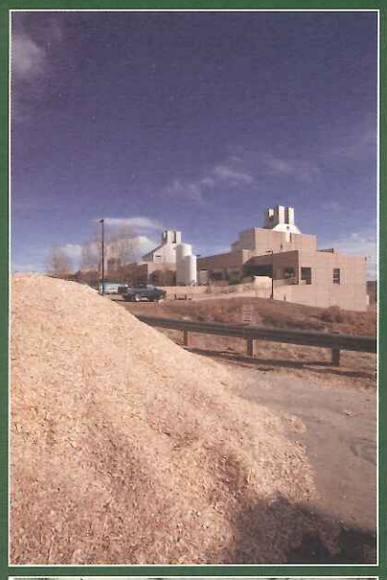
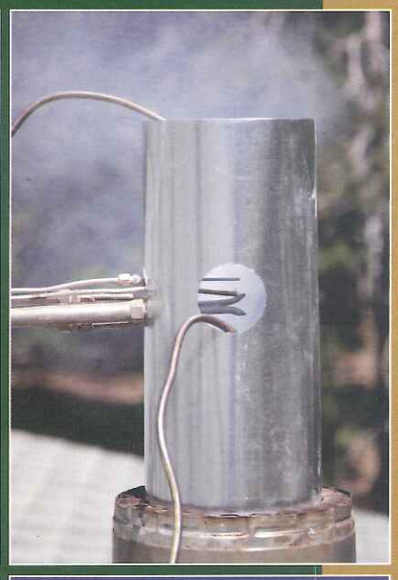
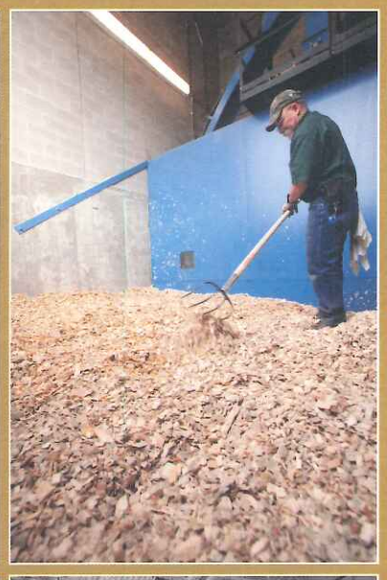




Where Wood Works

Harnessing the Energy of Woody Biomass in Colorado

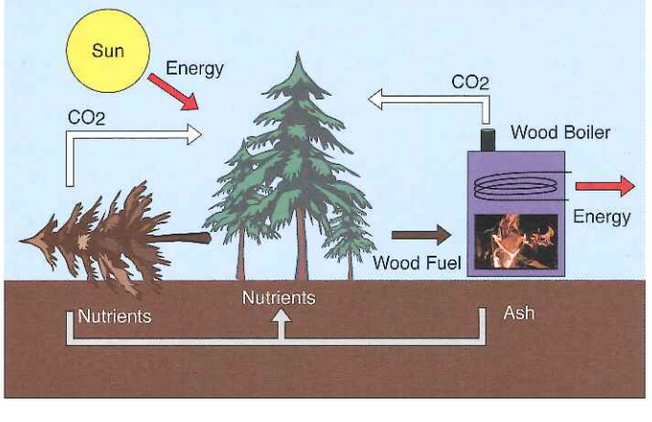
Colorado State Forest Service

Attachment W

What is Woody Biomass?

Woody biomass is the material from trees, including bark, wood, leaves, needles, and roots. Biomass-based energy projects around Colorado are providing a renewable and affordable source of heat for buildings of all types – from small homes heated by wood pellet stoves, to large multi-building campuses heated by commercial wood chip boilers. Soon, biomass also will be helping generate renewable electricity in Colorado.

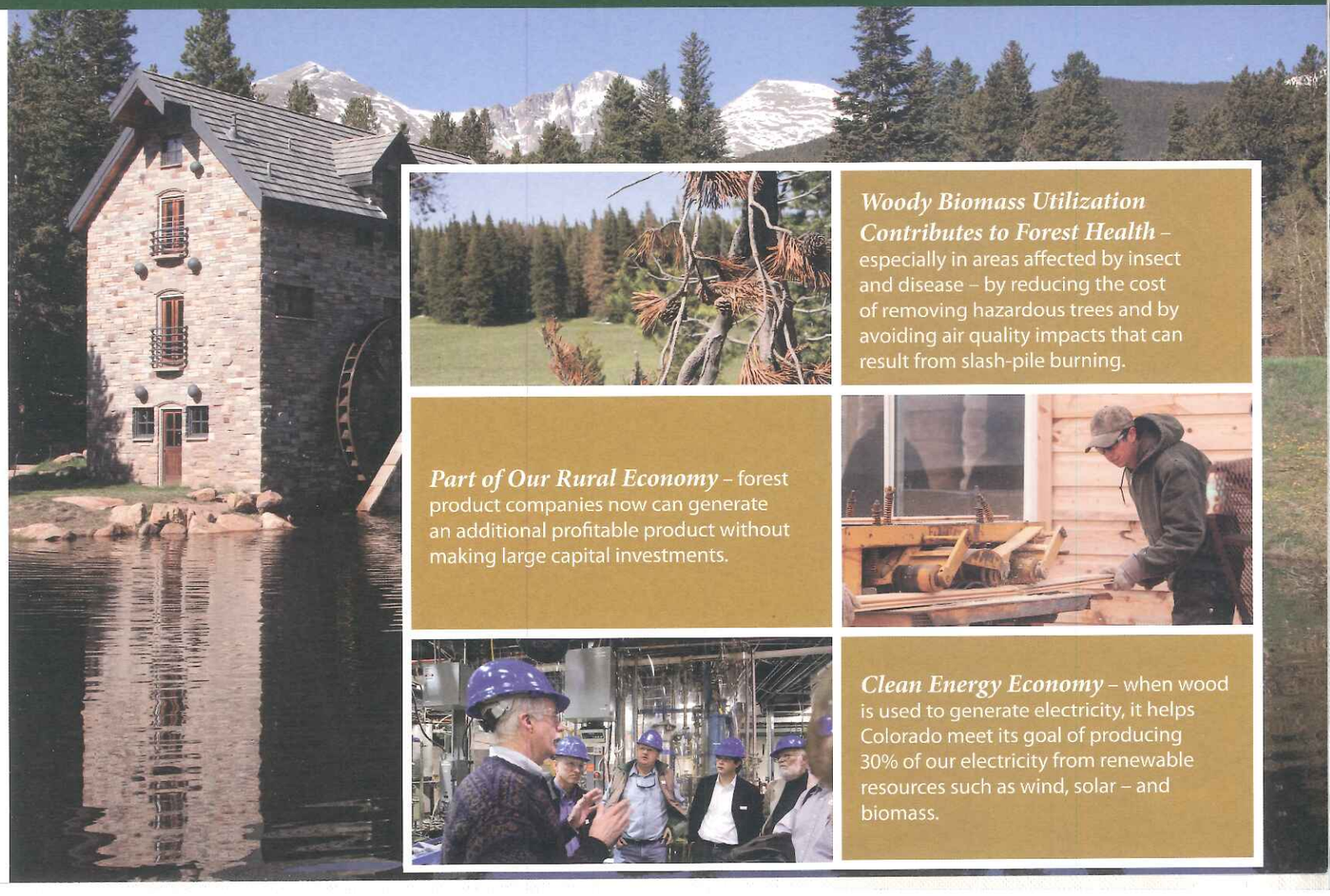
This booklet illustrates why biomass is important to Colorado. It presents the diversity of working applications, which technologies might be appropriate to your application, the key success factors you should look for, a discussion of important air quality issues, and suggestions on potential funding opportunities for your project.



Woody biomass is stored solar energy that is available 24-7, not just when the sun shines. The carbon released into the atmosphere when the wood burns is the same carbon the tree absorbed from the atmosphere when it was growing. As long as that tree is replaced with new growth and the soil biology is not significantly altered, the cycle is renewable and carbon neutral.

However, the fossil fuel used to transport the wood can dramatically change this equation, so keeping biomass local is important.

An Integral Part of Colorado

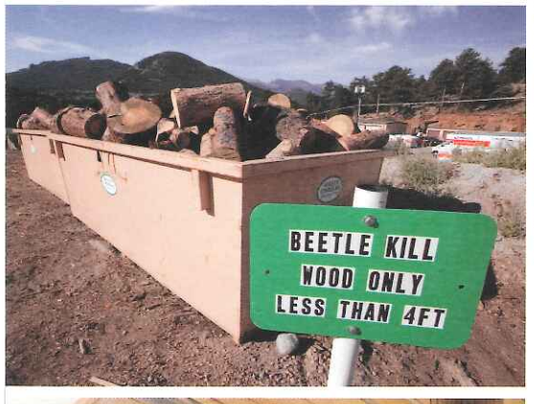


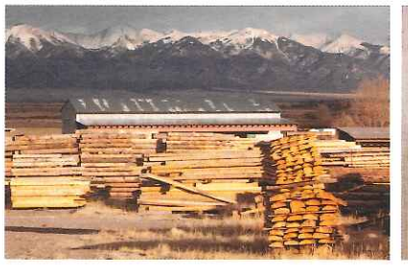
Woody Biomass Utilization Contributes to Forest Health – especially in areas affected by insect and disease – by reducing the cost of removing hazardous trees and by avoiding air quality impacts that can result from slash-pile burning.

Part of Our Rural Economy – forest product companies now can generate an additional profitable product without making large capital investments.

Clean Energy Economy – when wood is used to generate electricity, it helps Colorado meet its goal of producing 30% of our electricity from renewable resources such as wind, solar – and biomass.

Healthy Forests





Colorado's mountain pine beetle outbreak, along with spruce beetle, spruce budworm, and aspen decline continue to affect millions of acres of Colorado's public and private forests. Threats to our public health and safety, watersheds and drinking supplies, recreation and tourism, and critical energy transmission and transportation infrastructure are examples of impacts that our state is experiencing now and for decades to come.

Part of the solution is to support the businesses that are members of the Colorado Forest Products™ Program. By purchasing wood products from member businesses, consumers can:

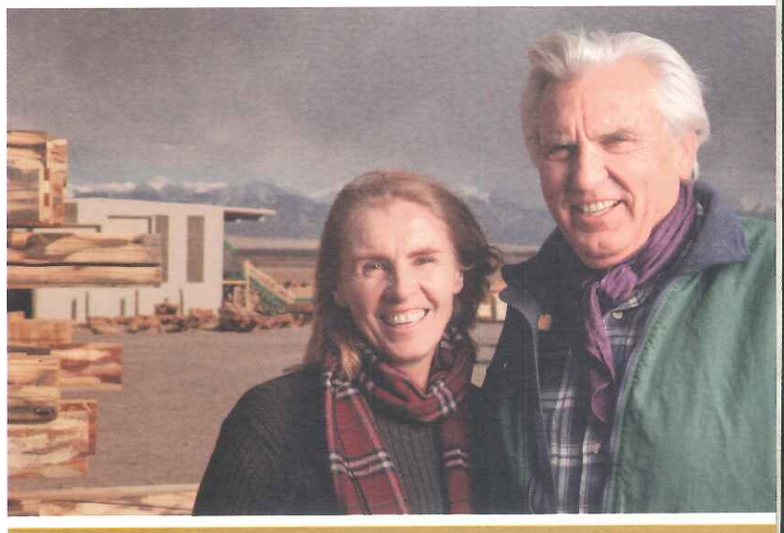
- Encourage the development of businesses dedicated to the use of wood from Colorado's public and private forests.
- Reduce our reliance on imported wood products (more than 90 percent of all the wood products we use are imported from other states and countries).
- Find new ways to use wood in Colorado's $4 billion wood products markets.
- Help reduce the costs of forest management activities.
- Reduce fossil fuel consumption and greenhouse gas emissions that result from transporting wood products to our state.
- Help retain and create jobs in our forest products business sector.

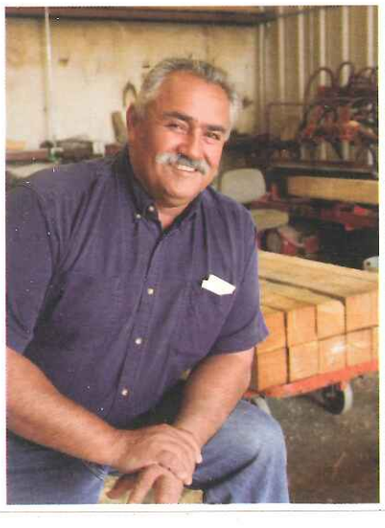
Healthy Rural Communities

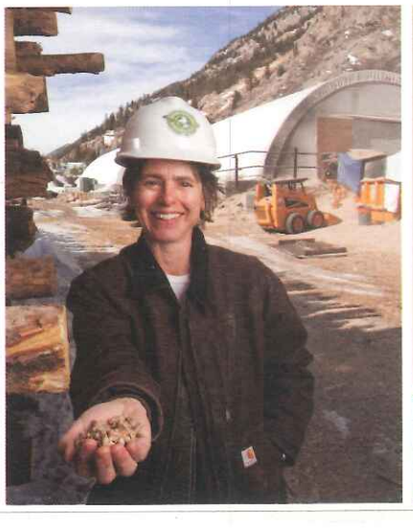
Most Coloradans are unaware of the role that forest products businesses play in meeting our forest health challenges and management priorities. Many of our rural communities have lost businesses and the work force necessary to find economical uses for the wood removed in our forest health, restoration, and hazardous fuels treatments.

Communities across Colorado that have identified their management priorities are, in many cases, unable to find businesses and work force capable of accomplishing the work without large outlays in public funding.

As one forest manager remarked concerning the need for our forest products businesses, "If your community has a local sawmill, keep it. If it does not, get one."







The Colorado Forest Products™ Program is a trademarked business membership and wood products consumer education program of the Colorado State Forest Service. It supports the use of Colorado wood and educates consumers about the benefits of purchasing local wood products.

Visit csfs.colostate.edu/cowood/cfp.html to find local Colorado businesses and learn more about our program.

Working to Heat Colorado

Wood is working in Colorado today. These nine showcase projects demonstrate a wide range of heat output ranging from 150,000 Btu/hr to 9.9 MMBtu/hr. These projects use a variety of wood fuel products – cordwood, wood chips, and wood pellets.

All these projects heat buildings owned by public or non-profit organizations. However, due to the long payback periods (typically 10 to 20 years), biomass usually does not work for commercial buildings.

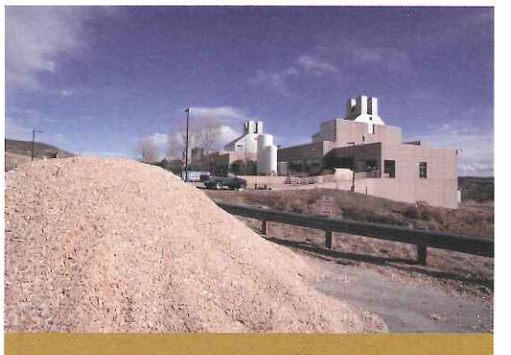
Most biomass systems include a conventional fuel backup boiler that provides heat when chips are temporarily unavailable, in the summer when only a small amount of heat is needed, or on the very coldest days when both systems are needed.

Heat Energy Measurements.

A Btu (British Thermal Unit) is a common measurement of heat. About 1 Btu of heat is released by a single match. An MMBtu, is a million Btus. Home furnaces are typically between 25,000 to 100,000 Btu per hour (Btu/hr).

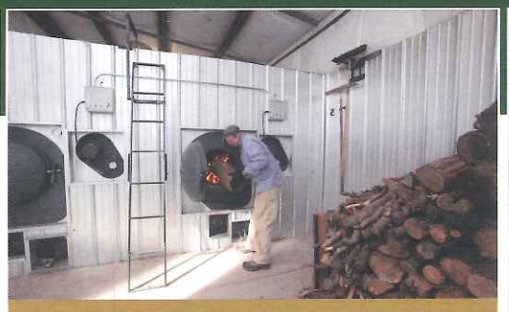
2007 Boulder County.
This 3.3 MMBtu/hr wood chip boiler heats five new buildings by circulating hot water underground through insulated pipes. The natural gas backup boiler can be seen in the background.

2008 South Routt School District.
When the old coal-fired boiler needed to be replaced, a 600,000 Btu/hr wood pellet boiler was selected for the job. Local pellet mills provide the fuel made from local beetle-kill trees.

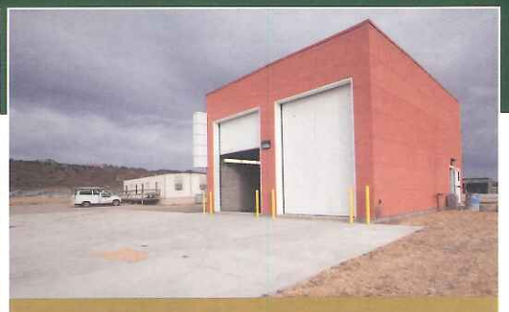


2009 National Renewable Energy Lab in Golden. The campus is heated by a large 9.9 MMBtu/hr wood chip boiler that was integrated into the existing district heating system. This is the largest biomass system in Colorado.

2008 Gilpin County. The Road and Bridges building is heated with a 3.3 MMBtu/hr wood chip boiler. In-floor heating creates a productive work environment for the large garage that requires the doors to be open frequently.



2009 Mountain Park Environmental Center. The 18,000 ft² overnight educational facility is heated by two manually fed 425,000 Btu/hr cordwood boilers. Most of the wood comes from on-site fuels mitigation projects. It takes work, but it is economical.



2009 Colorado State University Foothills Campus. A 1.5 MMBtu/hr wood chip boiler heats water for the local district energy heating system. The use of local beetle-kill wood chips helps CSU meet its carbon reduction goals while keeping energy dollars in the community.

2009 Park County Recreational Center. A 650,000 Btu/hr wood pellet boiler provides much of the year-round heat for the pool and building. Pellets are delivered in bulk by truck from a Colorado pellet mill. Pellets cost more but are much easier to manage.

2010 Mountain Parks Electric. A 1.1 MMBtu/hr wood pellet boiler provides heat to this innovative rural electric cooperatives's large service building. Pellets are delivered in bulk by truck from a Colorado pellet mill.

2010 Colorado State Forest Service Office. A small 150,000 Btu/hr wood pellet boiler heats this 3,700 ft² office building. It is fully automatic – bulk pellets only need to be delivered a few times a year.

Part of Colorado's New Energy Economy




Colorado has emerged as one of the top clean energy states in the country and is home to:

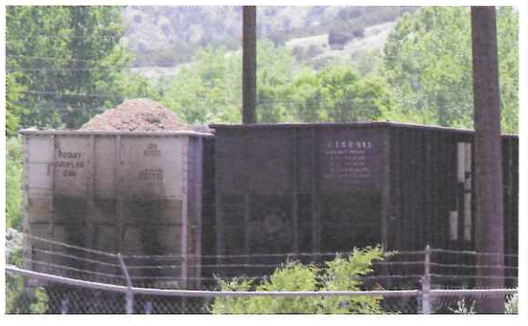
- Leading universities engaged in research and development
- The National Renewable Energy Lab (NREL) in Golden
- Many start-ups and national and international corporations

All providing high-paying primary jobs to Coloradans. Biomass is a key part of this new economy.

Co-firing with Coal. Many coal-fired power plants can be adapted to use a blend of wood chips and coal, a process called "co-firing" or sometimes "co-combustion." Using 10% wood chips and 90% coal can be easily accommodated, and much higher percentages are possible.

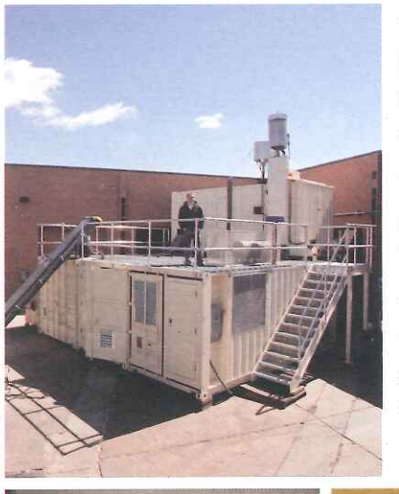
In 2012, Colorado Springs Utilities is scheduled to complete the conversion of one of its 131 megawatt (MW) coal units to use a mix of 15% wood chips and 85% coal – consuming about 100,000 tons of wood chips each year.

The percentage of electricity produced by biomass counts towards a utility's renewable energy requirements and helps reduce mercury and sulfur pollution.

◀ Colorado's first biomass co-fired demonstration project, Cañon City.

Today and Tomorrow



The modular combined heat and power (CHP) system on the left will generate 100 kilowatts of electricity and provide 400,000 Btu/hr of heat. The system consumes 2.5 tons of wood chips per day (roughly the equivalent of a rounded pick-up truck load) and provides enough electricity to support a facility such as a school building or recreation center.

This system converts wood chips to fuel gas (synthetic gas) that is fed into a conventional internal combustion engine to drive a generator. It has been measured independently and found to meet the 2003 California Air Resource Board standards. ***The system uses no water.***

This modular design uses five 20 foot standard shipping containers for easy transportation and rapid installation and requires less than 1,000 square feet of space. The first unit in Colorado is scheduled to be installed at the Ft. Carson Army Base in Colorado Springs in mid 2011. It will use wood chips generated from mountain pine beetle forest treatments.

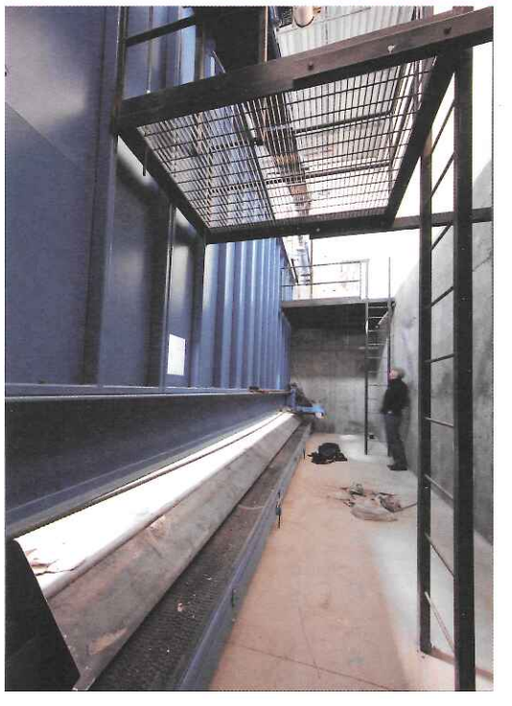
Liquid Transportation Fuel from biomass is being aggressively researched in Colorado's universities and at the National Renewable Energy Lab in Golden. While a commercially viable process has yet to be developed, this may change with higher gasoline prices.

Biochar is charcoal made from biomass. It can be used as a soil amendment to improve soil conditions and sequester carbon. Much basic and applied research is happening today in Colorado and around the world. Someday it may become a profitable new product.

Does Biomass Make Sense for You?

Using woody biomass isn't always easy and it isn't for everyone, but there are places where woody biomass is exactly the right answer for you and your community – and for Colorado. If you meet all the criteria covered on the next page, your project may be a good candidate for biomass. The most important factors are:

- ***Appropriate technology.*** The size of your project is the most important factor determining the right technology. For smaller projects, wood pellets often are the best choice because, even through the fuel is more expensive, it is much easier to automate fuel handling. For larger projects, wood chips often are the lowest cost solution.
- ***Proven Technology.*** If the technology that matches your project also is being used elsewhere in Colorado, you can visit a similar site and talk to the people who operate the biomass system. Get to know them a bit, ask them if they would do it again and, if so, what might they do differently. Talk with the people who operate the system – project managers and sponsors often have a vested interest in discussing only the positive aspects of their project. You need to hear the whole story.
- ***Clean Technology.*** The next step is to make sure you are in contact with the appropriate air quality people.



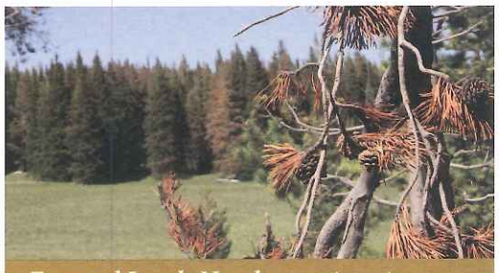
Key Factors for Success in Colorado

If ***all*** these factors are on your side, your chances of having a viable biomass project are good.

Expensive Fuel like propane or electricity, not today's low-cost natural gas.

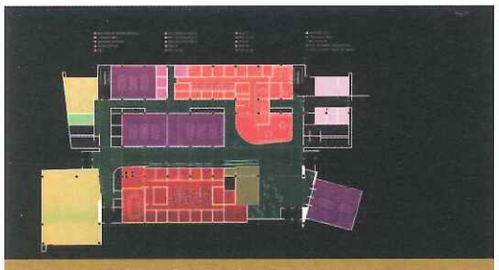
Year-round Heating like this swimming pool in Fairplay.

Large Heating Bills like those found in winter mountain camps and lodges.



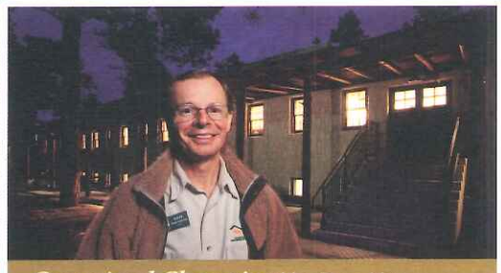
Forested Lands Nearby to reduce the cost of transporting the fuel.

Community Ownership and Buy-in needed to support long payback periods.



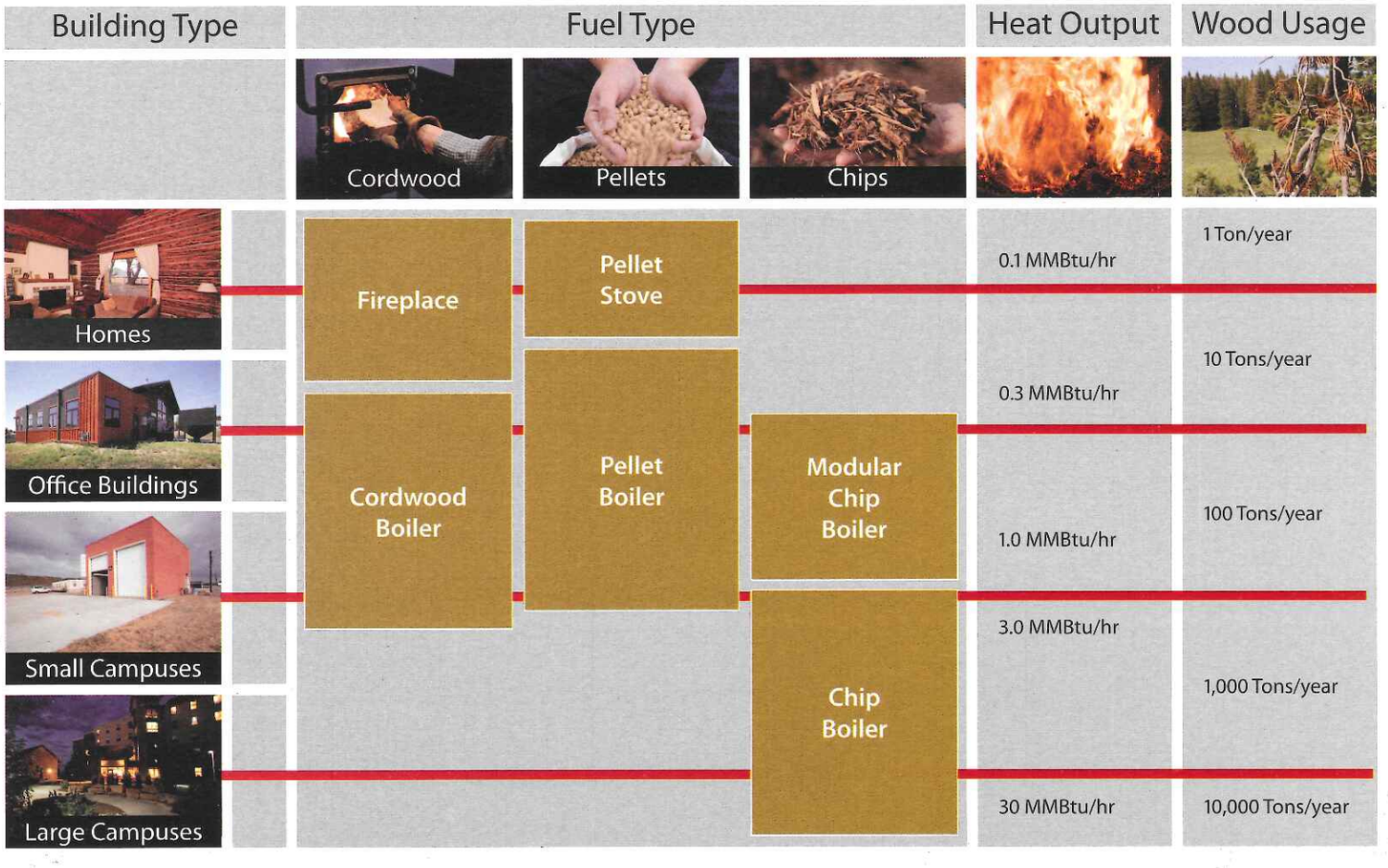
Designed-in from the Beginning to minimize high retrofit costs.

Proven Technology like this commercial boiler in Longmont.



Committed Champion like Dave Van Manen in Beulah.

The Biomass Heating Application Landscape



This chart provides a ***rough*** idea about which technology makes sense for various application. It is not a planning or design tool.

The Right Stuff - Wood Chip Attributes

Wood chip quality varies dramatically in size, species, moisture, and impurities – and that affects cost. Some boilers can use a wide variation of wood chip quality, but many have precise requirements that may be difficult or expensive to buy.

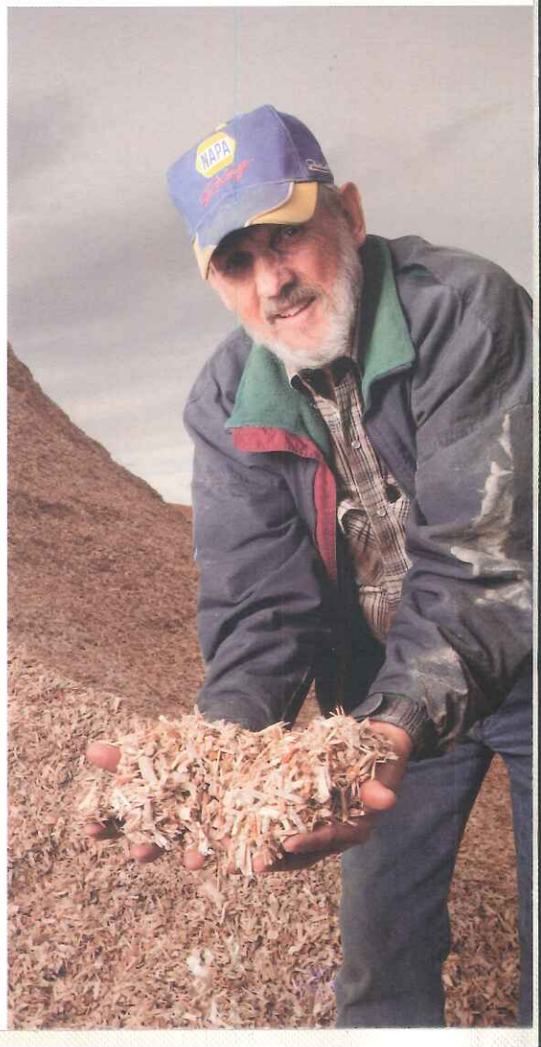
Success or failure of a project often comes down to access to an affordable, consistent fuel that meets the operational needs of your boiler. Before committing to a biomass project, make sure you have a supplier that understands the specific requirements of your system. ***Include these specifications in your procurement contracts.***

- Size (minimum and maximum) – High quality chips are the size and shape of a matchbook (1" to 2" wide and long by 1/8" to 1/4" thick).
- Species of Wood – Sounds obvious, but it is not. Many important properties of wood depend on the species. Make sure you know what you're buying.
- Weight, Moisture Content, and Energy Content – If you pay $40 for a ton of wood chips, is that a ***bone-dry ton*** or a ***green ton?*** If it is green, what is the moisture content and how is that measured (wet basis or dry basis)? Energy content of wood varies dramatically with moisture content. How many Btus (energy) are in a pound?

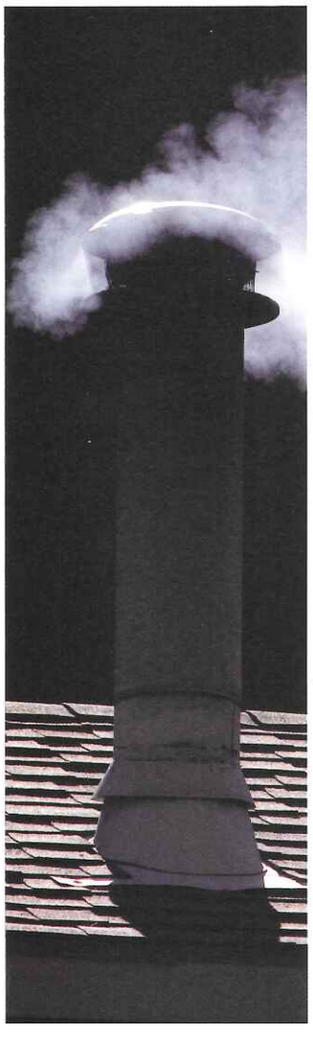
Be sure not to confuse "contamination" with "cleanliness." These are technical terms with very specific – and very different – meanings in the wood chip business.

- Contamination – The amount of non-wood material such as dirt and rocks contained in a shipment of wood chips.
- Cleanliness – "Clean" chips are produced from wood where the bark has been removed and are more expensive. "Dirty" chips are produced from the entire (whole) tree including branches, stems, bark, needles, and even roots. If your system can reliably use dirty chips, they are usually much cheaper than clean chips.

A reliable source of wood chips is an essential part of a successful biomass project. Include quality specifications in your contract.



Air Quality Job One



Clean air is serious business. Wood can be burned very cleanly, but poor design, incorrect operations, or inadequate maintenance of a biomass system can create emissions that can have serious health and environmental impacts. It is the job of the Colorado Department of Public Health and Environment (CDPHE) to protect public health and the environment by administering state and federal air quality laws and regulations. These regulations cover biomass systems.

Due to existing ozone-related air quality problems in the Denver and Fort Collins areas, Colorado currently is divided into two regions with different reporting and permitting thresholds: the 'nonattainment' area and the rest of the state. The nonattainment area extends from Larkspur in the south to Wellington in the north and includes all of Denver, Boulder, Adams, Jefferson, Douglas, and Arapahoe counties and the southern part of Larimer and Weld counties.

If you plan to install a biomass system smaller than the **notification threshold**, you do not need to contact the CDPHE. If your proposed system is larger than the notification threshold, you'll need to contact the CDPHE and file an Air Pollutant Emission Notice (APEN) form. If the system is larger than the **permit threshold**, you also must apply for a permit using the same APEN form. **You must file all forms before construction begins.**

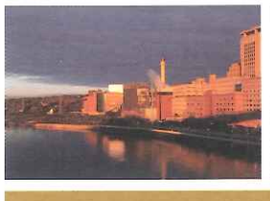
	Notification Threshold	Permit Threshold
Front Range Nonattainment Area	470,000 Btu/hr	2.33 MMBtu/hr
Remainder of Colorado	760,000 Btu/hr	2.85 MMBtu/hr

It is recommended that you include air quality testing as part of the acceptance criteria for your project, requiring the system to pass basic testing before final payment is made to the vendor or project developer. In some cases, it is recommended that you design your system to accommodate post-combustion cleanup technology – such as an electrostatic precipitator (ESP) – should it be needed later.

Once your biomass system is up and running, **no matter the size**, it must meet smoke opacity and odor regulations. The opacity of the smoke must be less than 20% during normal operations and cannot exceed 30% during start-up or process adjustment (e.g., adding fuel). You can be fined and your system shut down if you fail to meet these requirements.

Inspections and potential tune-ups are required **every two years**.

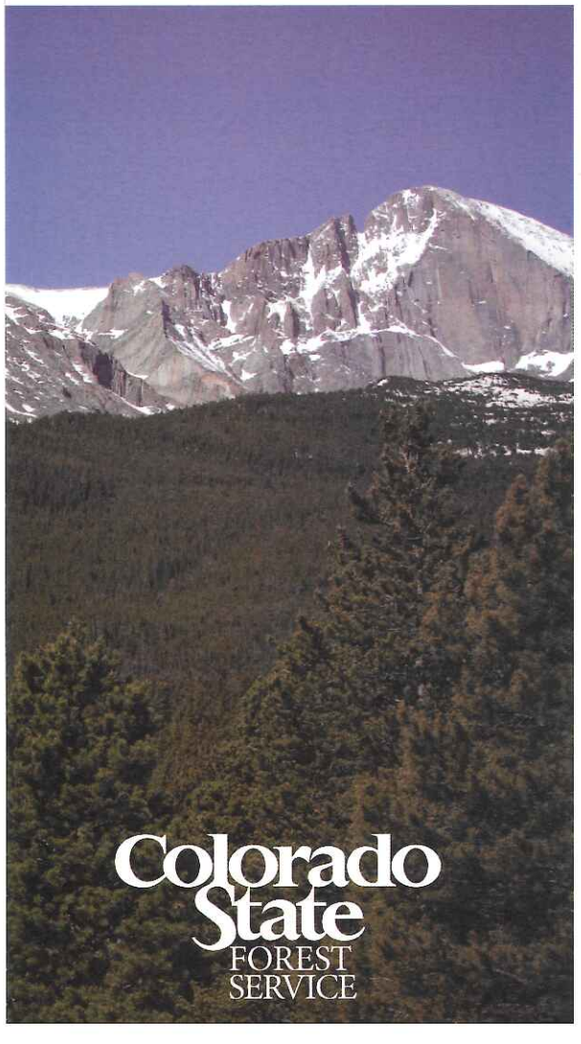
Air Quality at a Glance

Project Type & Size	Northern Front Range *	The Rest of Colorado
 ***Small Pellet Boilers.*** This 150,000 Btu/hr pellet system installed at the Colorado State Forest Service office in Fort Collins is smaller than the notification threshold.	Below Notification Threshold (470,000 Btu/hr)	Below Notification Threshold (760,000 Btu/hr)
 ***Medium-size Pellet or Chip Boilers.*** This 650,000 Btu/hr pellet boiler in Fairplay is outside of the nonattainment area, so it does not exceed the notification threshold. The same system in the Northern Front Range would need to file with the CDPHE.	Above Notification Threshold (470,000 Btu/hr) Below Permit Threshold (2.33 MMBtu/hr)	Below Notification Threshold (760,000 Btu/hr)
 ***Large Wood Chip Boilers.*** This 3.3 MMBtu/hr wood chip boiler in Longmont exceeds the permit threshold anywhere in Colorado. A similar system has just been installed at the Boulder County Jail.	Above Permit Threshold (2.33 MMBtu/hr) Below National Threshold (10 MMBtu/hr)	Above Permit Threshold (2.85 MMBtu/hr) Below National Threshold (10 MMBtu/hr)
 ***Large District Energy Systems.*** Central St. Paul, Minnesota, is heated and powered by a central combined heat and power (CHP) power plant fueled by 80% biomass. The system produces up to 25 MW of electricity and 222 MMBtu/hr of heat.	Above National Threshold (10 MMBtu/hr) Federal Regulations Apply	Above National Threshold (10 MMBtu/hr) Federal Regulations Apply

* The nonattainment area extends from Larkspur in the south to Wellington in the north and includes all of Denver, Boulder, Adams, Jefferson, Douglas, and Arapahoe counties, and the southern part of Larimer and Weld counties.

All biomass systems must comply with smoke opacity limits.
This system being tested does not. ➤

Technical & Financial Support



Many sources of technical and financial assistance are available to support your wood-to-energy project. Private companies and consultants, as well as governmental organizations can provide assistance along the way. Local, state, and federal organizations also provide assistance in the form of grants, loans, and loan guarantees. Many businesses and communities across Colorado have successfully applied for and received financial assistance for their projects. Funds can be used for:

- Woody Biomass Supply Planning
- Feasibility Studies
- Operating Capital
- Technical Assistance
- Education and Outreach
- Trainings
- Business and Market Planning
- Woody Biomass Treatments

Contact the Colorado State Forest Service to help locate and access assistance for your wood energy and non-energy projects. Visit us at csfs.colostate.edu.

Grants are NOT a substitute where underlying economics, technologies, and wood supply is not demonstrated or sustainable.

The Colorado State Forest Service has produced this booklet, with assistance from the US Forest Service, to help guide you and your team through the important but challenging task of making wood work in Colorado.

Colorado Wood Utilization & Marketing Program

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE