practices
 - Green wood?
 - Big pieces?
 - Tires?
 - Plastic?
 - Trash?
 - Waste oil?





Dirty

Wood smoke is a complex mixture of chemicals and particulates.

- ◆ Carbon monoxide and other organic gases,
- ◆ Particulate matter,
- ◆ Chemicals, and some inorganic gases.

Actual Monitoring Results

- ◆ Study looked at ambient levels at 50 to 150 feet away from the unit.
- ◆ Differences were seen between within one hour since fuel added to the OWB and 22 to 24 hours since fuel added.

	22-24 hr since last load			0-1 hr since last load		
PM2.5 15-s avg values ($\mu\text{g}/\text{m}^3$)	Damper open	Damper closed	Open and closed	Damper open	Damper closed	Open and closed
Minimum	1	2	1	24	26	24
Mean	118	110	115	838	118	416
Maximum	1092	1071	1092	8880	3328	8880
Sampling events	516	272	788	101	143	244

PM2.5 _{15-s} avg values ($\mu\text{g}/\text{m}^3$)	150 ft Damper open	150 ft Damper closed	130 ft Damper open	130 ft Damper closed
Minimum	17	16	1	2
Mean	130	133	92	134
Maximum	810	3328	1092	1025
Sampling events	200	136	160	36
Minutes	50	34	40	9



Uneconomical?

- Efficiency

- ◆ Conventional wood stoves
 - about 54 percent efficient (*potential BTUs in the fuel vs. BTUs radiated into home heat*)
- ◆ EPA-certified wood stoves
 - 68 to 72 percent efficient
- ◆ OWBs
 - 28 to 55 percent, with an average of 43 percent efficient
 - data obtained from manufacturers

Uneconomical?

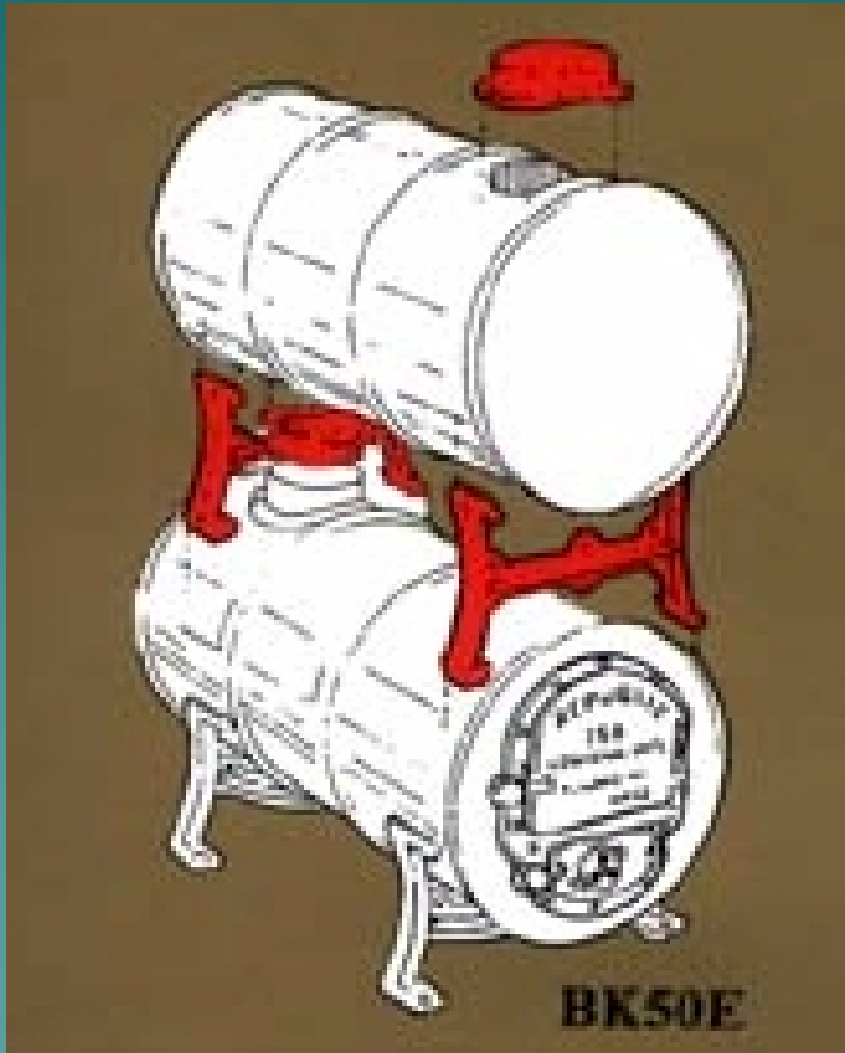
- Cost

- ◆ These units are being sold as economical and are more popular due to rising fossil fuel costs.
- ◆ May be economical depending on fuel used
 - Does not consider time and effort spent cutting wood or the amount of wood required; thereby making the burning of solid wastes attractive

Design

- ◆ Early stage of development; much like wood stoves were in the 1970's.
 - No controls
 - Primitive combustion chambers

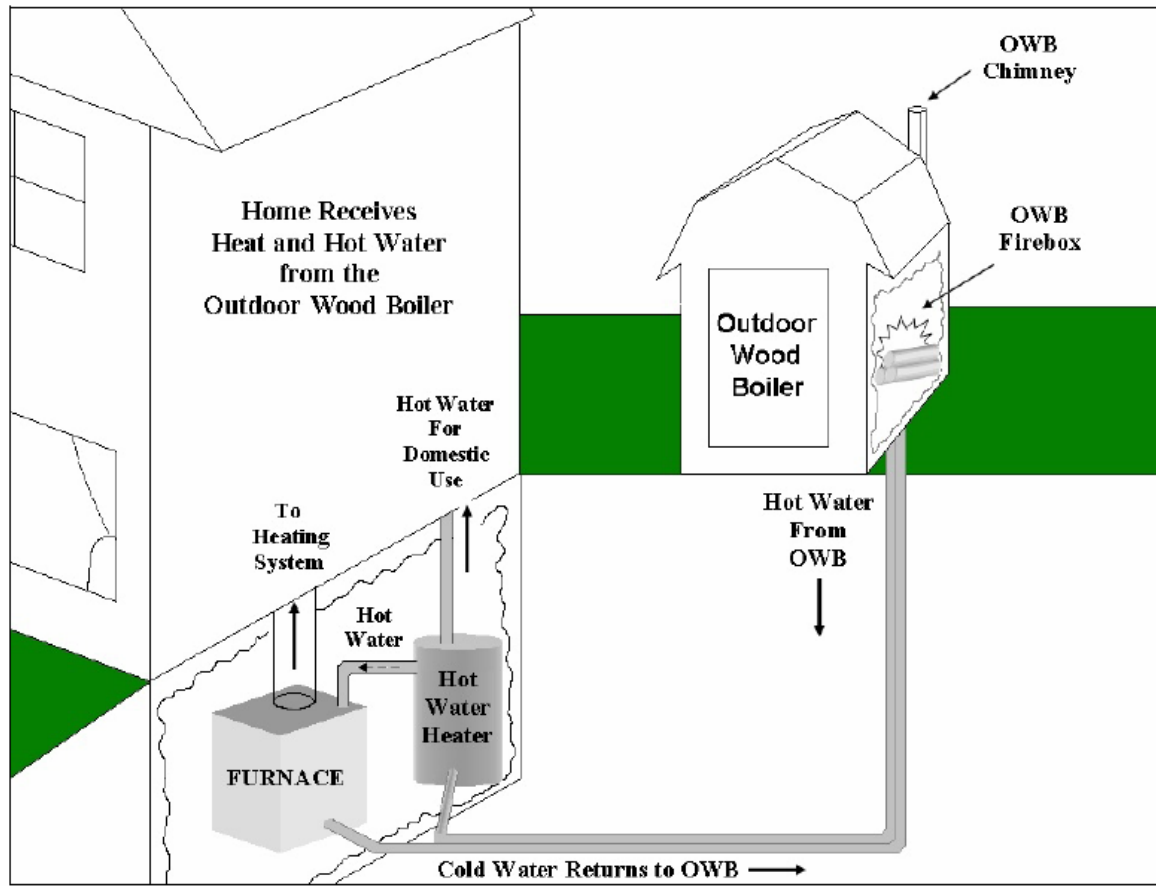
Early wood burning “furnace”



OWBs are not much better than this 1970s homemade “furnace” from an emissions standpoint

Design

Figure 1: Schematic of OWB and Home



From NY Attorney General's Report

Design

- ◆ The firebox of most units is fully surrounded by a water jacket.
 - Good for heat transfer
 - But, it makes complete combustion of the wood just about impossible.

Design

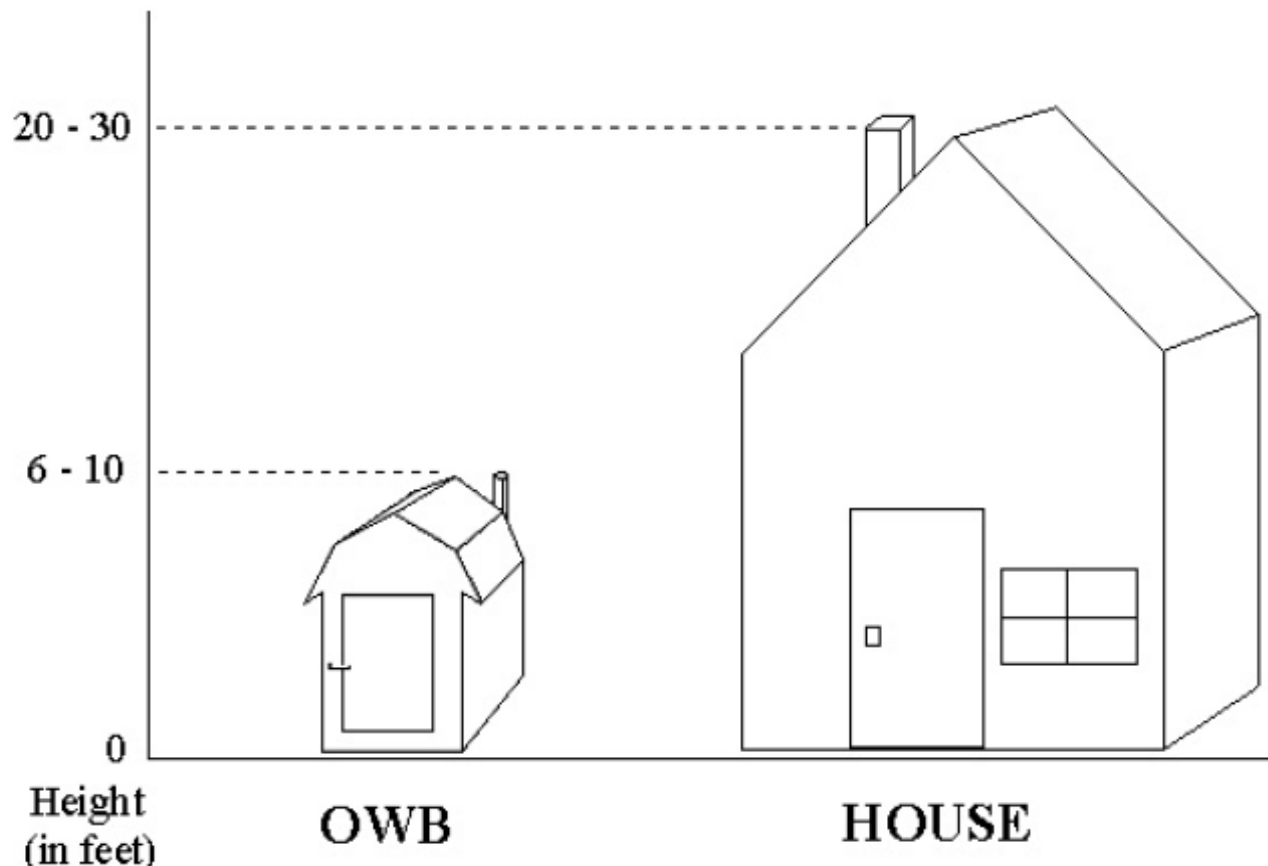
- ◆ Some outdoor boiler manufacturers compound the problem by running a series of water pipes right through the firebox so the exhaust has to sweep past them to reach the chimney.
- ◆ The flaming combustion of wood cannot occur below about 1000°F.
- ◆ So those steel surfaces backed up by water at 150°F chill and quench the flames well before combustion is complete.

Design

- ◆ Slower cooler fires are inefficient and create more smoke and creosote.
- ◆ Incomplete combustion of the wood, wood choice (soft versus hardwood) and the moisture content in the wood all effect the emissions
- ◆ OWB owners sometimes burn household garbage, tires, cardboard and yard waste, which leads to elevated smoke level and unpleasant odors.

Low Stack Height Leads to Poor Smoke Dispersion

Figure 3: Comparison of Chimney Heights



From NY Attorney General's Report

Operation

- ◆ When the boiler's water temperature falls below a set point, the combustion air damper opens and/or a small fan forces combustion air into the firebox.
- ◆ Once the water is heated back to the upper set point, the fan is turned off and/or the combustion air damper closes.

Operation

- ◆ During off cycles, the fire smolders and much of the smoke condenses as creosote on the cold steel internal surfaces.
- ◆ When the thermostat again calls for heat and incoming combustion air rekindles the fire, the heat ignites the creosote clinging to the boiler walls and belches of smoke from the stack for about ten minutes, before the system settles back into its normally smoky fire.

Levels of Pollutants Expected

Figure 4: Relative Emissions of Fine Particulate Matter From Home Heating Devices



From NY Attorney General's Report

Levels of Pollutants Expected

- ◆ Compared to other emission sources, one OWB produces approximately as much PM 2.5 per hour as two heavy duty diesel trucks, 45 passenger cars, 1000 oil furnaces, or 1800 gas furnaces.

A growing problem

- ◆ Sales data gathered by the New York Attorney General's Office NESCAUM estimated that over 155,000 OWBs have been sold in the United States since 1990 nationwide,
- ◆ 95% have been sold in nineteen states, including Connecticut, Indiana, Illinois, Iowa, Kentucky, Maine, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New York, North Carolina, Ohio, Pennsylvania, Vermont, Virginia, West Virginia, and Wisconsin.
- ◆ National sales have been growing in the past five years at rates of **30 to 128 percent**.
 - From the NESCAUM report

A growing problem

- ◆ Based on sales estimates, OWBs could have emitted over 233,000 tons of fine particulate matter nationwide in 2005.
- ◆ Considering sales trends, NESCAUM estimates that there could be 500,000 OWBs in place nationwide by 2010. Based on that estimate, emissions from OWBs would reach 873,750 tons of fine particulate matter nationwide per year by 2010.
 - From the NESCAUM report

Several States Actions - 2005

New York, Connecticut, Maryland, Massachusetts, Michigan, New Jersey and Vermont, and the Northeast States for Coordinated Air Use Management (NESCAUM) petitioned EPA to list outdoor wood boilers (OWBs) as a category of stationary sources

In the alternative, EPA could revise the existing standards for residential wood heaters to include OWBs

EPA response

Air Quality Management (AQM) Work Group was established. The AQM Work Group met in October 2005 and on their agenda was the high priority issue of residential wood smoke.

EPA Test method?

- ◆ ASTM unable to reach consensus on test method – Should they use dried oak or cordwood?
- ◆ EPA says a proposed federal rule
Dec 06 / Jan 07

Washington State Dept. of Ecology perspective

- ◆ Once an ASTM or EPA test method is adopted, we may want to add that method to our rule to allow testing of OWBs.
- ◆ Current standard of 4.5 grams/hour will be retained.
- ◆ Currently OWBs emit at far higher rates but there is a lot of room for improvement.

Web resources:

◆ NY Attorney General's Report

- <http://www.oag.state.ny.us/press/2005/aug/August%202005.pdf>

◆ NESCAUM Report

- <http://www.nescaum.org/documents/assessment-of-outdoor-wood-fired-boilers>

◆ Wood Heat Organization Inc.

- <http://www.woodheat.org/technology/outboiler.htm>

Publications:

- ◆ Human and Ecological Risk Assessment, 12: 1153–1170, 2006