

SMALL-SCALE LUMBER DRYING USING WOOD GASIFICATION AS A HEAT SOURCE

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ABSTRACT

Small, rural forested communities have the economic need to develop a wood products industry to replace the loss of large sawmills and maintain forest health. The main objective of this study was to explore the potential of using producer (wood) gas to fire a hot water boiler for a small dry kiln capable of drying both softwood and hardwood lumber. A BioMax wood gasifier, a hot water boiler, and dry kiln were integrated as parts of a whole lumber drying system for a field test in southwestern United States. Results so far found the amount of gas heat produced from the wood chip-fed BioMax 15 and 50 is 250,000 and 1,000,000 Btus per hour respectively, while the hot water boiler provides 109,000 Btus per hour for a 3,500 board foot dry kiln.

INTRODUCTION

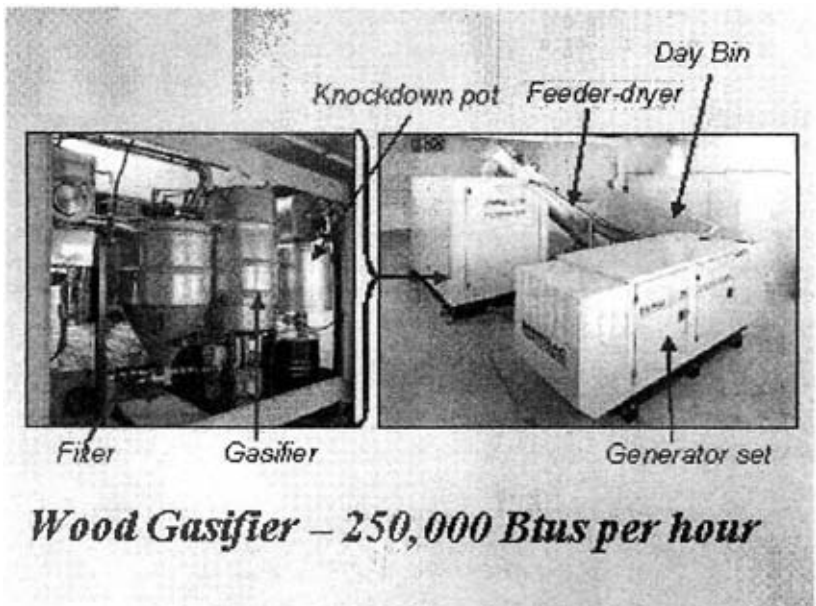
There are several million acres of forestland in the United States, particularly in the West that contains stand of pine so dense that forest health is affected and the risk of catastrophic forest fires is high. Removal of the small stems is expensive, and therefore interest in using this woody material is high. Also, as fossil fuel prices continue to increase, alternative renewable fuels, like the gas produced from gasifying wood (producer gas), becomes more economical favorable.

The harmful effect of high and rising oil prices on the economies and development efforts of oil-importing developing countries have become apparent. As a result, there has been increased interest in indigenous renewable energy sources, of which biomass in the form of wood or agricultural residues are the most readily available in many developing countries. In many developing countries—particularly in rural areas—internal combustion engines are widely used in stationary applications such as electric power generation and operation of water pumps and mills. Technologies such as wood gasification, which allow utilization of biomass fuel in such engines after minimum preparation, are therefore of particular importance.

Designing and developing wood gasifiers as well as charcoal gasifiers have been around for more than a hundred years. Wood gasification is the process of heating wood in an oxygen-limited chamber until volatile pyrolysis gases (i.e., carbon monoxide, hydrogen, and oxygen) are released from the wood. In the range of 395 °F to 535°F, the majority of the gases, which yield from 60% to 80% of the heat content of the wood, are driven off. This emitted wood gas, typically called producer gas, has energy content of 150 Btu per cubic ft that is approximately 15% as strong as natural gas; still the producer gas can operate an internal combustion engine. The major advantage wood gasification has over wood combustion is the substantial increase in efficiency. Extremely high combustion efficiency is obtained by gasification, thereby generating minimal emissions particularly particulate emissions.

Small, rural forested communities have the economic need to develop a wood products industry to replace the loss of large sawmills and maintain forest health. The main objective of this study is to explore the potential of using producer gas to gas fire a hot water boiler providing heat for a small dry kiln capable of drying both softwood and hardwood lumber. Other objectives in this study include the following:

- Determine sizing of the (BioMax) wood gasifier required to run a dry kiln on a particular species
- Find out if the dry kiln is capable of producing high quality kiln dried softwood and hardwood while using producer gas in a hot water boiler
 - Softwood lumber for construction
 - Hardwood lumber for flooring
- Determine potential part-time kiln drying
- Determine potential kiln drying using heat from a storage tank overnight



BACKGROUND

Using renewable fuels like solid-wood fuel to provide heat for conventional steam kilns are quite typical and a common practice. On the other hand, very little work, if any, has been done using producer gas to fire a boiler to heat a hot water kiln. In rural areas, fossil fuel prices continue to increase where wood residue has significant availability.

One problem in connecting new, not quite commercially available technology (wood gasification) with standard technology like a hot water dry kiln is determining proper size of either unit. A proper-sized wood gasifier connected to proper-size dry kiln is also dependent on the specie. Depending on specie, you can expect to kiln dry lumber from 4 days up to 4 weeks.

Community Power Corporation (CPC) is adapting its BioMax 15 and BioMax 50 Gas Production Modules to provide thermal energy for drying lumber. In order to provide a system that can meet the widest range of market requirements, we will be demonstrating the ability to kiln dry both hardwoods and softwoods at the Zuni Sawmill in New Mexico. The kiln will have the flexibility to dry a range of woods to various quality standards as opposed to picking the easiest drying requirements and having a product with minimal market appeal.

A packaged kiln capable of holding 3,500 board feet of 4/4 lumber will be obtained and tested at a facility selected by CPC, and then put in the field at Zuni, New Mexico, for a 1-year test.

A method must be developed to transfer thermal energy in a controlled manner from a combusted flame to the packaged kiln. Proper kiln drying to produce high quality lumber is another issue that will be addressed in this study because of the uncertainty of whether the kiln can function part-time. Also, the potential of utilizing heat from an insulated water tank when the wood gasifier is shutdown will be determined.

If the BioMax 15 is oversized for a 3,500 board foot kiln, the options exist to operate multiple kilns, find other on-site uses for the excess energy, flare the excess energy, store the energy, or cycle the system.

While testing, we will dry both hardwoods and softwoods to confirm the viability of the system. We will also dry softwoods and hardwoods in the field in New Mexico.

It is believed that the current design of the BioMax 15 can provide 250,000 Btu/hour for at least 8 to 10 hours per day and that the current design of the BioMax 50 can provide 1,000,000 Btu/hour for at least 16-24 hours per day.

Three different sizes of the BioMax have been or soon will be operating in the field with a variety of functions, including providing heat and power for a research house, traditional housing (Hogans), greenhouses, and small businesses, particularly wood products industry.

The BioMax 15 was the first of the three models to be field-tested with a unit running on coconut shells installed to provide electricity for a Philippine village in the 1990s. Due to the forest fires of 2000, an emphasis was given to manage our National Forests to prevent the catastrophic forest fires that still continue to occur to this day through mechanical thinning. A good use of this thinning material is wood for energy although it is not as good as a revenue generator as are saw logs. It does utilize material that would otherwise be left in the woods as a potential fire hazard. Through a partnership of the USDA Forest Service State & Private Forestry Technology Marketing Unit (S&PF TMU) located at FPL, the National Renewable Energy Laboratory (NREL), and CPC, we are field-testing three BioMax 15s and one BioMax 50.

As a continuation of utilizing this wood gasification technology, we are providing technical assistance to CPC as the company works on integrating their technology with standard commercial dry kiln technology. Presently, the boiler is being tested at CPC using the producer gas from the BioMax. The second step is integrating the hot water boiler dry kiln.

PROCEDURES

Material

- BioMax 15 / 50 – wood gasification production module
- Gas-fired hot water boiler (109,000 Btus per hour)
- -3,500 board foot hot water dry kiln
- (1) Load of Ponderosa Pine / (1) Load of poplar

Experimental Design

The study will follow the design and development of an integrated system capable of combusting producer gas from a BioMax in a gas-fired hot water boiler, using the thermal energy to dry both softwood and hardwood lumbers on a small-scale.

- Test the boiler with producer (wood) gas from the BioMax at CPC to ensure proper operation of boiler prior to field-testing.
- Assemble the dry kiln prior to transportation to the Zuni Sawmill in Zuni, NM (by dry kiln manufacturer).
- Install the whole system on site and test with a load of softwood and hardwood to compare drying times plus lumber quality.

Data collection will include the following during kiln operation:

- Wood consumption (pounds per hour)
- Moisture content of wood fuel (% MC)
- Producer gas flowrate (ft^3 per hour)
- Estimated energy content of producer gas (BTU per ft^3)

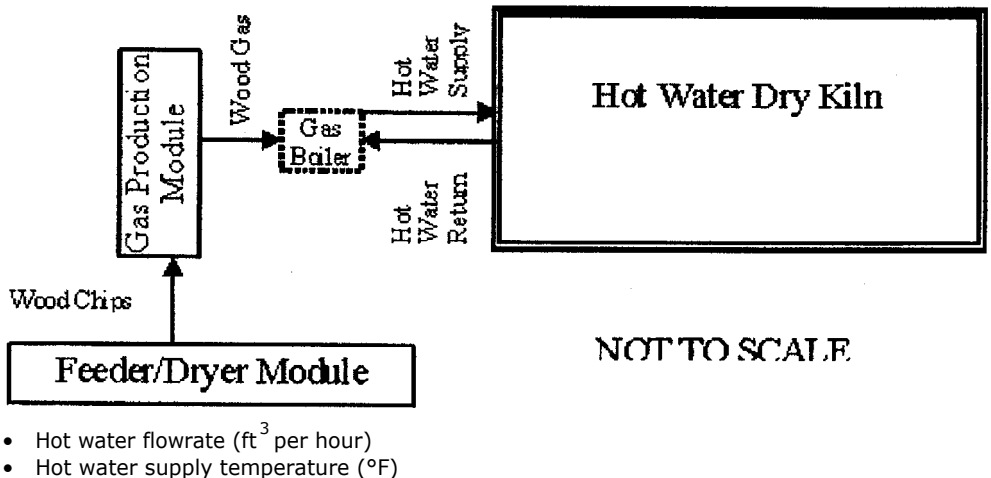


Figure 1. Block diagram of BioMax 15 integrated to hot water dry kiln.

- Hot water return temperature (°F)
- Volume of hardwood lumber (thousand board feet)
- Volume of softwood lumber (thousand board feet)
- Initial %MC / Final %MC for both softwood and hardwood
- Kiln Temperature (°F) / Relative Humidity (%MC)
- Moisture loss per day (%MC) – kiln samples / moisture sections

Kiln Drying

Ponderosa Pine Schedule (Approximate): 3-4 days at 140°F: Green to 19% MC

Yellow Poplar Schedule (Approximate): 5-6 days at 140°F: Green to 6% MC

ANALYSIS

(1) For a 5,000 board foot kiln that is using the thermal energy from a BioMax 15 (up to 250,000 Btu/hr), how much energy (hourly, daily, total) is needed to dry softwoods and hardwoods to market requirements given that the system must have the capability to dry wood in both summer and winter environments. If there is a quality difference in the type of wood being dried (furniture vs. structural applications, for example), how will this impact the energy needed?

(2) What are the desired temperature profiles for drying hardwoods and softwoods of different quality types? If the user cannot provide the labor to operate the system 24 hours per day and does not want to leave the system unattended during operation, is it possible to operate the kiln in shifts of 8 to 10 hours per day, 5 days per week? What are the disadvantages of the thermal cycling that this drying strategy would entail?

(3) Is there a value to energy storage? How would we store the energy? How would we release it in a controlled manner?

(4) What are the different heat transfer options? What are the advantages and disadvantages for each? Which is the preferred option for CPC?

(5) What is the preferred design of a packaged dry kiln that has been integrated with a small modular biopower system? Provide a schematic of the integrated system.

(6) Is the 250,000 Btu/hr system oversized? How can we best use the excess energy if this is the case?

(7) What are the fundamental design decisions that we need to make as we go along in the program?

(8) What are the details of lumber drying tests to be conducted at CPC including, but not limited to, such considerations as types of wood, quality types, sources of supply, estimated cost (including transportation), moisture content, kiln loading, temperature profile, measurements needed, etc?

TIME SCHEDULE

September 2004	Initiate development of gasifier
January 2005	Research kiln design
May 2005	Obtain hot water boiler
August 2005	Obtain dry kiln / integrating with boiler
November 2005	Field Test BioMax and dry kiln

BUDGET

Community Power Corporation will cover all costs for the project. Funding of \$750,000 came from the Small Business Innovation Research (**SBIR**) Program.

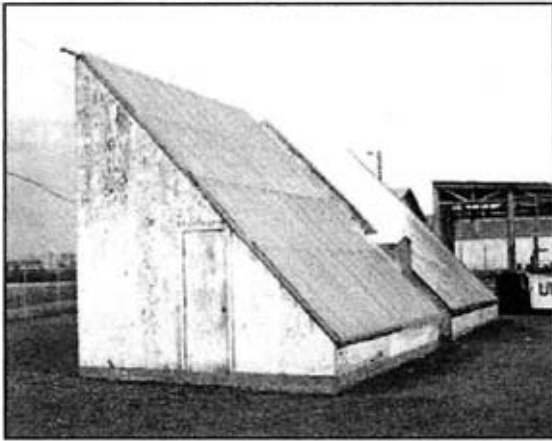
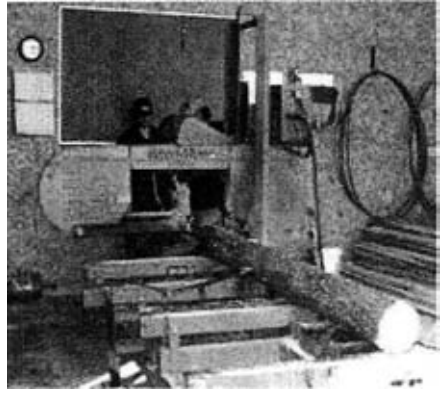
TECHNOLOGY TRANSFER

One publication is expected that describes how well the integration of the BioMax to a hot water dry kiln performed for both softwoods and hardwoods and proper sizing of the BioMax to the hot water dry kiln.

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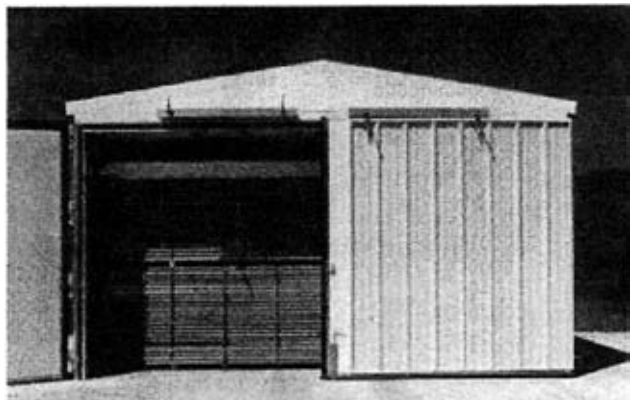
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Zuni Sawmill



Zuni Solar Dry Kilns-Present

Hot Water Dry Kiln-Future



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