

# Mechanics of Small Scale Boiler System

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## WHY A SMALL BOILER SYSTEM?

High propane costs-15,000 sq ft of buildings needed to be heated- 25 year learning curve

barrel stove-in building  
burn wood scraps  
heat a small area  
move hot air  
fire hazard

larger barrel stove-in building  
same conditions  
larger fire hazard

small outdoor wood stove-in building  
burn lumber scraps  
heat a larger area  
move heat around with hot water  
less fire hazard

## Why a Small Boiler System ....(cont'd)

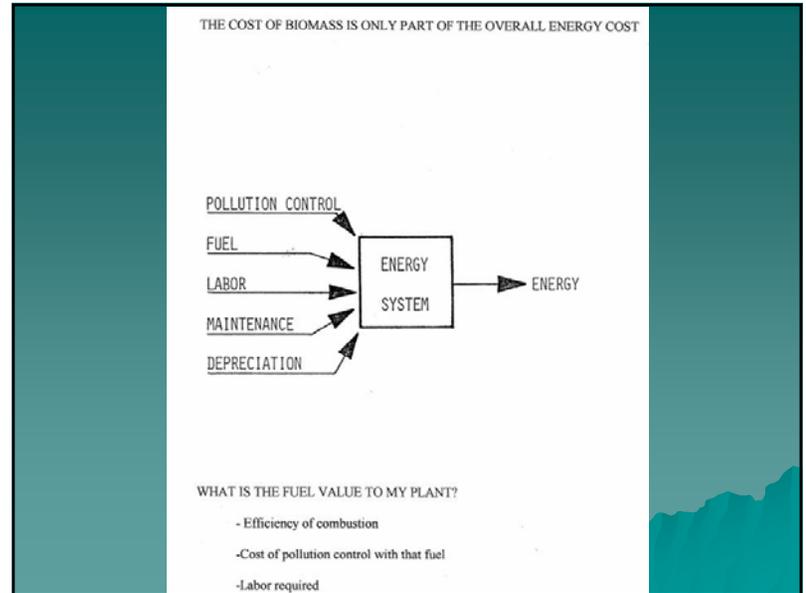
larger outdoor wood stove-in building  
burn lumber scraps and dry slabs  
generate creosote  
heat larger area  
heat dry kiln  
labor intensive-seven days a week and evenings

12 HP commercial boiler-separate metal building  
prepared wood fuel  
regulate combustion with fuel and air  
clean burning  
heat larger area with hot water-better temperature control

50 HP commercial boiler-separate metal building [2,000,000 BTU]  
automatic fuel feed  
sawdust      old, green, dry  
shavings     green and dry  
chips        green and dry  
regulate combustion with fuel and air  
heat larger area and add dry kilns  
very user friendly  
most problems have been with conveying systems and poor fuel mix:  
non-uniform fuel size, variable moisture content, trash in fuel







### BASIC COMBUSTION PRINCIPLES

COMBUSTION IS A CHEMICAL PROCESS

- Reaction occurs on a molecular basis

WOOD FUEL MUST BE DRIED BEFORE BURNING

- Drying may be done as part of the combustion process or
- May be done separately in equipment designed for that purpose

WOOD MUST BE GASIFIED TO BURN COMPLETELY

GOOD COMBUSTION REQUIRES

- Temperature for ignition
- Turbulent air for maximum efficiency
- Time for completion of process

AIR SHOULD BE IN PROPER PROPORTION TO THE FUEL

GOOD CONTROL SYSTEM RECOMMENDED

### TYPICAL WOOD WASTE FUELS

| COMMON NAME      | SIZE RANGE        | MOISTURE          | ASH PLUS       |
|------------------|-------------------|-------------------|----------------|
|                  |                   | RANGE (WET BASIS) | DIRT RANGE     |
| SANDER DUST      | 100 - 1/32"       | 2% - 8%           | 0.1% - 0.5% WT |
| SHAVINGS         | 1/32" - 1/2"      | 10% - 20%         | 0.1 - 1.0%     |
| SAWDUST          | 1/32" - 3/8"      | 25% - 40%         | 0.5% - 2.0%    |
| BARK (HOGGED)    | 1/32" - 4"        | 25% - 75%         | 1.0 - 20%      |
| FOREST RESIDUALS | NEEDLES TO STUMPS | 30% - 60%         | 3 - 20%        |

### Moisture Effect on BTU Content

| MOISTURE CONTENT % | BTU/lb. | TREE CHIPS lbs./cu. ft. | SAWDUST lbs./cu.ft. |
|--------------------|---------|-------------------------|---------------------|
| 9                  | 7414    | 11.0                    | 9.5                 |
| 13                 | 7036    | 11.5                    | 10.0                |
| 17                 | 6712    | 12.0                    | 10.5                |
| 20                 | 6388    | 12.5                    | 11.0                |
| 23                 | 6136    | 13.0                    | 11.5                |
| 26                 | 5866    | 13.5                    | 12.0                |
| 29                 | 5596    | 14.0                    | 12.5                |
| 31                 | 5362    | 14.5                    | 13.0                |
| 33                 | 5164    | 15.0                    | 13.5                |
| 38                 | 4750    | 15.5                    | 14.0                |
| 41                 | 4426    | 17.0                    | 15.0                |
| 44                 | 4102    | 18.0                    | 16.0                |
| 47                 | 3824    | 19.0                    | 17.0                |
| 50                 | 3590    | 20.0                    | 18.0                |
| 55                 | 3167    | 22.0                    | 20.0                |
| 58                 | 2789    | 24.0                    | 21.0                |
| 61                 | 2519    | 26.0                    | 23.0                |
| 64                 | 2231    | 28.0                    | 25.0                |
| 67                 | 2051    | 30.0                    | 26.0                |

### A Comparison of Wood Heat to Other Fuels

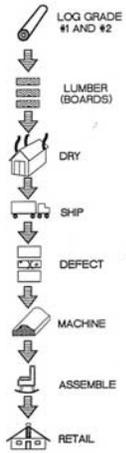
This current estimate is based upon data from the Forest Products Laboratory and assumes air-dry wood has a moisture content of about 20%.  
 \* A standard cord of firewood includes about 80 cubic feet of sound, solid wood.  
 \* A pound of air-dry wood contains about 7000 BTU of potential heat (heater efficiency will determine how much heat is distributed to the room).  
 \* Efficiencies assumed for these comparisons: wood heater = 80%, oil furnace = 60%, natural gas and propane gas = 95%, electricity = 100%.

One standard cord, air-dry, equals:

| SPECIES             | WEIGHT FT. CORD (lbs.) | BTU ST. CORD (millions) | #2 FUEL OIL (gals.) | NATURAL GAS (therms) | PROPANE GAS (gals.) | ELECTRICITY (kwh) |
|---------------------|------------------------|-------------------------|---------------------|----------------------|---------------------|-------------------|
| Apple               | 3600                   | 26.6                    | 156                 | 204                  | 252                 | 3803              |
| Ash, black          | 2800                   | 19.6                    | 116                 | 150                  | 194                 | 2898              |
| Ash, white          | 3503                   | 25.1                    | 136                 | 178                  | 193                 | 3388              |
| Aspen               | 2163                   | 15.1                    | 90                  | 116                  | 120                 | 2219              |
| Balsawood           | 2036                   | 14.2                    | 85                  | 110                  | 119                 | 2088              |
| Beech               | 3502                   | 24.5                    | 146                 | 188                  | 205                 | 3592              |
| Birch, white        | 3044                   | 21.3                    | 127                 | 164                  | 178                 | 3122              |
| Birch, yellow       | 3420                   | 23.9                    | 142                 | 184                  | 200                 | 3509              |
| Butternut           | 2207                   | 15.4                    | 92                  | 119                  | 129                 | 2264              |
| Cherry, black       | 2868                   | 20.3                    | 121                 | 156                  | 170                 | 2973              |
| Cottonwood          | 2299                   | 16.1                    | 96                  | 124                  | 134                 | 2358              |
| Elm, rock           | 3535                   | 24.7                    | 147                 | 190                  | 207                 | 3626              |
| Elm, white/red      | 2927                   | 20.6                    | 122                 | 158                  | 172                 | 3010              |
| Fir, balsam         | 2096                   | 14.7                    | 87                  | 113                  | 123                 | 2160              |
| Hackberry           | 2997                   | 21.0                    | 125                 | 161                  | 175                 | 3074              |
| Hemlock             | 2327                   | 18.9                    | 103                 | 133                  | 145                 | 2539              |
| Hickory             | 4032                   | 28.2                    | 168                 | 217                  | 238                 | 4136              |
| Honeylocust         | 3659                   | 25.8                    | 152                 | 197                  | 214                 | 3754              |
| Ironwood            | 3947                   | 27.8                    | 164                 | 212                  | 231                 | 4048              |
| Locust, black       | 4008                   | 28.0                    | 167                 | 218                  | 234                 | 4108              |
| Maple, sugar        | 3371                   | 23.6                    | 140                 | 182                  | 197                 | 3488              |
| Maple, red/silver   | 2847                   | 20.0                    | 119                 | 153                  | 167                 | 2920              |
| Oak, red            | 3504                   | 24.5                    | 146                 | 189                  | 205                 | 3654              |
| Oak, white          | 3700                   | 26.9                    | 154                 | 199                  | 216                 | 3796              |
| Pine, white         | 2068                   | 15.4                    | 92                  | 118                  | 129                 | 2267              |
| Pine, jack          | 2443                   | 18.2                    | 108                 | 140                  | 152                 | 2667              |
| Pine, red           | 2514                   | 18.7                    | 111                 | 144                  | 156                 | 2743              |
| Poplar, balsam      | 1844                   | 12.9                    | 77                  | 99                   | 108                 | 1892              |
| Red Cedar           | 2711                   | 20.2                    | 120                 | 155                  | 169                 | 2959              |
| Spruce, white/black | 2315                   | 17.2                    | 100                 | 130                  | 144                 | 2627              |
| Sycamore            | 2827                   | 19.8                    | 118                 | 152                  | 165                 | 2900              |
| Tamarack            | 3028                   | 22.5                    | 134                 | 173                  | 188                 | 3306              |
| Walnut, black       | 3130                   | 21.9                    | 130                 | 168                  | 183                 | 3210              |
| White cedar         | 1750                   | 13.2                    | 79                  | 102                  | 111                 | 1942              |
| Willow, black       | 2106                   | 14.7                    | 88                  | 113                  | 123                 | 2161              |

### Comparison of Traditional Processing With Green Dimension Processing

#### Present Process Flow



#### Green Dimension Process Flow

