Torrefaction for Biomass Energy Applications

Making "Green Coal" from Biomass

Biomass is a Great Energy Source, But…

Biomass has an advantage over renewable energies (such as solar, wind and hydro) in that it can produce both electrical power and liquid transportation fuels. Biomass is also carbon-neutral because in a broad sense, the CO_2 released in combustion of current vegetation is captured by the next generation of vegetation through photosynthesis. However, biomass feedstocks (both forestry and agricultural) have low energy density and they are bulky, moist, and perishable so that they are relatively expensive to transport and store. Torrefaction solves these problems by making a feedstock that is dry, does not rot, and holds much more energy per unit of volume and mass. Torrefied wood (also known as biochar), when used as a soil amendment, can also be the foundation of a carbon storage system while increasing overall crop productivity 20-80% (add references here as footnotes).

The Torrefaction Process

Torrefaction changes plant material from a moist, fibrous, perishable material into a dry, grindable, stable fuel. Torrefaction is carried out under atmospheric pressure in the absence of oxygen at a temperature between 500-800 °F. During torrefaction, all moisture and volatile organic compounds in the biomass are removed and the properties of biomass are changed to obtain a much more energy dense fuel. The gaseous and liquid products of torrefaction are combustible,

- **Woody Biomass is:**
  - **Bulky**
  - **Moist**
  - **Fibrous**
  - **Perishable**
  - **Waste**
  - **Expensive to**

and depending on the specific

process can be used to make the process self sustaining, thus minimizing the need for an external energy source to maintain the process. Figure 1 provides a schematic of the self-sustaining process used by Extension Forestry at North Carolina State University.

- **Torrified Wood (TW) is:**
  - **Dense (if pelletized)**
  - **Dry, water resistant**
  - **Easily crushed**
  - **Does not rot**
  - **Valuable fuel**
  - **Energy dense**

When green wood chips (approximately 50% water by weight) are torrefied, a portion of the wood energy is used to dry the wood before

NC Woody Biomass
"Nature's renewable energy!"

http://www.ces.ncsu.edu/forestry/biomass.html

Extension Forestry
Campus Box 8008
NC State University
Raleigh, NC 27695-8008

NC State University A&T State University COOPERATIVE EXTENSION
Empowering People · Providing Solutions

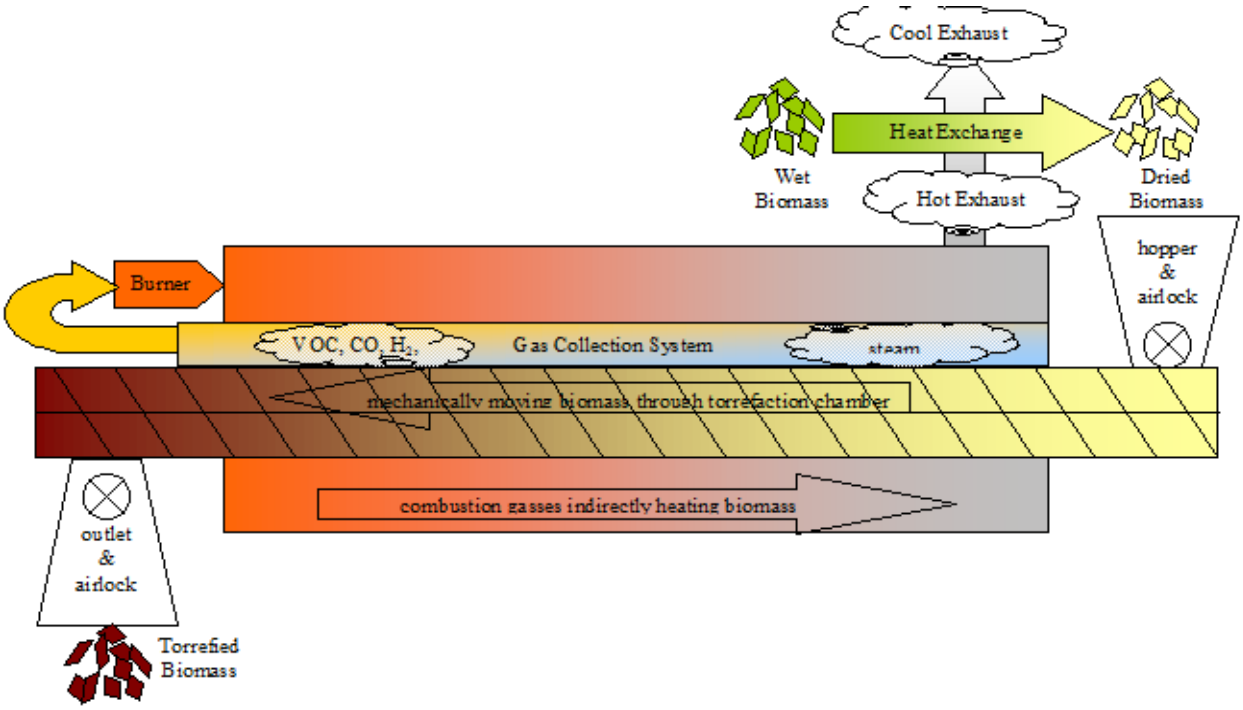

Figure 1. Schematic of the NC State University Extension Forestry Torrefaction Process

torrefaction, so about 80% of the original energy is available in the final torrefied product, while only 40% of the initial weight remains. This is a doubling of the energy density from the original wood. The process used by Extension Forestry currently yields product that is 30% of initial weight and retains between 50% to 75% of the energy.

Torrefied Wood is Especially Appealing to the Power Industry

North Carolina annually spends over $4 billion on coal imports to produce electricity. Yet, woody biomass from currently unused forest thinnings, culls and logging waste currently left in the forest after harvest (collectively called woody biomass) could be potentially used to satisfy a major portion of the electricity currently made from coal. However, green wood chips must be dried and pulverized in order to be used in today's modern pulverized coal boilers. Torrefied wood, on the other hand, is easily pulverized and can readily be mixed with coal. Additional benefits of replacing coal with torrefied wood for power production include:

- reduced mercury emissions
- reduced sulfur emissions
- use of a locally derived fuel
- monies spent for fuels stay in the local economy

Torrefied Wood Has Enormous Potential for the Pellet Industry

The fuel pellet industry is one of the fastest-growing uses of biomass for energy. Pellet stoves have been popular, especially in the Northeast, and their popularity is growing. Most consumers purchase pellets as 40-pound bags. However, the last several years have seen the emergence of large wood pellet mills in the Southeast that

are targeting the European power and heating industry. For these markets, pellets are shipped via rail to ports for loading bulk-freight based ships. For these markets, energy density and pellet stability are key. In our own work, torrefied wood has been shown to have the following advantages to green wood chips:

- At torrefaction temperatures, the lignin in wood becomes plastic and can actually become a binder for individual wood particles.
- Pellets made from torrefied wood may withstand 1.5 to 2 times the crushing force of normal wood pellets.
- Torrefied pellets show little water uptake on immersion (7-20% of mass), unlike normal wood pellets.

Current Limits for Application of Torrefaction Technology and Opportunities for Further Development

In theory, the ideal place to torrefy material is at the point of collection so that low-moisture material is transported from its origin thus reducing transportation costs per unit of energy. For logging residues, torrefation would thus occur at the log deck where residues are collected and chipped. However, most torrefaction technologies now in use or under development reduce portability of machines. Most technologies requires that the machine be brought up to operating temperature and then be maintained there for periods longer than a work-day to produce production efficiency. Torrefied material also should be watched and managed to reduce possibilities of fires from spontaneous combustion that can occur under rare circumstances. And, existing torrefaction machines tend to also be relatively large for a given level of throughput. Thus, until the technology is further developed to provide better portability, torrefaction will usually be done at the point of use or at pellet plants.

Until the technology is further developed to provide better portability, torrefaction will usually be done at the point of use or at pellet plants

Prepared by
Chris Hopkins, Research Associate
Dennis Hazel, Ph.D., Associate Professor and Extension Specialist

www.ces.ncsu.edu/forestry/biomass.html

Published by North Carolina Cooperative Extension

COLLEGE OF
AGRICULTURE & LIFE SCIENCES
ACADEMICS ▲ RESEARCH ▲ EXTENSION

NC STATE UNIVERSITY

WB-0015/2013 copies of this public document were printed at a cost of or per copy.