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Community Biomass Handbook
Volume I: Thermal Wood Energy

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About This Book

This handbook and financial app is a guide to help communities quickly determine if biomass energy projects might work for them so that this option is not overlooked. Its purpose is as a screening tool designed to save significant time, resources, and investment by weeding out those wood energy projects that may never come to fruition from those that have a chance of success. It establishes technical, financial, and social criteria and indicators to evaluate proposed biomass investment options. Through showcasing of successful projects using text, photos, video interviews, and diagrams, it facilitates virtual project planning and interaction with experts. The interactive wood energy financial app allows estimation of capital investment costs to facilitate project design and screening across a variety of wood energy options. The calculator can be accessed from the eBook or from the Web.

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Product Disclaimer

The financial calculator is for information and education purposes only (e.g., project guidance, scoping, and pre-feasibility assessment). It should NOT be used for investment purposes. The authors, USDA, and the Forest Service claim no responsibility for its use.

All photographs and videos by Dan Bihn

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Chapter 1

Introduction

Overview

The *Community Biomass Handbook* is a living electronic workbook and reference guide to help you answer initial project development questions about proven thermal energy options for your community or business. The handbook walks users through the initial stages of project scoping and feasibility analysis by providing:

- **Guidance** – Matching project motivations and local resources with appropriate technologies and investment pathways
- **Personal stories** – Identifying what has worked in other places with common financial and technical challenges faced
- **Options** – Checklist of possible products with important planning and investment considerations
- **Project screening** – Initial financial assessment to narrow the range of options

Tap the icon above to launch the Wood Energy Financial App. See chapter 5 for full details on how to use.

Who Should Use This Handbook

Project development requires a phased and iterative process of reducing uncertainty. The *Community Biomass Handbook* provides information to help the user quickly screen projects and make timely decisions regarding technical and financial feasibility. The handbook is suitable for a wide range of applications and users, including:

- Local and regional economic development agencies
- Local businesses and entrepreneurs
- Community organizations and stakeholders
- Local school districts and colleges
- City planners
- State and federal forest management agencies

With just a few inputs, users can estimate capital investment and operations costs, biomass requirements, and return on investment.

Using this handbook removes the need for costly prefeasibility studies to narrow the range of options, and significantly increases the likelihood of projects successfully navigating late-stage development. Reducing early stage costs saves scarce resources for later stage engineering studies.

The handbook will help you set objectives, define project scope, and conduct a preliminary financial appraisal of a range of options.

The Case for Biomass

You are probably aware that there is a surplus of underutilized biomass abundantly available from our national forests and other public and private lands, and maybe you know that some of this biomass fuels the catastrophic wildfires experienced in the last two decades.

What you might not know is how to convert that excess biomass into durable products and energy while providing rural economic development opportunities.

The potential benefits of using woody biomass are significant, but there is a lack of uniform knowledge about successful project siting and operation, how to coordinate investments with ongoing public and private forest management activities, and other critical project development tasks.

There is an urgent need to find revenue-generating uses for forest biomass to mitigate environmental stressors and offset the public burden of funding their removal and utilization. Forest management practices that promote sustainability, if coupled with qualified industrial expertise, can provide opportunities for stable employment and economic growth in the Nation's forest products industry.

The case for woody biomass can be made when it is used in a manner that enhances the environment and the well-being of the people, communities, and businesses dependent upon it. The result will be a vibrant forest products industry and resilient forests capable of providing an array of ecosystem goods and services.

Local Economic Health

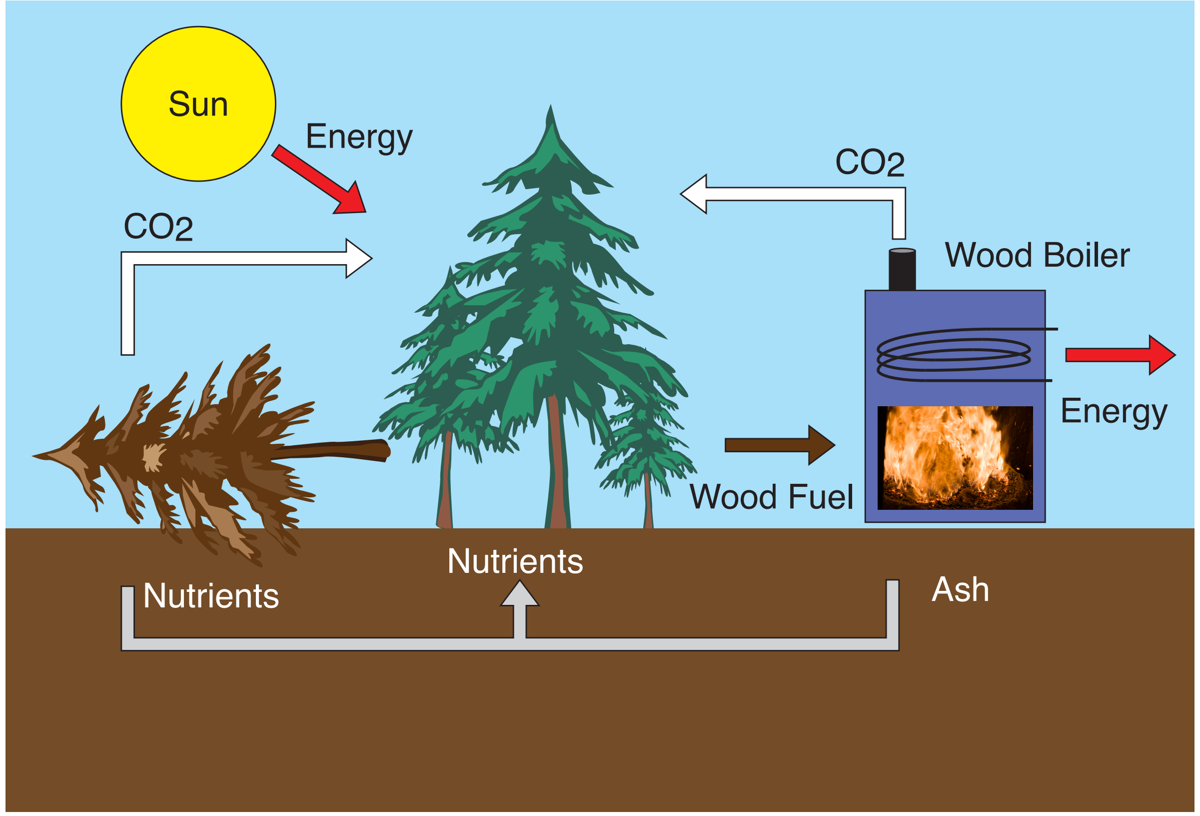
About one third of the energy consumed in the United States is used to produce thermal energy, and one third of that is generated from petroleum products. That’s money leaving the community – and not invested in local schools and businesses.

Rising costs and volatility of heating oil and propane-based heating have significant negative economic impacts in communities across the Nation. Heating with biomass provides a clean, commercially viable, and cost-efficient means to keep more dollars local. Even a small heating system can save hundreds of thousands of dollars annually and create stable employment in the woods.

Local Forest Health

Local forest health and biomass utilization are inextricably linked – biomass markets help to underwrite the cost of hazardous fuels reduction, enable forest health and restoration treatments, and increases forest productivity through precommercial thinning. The biomass removed during these activities is crucial – the greater the value, the more treatments that can be accomplished. Biomass utilization is the linchpin of forest health on public and private lands throughout the country.

But biomass markets shouldn't drive forest treatments. It is important to establish safeguards to ensure sustainable harvesting practices are independent of market demand. Many states are implementing biomass harvesting guidelines to balance demand with the need for healthy forests, productive soils, water quality, and suitable habitat.



Carbon Reduction

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.

The degree to which biomass heating is "carbon neutral" depends on the rate of carbon uptake (sequestration) of the new and surrounding trees, how those trees were harvested in the first place, and the technology used in combustion. Fossil fuel used to transport biomass can also change the equation, so keeping biomass local is important.

CHAPTER 2

Heating With Wood

Is Biomass Heating Right for You?

Sometimes, a biomass heating project can be justified on purely financial grounds. These are the exceptions. Most projects work because of the significant noneconomic benefits they provide their owners. That is why many biomass heating projects are located at colleges and schools, public buildings, and facilities run by nonprofit organizations.

When done correctly, a biomass heating system can provide local jobs, reduce carbon emissions, and improve forest health by offsetting the cost of prescribed forest health treatments that may not otherwise be affordable. If these benefits are valuable to your community, heating with biomass can be a very good decision.

The wood chip handling system at the Colorado State University biomass heating plant.

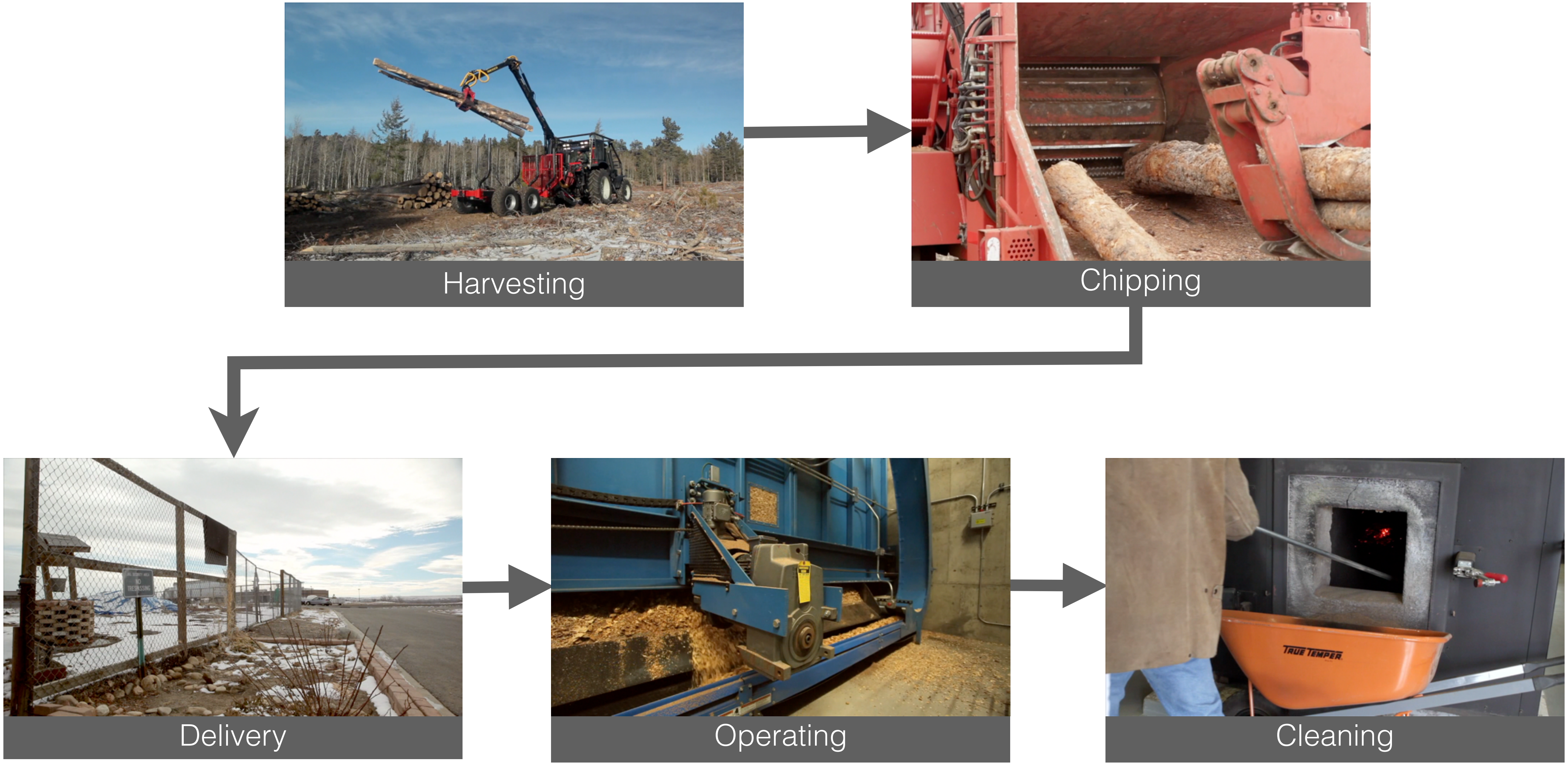
The benefits of heating with biomass can be substantial, but they don't come easy. Here are just a few of the important challenges that need to be considered:

- **Energy economics.** Delivered, quality biomass is not cheap. In today's energy market, wood chips cost about the same as natural gas. However, wood can be significantly less expensive than propane, heating oil, or electricity, depending on your part of the country.
- **Capital costs.** Thermal energy systems are expensive. For anything beyond a fireplace, the initial investment may cost three times more than a conventional system.
- **Operation and maintenance (O&M) costs.** Handling a solid fuel is more difficult than handling a gas or liquid fuel – moist chips freeze, augers jam, conveyor belts break, ash accumulates, and chimney's clog.
- **Stable supply.** Long-term, stable biomass supply can be challenging. Wood is subject to both seasonal availability and long-term supply disruptions owing to public policy changes or a natural disturbance such as fire or disease.
- **Social license.** Community buy-in is critical. Projects can become quickly derailed without strong local support. With it, you can overcome other challenges like financing and biomass supply.

In spite of these challenges, biomass systems are successfully working in many parts of the country. This handbook will help you decide if heating with biomass is right for your community or business.

Biomass Heating is Working Today

3.5 MMBtu/hr wood chip boiler system, $500,000 capital investment, South Park School, Fairplay, Colorado – completed in 2012.



This is the forest-to-ash life cycle for a typical wood chip boiler system. This isn't your grandfather's fireplace!

(Tap on a video image to play – use spread gesture for full screen.)

Chapter 3

Technology That Works

Technology Considerations

Selecting the right technology is key to having a successful project. The most important factors are:

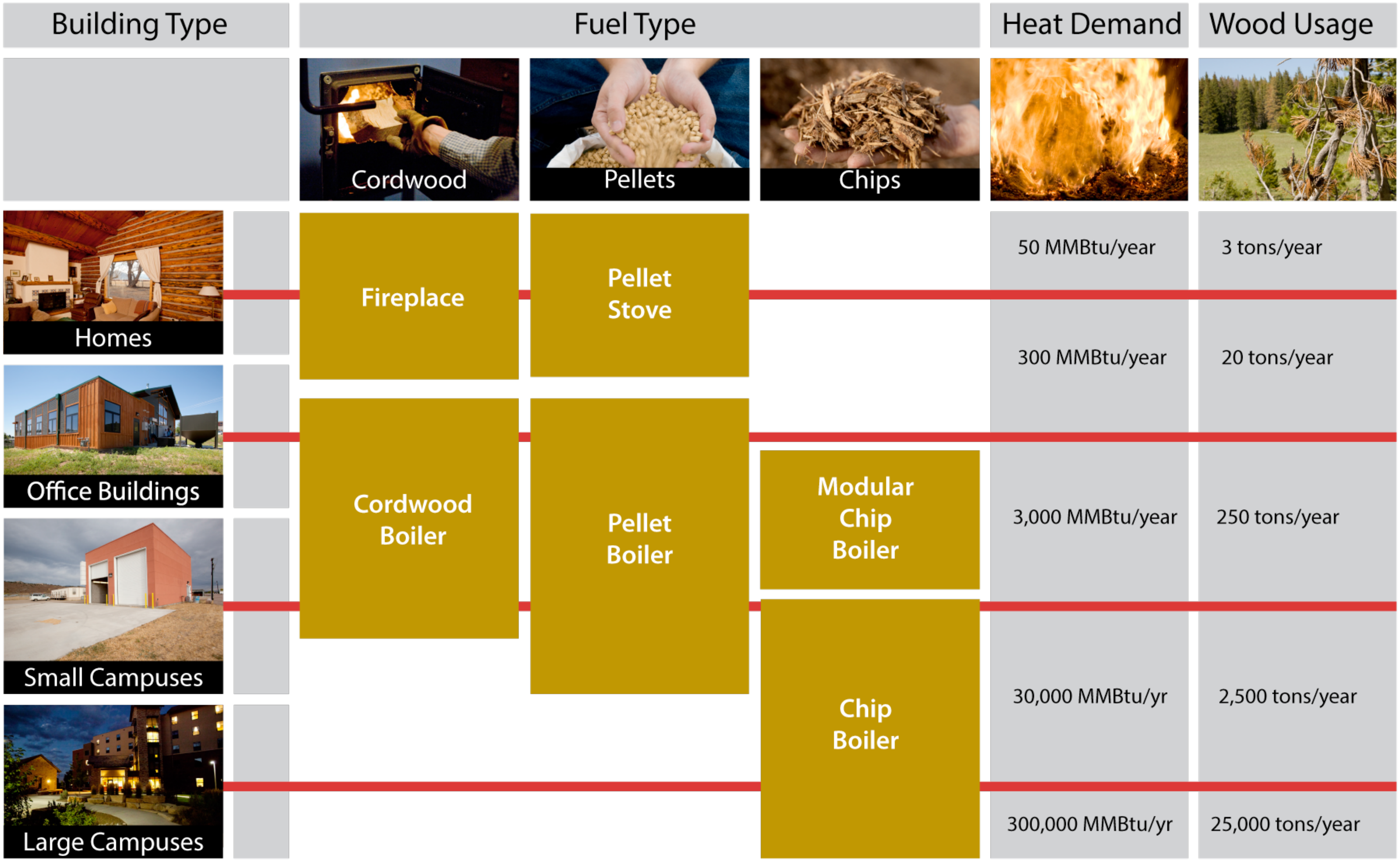
Matching technology. The size of your project is the most important factor in determining the right technology. For smaller projects, wood pellets often are the best choice because it is much easier to automate fuel handling. For larger projects, wood chips often are the lowest cost solution.

Proven technology. If the technology that matches your project is being used elsewhere in your region, it is a good idea to pay a visit. Ask those who operate the system if they would do it again and, if so, what might they change. Talk with the operators, as project managers and sponsors often have a vested interest in discussing only the positive aspects. You need to hear the whole story.

Clean technology. Make sure you are in contact with the appropriate local air quality authorities and seek necessary permits.

The following pages will help you narrow your technology choice and size of boiler.

Size Determines Choices



This chart provides a **rough** idea about which technologies are most appropriate for your application. It is not a design tool.

Cordwood

Cordwood fuel needs the least amount of processing and the smallest amount of capital to both process and burn. Modern cordwood boilers are clean, efficient, and affordable. The capital investment is low, but the labor requirement is high. However, if you have a wood supply and staff that can feed the boilers several times a day, this can work for you.

Wood Chips

Wood chips are the workhorse of the biomass world. Small working wood chip systems start at 1 MMBtu/hr and can be quite large. System complexity and maintenance are similar to coal-fired systems. If you're heating 50,000 square feet or more, this may be the right system for you.

Wood Pellets

Wood pellets are the most processed, most uniform type of biomass fuel. They are also the easiest to use, but the most expensive to buy. The small uniform size of pellets is similar enough to grains such as corn, that the same processing equipment (augers, bins, etc.) can be easily adapted. Their uniformity allows for more efficient transport, and they can be an ideal fuel for small projects or facilities more than 100 miles from a biomass source.

Cordwood Technology

Cordwood, or firewood, needs the least processing (a chain saw and pickup truck are enough), is the least expensive of all the biomass fuels, and is the most labor intensive. Unlike the fireplaces and cordwood boilers manufactured prior to 2007, modern cordwood boilers are clean, efficient, and affordable.

Most commercial systems are between 50,000 and 500,000 MMBtu and require manual fuel loading every few hours when operating at full power. These systems are practical at lodges and camps where both fuel and a capable workforce are available.

There are many systems successfully operating around the country, with most heating between 5,000 and 25,000 square feet.

Cordwood Technology

This 198,000-Btu/hr TARM cordwood boiler system, installed in 2008, heats the 6,000-square-foot dining hall at a mountain camp. Cold winters and cool summers at 10,000 feet above sea level keep the boiler going most of the year. The system cost about $60,000 installed.

Cordwood Technology

Two GARN WHS 2000 wood boilers can provide up to 850,000 Btu/hr when continuously fired (about every 2 to 3 hours). In typical operation, it has no trouble heating this recently renovated and winterized 18,000-square-foot mountain camp.

Camp director, David Van Manen, acknowledges the labor costs but says, “it is still much cheaper than propane, and the money we spend on wages stays in our community.”

The system costs about $100,000 installed.

Wood Chip Technology

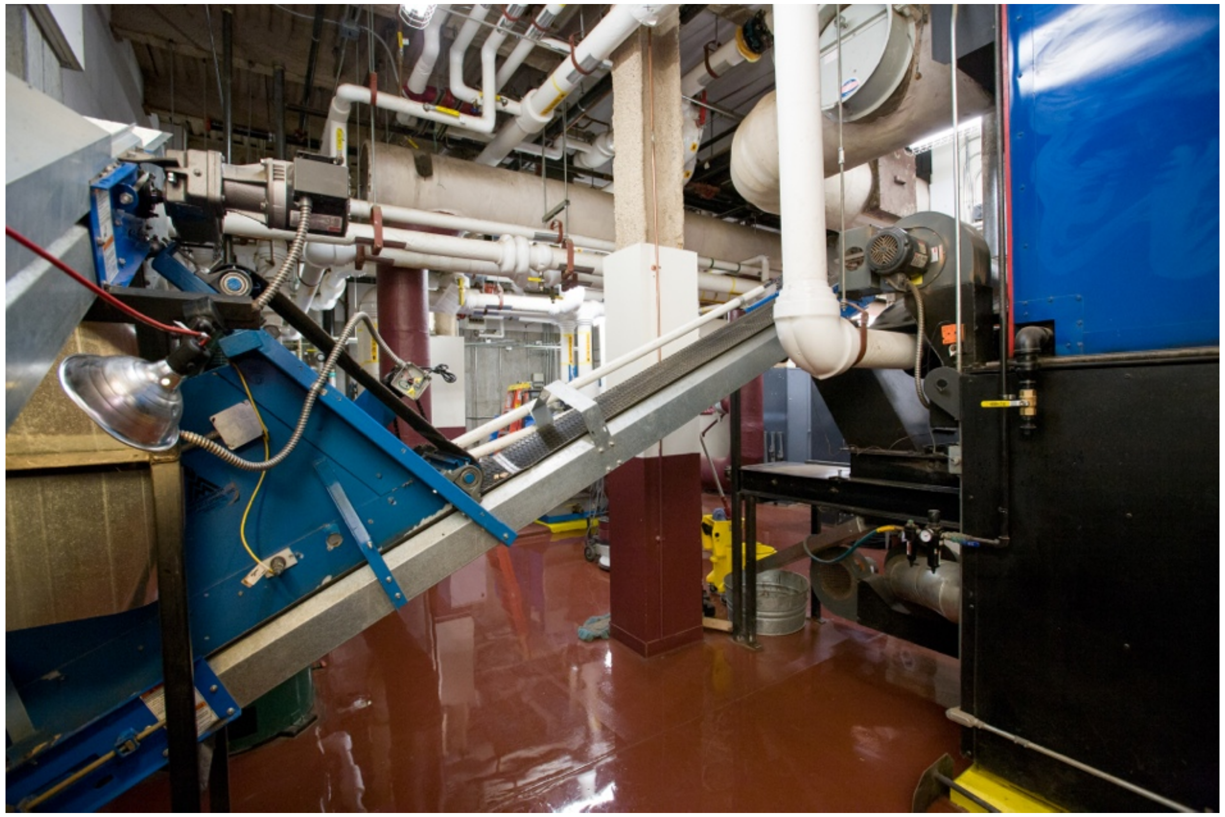
Wood chips are the workhorse of the biomass world. Most (but not all) common wood chippers are capable of creating fuel-grade chips from debarked trees. Wood chips can be transported and stored relatively easily, but keeping the chips dry and free of contamination, such as rocks and dirt, on their way to your boiler is a challenge – sometimes a very expensive challenge.

Wood chips usually have a moisture content of between 20 and 60% (wet basis). More moisture means you're hauling more water and less wood fiber – and when moist chips are burned, some of the energy is wasted evaporating that moisture, which also creates more carbon emissions.

Virtually all the wood chip systems automatically transport chips from a storage bin to the firebox. Because these transport systems need to be well-engineered and constructed to tolerate a wide range of chip sizes, they are complex and expensive. That is one of the main reasons wood chips systems are normally 1 MMBtu/hr or larger.

Practically, this means you'll probably need to heat at least 100,000 square feet.

Wood Chip Technology



A 15-MMBtu/hr wood chip system – a ChipTec gasifier and a Hurst boiler – provides most of the heat and hot water for the North County Hospital in Newport, Vermont. The system also provides steam to an absorption chiller to help cool the hospital in the summer.

Initially, the system generated electricity, but that part of the system has since been shut down owing to maintenance and economic reasons.

The system cost about $1.5 million installed, with an estimated payback period of 11 years.

Wood Chip Technology

This 3.5-MMBtu/hr Osby Parca P500 wood chip boiler heats this LEED (Leadership in Energy and Environmental Design) certified school at 10,000 feet above sea level in Fairplay, Colorado. This system features an innovative chip bin and a rolloff container with a “walking floor” that automatically moves the chips to the end of the container and into the boiler’s chip feeder. The system cost about $500,000.

Wood Pellet Technology

Uniform size and low moisture content make wood pellets a very attractive fuel.

Pellets are about the same size as many agricultural grains so proven, low-cost equipment like augers and bins can be used for transportation and delivery.

Pellets have two to three times the density of wood chips and cordwood and often lower moisture content. This can significantly reduce emissions and transportation costs – so much so that wood pellets are routinely exported from the United States to Europe in dedicated grain ships.

The small, uniform size of wood pellets simplifies boiler design, reducing cost, increasing reliability, with lower maintenance costs. Pellet boilers often have highly tuned combustion systems that are cleaner and more efficient than boilers needing to accommodate less uniform fuels like wood chips and cordwood.

The many advantages of wood pellets come at a cost. Pellets cost more than $200 per ton delivered – compared to less than $50 per green ton for wood chips. Energywise, pellets often cost three times as much as wood chips.

Wood Pellet Technology

This 300,000-Btu/hr Boilersmith, LTD. pellet boiler heats the Town Hall in Eagar, Arizona. Pellets are delivered in bulk to reduce both fuel and labor costs.

Wood Pellet Technology

This 200,000-Btu/hr Froling P4 pellet boiler easily heats this 2,000-square-foot office building in Fort Collins, Colorado. The system is designed for bulk delivery of pellets, but the local market only offers bag delivery.

Installed cost is $64,000.

Chapter 4

Biomass Supplies That Work

Assess Local Biomass Supply

Success or failure of a project can depend on access to an affordable, consistent source of biomass fuel that meets the operational needs of your boiler. Before committing to biomass heating, make sure you and your supplier understand the specific requirements of your system. Include these specifications in your procurement contracts.

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

The Right Source of Biomass Fuel

Reliable Access to the Biomass Resource

Weather, fire, and policy can temporarily or permanently disrupt your biomass supply chain. Or, if your biomass is a byproduct of a sawmill, changes in regional and global economics can affect cost and availability. Short-term and seasonal disruption that prevents harvesting can be mitigated by storage – either at your site or at an intermediate location. Diversifying your supply sources is also critical for long-term success.

Affordable Transportation

Transportation is often the single major contributor to the cost of your delivered fuel. Distance between the resource and your site is obviously a big factor, but the size of your onsite storage affects the truck size, as do road conditions, legal weight limits, and access in the forest.

High moisture content means you are paying to haul water to your facility instead of fuel. That water will either be removed when the biomass dries, or evaporated when the biomass burns, wasting valuable energy.

High-Quality Delivered Fuel

If your biomass fuel is **cordwood or wood chips**, its moisture content is the most important factor. Generally, drier is better, but some boilers need a minimum moisture content, otherwise they will produce a lot of smoke. It's also important to keep wood chips free of contaminants like rocks and dirt that can damage your boiler.

If your biomass fuel is **wood pellets**, the main challenge is keeping the pellets from falling apart. That means keeping them dry and not subjecting them to a lot of handling and vibration.

Biomass Fuel Economics

Before estimating financial feasibility of a specific project, it's important to know a few basics about the economics of your biomass supply. Just because biomass can be a bargain, it may not be a good match to your situation. It depends on the cost of the fuel you're replacing, the energy content of the biomass used, and any new construction. If you're replacing natural gas, for instance, the economics may be against you once you factor in the capital cost of new equipment and infrastructure.

But, if you are currently using propane, heating oil, or perhaps electricity, the economics are encouraging. A comparison of biomass heating and conventional fuel systems is provided on the next page.

What is an MMBtu?

This is a common unit of energy used in the United States.

For our purposes, an MMBtu is a very convenient way of comparing apples to oranges – or gallons of propane to tons of green wood.

The two Ms are the roman numerals M for 1000 (as in millennium, not mega). So MM is 1000 times 1000 or, 1 million. Btu is the abbreviation for British thermal unit, the amount of energy it takes to heat 1 pound of water, 1 degree Fahrenheit. So an MMBtu is 1 million Btus, enough energy to heat 1 million pounds of water 1 degree Fahrenheit.

Comparison of Energy Costs by Fuel Type

Fuel	Assumed Unit Price	MMBtu/Unit	$/MMBtu
Wood chips (30% moisture content)	$50/ton	10.5/ton	**$4.76**
Natural gas	$5/MMBtu	—	**$5.00**
Wood pellets (8% moisture content)	$200/ton	14.5/ton	**$14.54**
Propane	$2/gallon	0.091/gallon	**$21.91**
Heating oil	$4/gallon	0.14/gallon	**$28.57**
Electricity	$0.10/kWh	0.0034/kWh	**$29.31**

Energy (Moisture) Content

The good news is that the energy content of biomass does **not** depend very much on the species of wood. The bad news is that it varies greatly with moisture content (also called water content). Biomass fuel from wood is made up of wood fiber and water. The wood fiber contains energy. The water is like an energy-consuming parasite, so generally, the less of it, the better.

Moisture Content – Wet or Dry?

The amount of water in biomass is called the moisture content. There are two common ways of defining moisture content, wet basis and dry basis.

Wet basis moisture content is used extensively in the paper industry, the biomass community, and in this handbook. However, for other wood industry products, dry basis is commonly used. Make sure to clearly state which definition is being used.

Wet basis moisture content:

$$MC_{Wet} = \frac{Weight_{Wet} - Weight_{Dry}}{Weight_{Wet}}$$

Dry basis moisture content:

$$MC_{Dry} = \frac{Weight_{Wet} - Weight_{Dry}}{Weight_{Dry}}$$

Where MC = moisture content.

Moisture content of biomass fuel affects energy in two ways.

The primary impact is simply that the higher the moisture content, the lower the wood fiber content.

The wood fiber part of biomass contains about 16 MMBtu/ton of recoverable energy. If your biomass has a moisture content of 30%, that means you only have 70% energy-containing wood fiber. So, in this case, the energy content of your wood fiber is 11.2 MMBtu/ton (16 MMBtu x 70%).

The secondary impact is that energy is needed to boil off the water during combustion. Energy is consumed creating steam, but biomass boilers do not recover that energy, which is exhausted into the environment through the chimney or smokestack. This wasted energy can be significant.

It takes about 2.23 MMBtus to boil 1 ton of water from room temperature (68° F) into steam. So, 1 ton of biomass with a moisture content of 30% will **consume** 0.67 MMBtus just to evaporate the water.

Energy = energy in wood fiber - energy to evaporate water

10.53 MMBtu = 16 MMBtu x 70% – 2.23 MMBtu x 30%

For Example...

Moisture content of wood chips and cordwood can easily vary from 20 to 60% and can be as low as 4% for wood pellets. Moisture content can vary by season, species, region of the country, and the amount of time since the tree was felled, and many other factors.

If your biomass supplier tells you she'll provide you with wood chips for $50 per green ton with moisture content of 30% (wet basis), that works out to $4.76 per MMBtu. However, if the moisture content is 50%, it works out to $7.26 per MMBtu. Moisture content affects the **energy content** of biomass fuel.

Moisture content also affects the **quantity** of biomass fuel you'll need to purchase. Assuming you have an annual heat demand of 4,500 MMBtus with a wood chip moisture content of 30%, you'll need about 425 green tons of biomass per year. At 50%, you'll need about 650 green tons per year.

For 30% moisture content: $425 \times \$50 = \$21,250$

For 50% moisture content: $650 \times \$50 = \$32,500$

Green Ton, Dry Ton, or MMBtu?

Biomass supply contracts are usually specified in green tons, dry tons, or MMBtu (energy content).

A **green ton** is the actual physical weight of the biomass – including the moisture. In this case, "green" doesn't imply the wood has or hasn't been dried.

A **dry ton** (also referred to as a bone dry ton, or BDT) is a calculated value of the actual weight of the biomass minus the weight of the water. In other words, it's just the weight of the wood fiber.

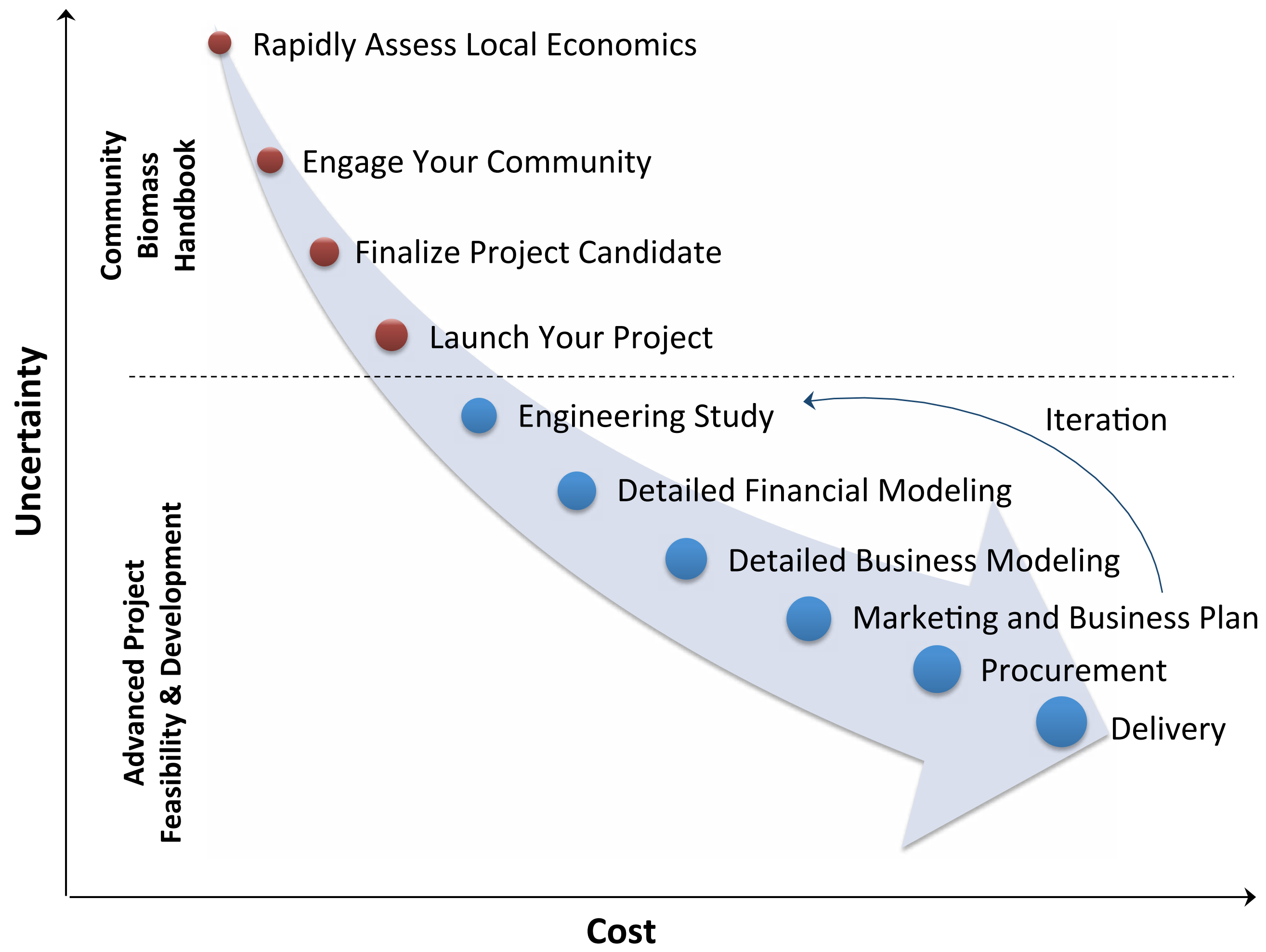
A dry ton is a useful, but imprecise measure of energy content because it doesn't include the additional loss of energy resulting from evaporating the water during the combustion process. Biomass is also hygroscopic meaning it attracts and holds water. Even if you completely dry biomass in an oven, when you take it out, it immediately starts absorbing water from the air. Biomass is never completely dry.

Contracts can also be specified using energy content – usually in **MMBtus.** This is a good way to ensure you're getting what you pay for. But keep in mind that the quantity of biomass needed can vary significantly with the moisture content – and also the efficiency and operation of the boiler.

CHAPTER 5

Roadmap to Success

Key Components of a Project



Based on original work by the International District Energy Association.

Project development requires a phased and iterative process of reducing uncertainty. The Community Biomass Handbook provides information to quickly screen projects and navigate early stages of project planning.

Chapters 6 through 9 will guide you through the initial steps and key considerations for making wise investment decisions.

Milestones on the Road to Success

1

Rapidly Assess Local Economics

You don't need to hire a consultant to understand the basic economics of biomass, at least not yet. All you need at this stage are the utility bills of the building(s) you're interested in converting, Internet access, and a verbal price quote for delivered biomass in your area. Enter a few other numbers into the Wood Energy Financial App to instantly calculate energy savings and preliminary return on your investment.

2

Engage Your Community

It's never too early to begin dialog with your community, local government officials, school boards, and other key players. Using this handbook, these individuals can help you identify potential scenarios – and become part of your larger team.

3

Finalize Project Candidate

To keep capital costs down, biomass heating projects are usually best **designed into** new construction or major renovations, not as an afterthought. This is challenging because most projects aren't made public until the design has been completed. If designing a "district" heating system (with multiple businesses or buildings), it's also important to focus on those main buildings with the greatest heating need.

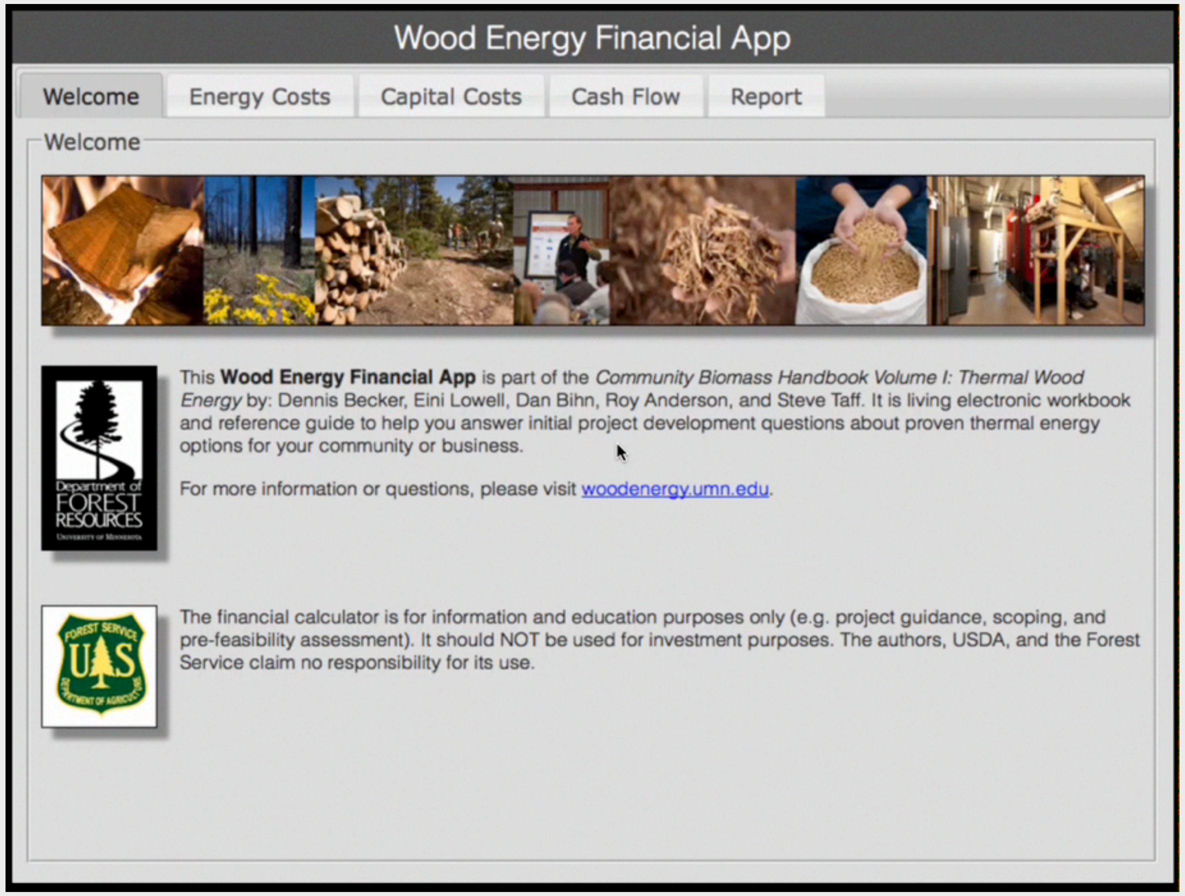
4

Launch Your Project

Once you have identified a potential project with acceptable financial estimates, and you are comfortable with the local biomass fuel supply options and community support, you'll need to create a project proposal that you can use to seek funding for an investment-grade engineering study. Now the real work begins.


CHAPTER 6
Wood Energy Financial App

The Wood Energy Financial App



Wood Energy Financial App demonstration and training video

With the Wood Energy Financial App, making a meaningful estimate of the financial viability of a potential wood heating project can be quick and simple.

User inputs are organized into three tabs found across the top of the app, which will guide you through fuel cost calculations, capital investment options, and estimated financial feasibility. By simply moving the slider bar at the bottom of the calculator, you can quickly make comparisons and analyze "what-if" scenarios (for example, varying the cost of propane, biomass moisture content, or assess possible financing options).

To get started, watch the demonstration video above. To launch the app, just tap the icon on the right. The next few pages walk you through examples and specific steps to calculate financial feasibility.

Tap to launch app

A Five-Step Rapid Assessment Process

The following five-step process provides instructions for using the Wood Energy Financial App including useful default values and important considerations. Once you're familiar with the app, jump around and use it to test the sensitivity of your inputs and compare project options.

Rapid Assessment

- [ ] Estimate heating needs
- [ ] Choose fuel type
- [ ] Obtain biomass price quote
- [ ] Calculate capital cost
- [ ] Estimate project finances

Step 1: Estimate your biomass heating needs. If this is a renovation project, use the actual heating bills for this building. If new construction, find a similar building in your area and use its heating bills, but be sure you're comparing to the same fuel (heating oil, propane, natural gas, electricity) as what your project would otherwise be using.

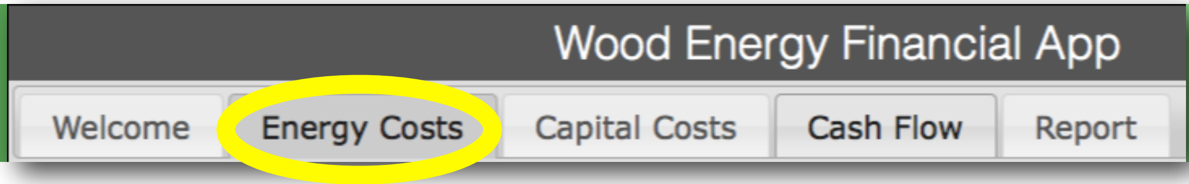
Step 2: Choose fuel type. Based on the estimated annual biomass energy needs, operational needs, and local availability, choose whether to use cordwood, wood chips, or wood pellets. You may need to consult an expert if uncertain.

Step 3: Obtain biomass price quote. Now that you know the fuel type and your annual biomass energy needs, find a local biomass fuel supplier and get a price quote. The exact quantity of biomass will depend on the moisture content of the delivered fuel.

Step 4: Calculate capital cost. There are many variables when calculating project capital costs, and it is still a relatively small market. The app can provide you with a useful, back-of-the-envelope estimate based on your annual heating needs and other parameters. However, finding a recently installed project, ideally in your region, and using those numbers can often give you a more accurate estimate.

Step 5: Estimate project finances. Whether or not a project is a good financial investment is an entirely separate question than how you pay for the project. At this stage of planning, you should be more concerned with identifying a project with a solid financial return. The app will help you narrow your options by screening out poor performing projects.

Estimate Heating Needs



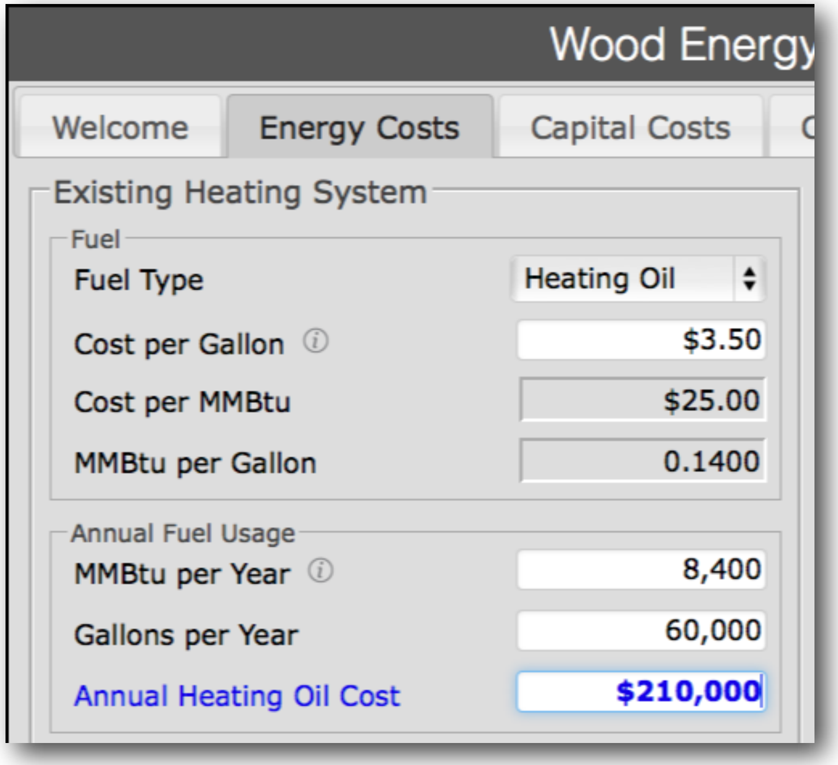
Rapid Assessment

- [x] Estimate heating needs
- [ ] Choose fuel type
- [ ] Obtain biomass price quote
- [ ] Calculate capital cost
- [ ] Estimate project finances

The first step is to estimate your project's heating needs. The best place to get that information is from last year's heating bills.

- If you are considering adding a biomass heating system to an existing building or campus, use the actual heating bills from last year.
- If you are considering adding a biomass heating system to a building that hasn't been constructed yet, you can use the heating bills for a similar building in your area. But be sure you're comparing the same fuel as what your project would otherwise be using.

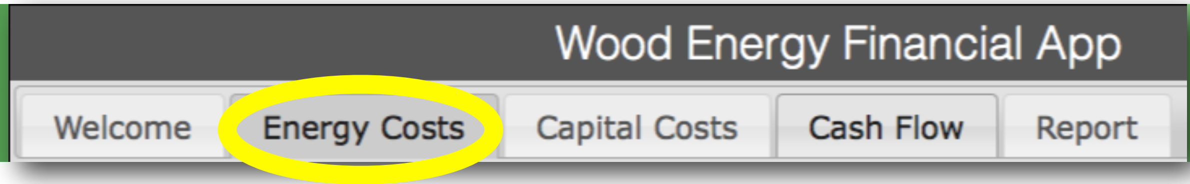
You will need to know the type of fuel (e.g, propane, heating oil, natural gas, or electricity), the unit cost of the fuel (e.g., $3.50 per gallon of heating oil), and either the total annual cost for the fuel (e.g, $210,000/year) or the total amount of fuel (e.g., 60,000 gallons/year).



You will also need to know the Substitution Percentage. This is the portion of your overall project heating needs that will be met with biomass. As a rule, biomass systems almost never supply 100% of your heat. On the coldest days, you may need supplemental heat from your conventional system (e.g., propane heat). And on very mild days when you might just need a little heat in the morning, it may be cheaper to use the conventional system, which also serves as a backup in case of emergency. A good figure is 80%.

Select the "Energy Costs" tab in the app, then enter your assumptions into the appropriate cells.

CHOOSE FUEL TYPE



Rapid Assessment

- [x] Estimate heating needs
- [x] Choose fuel type
- [ ] Obtain biomass price quote
- [ ] Calculate capital cost
- [ ] Estimate project finances

Now you'll need to decide whether to use wood chips or wood pellets. (Refer back to pages 17 and 18 for a general discussion of biomass heating options.)

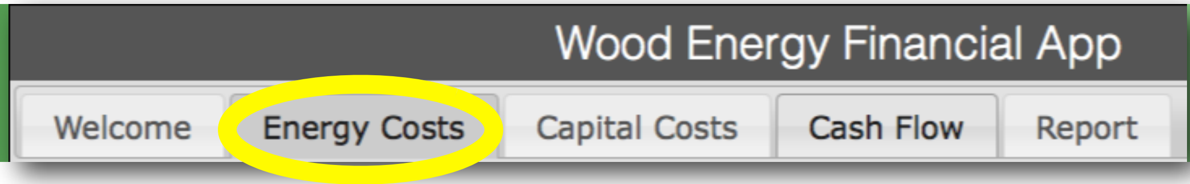
Sometimes your energy demand will determine which fuel type is most appropriate. For example, there are no commercial wood chip technologies with a heat output of less than 500,000 Btu/hr and no common wood pellet systems over 5,000,000 Btu/hr. The decisions in between are more complicated.

Sometimes local biomass availability and delivered cost will determine which fuel type is most appropriate. Pellets are convenient but typically cost three to five times more than wood chips, and delivery can be a challenge. For a residential-scale pellet stove, the pellets are usually delivered in 40-pound bags. For larger systems, pellets are delivered in bulk (often using a feed grain delivery truck). Bulk delivery is usually cheaper per unit but not available everywhere.

A good way to choose your fuel type is to find a successfully working project that is similar in size and type to your project, and use the same fuel type. But first ask the users what they would do differently.

If there aren't similar projects in your area, consider an online database, like www.wood2energy.org to find a similar project working somewhere in the United States.

Obtain Biomass Price Quote



Rapid Assessment

- [x] Estimate heating needs
- [x] Choose fuel type
- [x] Obtain biomass price quote
- [ ] Calculate capital cost
- [ ] Estimate project finances

You now know the fuel type (pellets, chips, or cordwood). Next, calculate your annual biomass needs and delivered fuel cost. Use the following values to quickly see how much biomass you'll need and the total cost. You can use these values for:

- Wood chips – a moisture content of 35% and a delivered cost of $40 per green ton.
- Wood pellets – a moisture content of 8% and a delivered cost of $200 per green ton.

Continuing with our example, last year your building (or proxy building) would have used 60,000 gallons of heating oil at $3.50/gal. The biomass system will replace 80% of your heating needs.

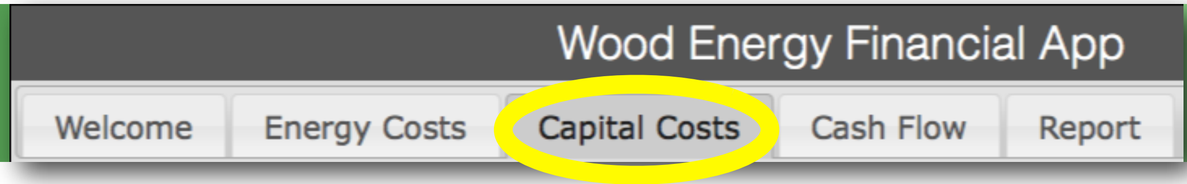
Using a wood chip moisture content of 35% and $40 per green ton results in a biomass demand of approximately 661 green tons for $26,000, plus an additional $42,000 of heating oil to meet demand for the remaining 20% of your heating needs. Your total heating cost with wood chips in this example would be $68,000, which generates an annual fuel cost savings of about $142,000.

Alternatively, if you choose wood pellets, enter 8% moisture content and $200 per green ton. The app calculates a need to purchase 435 tons of pellets for $87,000 and $42,000 of heating oil. Your total heating cost with pellets in this example would be $129,000, which generates an annual fuel cost savings of $81,000.

These annual fuel savings are what's used to offset the increased capital cost of the biomass heating systems and associated increased operating and maintenance costs.

For a more accurate estimate, contact a local fuel supplier and get a price quote for the quality of biomass chips delivered (clean or dirty), average moisture content, exact quantity available, and contingencies for supply disruptions.

Calculate Capital Cost



Rapid Assessment

- [x] Estimate heating needs
- [x] Choose fuel type
- [x] Obtain biomass price quote
- [x] Calculate capital cost
- [ ] Estimate project finances

Project capital costs are not easy to estimate.

However, there are a couple of ways to get a useful, back-of-the-envelope estimate without hiring a consultant or paying for a feasibility study.

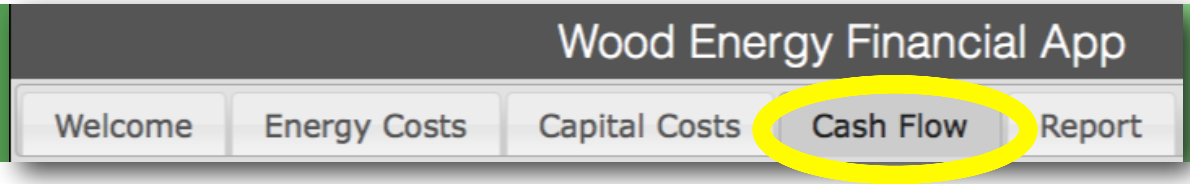
The simplest way is to use the app's built-in capital cost estimator. It provides a ballpark cost estimate for a biomass system based on the type of biomass used (e.g., wood chips or pellets) and your annual energy needs.

A more accurate way is to use the actual cost of a similar project that is successfully working somewhere in the country, preferably in your area. A quick and useful way to do this is to use an online database, like www.wood2energy.org. Search for similar projects and technologies employed. Contact the project sponsors to learn more.

In our example, your project will use about 6,270 MMBtu per year. To use the app's capital cost estimator, make sure the "Use Model-Driven Estimate" box is checked. The estimator calculates that a project this size will cost around $1,066,000.

If you have a more accurate estimate from either local data or from an online database, uncheck the "Use Model-Driven Estimate" box. You can then directly enter the boiler system cost.

You can also vary the Substitution Percentage on this tab and other project costs related to building remodeling or construction, pipe distance and linear foot cost, and the number of buildings or businesses connected to the system. You'll see that capital costs (and financial feasibility) can change dramatically based on small changes to these assumptions. Plan carefully!



Rapid Assessment

- ☑ Estimate heating needs
- ☑ Choose fuel type
- ☑ Obtain biomass price quote
- ☑ Calculate capital cost
- ☑ Estimate project finances

You now have estimates of
annual fuel cost savings and capital costs. In the app's Cash Flow tab, you'll need to enter:

Interest rate. This is your cost of capital. A good default is 3 to 6%, depending on the amount of capital required and access to funding.

O&M % of capital cost. This is an estimate of your operation and maintenance costs calculated as a simple percentage of the projected total installed cost including your boiler, building construction, piping, fuel handling, and related expenses. One percent is a useful estimate for calculating financial return.

Project lifespan. Properly maintained, biomass systems can easily last decades; however, 20 years is a useful estimate.

Capital grant. This is the amount of third-party grants or forgivable loans provided to help pay for the project. Enter $0.00 unless you have already received or anticipate receiving a grant.

The app calculates **annual debt payment, annual expense, annual savings, net present value, and the system cost per MMBtu.**

For our example, using the results of the Energy Costs and Capital Cost tabs with the above defaults, our biomass heating system an annual cashflow savings of about $54,000, and a net present value of $646,000.

Now change some of the assumptions to see how sensitive your results are to the cost of fuel, cost of capital, and other variables from previous tabs.

Chapter 7

Engage Your Community

Deputize Your Community

“Do we have the tools, people, and resources to make the project happen?”

To realize your biomass heating goals, it is not enough to simply find solutions to challenges like fuel supply and technology. Some of the biggest barriers are social. The pace of project development can be frustratingly slow and the risk of failure high if the community lacks trust in the project or the individuals involved. Successful project development must include mobilizing local entrepreneurs, experiences, and expertise. Balancing the needs of the many stakeholders vested in the outcome is what some refer to as “social license.”

This might mean presenting the results of your analysis to county commissioners, city council, school board, or local grassroots organizations.

You will need their support because...

- Not everyone will be in favor of harvesting trees.
- Delivering biomass will increase truck traffic.
- You have a better chance of identifying new construction projects before they are designed.
- Investing in a project with a payback of 10 years or more requires patience (your project could be less, but many have a payback of more than 10 years).

What you need to know

- ☑ Community capacity ... to do what?
- ☐ History and project familiarity
- ☐ Community attitudes and beliefs
- ☐ Project scale and impact
- ☐ Degree of community involvement
- ☐ Scope of social and political support

In short, community capacity provides the cache of resources and abilities to complete a project. It includes the natural resource base and physical infrastructure, as well as the unique skills, education, and experiences of local residents. Tapping into community capacity is critical to project success and requires mobilizing a broad range of skills of landowners, loggers, truckers, wood products manufacturers, agency administrators, local business groups, and conservation organizations – to mention just a few. Key questions to ask include:

- Where are existing electrical, water, heat distribution, and roads/rail located? What is the state of repair and level of current use?
- Are there industrial sites and sufficient zoning?
- How capable is the local workforce in terms of skills, wage levels, and industry and market knowledge?
- Who in the community has access to financial capital, or how can it be mobilized through bonding, partnerships, or other means?
- Do residents have a history of working together to solve problems?

What you need to know

- [x] Community capacity ... to do what?
- [x] History and project familiarity
- [ ] Community attitudes and beliefs
- [ ] Project scale and impact
- [ ] Degree of community involvement
- [ ] Scope of social and political support

History has a way of repeating itself, or at least that's what some in the community may fear. Do they have a reason to be skeptical? Past experiences play an important part of project success, and you may need to overcome some not-so-good history to explain how your project is different.

Past experiences can also positively shape your project. Communities with a history of forest products manufacturing are more likely to be familiar with and support related projects. Key questions to ask about the history of the community include:

- How familiar are residents with the proposed project? Has a project similar in type and scale been attempted before?
- How do previous experiences influence perceptions about community benefit, negative impacts, or things that should be avoided?
- To what degree do residents trust the agencies, businesses, or other parties involved?
- How tolerant are residents to new ideas?

Community Attitudes and Beliefs

What you need to know

- [x] Community capacity ... to do what?
- [x] History and project familiarity
- [x] Community attitudes and beliefs
- [ ] Project scale and impact
- [ ] Degree of community involvement
- [ ] Scope of social and political support

Attitudes are the sum of one's beliefs about a behavior and evaluation of expected outcomes. Do you have a positive attitude about using biomass because you believe it contributes to wildfire risk reduction?

A belief, which is the acceptance something is true or real, is generally shaped by past experiences and rooted in how we react to new situations or ideas. Do you believe that burning biomass creates unacceptable levels of air pollution?

Attitudes towards a particular activity may evolve, but beliefs are durable and unlikely to change regardless of your efforts. Key questions to include:

- What are the dominant attitudes and beliefs about using biomass and related forest industries?
- What about broader environmental issues related to energy production, climate, and forest health?
- Is there an opportunity to influence local attitudes about potential job creation, wealth retention, impact on forest health, or air quality impacts?
- Are existing businesses concerned about how your project will affect their operations?

What you need to know

- [x] Community capacity ... to do what?
- [x] History and project familiarity
- [x] Community attitudes and beliefs
- [x] Project scale and impact
- [ ] Degree of community involvement
- [ ] Scope of social and political support

The scale of a project can make all the difference. Too big and some will be concerned about impacts to forests, or the number of logging trucks driving through town. Too small and the project finances won't work or the ability to reduce hazardous fuels is insufficient. "Right-sizing" balances local concerns with financial and ecological realities. Unfortunately, identifying the right size can be an ever-changing target.

One approach is to start small to demonstrate results and develop trust among community and project partners. Trust can lead to increased forest planning, financing, and mobilizing expertise to implement a project. Smaller projects also generally have a smaller environmental footprint, are financially less risky, and can minimize fuel supply concerns. The challenge is ramping up production to a financially acceptable threshold that addresses the magnitude of ecological need while still being socially acceptable. Key questions include:

- How scalable is your project? Can it be designed and financed to accommodate future growth or connect to other business clusters?
- How does project size affect air quality, truck traffic, noise and dust pollution, and other impacts to community health and aesthetics?
- What scale of production is necessary to address the magnitude of agreed-upon forest management needs?
- Has the technology been successfully applied elsewhere at this scale?

What you need to know

- ☑ Community capacity ... to do what?
- ☑ History and project familiarity
- ☑ Community attitudes and beliefs
- ☑ Project scale and impact
- ☑ Degree of community involvement
- ☐ Scope of social and political support

Regardless of the size of the project, communication is key. It is especially important that residents feel they have been honestly informed and, to the degree practical, involved in decisions affecting them. Engaged residents are also more likely to have "buy-in" and support your efforts. How and to what degree they are involved is often a source of conflict, so it is especially important to set clear expectations about how decisions will be made, by whom, and at what step in the process. Key questions to ask throughout the process include:

- What avenues exists for residents to contribute ideas and provide feedback?
- How will stakeholder information be used in making decisions, and is it done in a transparent manner?
- Have you genuinely sought input from key individuals or groups affected by your project, including skeptics?
- What are the consequences of excluding groups or individuals?
- Does everyone have equal power in the collaborative process? If not, what are the implications for decisions made?
- To what degree will land management agencies include stakeholders in their decision processes? Have they clearly articulated those roles?

Scope of Social and Political Support

What you need to know

- ☑ Community capacity ... to do what?
- ☑ History and project familiarity
- ☑ Community attitudes and beliefs
- ☑ Project scale and impact
- ☑ Degree of community involvement
- ☑ Scope of social and political support

Identifying the key political players and understanding how they influence decisions is key to community involvement. This will help you navigate the local political waters including understanding which issues are likely to create resistance or hostility. The goal is to bridge factions in the community to build a coalition of support. In reality, not everyone will agree, but hopefully the magnitude of support combined with transparent planning will be sufficient to keep your project on track. Key questions to ask include:

- What is the function and level of involvement of local government in your project?
- Have you adequately informed and sought counsel of key local representatives and organizations?
- Who are the gatekeepers or individuals that are most capable of motivating residents? How do they perceive your project?
- Do you have the political support and ability to overcome public resistance? What are the implications of doing so?

Chapter 8

Finalize Project Candidate

What to Look for...

Heating with a solid fuel such as biomass is different than heating with conventional liquid or gaseous fuels like heating oil, propane, or natural gas.

The equipment is much more expensive so you'll want it to be operating much of the time. And the whole system takes more staffing, so the biomass fuel will need to be less expensive than the conventional fuel to make up the difference.

Successful biomass heating systems are both small and large. Large systems are capable of heating 100,000 square feet or more of building space, which usually means creating a district heating system – heating multiple buildings by distributing heat through buried insulated hot water or steam pipes.

Large or small, you'll need to meet the following criteria to make heating with biomass work for you and your community.

Expensive fuel

What to Look for...

- ☑ Expensive fuel
- ☐ Centralized heating system
- ☐ Large heating bills
- ☐ Year-round heating
- ☐ Proven technology
- ☐ Committed champion

Propane, heating oil, or electricity are generally several times more expensive than delivered biomass. Natural gas, however, is often less expensive than biomass.

What to Look for...

- [x] Expensive fuel
- [x] Centralized heating system
- [ ] Large heating bills
- [ ] Year-round heating
- [ ] Proven technology
- [ ] Committed champion

Retrofitting a building with biomass is much easier and less expensive if the building is connected to a centralized system. Retrofitting a building that has many distributed furnaces, for example, can be prohibitive.

What to Look for...

- ☑ Expensive fuel
- ☑ Centralized heating system
- ☑ Large heating bills
- ☐ Year-round heating
- ☐ Proven technology
- ☐ Committed champion

The higher your conventional heating bill is, the bigger the opportunity to save money – and the larger the biomass system, the lower the cost per unit of heat.

What to Look for...

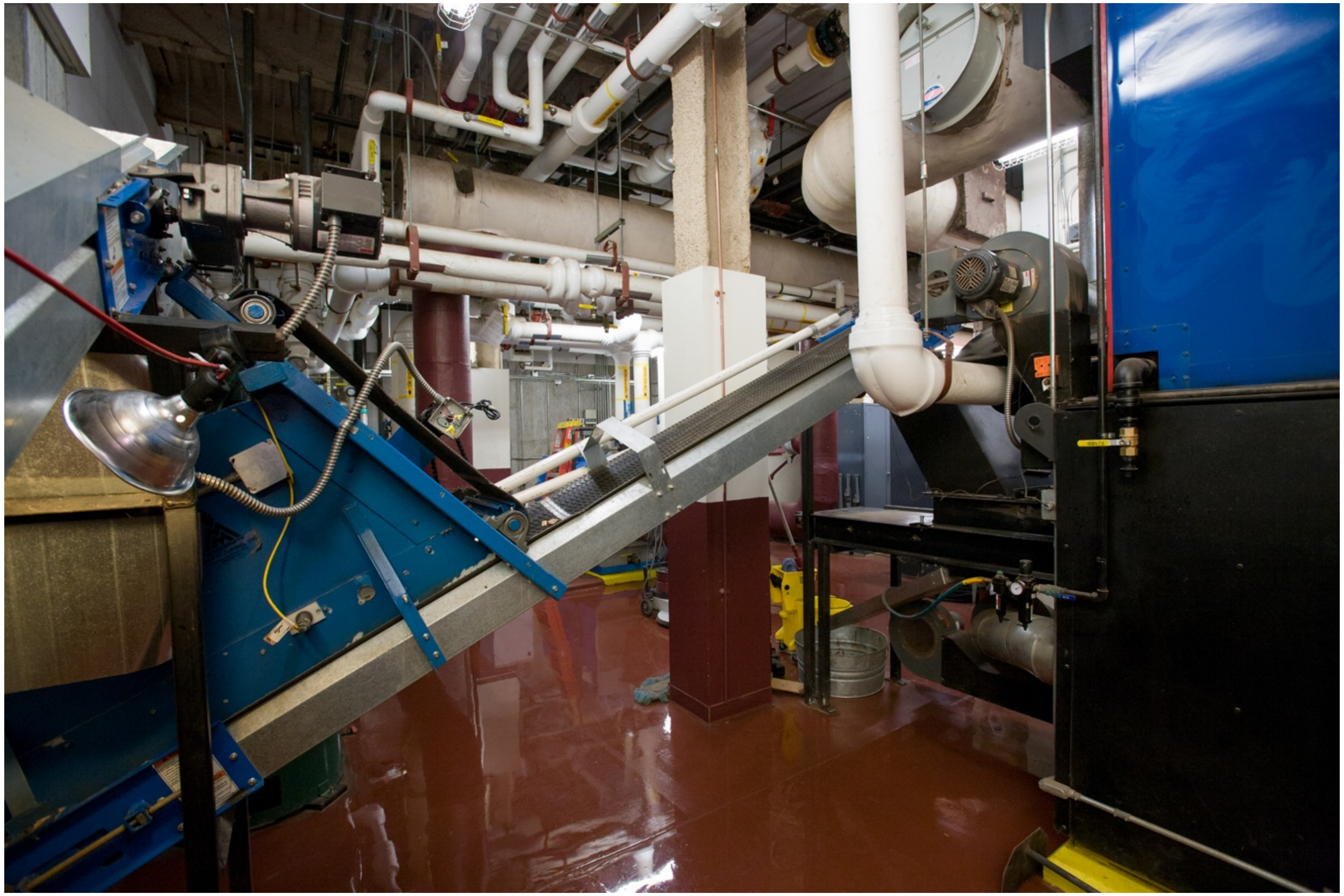
- [x] Expensive fuel
- [x] Centralized heating system
- [x] Large heating bills
- [x] Year-round heating
- [ ] Proven technology
- [ ] Committed champion

Year-round facilities like swimming pools and laundries are good applications. The more constant your biomass system operates over the course of a year, the better the economics.

Proven technology

What to Look for...

- [x] Expensive fuel
- [x] Centralized heating system
- [x] Large heating bills
- [x] Year-round heating
- [x] Proven technology
- [ ] Committed champion



Many biomass heating systems have been working for years – even decades – throughout the United States and Europe. There are also many new exciting technologies entering the market. But unless you are getting paid to do research, stick with the proven ones.

What to Look for...

- ☑ Expensive fuel
- ☑ Centralized heating system
- ☑ Large heating bills
- ☑ Year-round heating
- ☑ Proven technology
- ☑ Committed champion

Biomass projects include a lot of moving parts and seldom succeed without a committed champion to help overcome challenges. Be sure you have one or more trusted individuals to see it through.

Chapter 9

Launch Your Project

Develop a Proposal

Now the real work begins, but you're still a long way from deciding if your candidate project is worth the investment.

You'll need to conduct detailed engineering and financial analyses, prepare a business plan, develop procurement plans and draft contracts, and secure financing for project planning and construction.

A good place to start is to create a one-page fact sheet or proposal you can share with community stakeholders and prospective project developers.

Estimates will change, costs may go up. It is very important to set expectations carefully. Honest and timely communications with your stakeholders is also essential.

Listen to their feedback and update your proposal. You can quickly go back to the Wood Energy Financial App if any key assumptions change.

This is the proposal you will use to seek the funding needed to begin the design and development process.

Things to think about:

Final project planning and design are likely to cost more than 10% of your estimated capital investment cost. That's more than $100,000 for a $1 million project.

Where will you get the money? Is the community or county willing to front the planning costs? Are you able to independently secure financing for project development?

There are many potential sources of funding.

One option is the U.S. Forest Service Woody Biomass Utilization Grant Program (http://www.fpl.fs.fed.us/research/units/tmu/tmugrants.shtml), which funds late-stage engineering and financial analysis for community-scaled wood energy projects. Other sources include state agencies, other federal programs, and private foundations (both local and national).The following page provides a checklist of key items you'll want to address during the next stage of project planning.

THINGS TO THINK ABOUT:

- **Fuel, handling and storage** – Automated versus manual feed system, size of fuel storage, truck delivery access.
- **Supply contracts** – Required volume and delivered biomass specifications, number of sources, stability of supply, ability to enter into long-term contracts.
- **Boiler efficiency** – Divide the nameplate heat output by the nameplate heat input.
- **Backup heat and peaking** – Source of nonbiomass emergency heat or peak demand.
- **Boiler replacement** – Life expectancy of existing boiler, risk of failure, repurposing boiler for backup.
- **Heat load** – Projected number of customers, consistency of demand by season.
- **Efficiency upgrades** – Effect of insulation and other efficiency upgrades on expected heat load.
- **Shoulder seasons** – Boiler ability to turn down heat or run in parallel during shoulder seasons (spring and fall).
- **Piping** – Location, linear feet, and depth of distribution pipes, right-of-way access, heat loss.
- **Building interconnection** – Existing source of heat (baseboard electric, duct air, hot water), required modifications, building hookup costs.
- **Truck traffic** – Number of trucks per day, time of day, truck route, neighborhood safety, noise, dust.
- **Air quality** – Regulatory requirements, sensitivity of community to particulate matter, emission control technology.
- **Labor costs and staffing** – Source of labor, expertise, tasks, automated monitoring.
- **Ownership costs** – Engineering and planning costs, freight, installation, taxes, depreciation.
- **Discount rate** – Converts future costs to present value, based on interest rate or weighted cost of capital.
- **Debt ratio** – Percentage of project capital costs financed by third party.
- **Ownership structure** – Private provider versus municipal ownership versus public-private joint venture, rate structures.

Workable Financing

It’s never too early to think about how you’re going to finance your project – but don't let financing or the availability of grants (no matter the size) dictate early project planning.

Remember, how to finance and whether the project is right for your community or business are entirely separate questions. It will be important to hire a qualified project developer to help you craft a business plan and carefully manage project uncertainty.

Case Study

CHAPTER 10

Park County Schools RE-2

Biomass Boiler System

Name: Park County Schools RE-2

Type: Wood chip hot water boiler

Peak output: 3.5 MMBtu/hr

In-service date: April, 2012

Location: Fairplay, Colorado

Boiler system capital cost: $540,000

Building size: 120,000 square feet

Conventional heating fuel: Initially propane, now natural gas

When this project was developed and funded, the school was heated with propane at $23/MMBtu. In 2011, a natural gas line was "years away." By December, 2012, the natural gas pipeline arrived in Fairplay, and a gas contract was signed for around $12/MMBtu. While still much higher than the $5/MMBtu for delivered wood chips, the anticipated system payback of 5 to 8 years more than doubled. While it is questionable whether the school would have pursued this project had they known the pipeline was only a year away, the system is working very well.

According to project champion and manager Foss Smith, "Even though we're now using cheaper natural gas, running the boiler saves us money, and we plan to run it even more in the coming season."

2012-14 Operational Performance

Annual duty factor: Fifty 24-hour days (14%)

Delivered energy: 1,000 MMBtu

Tons delivered: 100 green tons

Average moisture content: 25%

Notes: It took two seasons to get most of the operational and supply issues smoothed out. Today, they are planning to triple the use of the biomass boiler in the upcoming school year, significantly improving the project's economics.

This 124,000-square-foot mountain school is primarily heated by wood chips.

Overview

When the new South Park School District RE-2 middle school and high school in Fairplay, Colorado, opened on April 10, 2012, it was below freezing outside. But thanks to locally produced wood chips and the school's state-of-the-art "biomass" boiler, students and faculty were greeted by classrooms economically heated to a comfortable 68 degrees – automatically.

In Colorado's high country, the word "biomass" means wood used for heat and energy – wood chips, wood pellets, and firewood. Here in Park County, biomass means local jobs, healthier forests, and lower heating bills for their new school.

Although the new 124,000-square-foot school is built to high performance, energy-efficient building standards, at an elevation a few feet shy of 10,000 feet, it would have used and estimated 60,000 gallons of propane a year. Instead, the school will be using about 400 to 500 green tons of wood chips to replace much of this propane – saving an estimated $72,000 a year. While automatic biomass systems are not cheap, the $540,000 biomass system is a solid investment for this school and community. Their investment has an estimated payback of less than 10 years – and maybe much less, depending on the volatility of fossil fuel prices.

Though the idea of using wood to heat a building is prehistoric, burning wood cleanly (no detectable smoke when operating) and conveniently (the system is fully automatic) isn't easy. It took a lot of hard work, the right technology, the support of the community, and the persistence and commitment of "biomass champions" – the individuals committed to making it happen.

To make the economics and logistics of wood chips work out, a biomass system is best designed into the building from the start: Where to put the large boiler room? How to deliver 22-foot-long chip containers? How to source a consistent supply of chips? And how to integrate it with the school's conventional heating system?

Adding a biomass system after a building has been designed can be prohibitively expensive or physically impossible. It's not to say it can't be done, but starting with new construction is one less hurdle to overcome.

Timing Is Key

In 2009, the right combination of factors came together for the Park County RE-2 School District: the district obtained a state grant through the state's BEST (Building Excellent Schools Today) program, the taxpayers approved a bond measure to provide district matching funds, and some retired business leaders became engaged in the project to provide specific business expertise to help make the project successful.

The district school board approved the concept of the biomass heating system through the efforts of one of these businessmen, Foss Smith, who was working with the Colorado Governor's Energy Office assessing and promoting biomass projects around the state.

Combining due diligence with a little financial assistance helped make the project a reality.

MOVIE 10.1 A 2-minute interview with biomass champion, Foss Smith

Every project needs a champion. Foss Smith is South Park's.

Wood chips from local forest thinnings

Fuel

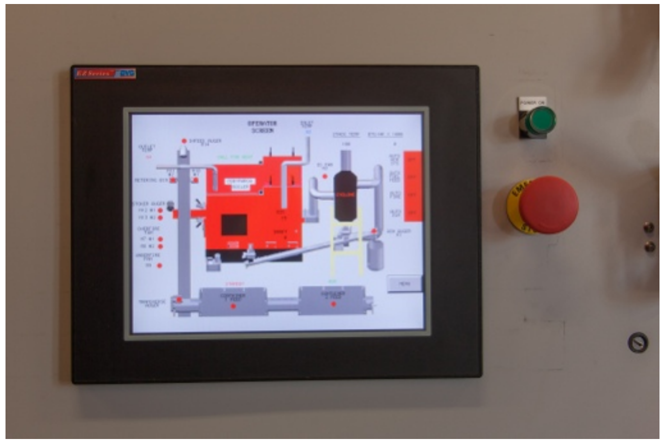
In many communities surrounded by forests (public or private), wood chips are a bargain compared to heating oil and propane – often less than a third the cost. For comparison, wood chips cost about $6/MMBtu and propane more than $22/MMBtu.

The Park County school will use somewhere between 400 and 500 green tons of local wood chips each year – most of that wood would have been burned in slash piles or left to degrade – or worse, become fuel for a wildfire. Wood chips are a triple economic win for the community: lower fuel cost, lower forest management costs, and nearly all of that money will remain in the local community.

The Boiler Systems

The heart of this biomass system is the Osby wood chip boiler from Sweden, capable of producing 3.4 million Btus per hour. Why Sweden? Domestically grown wood makes up more than 30% of Sweden’s energy production. Reliable technology for cleanly burning wood has been a national priority for many decades.

But a boiler is only one part of the system. The wood chips need to be stored and then fed into the combustion chamber of the boiler, the hot water integrated into the school’s heating system, and finally, the ash needs to be removed.



Biomass boiler controller integrates with the schools building automation system – and can be used for remote diagnostics.

While fuel costs compared to propane are very attractive, not all the biomass technology on the market is as clean or reliable as it needs to be. That's where the right technology partner is key.

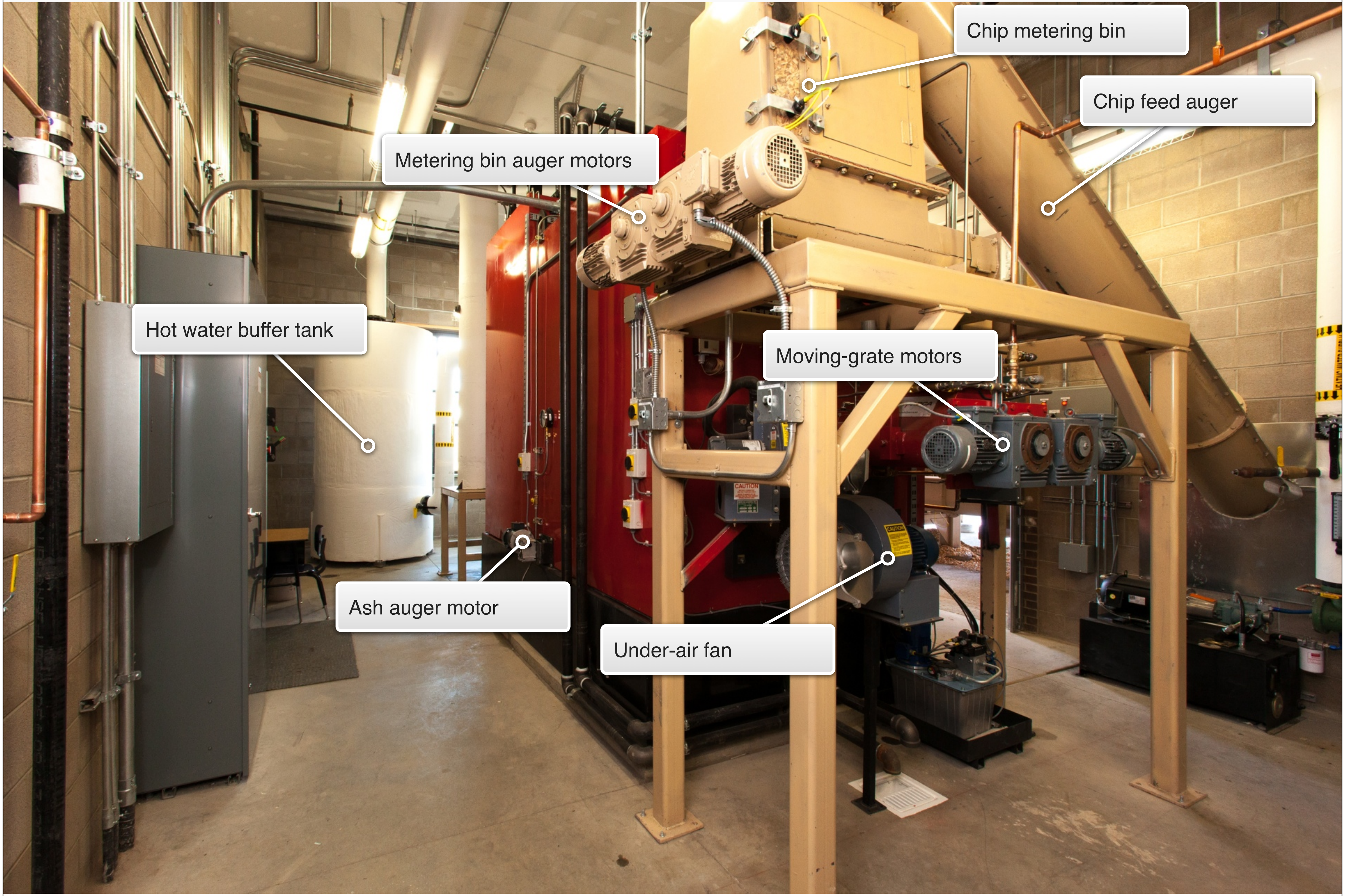
To be practical in rural schools – or other institutional or commercial facilities for that matter – biomass heating systems need to be automatic. That's where Forest Energy Systems from Show Low, Arizona, comes in. They have designed and engineered a complete system – from the mobile chip containers to the final ash removal system – that is "about as automatic as biomass can be," according to their boiler engineer, Dave Gibney.

Once a container full of wood chips arrives and is connected to the system, the chips are automatically transported to the boiler using heavy-duty augers. The control system monitors oxygen levels and adjusts intake air fan speeds to maintain the optimal combustion mixture – maximizing efficiency and minimizing smoke and other pollutants. The ash from the small amount of wood material that can't be burned (primarily dirt and silicates in the bark) is automatically collected and put into 50-gallon drums. The drums are emptied every few weeks during the heating season depending on the quality of the fuel and the amount of fuel used.

The hot water heated by the biomass boiler is then distributed throughout the Park County building and directly controlled by the school's energy management system – just like any boiler.

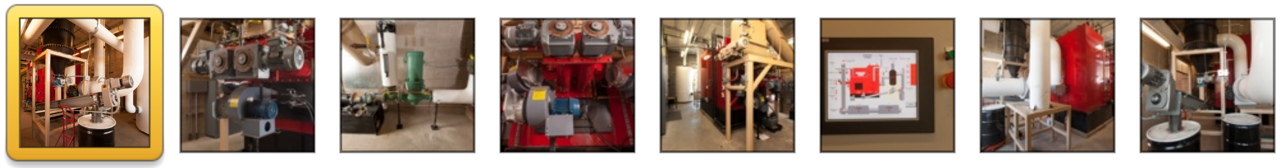
Biomass systems take a while to turn on and off and are most efficient when running continuously at more than 50% firing rate. The school has a backup propane boiler system that operates in the warmer months to save wear and tear on the biomass system that also provides supplemental heating on the very coldest days, or when the biomass system is down or biomass fuel is unavailable.

INTERACTIVE 10.1 Overview of boiler system



GALLERY 10.1 Various views of the biomass boiler system

Overview of the whole boiler system.



The Containers

Most biomass systems store their wood chips in large covered bins or pits – about the size of a public swimming pool. These are expensive, take up valuable space, and are difficult to clean.

That's why Forest Energy Systems developed unique hydraulically controlled rolloff containers that serve two purposes: transporting the chips from the source to the school, and storing the chips at the school as they are fed into the boiler.

The rolloff truck delivers the chip container and docks it to the biomass system. Hydraulic hoses are connected, and the docking gate is opened. A container can be swapped out in less than 10 minutes. The containers have what is known as a "live floor" or a "walking floor" that automatically moves the wood chips into the auger feed system. It's an elegant solution to a usually messy problem.

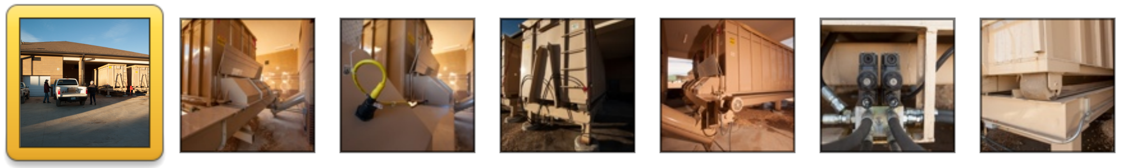
Each container holds about 11 green tons of wood chips – enough to heat the school during the coldest months for about 4 days. During most of the heating season, that means less than one container a week.

The Fairplay system has two docking container bays, so the biomass boiler can run continuously – even when one of the containers is being filled in the forest.

Two 11-ton chip containers. Custom designed to automatically feed chips directly into the boiler systems. A standard rolloff truck moves the containers and their contents from forest to furnace. Swap time: 10 minutes.

Gallery 10.2 Various images of chip rolloff containers

Chip container docking bay holds two containers, holding enough chips to heat the school for about 4 days during the coldest months.



Mountain pine beetle has killed much of Colorado's lodgepole pine forests.

The Bottom Line

The Fairplay school is an excellent example of how biomass can work in a high-altitude, medium-size school. At 10,000 feet above sea level, they need a lot of heat. Located near forested lands prone to mountain pine beetle outbreaks and wildfires, wood chips are affordable. And, most importantly, conventional heating with propane, heating oil, or electricity is expensive.

Case Study

Chapter 11

Colorado State University

At a Glance

Biomass Boiler System

Name: Colorado State University (CSU) Pilot Biomass Plant

Type: Wood chip hot water boiler

Peak output: 46 BHP, 1.5 MMBtu/hr

In-service date: April, 2009

Location: Colorado State University, Foothills Campus, Fort Collins

Boiler system capital cost: $422,313 (includes fuel handling equipment, blowers, cyclone separator, and associated controls)

Boiler building size: 1,500 square feet

Building and system integration cost: $851,882 (building, distribution piping, end point connection, heat exchanger, and pumps)

Conventional heating fuel: Natural gas

Notes: This is a pilot project designed to give CSU real experience in managing biomass systems. Because of the current price of natural gas, this system is too small to be economically attractive, but it's an ideal size for a meaningful pilot project or where natural gas is not an option.

2012 Operational Performance

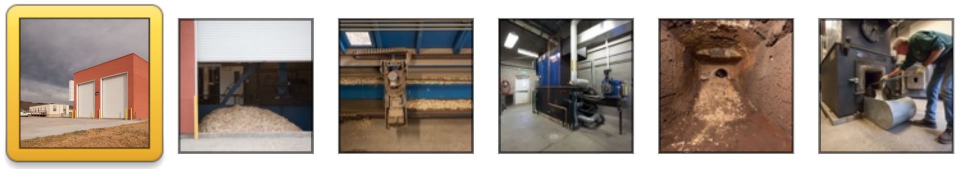
Annual duty factor: 3,334 hours (operated 38% of the year)

Delivered energy: 2,381 MMBtu

Tons delivered: 299 green tons, 229 bone-dry tons

Average moisture content: 23%

Average efficiency: 74.9%



This 1,500-square-foot outbuilding houses the 1.5-MMBtu/hr biomass boiler. The system creates hot water that is distributed to nearby buildings via underground pipes.

Motivation

Like an increasing number of universities around the country, Colorado State University (CSU) in Fort Collins has a strong commitment to sustainability. In 2008, CSU was an early signatory of the American College and University Presidents' Climate Commitment – pledging to reduce carbon emissions by 80% by 2050. Today more than 600 colleges and university have made the same commitment.

Biomass heating is helping CSU meet that commitment.

District Heating

About 25% of CSU's carbon footprint comes from burning natural gas to heat about 7 million square feet of building space – including classrooms, research labs, and student housing – for more than 29,000 students and 1,500 faculty members.

Like many large campuses, most of CSU's buildings are heated with steam and hot water circulated through underground pipes from central boiler plants. Adding a biomass boiler, a centralized system was relatively easy (much easier than having a fireplace or pellet stove in each classroom).

They needed to find a site that:

- Was close to heat distribution pipes.
- Could house a boiler in a 1,500-square-foot building (for the boiler with a 1 week chip supply).
- Could easily accommodate the semitrucks that deliver the chips.

Note: If each building had been heated by its own furnace or boiler, biomass probably would have been rejected early on. This is something you might want to think about if you're building a new campus or doing a major renovation.

District heating requires expensive insulated pipe to carry the steam, hot water, or chilled water from the central plant to each building. This infrastructure already exists on many university and college campuses around the country.

Forestry Management Connection

Unlike most universities, CSU is also home to the state's forest service – the Colorado State Forest Service (CSFS). The forests CSFS manages have a couple of problems: beetles and forests overgrown from years of fire suppression.

Today, Colorado's mountain communities face an increased threat of wildfire, and part of the answer is to remove the dead or excess trees. Unfortunately, there isn't much of a demand for these trees, and slash pile burning has air quality and safety challenges.

Using this material to heat buildings is an attractive idea. And the CSFS is trying to promote it – starting right in their own backyard at CSU.

Fortunately, CSU has an innovative facilities department that continuously looks for ways to provide energy services that are both economically and environmentally viable. They visited several biomass heating plants around the region and developed a pretty good idea of what worked and what didn't.

Still, a full-scale biomass facility is a big commitment and not without risk. Is the technology reliable? Will the economics still make sense in 10 years? Will there be an affordable source of wood chips in 10 years, or will a large forest fire (which indeed happened in 2012) affect the fuel supply?

Based on sound business planning and an appropriate weighing of the financial and environmental risks involved, CSU took a bold

"High Park Fire" burned more than 87,000 acres in June, 2012. Flames were within 1 mile of the biomass boiler.

and prudent step forward: they decided to build a small but credibly sized biomass plant.

In 2008, they broke ground on their modest 1.5-MMBtu/hr wood chip heating system. The following spring, they took delivery of their first load of chips and fired the system up.

Five years later, the system is working well and as CSU's district energy manager, Roger Elbrader says, "It's just another part of our district energy plant."

Today, CSU knows exactly how to own and operate a biomass heating facility. The current economics of natural gas are keeping them from pursuing a larger, more practical system. In the meantime, they're very satisfied – but ready to further reduce CSU's carbon footprint.

The wood chip pit holds about 1 week of fuel during the coldest months.

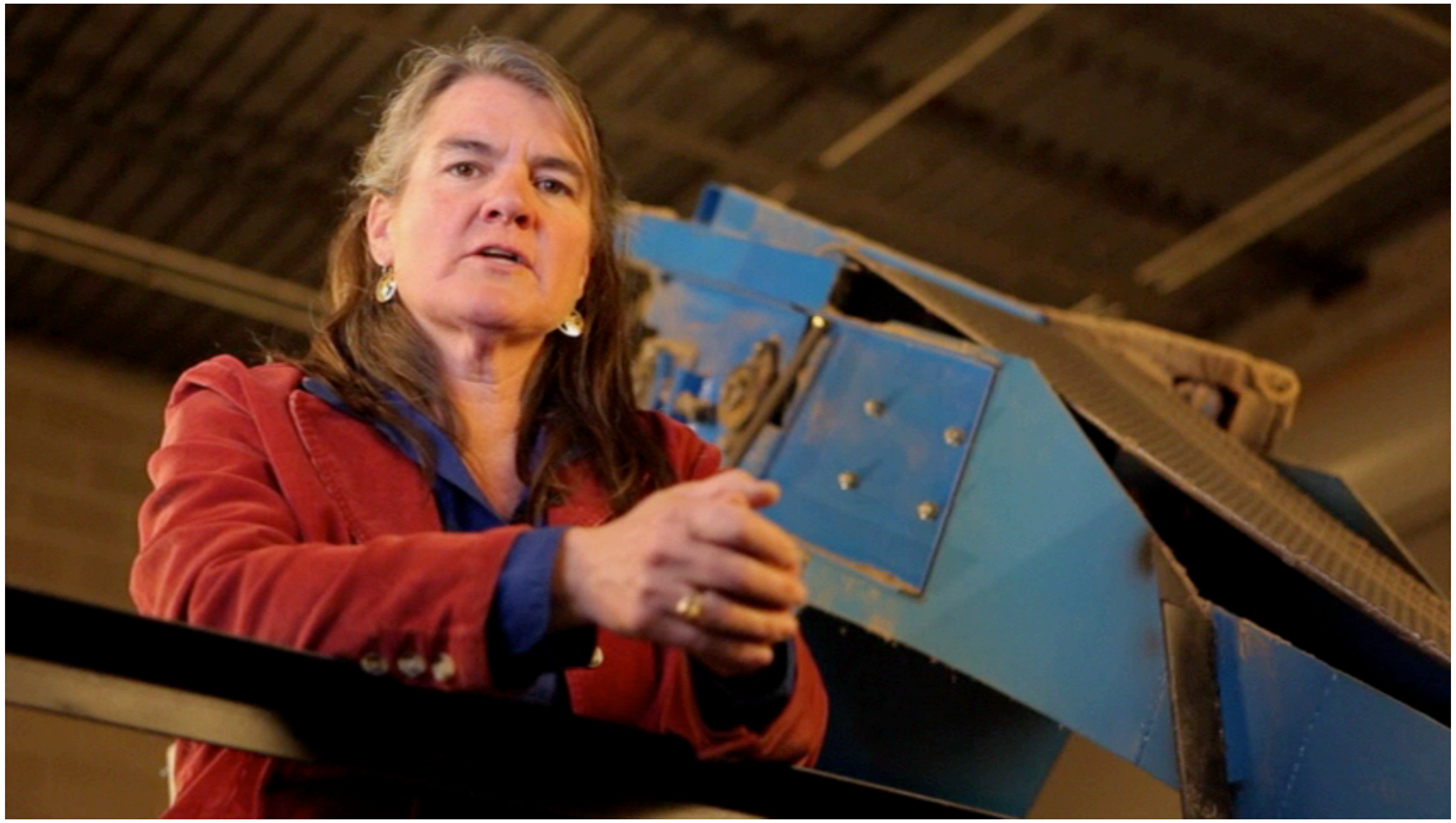
Learning Opportunities

Their due diligence paid off with very few surprises – but there were some:

- The combustion system needed to be slightly redesigned to accommodate Colorado's dry wood (23% average moisture content – but can be less than 20%), which burns faster and needs more air to keep from melting the silicate into glass (beautiful, but expensive to remove).
- The primary chip auger needed to be slowed down – it kept dropping chips on the floor. At any given moment, the boiler needed less of the dry, high-energy chips than the manufacturer anticipated. The CSU facilities engineering staff installed a variable-speed motor to slow the auger. Problem solved.
- A small fire caused the facilities staff to modify the fire-extinguishing system. The first one worked as designed, but it made a big mess. The new one shouldn't.
- The biomass plant uses more electricity than they had calculated. Not a huge problem, but it reduces the economics of the project as well as the carbon-reduction benefit.
- A larger system would have much better economics – a lot more energy output for about the same amount of operational effort.

CSU's 1.5 MMBtu/hr boiler and fuel storage pit fits into a 1,500-square-foot building with truck access.

Carol Dollard, is an engineer and manager in CSU's Facilities Department. She has championed many of CSU's green energy projects including the biomass heating plant featured here.



Biomass Champion

I'm Carol Dollard from Colorado State University, and I'm an energy engineer at Colorado State, and I get involved in renewable energy and energy efficiency projects. That's what got me involved in this biomass project several years ago.

Improving local forest health and air quality

So why did we get into the biomass business? Our partners at Colorado State Forest Service are part of the umbrella organization that is the land grant that is Colorado State University. They came to us and said, "Hey, we've got a lot of beetle-killed trees in Colorado. How are we going to get rid of some of this wood?"

Frankly, burning it is not the highest-value use. If you can come up with other uses for that timber, great. But we figured that burning it here in a controlled environment is much better than uncontrolled wildfires or burning slash piles up in the woods to get rid of the wood, because this is much better from an air quality environmental standpoint is that we can control the combustion, and make a much cleaner-burning situation.

Reducing greenhouse gas emissions

Another benefit of this plan is that it reduces greenhouse gas emissions for the university. Part of my job at Colorado State is to do the greenhouse gas inventory every year. When we burn wood chips, not natural gas, it reduces our greenhouse gas emissions. It's because the greenhouse gas is associated with the trees, the carbon is sequestered in the tree in the same 100 years that it was cut down and burned. There's almost no net carbon emissions from burning solid wood.

When we first got into this business, we wanted to start with something that was little so that we could feel comfortable with solid fuels. We're really comfortable with natural gas boilers. We play with them all the time. But this was a new technology – at least new to us – and we wanted to make sure that we weren't taking on more hassles than we needed to.

The economics

What are the economics of this plant? When we started here, we started small, because we wanted to understand it better. What we've discovered in operating this plant for several years is that this scale doesn't play well economically, at least in the current environment that we're in. Your environment could be very different.

Now, remember that we're competing with natural gas here at Colorado State University. If you're in a situation where you're burning fuel oil or you're heating with electricity or some other high-expense fuel, I would look very hard at biomass at any scale, because I think the economics could be very promising. And again, in our situation, we're unique here, but I think everybody needs to evaluate their situation and see what their competing fuels are.

Would we do it again?

So would I do this again knowing what I know now? I think the answer is yes and no. I think I would still take biomass very seriously. Would I look at it at a different scale? Yes I would. I think you need to go to a larger scale to make this make sense.

Now, does that mean I would discourage you from doing another small system like we did? No. We've learned an enormous amount here, and we feel comfortable talking about bigger systems. And if that's what it takes for your administration or your leadership to say, "Yes, I'm comfortable with that technology," then go for a small boiler, because I think you'll learn a lot.

CHAPTER 12

Acknowledgments

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