Pennsylvania Wood Energy Prospectus

The Pennsylvania State Wood Energy Team
November, 2016

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The Pennsylvania State Wood Energy Team is a collaborative project sponsored by the USDA Forest Service with the goal of promoting and assisting the growth of wood as a statewide, top tier, energy resource in Pennsylvania. The team is led by Penn State Extension in collaboration with the PA Biomass Energy Association, and includes over 40 organizations and companies working together to educate and assist individuals and organizations wishing to use wood in a sustainable, renewable, ecologically friendly manner. For more information on the PA State Wood Energy Team, contact program leader Ed Johnstonbaugh at exj11@psu.edu.

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Summary

This prospectus provides an overview of issues and opportunities for wood energy in Pennsylvania. In short:

Pennsylvania's wood resources are extensive.
A dramatic increase in wood energy utilization is possible without requiring intensive high yield management such as plantations. This wood fuel can come from existing forest management activities, wood product manufacturing byproducts, and post-consumer or urban wood materials.

Wood energy is flexible.
Energy from wood can be used at a variety of scales and for a variety of uses. Residential, commercial, industrial, and utility scale opportunities all exist for the sustainable use of wood as an energy resource.

Wood energy can be beneficial.
Wood-based systems for heat and/or power can be a cost effective and sustainable component of the state's energy portfolio. As an added side benefit, wood energy harvests can be used to enhance the long term health and viability of the forest.

Policy is important.
Public policy and support has been a critical enabler of wood energy, especially at the commercial scale, in Pennsylvania, through the provision of educational, financial, and regulatory supports that encourage sustainable, renewable wood energy production.

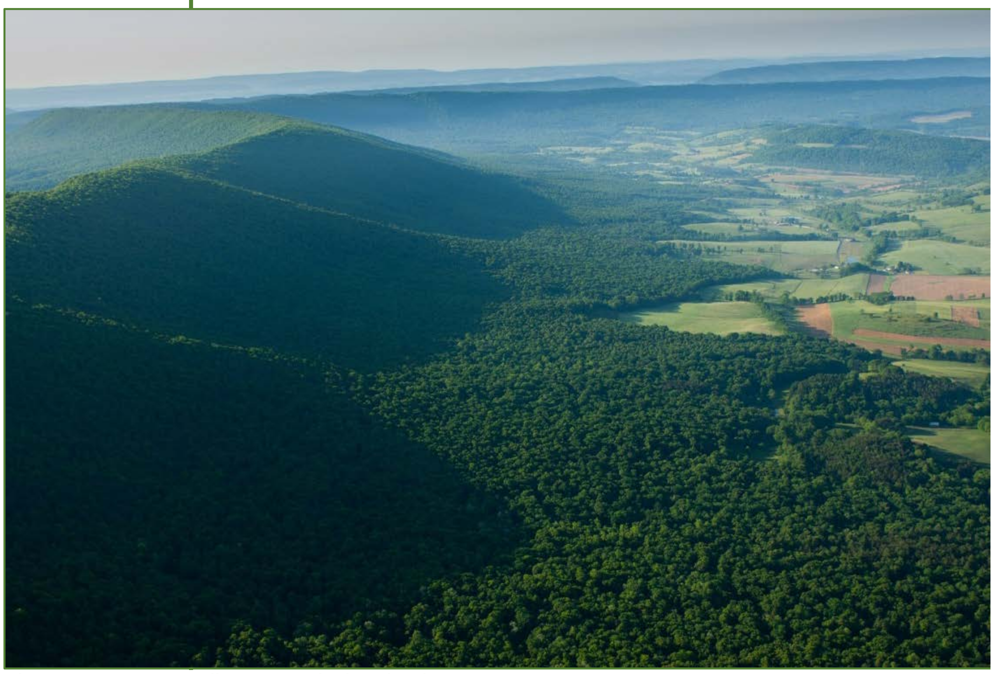


Photo: Penn State College of Agricultural Sciences

Contents:

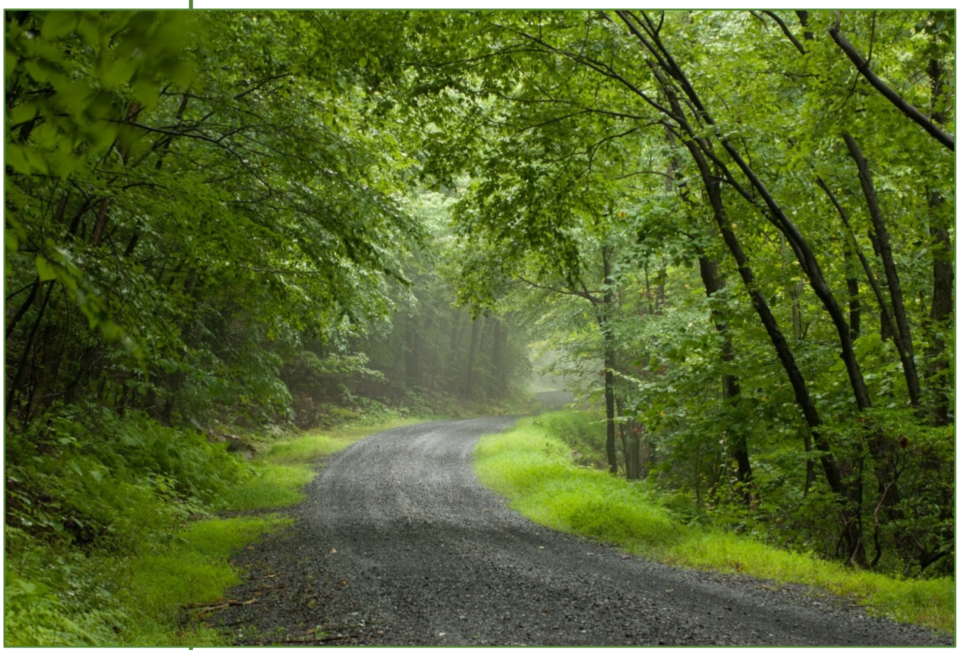


Photo: Penn State College of Agricultural Sciences

"Conservation means the wise use of the earth and its resources for the lasting good."

- *Gifford Pinchot, first chief of the US Forest Service and 28th governor of Pennsylvania*

1. Introduction

Pennsylvania's forests are the largest land use category in the state, and remain a critical component of our ecosystem, economy, and collective identity.

Pennsylvania has one of the largest forest products sectors in the country. Known worldwide for its valuable hardwood timber species, the forests can also provide abundant wood for energy purposes. Wood energy was the original heating fuel in Pennsylvania, and was the dominant source of energy until fossil fuels became available in large quantities during the 1800s. While widespread deforestation occurred in the region in the late 19th and early 20th centuries, natural regeneration and improved forest care has allowed much of the state's forests to flourish since that time, with total forested area near its highest levels in over 100 years[18]. The main threat to the quantity of forested land at this point is arguably suburban and urban sprawl.

Pennsylvanians value their forests for many reasons, including aesthetic, ecological, recreational, and economic considerations. These benefits are largely compatible and can be complementary to the use of wood for energy.

The combustion (or burning) of wood releases energy stored in the structure of the wood. The term 'biomass' is used to describe any wood or plant material that can be converted to energy. Unlike coal, which is also derived from plant material, woody biomass is renewable because wood (if the forest is well managed) grows back to be re-used time and time again.

Energy from biomass is used to provide heat (thermal) and/or power (electricity), as well as liquid biofuels that can be used to replace petroleum products. Woody biomass is also used to create high valued bio-products such as polymers, acids, bio-plastics, and biochar.

As society reduces dependence on fossil fuels and transitions to renewable and sustainable modes of living, bioenergy will have a significant role. In spite of the widespread use of fossil fuels such as coal, oil, and natural gas, wood continues to be popular and is still a common source of residential heat, especially in rural parts of Pennsylvania. While total numbers vary over time, over 120,000 households in Pennsylvania use wood to heat their homes – this corresponds to a bit over 2% of all households in Pennsylvania (Figure 1). Commercial scale facilities that use wood heat are less common, but are growing in popularity.

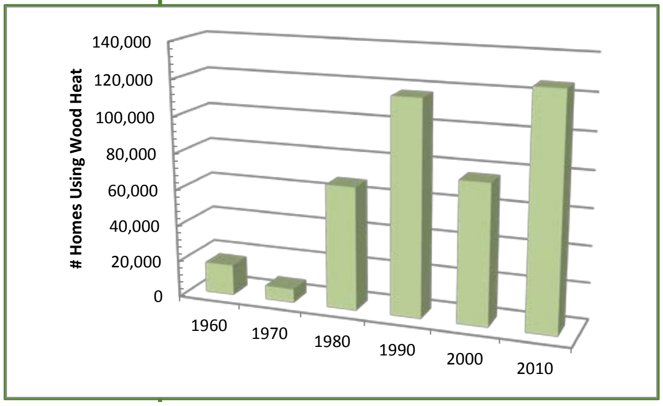


Figure 1. Number of Homes in Pennsylvania Using Wood Heat[1].

In recent years, developments in wood heat technology facilitated the expansion of new, high efficiency systems in the form of wood pellet stoves for homes and small businesses, as well as automated commercial-scale woodchip and pellet boilers for schools, hospitals, and similar-sized facilities. New and more efficient combustion technologies along with Pennsylvania's enormous store of woody biomass combine to provide synergies for a strong and valuable wood energy sector in coming years.

This prospectus, prepared as part of the USDA Forest Service-funded State Wood Energy Team project, provides an overview of key issues and opportunities related to wood energy in Pennsylvania. In brief, the document covers the following topics, separated into sections:

- Section 2 discusses types of wood energy and their status in the state.
- Section 3 describes the different sources of wood for energy.
- Following this, Section 4 outlines the major forms of wood fuel produced and used in the state.
- Section 5 provides a detailed rationale for using wood energy, and
- Section 6 presents four representative examples of wood energy use in the Keystone State.
- Sections 7 and 8 discuss policy impacts as well as an analysis of topics that have been debated about the merits of wood energy.
- The document finishes, in Sections 9 and 10, with a summary of prospects for wood energy in Pennsylvania and recommendations on how individuals can help encourage the sustainable use of wood energy in Pennsylvania.

2. Types of wood energy

This section discusses the types of energy that come from wood, namely heat, power, and liquid fuels.

2.1. Wood for heat energy

Arguably, the most effective energy use of Pennsylvania's wood renewable biomass resources is heating or thermally-led combined heat and power (thermal and electric generation) applications. The key factor is that the equipment being used to convert wood to heat must be efficient. For example, a fireplace, even though it provides heat directly to a home, can be very inefficient - wasting even more energy than other energy sources such as electrical power production.

Wood energy is adaptable and can be used to meet a variety of the state's energy needs.

Table 1. Typical Energy Efficiency of Different Wood Heating Systems[2].

Heating System	Typical Energy Efficiency (%)
Fireplace	0-20
Residential Wood Stove	55-65
Residential Pellet Stove	75-80
Commercial Wood Chip Boiler	65-75
Wood Fired Electricity Generation	25-30
Wood Fired Heat Plus Power (CHP)	60-70

Residential wood heat has been common throughout Pennsylvania's history, and is still popular in many areas of the state, often as a supplementary system to provide partial replacement of fossil fuels. Devices used for wood heat in the home include fireplaces, woodstoves, pellet stoves, and wood or pellet boilers. In many cases, wood is the lowest cost heating fuel for homeowners, especially when harvest and delivery are carried out by the end users, or when the supply of wood is close to the house.

Outdoor wood boilers are popular residential heating systems in Pennsylvania, but have gained a negative reputation with some because of improper use leading to smoky operation. Cordwood-burning appliances should always be run hot enough to prevent smoky exhaust. However, newer outdoor burners and indoor wood stoves that

Tips for running residential wood stoves and boilers efficiently and cleanly:

- *Use dry wood*
- *Burn hot*
- *Never "choke" the fire*
- *Have your equipment cleaned and inspected regularly*

The way that you operate your equipment can have a big impact on how efficiently and cleanly it performs. For more information, read the Penn State Extension fact sheet "Using your Wood Stove Efficiently and Effectively"[3].

use cordwood tend to be both cleaner burning and more energy efficient due to developments in technology and emissions regulation.

At the commercial scale, wood fueled heating systems are growing in popularity in the region, with schools, hospitals, prisons, and businesses increasingly turning to locally-grown, renewable wood heat delivered in large, high-efficiency, computer controlled boiler systems. These systems typically use wood chips as their fuel, delivered by the truckload and metered into the boiler using automated feed handling systems. Originally designed and used in the wood products sector, their versatility and cost effectiveness has made these systems a popular option for larger facilities, including schools, hospitals, greenhouses, and other businesses whose owners prefer to use renewable, locally produced resources.

Commercial scale wood boilers are large systems that supply hot water or steam to the building or facility they serve.

2.2. Wood for electricity

Wood can be an effective source of energy for electricity production. Pennsylvania does not have a dedicated wood power plant, but several other states in the Northeast do operate these facilities. Co-firing wood with coal could be a way to use existing power generating equipment to produce power from wood. This approach is widely used in Europe. When a power plant produces only electricity, about one-third of the energy in the wood is converted to electricity - the remainder is lost, due to the thermodynamic limitations of electricity production and other losses. However, Combined Heat and Power (CHP) systems can provide more efficient wood to electricity opportunities.

Wood can be used as a co-firing fuel in coal-fired power plants. Tests carried out in Pennsylvania have shown that co-firing a 10-30% mix of wood with coal can work well, increasing the renewable portion of a plant's power production and reducing emissions of sulfur and mercury that are associated with coal combustion[4, 5]. Some studies suggest that "torrefied" wood (thermally treated in an oxygen constrained environment) may be even more effective than plain wood for co-firing[6].

Wood-fired power plants are not common in Pennsylvania, but can be found in other Northeastern states (Photo: Justin Heavey).

Co-firing wood with coal can provide a massive market for woody material. For example, a 1,000 MW power plant co-fired with wood at 5% would utilize about 245,000 tons of wood per year – corresponding to removing forest residuals (low grade wood) from about 600,000 acres of mixed-use hardwood forest or 50,000 acres of dedicated woody crop production[7]. The maximum potential output for woody-based electricity production in Pennsylvania is on the order of 7,500,000 MWh per year, based on current annual sustainable availability of wood in Pennsylvania[1]. Development of purpose grown short rotation woody crops on marginal lands in the state has the potential to double that amount.

Regardless of the fuel type, the overall conversion efficiency for producing power from heat remains relatively low. Because of this, many have looked to Combined Heat and Power (CHP) as a way of improving overall efficiency. CHP is the process of generating electricity from combustion heat, then capturing the leftover heat and utilizing it to meet needs for space heating or industrial processes. Wood-fired CHP has been used at some facilities in Pennsylvania, but has not been adopted in a widespread fashion.

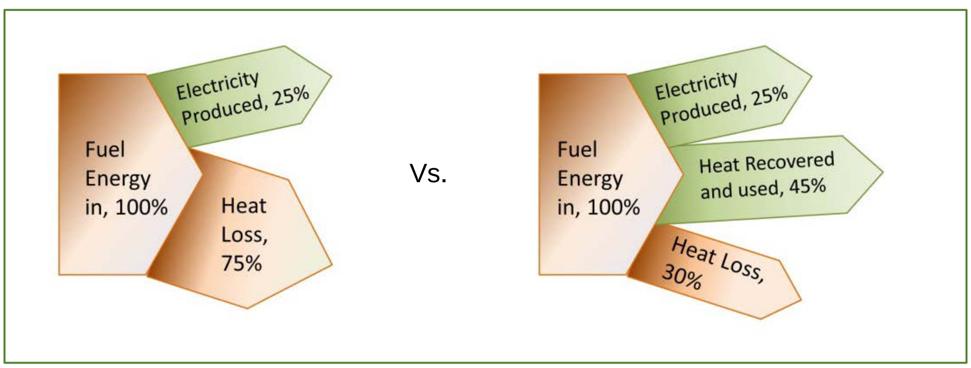


Figure 2. Energy Conversion Efficiency Graph for Power-only (left) versus Combined Heat and Power (CHP, right).

[1] Assumes that current forest growth rate and use of wood does not change, allowing for up to 5.6 million dry tons of wood per year (9.3 million green tons), as per Section 5.1. Also, power production is assumed to be 25% efficient. Using different (but still reasonable) assumptions about yield, efficiency, load factor, etc. would change the magnitude of this estimate.

The main benefits to CHP are that a higher percentage of the fuel's energy is utilized relative to "power only" systems, and that power is produced in a distributed manner, at or near the location where it is used. This reduces the need for transmission lines and other electrical distribution equipment.

2.3. Wood for liquid fuels

The energy stored in wood can be chemically converted to "cellulosic" liquid fuel such as ethanol. This is similar to the process used for corn-based ethanol, but is more technically challenging, due to wood's complex molecular structure. Additional processing is needed to convert cellulose in the wood (~50% of wood's dry mass is cellulose) into smaller molecules that can be fermented or otherwise converted into biofuel.

Starch (corn) based ethanol plants, like this one in Clearfield County, could serve as the starting point for advanced cellulosic ethanol production.

Thus far, Pennsylvania has not been home to a cellulosic biofuel plant, but the potential exists to build and operate one here in the Keystone State. The likely scale of a cellulosic biorefinery would be massive, probably requiring one million dry tons or more of feedstock per year.

3. Sources of wood biomass

Wood biomass for energy is derived from four main sources, namely 1) forest operations, 2) wood manufacturing byproducts, 3) post-consumer waste, and 4) energy crop plantations.

3.1. Forest operations

Pennsylvania has abundant forests covering over 60% of the land in the Commonwealth. Active care of the forest involves harvest, thinning, and removal of undesirable trees to enhance its long term health and productivity. Wood energy can be an important part of that process. Typically, wood for energy can come from forest operations either as a byproduct of timber harvest, or as a Timber Stand Improvement (TSI) activity.

Wood energy is usually not "purpose-harvested" in Pennsylvania, but is instead a component of other forest operations.

Smaller diameter trees, less desirable species, and residual material after harvesting the high valued stems can be used for woody biomass. The residues can include branches and limbs, bark, needles, and stumps. Therefore, woody biomass is the typical byproduct after commercial timber harvesting for sawtimber and all other higher valued materials. Typically, logging residues can make up about 25 to 45 percent of the tree's biomass when trees are harvested for sawtimber or pulpwood. Some of these biomass residues are used in pulp markets, and some is left on the forest floor to provide ecological benefits. In areas where the demand for pulpwood has decreased, bioenergy can provide a valuable market for this material.

Sustainable forest management activities are designed to optimize the forest's long term health and productivity.

In some cases, especially in forests with dead or dying wood, or with only low value sawtimber, harvests can be carried out to remove only wood for energy (a dedicated biomass energy harvest). Some state government agencies issue firewood permits to facilitate removal of deadwood for forest health benefits, while also providing local economic and job opportunities. State agencies also offer contract timber sales that facilitate the harvest of small and undesirable trees.

Some timber harvesters collect the woody materials and chip them on-site. They first remove bark which is used for mulch and the remaining wood is chipped directly into on-site chip wagons which haul the material to pulp mills or bioenergy facilities. Alternately, the low use wood is trucked to facilities where it is chipped and / or converted into biomass.

3.2. Manufacturing byproducts

Pennsylvania has hundreds of sawmills that make a variety of lumber products including furniture, kitchen cabinets and architectural woodwork. From this process comes many thousands of tons of leftover wood in the form of sawdust, slabs, edges and other discards from making lumber. Often the sawdust is used for animal bedding or pellets. The slabs and edgings from making lumber are usually chipped and sold or used directly by the mill for its own energy use. Many sawmills in Pennsylvania save money by utilizing their own byproduct to heat their buildings and/or their lumber drying kilns, but could benefit from additional demand for wood chips on the energy market.

Sawmills in Pennsylvania produce furniture, cabinetry, veneer, and other products.

3.3. Urban wood waste and recycling

A great deal of "waste" wood is landfilled on a regular basis - some of it comes from landscaping and right-of-way operations, and some from construction/demolition debris. All of these materials have potential to be used as an energy source, but extra care must be taken because of the risk of contaminants. In the case of landscaping and right-of-way clearing, woody material is often contaminated with dirt, which adds ash content and increases wear and tear on equipment.

Waste wood requires careful sorting and processing before it is suitable for use as a fuel.

In the case of construction/ demolition debris, a variety of paints, adhesives, and other contaminants may be mixed in with the wood. Thus, care must be taken when utilizing these materials, and extra restrictions are often placed on operations wishing to use "post consumer wood".

3.4. Energy crop plantations

Another source of wood that does not come from our mixed-hardwood forests is dedicated short rotation woody crops (SWRC). SWRC are grown using agronomic techniques in open fields. Willow and poplar are the two most common species used for SRWC in the Northeast, although other species may be good candidates as well. In the case of willow, rows of "live stakes" are planted in the ground and grow into tall shrubs. These shrubs are harvested every third year. The plant then regrows and is re-harvested for about 21 years (7 harvests) before it is time to replant[23].

Fast growing woody species such as shrub willow are a potential means for producing large amounts of wood fuel for energy (Photo: Justin Heavey).

Shrub willow has been extensively studied and tested in New York State, but the climate and soils of Pennsylvania are also quite suitable. Research and trials across the region are showing very good yields. More acreage is being planted in the Northeast with willow to supply power companies and schools with chips. Large scale cellulosic ethanol companies are considering supplying feedstock from dedicated energy crops.

4. Types of woody feedstocks

Wood fuel is used in many types and forms, making it suitable for a variety of applications. The most basic form is cordwood. Wood chips are also common, but in recent years the demand for wood pellets has skyrocketed to the point of becoming a major component of the state's wood energy use. The type of woody feedstock can influence the efficiency of the energy output. Generally smaller and more dense material can be more efficiently converted to energy. There are costs associated with processing and densifying woody biomass, but it can also save in transport and utilization costs, resulting in a lower cost per unit energy produced downstream.

Wood energy comes in many sizes and forms, each suited to different uses.

4.1. Cordwood

Cordwood is the traditional firewood, used for centuries in Pennsylvania. Typically, logs are cut to length, split and air dried before being burned in a fireplace, wood stove, fireplace insert, or wood boiler. The term "cord" refers to the unit of measure by which it is sold – a tightly packed stack of 128 cubic feet (3.62 cubic meters). Not all wood performs equally when used as cordwood. Hardwoods are usually more dense than softwoods, hence the name, and have better burn characteristics per volume of wood, such as producing less "creosote" buildup when burning. They also contain more energy per unit volume. Denser woods weigh up to 3 tons per cord, while the lighter woods are about 1.5-2 tons per cord. Beech, birch, maple, hickory and oak are among the most common hardwood species used as cordwood in Pennsylvania.

Cordwood from Pennsylvania's Hardwood Forests remains a popular choice for renewable heat in the Keystone State

Some think cordwood is free, but it requires equipment (chain saw, vehicle, wood splitter, etc.) and time to harvest. The value you place on the wood to rationalize its cost should include its sale price. Wood also requires labor when you want heat because someone has to be available to stoke the wood combustion appliance and remove ash. Stoves are available from sizes that heat a single room, to a boiler or furnace that can heat a house and outbuildings. There are active firewood markets in Pennsylvania for cordwood, especially during the winter heating months.

Table 2. Characteristics of Common Pennsylvania Firewood.

Species	% of PA Forest (by mass)	Mass-Based Energy Content (MJ/kg)	Volume-Based Energy Content (GJ/cord)
Douglas Fir	<2	19-21	22
Hickory	2	19-22	29
Pine	3	19-22	17
Oak	25	19-22	26-30
Aspen	<2	19-20	19
Birch	5	19-22	22
Poplar	3	19-22	16
Maple	26	18-19	20-25
Hemlock	6	19-20	20
Cherry	9	19-21	21.5
Ash	4	20-21	21-25
Locust	<2	29	29
Elm	<2	20-21	21
Walnut	<2	19-21	21

A key factor in cordwood use is to ensure the wood is dry. This is because the energy used to evaporate moisture reduces the net energy available from the wood, and also reduces temperatures in the firebox, which could lead to incomplete combustion, smoky exhaust, and lower thermal efficiency.

4.2. Wood Chips

Wood chips are commonly used in commercial-scale wood energy systems, and come in a variety of sizes and qualities. The two most common types used for energy in Pennsylvania are the Medium Clean Chip and the Medium Variable Chip, as defined by the PA Fuels for Schools and Communities working group[25].

Clean chips are ones in which leaves, bark and other materials are removed before chipping. Often the bark and leaves are left on site to provide nutrients for forest regrowth. They most commonly come from forest harvest operations or as timber mill byproducts. Clean chips are lower in ash content, and are thus preferred by many commercial-scale wood energy facilities. Clean chips are also usually required for pulp mills, liquid energy plants and pellet mills. Because of this, there is potential for energy use of clean chips to compete with pulp wood markets if the scale of the wood energy operation is sufficiently large.

Fuel Standards for Wood Chips as a Commercial Fuel:

The Pennsylvania Fuels for Schools and Communities working group has established a set of three recommended fuel classifications that can be used to specify fuel supply characteristics for a wood energy project. The specification covers important characteristics such as chip size, moisture content, and ash content, and requires that fuel be sourced from a sustainably managed operation. The three fuel classifications are:

- *Type A: Medium Clean Chip*
- *Type B: Medium Variable Chip*
- *Type C: Short Rotation Woody Chip*

These three fuel types are intended to meet the needs for nearly all commercial scale wood energy operations. To learn more, visit www.pafuelsforschools,.psu.edu.

Variable chips (sometimes called "dirty" chips due to the inclusion of bark, which can often have dirt on it) are a lower value material from a harvest because they have leaves and bark included or are not uniform in size – a real problem for some handling systems. There can also be competition for dirty wood chips as a landscaping material or for use as animal bedding. Wood chips are typically not used for residential heat applications because of the extensive equipment needed for handling the chips for feeding a boiler. At the commercial scale, wood chips are automatically fed into boilers by belts and augers, reducing labor.

4.3. Pellets

Wood pellets are made by grinding, hammer milling, and pelletizing wood material. Most pellet mills will take sawdust (preferred), chips, or roundwood as feedstock and prepare it for the pelletizer. The pelletizer takes the very finely ground material and uses high pressure to extrude it into a pellet.

From its humble beginnings as a means to get rid of excess sawmill sawdust, the pellet industry in Pennsylvania has grown to become one of the largest markets for wood energy in Pennsylvania. Currently, the state's pellet producers manufacture about 500,000 tons of pellets annually[24].

Wood Pellets are a popular fuel option for residential applications in the region.

Pellets are popular in residential heating systems and are increasingly more common in commercial and institutional boilers as well because of their ease of use, cleanliness, consistency of burn, and automation. Most pellet burning appliances are self-stoking, only requiring a hopper to be filled possibly once per day, but can be automated to maintain a full hopper from a bulk bin. Since they are self-stoking, the rate can be varied to better match the heating needs versus cordwood use. Pellets can be purchased in bags from many retailers or delivered in bulk from a pellet manufacturer or local distributor. Bulk deliveries require some type of bulk bin to hold them. Pellet stoves are available from a size to heat a single room, to a boiler or furnace to heat a large house or multiple homes. They can be located inside or outside and some have automatic ash removal.

4.4 Wood Fuel Costs

Regardless of form or shape, wood as an energy fuel represents a significant value when its cost is compared to that of fossil fuels. Even at current historically low prices for some forms of fossil fuel, wood continues to be competitive when compared on a "per useful gigajoule" basis. Wood fuel prices have tended to be more stable than those of fossil fuel, which can reduce risk associated with price volatility. Table 2 shows representative end-user costs of different forms of wood fuel and fossil fuel, along with their cost per useful gigajoule.

Table 3. Cost of Useful Heat from Different Fuels (at representative prices).

Fuel Type	Cost	Units	Energy Content (GJ)	Efficiency (%)	$/ useful GJ
Cordwood	$ 175.00	cord	25.3	60	$ 11.53
Wood Pellets	$ 220.00	ton	18	80	$ 15.28
Wood Chips	$ 50.00	ton	11	70	$ 6.49
Fuel Oil	$ 2.20	gallon	0.147	80	$ 18.71
Electricity	$ 0.12	kwh	0.0036	100	$ 33.33
Propane	$ 2.30	gallon	0.097	85	$ 28.00
Natural Gas	$17.00	kcf	1.076	85	$ 18.59

At the residential scale, cost savings are accrued in exchange for "sweat equity" from the additional labor required to fuel and operate the heating system. At the commercial scale, wood-fired systems are largely automated, but still require some inspection and maintenance.

5. Reasons for using wood energy in PA

There are many reasons why wood energy can be a good choice for Pennsylvania. Chief among these are availability of supply, opportunities to improve forest health, and economic benefits.

5.1. Available supply of wood for energy

The size of Pennsylvania's wood energy sector could be dramatically increased without outpacing available supply.

Pennsylvania's forests occupy more than half of the state. The majority of Pennsylvania's forests are privately owned, but most of the larger parcels are publicly owned by entities that include State Forests, State Game Lands, and a National Forest. All told, over 1 billion dry tons of standing timber are in the forests. The available annual harvest for energy, after protected and inaccessible land is removed from the analysis and usage for timber, paper, and other markets is subtracted, amounts to slightly over 8 million dry tons of wood, on an ongoing annual basis[19]. Currently, an estimated 2.4 million dry tons of wood are used annually for energy in Pennsylvania, leaving significant amounts of unused wood available for use as fuel.

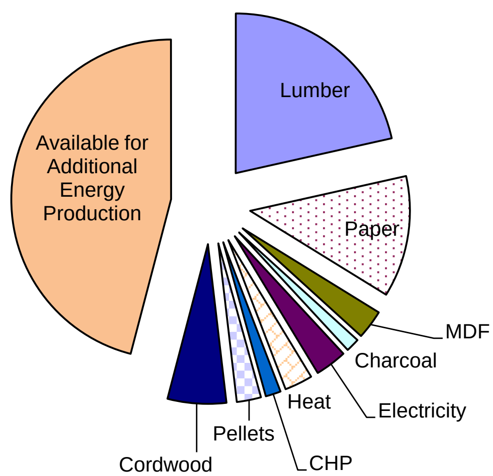


Figure 3. Estimated Uses of Wood in Pennsylvania, as Well as Unutilized Wood That is Practically Available for Energy.

In the future, an even higher sustainable yield of wood for energy in Pennsylvania could be achieved from improved forest management, and/or from development of fast growing "short rotation woody crops" (SRWC) such as willow and poplar. One estimate is that Pennsylvania could produce 5.5 million dry tons per year of wood fuel from short rotation woody crops on marginal lands[8].

5.2. Forest health opportunities

Removing undesirable trees from the forest can help maintain, regenerate, and improve forest health, biodiversity, aesthetics, and wildlife habitat. Having a market for the trees and associated residues in the form of biomass can help meet forest management goals. These goals include timber stand improvement, reduction of insect, disease, or fire risk, and reduced need to use herbicide for competition control. It is common for overstocked tree stands with unwanted species to have a higher susceptibility to insects and diseases that can damage or kill trees. In Pennsylvania, forests face significant pressure already from Emerald Ash Borer, Hemlock Wooly Adelgid, Gypsy Moth, and other pests.

This forest stand has been thinned to improve its condition, allowing more light, nutrients, and moisture to be available to the remaining trees.

Overstocked stands can also lead to more potential for fires and if they occur, they would spread more rapidly through a forest and thereby cause more damage. In the past, Pennsylvania's pulp and paper industry has helped provide a market that could facilitate timber stand improvement activities, but the downturn of that sector has left a need that could be filled by wood energy.

Improving the overall quality of the forest often requires removing poor growing, dying, and undesirable species. These low value species are good candidates for woody biomass. There are a variety of harvesting treatments such as pre commercial thinnings, commercial thinnings and Timber Stand Improvement (or intermediate) thinning. These treatments generally are used to increase the long term value of the forest by retaining better quality trees. In other words, removing the undesirable species and using them for biomass actually helps long-term forest health.

Unfortunately, many harvests that occur in Pennsylvania have consisted of short sighted partial harvests, especially 'high grades" or diameter limit cuts (that cut only the big trees and leave large amounts of smaller and undesirable species). High grading is not recommended, as it often results in a degraded stand that is ecologically and economically unsustainable. Ecologically, the stand loses its habitat quality for many valuable tree and wildlife species. Economically, the forest changes in composition from high-value species to lower-value species. Furthermore, the high grade diameter-limit cut narrows the range of alternative management activities a landowner can pursue. The only alternative after repeated diameter-limit cuts may be expensive restorative activities[9].

5.3. Economic opportunities

Harvest, processing, and use of woody biomass provide multiple benefits and cost savings. Cost savings can come from using wood heat instead of fossil fuels. Developing a market for woody biomass will also provide improved forest values and job opportunities for those supplying wood fuel and those manufacturing wood fuel equipment.

Dollars spent on sustainable biomass fuel stay within the Pennsylvania economy and go directly to Pennsylvania businesses and citizens that own, harvest, process, and transport the fuel. In comparison, approximately 75 cents of every dollar spent on fuel oil are exported from the state. This equates to exporting Pennsylvania jobs and reliance on other states for energy. The Northeast Biomass Thermal Working Group's economic analysis of fuel oil use in Pennsylvania showed that replacement of 120 million gallons of fuel oil with local biomass fuel would result in the creation of 31,100 permanent, sustainable jobs[10].

Several manufacturers design and build biomass boilers in Pennsylvania (Pictured here: AFS Energy Systems, Total Energy Concepts, Abbott Energy Systems, Agripower/Challenger).

Biomass heating and CHP equipment is manufactured in Pennsylvania, and installation of the equipment puts local contractors to work. Pennsylvania is already a US leader in the manufacture and supply of biomass thermal and CHP equipment to other states, and thus installation of biomass equipment results in creating manufacturing and supply chain jobs. Pennsylvania businesses manufacture the combustion units, boilers, turbines, controls, emission control equipment, and many of the materials that are used to manufacture these key pieces. Pennsylvania has a concentration of commercial-scale US biomass boiler manufacturers with 6 out of approximately 15 in the US. Companies such as Abbot, AFS Energy Systems, Agripower/Challenger, Biomass Boiler Technologies, Enginuity Energy, and Total Energy Solutions have all manufactured systems in the state.

Pennsylvania is also a leader in residential and small-scale commercial biomass systems with Harman Stoves. This firm builds over 25,000 appliances annually with a number of other biomass boiler manufacturers in this sector. Pressure vessels for commercial boiler systems are also made in Pennsylvania, by companies such as Burnham Boilers. Pennsylvania provides the steam turbines for biomass combined heat and power projects, as both Elliott and Skinner Power Systems are headquartered in PA.

Examples of residential scale wood energy equipment from Pennsylvania (photos courtesy of Harman Stoves).

6. Examples of wood energy in PA

Several notable examples exist in Pennsylvania of wood energy facilities that make use of locally grown, renewable wood fuel. We highlight two schools, one commercial greenhouse, and one pellet plant that are successfully utilizing Pennsylvania's forest products as a renewable energy resource.

6.1. Northern Bedford High School

Northern Bedford School District, in Loysburg, installed a wood boiler in 2012 to replace the fuel oil heating system for the High School /Middle School, Elementary School, and Vo-Tech School. The project was managed by an Energy Services Company (Reynolds Energy), and features a Pennsylvania-manufactured "AFS Energy" boiler that provides 2.1 MW (7.4 million btu per hour) of heat to a hot water loop that serves all of the buildings on the campus. Wood chips from both mill residues and whole tree chips are delivered via walking floor trailers to a fuel storage bin with a two day capacity. According to facility manager Kelly Sparks, the school is supplied by a combination of sawmill chips and forest-harvested whole tree chips.

Northern Bedford High School (left) and their wood fuel storage bin (right).

The $1.9 million project was supported by an Alternative and Clean Energy grant from the PA Department of Economic and Community Development, and is projected to pay back within five years (after grant support). Air emissions from the boiler are very low, thanks to high efficiency combustion coupled with multi-clone cyclonic separators that remove particulate matter from the exhaust stream.

- Boiler Size: 2.25 MW (7.8 million btu/h)
- Manufacturer: AFS Energy Systems, Lemoyne PA
- Fuel: Timber mill residue and whole tree chips
- Estimated Annual Fuel Use: 1,100 tons per year (green tons)
- Estimated Annual Cost Savings: $200,000

6.2. Dillon Floral

Commercial greenhouse Dillon Floral in Bloomsburg, PA grows cut flowers for regional floral centers. As you can imagine, the heating bill for their many greenhouses is not small. Thus, to help control costs, in 2007 they switched from natural gas and coal to a modern wood-fired heating system. The "Challenger" boiler, manufactured in Pennsylvania, generates steam that is piped through the greenhouses, keeping temperatures in the optimum range for a variety of plants.

In order to further increase their savings, the company decided to utilize wood chips from highway maintenance and landscaping operations. These chips are often a nuisance for local landscapers, thus Dillon Floral is able to obtain them at a lower price than sawmill or whole tree chips. However, the material tends to be more variable in composition. Facility operator Tim Cotner re-grinds the fuel, making it suitable for use. He also performs maintenance on a shorter time interval due to the more abrasive nature of the grit that is sometimes found in the fuel. That being said, the savings in fuel cost is worth it to the company.

- Boiler Size: 1.75 MW (6 million btu/h)
- Manufacturer: Advanced Recycling Equipment / Challenger, St Marys, PA
- Fuel: Roadside Maintenance and Landscaping Chips
- Estimated Annual Fuel Use: 3,400 tons per year (green tons)
- Estimated Annual Cost Savings: $266,000

Dillon Floral's biomass boiler (top), greenhouse flowers (middle), and fuel being augered into boiler (bottom).

6.3. Hughesville High School

In 2010, East Lycoming School District decided to go renewable by installing a 1.75 MW (6 million BTU per hour) biomass heating plant to replace their natural gas boiler. The boiler, built by Messersmith Manufacturing, heats hot water that is piped through the school, providing reliable and renewable warmth throughout. Wood chips are delivered by truck to a fuel storage bin, where they are conveyed to the boiler as needed. The boiler is installed in a new mechanical room that

A view of the boiler at Hughsville high School (left) and looking down a row of shrub willow (right).

was built to harmonize with the existing architecture, and includes storage space for up to several days' supply of wood fuel. Automatic ash removal and computer controls help to minimize labor on the system. "Multiclone" cyclonic separators remove particulates from the exhaust, keeping emissions well below mandated limits.

In a visionary step, the school district also decided to grow a portion of its fuel by planting 40 acres of fast growing, native "shrub willow" as a short rotation woody crop. The willow is planted as a field crop, and is harvested every second or third year using specialized equipment, yielding wood chips to be used in the boiler. These 40 acres of land are expected to provide about one third of the school's heating needs in a typical winter, with the remainder provided from local forest operations. This is the first commercial-scale planting of shrub willow for energy in Pennsylvania, and is based on successful research and projects in Upstate New York and abroad. According to school business manager Dave Maciejewski, the willow is intended to be a hedge against fuel price variability, as well as to serve as an educational tool for the students and community.

The entire project was carried out by an energy services company (McClure Company), working in partnership with the school district. The project was projected to pay back in about 15 years, but the recent dip in natural gas prices has lengthened that payback period to about 20. The work was carried out as part of the school district's comprehensive energy master plan, which included energy efficiency retrofits as well as installation of a solar photovoltaic array at the school campus.

- Boiler Size: 1.75 MW (6 million btu/h)
- Manufacturer: Messersmith Manufacturing, Bark River, MI
- Fuel: Timber mill residue and short rotation woody crops
- Estimated Annual Fuel Use: 750 tons (green tons)
- Estimated Annual Cost Savings: $45,000

6.4. Greene Team Pellets

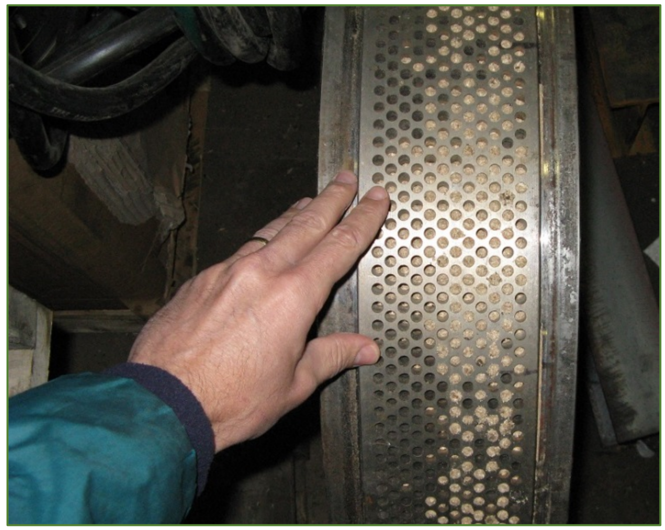
In the southwest corner of Pennsylvania, coal has long been the fuel of choice, providing heat for homes and industry, and electricity for the region. Greene Team Pellets is building on that energy heritage with its wood pellet plant, located on the site of an abandoned coal mine in Greene County. The facility utilizes wood from a variety of sources that is ground, dried, then extruded into wood pellets using a large ring die pelletizer built by the Andritz Corporation of Muncy, PA.

The Greene Team pellet facility, a re-purposed coal mine site that now produces renewable energy.

People sometimes mistakenly think that a glue is added to pellets to hold them together. Actually, the naturally occurring lignin in wood becomes soft and sticky under high pressure and temperature, and serves as a "built in" binder to hold the pellets together.

At Greene Team Pellets, over 25,000 tons of pellets per year are bagged, stacked on pallets, and shipped to big box retailers and wood stove shops throughout the local area. This is enough product to heat approximately 5,000 homes. Operations continue year round, building up inventory during the summer, and selling off product during the winter heating season. Greene Team is one of several wood pellet producers in the state – these facilities tend to be independently owned and operated, and provide both renewable fuel and much needed job opportunities to rural areas in the state.

- Plant Capacity: 25,000 tons per year
- Pellet Machine Manufacturer: Andritz, Muncy PA
- Fuel: Timber mill residue, whole tree chips, forest thinnings
- Estimated Annual Fuel Use: 55,000 tons (green tons)



The metal die that feedstock is forced through to create wood pellets.

Note that slightly more than 2 tons of green wood is needed for every ton of pellets, due to the high moisture content of the green wood, plus the use of a small amount of wood to fuel the dryer.

7. Policy and wood energy

In general, public policy regarding wood energy has been based on the principle that wood energy use should be encouraged in general, but restrictions should be in place to prevent poor planning or execution that would cause undue environmental or ecological impact. Policies at the federal, state and local level in the form of incentives or regulations, are available for biomass producers and consumers, while restrictions on harvest methods and combustion emissions are in place at the state and federal level.

Public policy is a key driver in encouraging wood energy in Pennsylvania.

For producers there can be tax incentives such as investment tax credits, production tax credits, and other tax deductions. There can also be financial incentives that include subsidized loan guarantees, grants and rebate programs. Energy producers may be eligible for production incentives such as net metering, feed-in tariffs, and renewable energy credits.

Consumers, such as those purchasing wood stoves, can be eligible for state tax deductions and/or rebates. Regulations that favor wood energy typically take the form of state or federal mandates such as Renewable Portfolio Standards and the Clean Power Plan. In addition, public efforts have supported a limited amount of education and extension work in the area of wood energy, working through programs such as Penn State Extension and the State Wood Energy Team program.

7.1. Examples of Federal Programs

The Energy Independence and Security Act (EISA) of 2007

(P.L. 110-140) includes a number of provisions related to the production of bioenergy, including an expansion of a national Renewable Fuel Standard (RFS). The RFS mandates the production and use of 36 billion gallons of advanced biofuels by 2022, and is likely to serve as a primary market driver for liquid biofuels in the future.

The Farm Bill Programs of 2014

This bill contains an energy title for bioenergy market development. The energy title includes a number of financial incentives for liquid biofuels production, including a sizable cellulosic biofuels tax credit of $1.01 per gallon. The Farm Bill also includes several programs intended to assist thermal, CHP, and biopower projects. The Biomass Crop Assistance Program (BCAP) is one such Farm Bill program that authorizes payments to agricultural producers for the establishment, maintenance, collection, harvest, transport, and storage of eligible biomass energy feedstocks, including woody biomass from non-industrial private forestlands.

Federal Tax Credits

An example of a federal tax credit is the federal Renewable Electricity Production Tax Credit (PTC) which offers a per-kilowatt-hour tax credit for the production of renewable energy.

7.2. Examples of Pennsylvania biomass energy related policy and programs

The Alternative Energy Portfolio Standard

This law requires each electric distribution company and electric generation supplier to retail electric customers in Pennsylvania to supply 18% of its electricity using alternative energy resources by 2020.

The Alternate Energy Investment Act

The Alternate Energy Investment Act provides funds for energy efficiency improvements by homeowners and small businesses statewide.

Pennsylvania Net Metering

This state law requires investor-owned utilities to offer net metering to residential customers that generate power. This simplifies the process of receiving revenue when generating power at the residential scale (http://www.puc.state.pa.us). Rural Electric Coops (which cover large areas of rural Pennsylvania) are not required to meet this requirement.

Photo: Penn State College of Agricultural Sciences

The Pennsylvania Energy Development Authority (PEDA)

This program issues periodic funding solicitations to provide support for innovative, advanced energy projects and for businesses interested in locating or expanding their alternative energy manufacturing or production operations in Pennsylvania (http://www.dep.pa.gov/Citizens/GrantsLoansRebates/Pages/PEDA.aspx).

Woody Biomass Harvesting Guidelines

The state has developed Woody Biomass Harvesting Guidelines for producing alternative energy, and expects that they be followed when biomass harvests are carried out on state owned land. This includes best management practices that include responsible biomass harvesting to take advantage of natural disturbances like wind damage, ice damage, pest invasions, and invasive plants http://biomassmagazine.com/articles/1825/pennsylvania-releases-woody-biomass-guidelines).

7.3. Analysis

It is apparent that a large variety of policy-driven programs and incentives exist that impact the development and use of wood energy. Some of these programs and incentives encourage the use of wood energy, while others limit its use. Furthermore, they come from a variety of sources, not all of which are coordinated. Lastly, policy initiatives can vary from time to time, as governmental bodies fund, defund, establish, or modify existing efforts. There are two conclusions to be drawn from this. First, help is available for individuals, companies, or organizations that are interested in wood energy. Second, it is a good idea to check and re-check what is available, to ensure that you are taking advantage of opportunities when they arise.

Photo: Penn State College of Agricultural Sciences

8. Issues regarding wood energy

While the authors have attempted to present a fair discussion, this document, by its very nature, is optimistic about the value and benefits of wood energy. However, some questions and concerns have arisen about the topic, and not all individuals agree about the advisability of using wood for energy (or the extent of appropriate use). This section discusses some of the objections that have been raised. You are encouraged to read this section as well as examine alternate views, and make an informed and balanced decision about these questions.

8.1. Forest sustainability

Forest bioenergy production could have both positive and negative impacts on the environment. On one hand, forest bioenergy can displace CO_2 emissions from burning fossil fuels, and thinning unhealthy or damaged stands can enhance the health and productivity of forest ecosystems. On the other hand, there is some concern about the potential loss of soil productivity resulting from excessive removals of biomass.

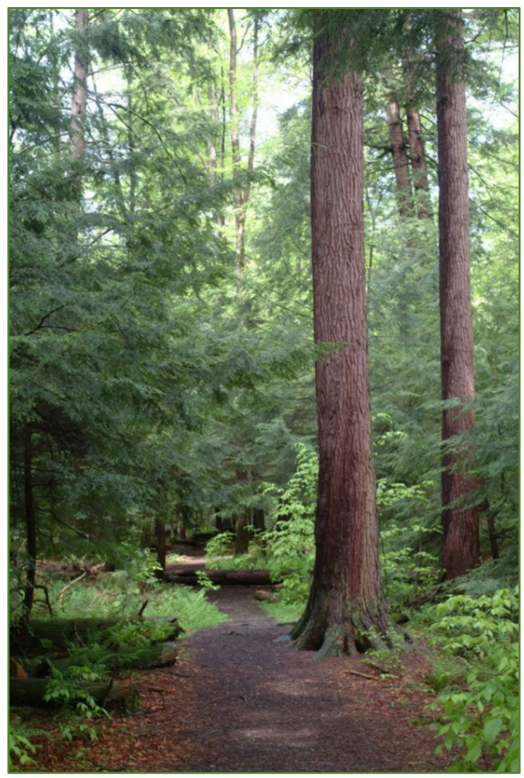
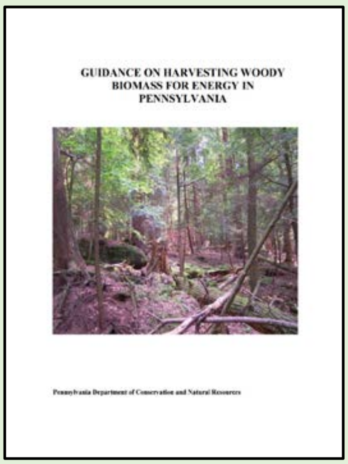


Photo: Penn State College of Agricultural Sciences

There are questions about sustainable harvesting of woody biomass, especially as it pertains to long term site productivity. A commonly expressed environmental concern is that harvesting biomass for energy removes too much of the important litter, debris and nutrients (soil organic matter and moisture-holding capacity). However, impacts on the inherent fertility of sites depend on harvest intensity and length of the rotation. Generally, shorter rotation and more intensive harvests deplete fertility sooner. Pennsylvania forests are relatively slow growing and therefore are harvested infrequently, many every 50-100 years, but it is important to ensure that a certain percentage of woody residues do remain in forest and that not every stick is removed. Where whole-tree harvesting and skidding are used, the majority of logging residue is concentrated at log landings, but some residue inevitably remains near where each tree was felled and along skid trails. Because of these factors, as well as other environmental concerns, not all logging residue is or would be available for use as a woody biomass feedstock. It is also important to consider other management objectives such as wildlife and biodiversity that could influence how much woody debris remains after a harvest.

Many states in the northeast, including Pennsylvania, have developed forestry Best Management Practices (BMPs) for water quality, wildlife habitat, and other environmental considerations. There are also some BMPs and guidelines specifically for biomass harvesting. Common topics discussed in most of these guidelines include: deadwood, wildlife and biodiversity, water quality and riparian areas, soil productivity, and silviculture. For example, many guidelines have recommendations for retaining forest floor, stumps, and snags, a certain percentage of slash (e.g. 30%), avoiding reentry after harvesting and avoiding sensitive areas like wetlands, bogs, etc. Biomass harvest can also be a detriment to wildlife; for example, ones that depend on downed woody debris. Finally, larger openings when all vegetation is removed make it more likely for invasive species introduction. These hazards are minimized when BMPs are followed. BMP information is available through forestry Cooperative Extension and state forestry programs for each state.

Guidelines for woody biomass harvest for energy in Pennsylvania:



This report, prepared by the PA Department of Conservation and Natural Resources establishes guidelines for harvesting methods and approaches that are designed for Pennsylvania forest types and conditions. The document includes recommended best management practices (BMPs) for nine key categories, including forest regeneration, water, wildlife, and aesthetics[11].

Forest managers who manage for bioenergy production can use harvests as a tool to affect habitat and habitat diversity. This is primarily due to manipulation of the vegetation, soil, water, and temperature of a given site. Potential bioenergy-related activities can increase or decrease the quantity and quality of habitat available at both stand and landscape levels. Activities that impact habitat include harvesting of trees and deadwood for energy feedstock, increasing road networks to access previously unmerchantable fiber, more frequent interventions into the forest, and land use changes and inadequate provision of protected areas.

8.2. Air emissions

Combusting wood for heat emits gases and particles into the air, but the amount of those materials varies widely, depending on the manner with which it is combusted, and the impact of these emissions depends on many factors, including the geography, surrounding land use, and weather, ambient pollutant levels, operating conditions, etc.

Since air is declared to be a public resource, government regulations dictate what may be emitted from combustion equipment. Beyond that, it also stands to reason that, as good neighbors and conscientious citizens, we should understand the air quality implications of wood heat and keep that in mind when making decisions about heating systems and air quality.

In general, higher efficiency combustion equipment produces fewer and less hazardous pollutants. When we look at residential wood heat, fireplaces are the least efficient and most prolific pollution producers for wood heat. Wood stoves improve upon that and pellet stoves are even more efficient. Larger scale commercial combustion equipment tends to have the lowest emission rates, especially when equipped with additional pollution control equipment such as cyclonic separators or electrostatic precipitators to remove fly ash from the exhaust gas.

Pollutants that are usually found in wood heat exhaust gas include products of incomplete combustion, normal products of combustion, and ash particles:

- Aromatic Hydrocarbons - primarily found in low efficiency combustion emissions, these products of incomplete combustion are probably the most hazardous emissions from wood energy - several are identified as being carcinogenic.
- Elemental Carbon Particles- these are also primarily found in low efficiency combustion emissions, but tend to be less hazardous than aromatic hydrocarbons.
- Carbon Monoxide - a product of incomplete combustion, elevated concentrations of carbon monoxide can be quickly lethal.
- Carbon Dioxide - a normal product of combustion reactions, CO_2 was not traditionally considered a "pollutant", but has drawn increased scrutiny in recent years (see next section).
- Water Vapor - also a product of normal combustion, water vapor is not usually considered a pollutant.
- NOx - Nitrogen oxides can be formed in a combustion chamber as nitrogen from the air or fuel reacts with available oxygen.
- Fine Ash Particles - wood ash particles, consisting primarily of mineral oxides, are carried along in the exhaust stream. They are less hazardous than carbon compounds, but are associated with increased risk of respiratory and pulmonary (heart) health problems.

Table 4. Typical Emissions From Wood Energy Appliances[20, 21].

Equipment Type	CO (mg/MJ)	NOx (mg/GJ)	Particulates (mg/MJ)
Residential Fireplace			
Residential Woodstove, old	7,000	30	1900
Residential Woodstove, new	1,700	60	100
Residential Pellet Stove	315	26	28
Commercial Wood Boiler	450	100	60

Note: reported emission rates vary widely – these numbers should be considered representative only as equipment design, fuel type, and operating mode all impact emissions to a great degree.

Many of these pollutants tend to break down, disperse or settle out of the air within a limited distance of their point of emission[12]. Also, the ambient pollutant level can impact whether or not wood heat emissions increase pollutants to a level of concern. These factors and others make the assessment of the health impact of wood heat emissions very challenging to accurately discern.

Controls on Wood Heat Emissions

A variety of regulations and restrictions limit the magnitude of emissions permitted from wood combustion. In the case of residential scale devices, manufacturers are required to meet efficiency and emissions standards on equipment sold for use. Larger, commercial scale devices are regulated by a permit system in Pennsylvania, in collaboration with federal standards for combustion system emissions. Extremely large (utility scale) systems are regulated separately by federal law, but also implemented by the state.

Additional emission restrictions are in place for the densely populated areas of Philadelphia and Pittsburgh. The air quality in Pennsylvania is monitored by the state Department of Environmental Protection, reporting measured pollutant levels as well as an “air quality index” based on ozone and PM2.5 (particles smaller than 2.5 microns in size) concentrations.

Are these measures to ensure acceptable air quality appropriate? Should regulations be changed? These are questions that remain a topic of debate, and are not always easy to resolve.

8.3. Carbon Dioxide Emissions[22]

Carbon dioxide emissions from combustion are of increasing interest globally and nationally, but its relevance to wood energy is not always well understood. In recent years, several studies have been reported that claim that bioenergy actually emits more carbon dioxide than fossil fuels[13, 14]. One of the most publicized of these is the “Manomet” study, an analysis of Massachusetts forests that was reported to show that wood-based power is worse than coal fired power in terms of carbon dioxide emissions[15].

The first thing to note is that most people agree that wood energy can be carbon neutral over the long term, as long as the long term productivity of the forest is not diminished. After all, the forest grows, converting solar energy to stored biomass energy to replace the wood that is harvested for use as fuel. However, as the Manomet study showed, things can be a bit more confusing in the short term. For example, if you harvest a forest stand for energy, it will take many years for biomass to regrow on that stand. Should we say that wood energy is not fully “carbon neutral” until that forest stand has regrown as much biomass as was originally removed? Some people argue “yes”[16]. Others would say that you must analyze the entire landscape (not just a single plot of forest land), and acknowledge that the carbon harvested from one forest plot is reabsorbed by plants growing throughout the region. Still others argue that past growth of biomass is what should be counted against a biomass harvest, thus making wood energy carbon neutral from the start (a "grow then harvest" model rather than "debt then dividend")[17].

Things also get confusing when you factor in any reductions in fossil fuel use that are a result of using wood energy (fossil fuel "offsets"). Fossil fuel energy systems can be high efficiency or not, and the same is true of wood energy systems. Furthermore, not all fossil fuels are equal – for example, natural gas emits about 40% less CO_2 per unit energy than coal. It can be tempting to make assumptions that favor one type of energy over another.

Photo: Penn State College of Agricultural Sciences

Likely scenarios for Pennsylvania wood energy involve utilizing forest thinnings and timber harvest residues as wood energy feedstocks. When this is done, carbon benefits of wood energy are maximized, and even the pessimistic "debt then dividend" analysis method indicates that the carbon benefit of wood energy begins occurring very quickly - on the order of five years. Furthermore, if wood energy systems are as efficient as the fossil fuel energy systems they replace, carbon benefits can begin immediately.

Which analysis methods and assumptions are correct for predicting carbon emissions from wood energy? This is as much a matter of opinion and point of view as it is of science. However, like so many things in life, wood energy that is done well performs much better than wood energy that is done poorly. Regardless of the analysis method used, wood energy from a sustainably and efficiently managed forest is always superior to fossil fuels in terms of long term carbon emissions.

9. Prospects for Wood Energy in Pennsylvania

It is always risky to predict the future, but given past trends, resources, and opportunities in the Keystone State, here are a few likely scenarios for the future of wood energy.

Wood Supply in Pennsylvania will continue to exceed demand, and the energy market will help landowners and forest managers better care for their forests. This trend will likely be impacted by the status of the timber industry, as wood for energy typically comes from coordinated timber harvest and forest management operations.

Residential Wood Heat will continue to slowly grow in use, and the introduction of new combustion technology will steadily increase both the efficiency and air quality impacts of this sector. This trend will likely also be impacted by federal and state air quality standards, stove swap-out programs, and the continued growth in popularity of wood pellets.

Commercial Wood Heat will continue to see steady increases in numbers as more existing buildings switch over to wood heat. In addition, we will see new construction turning to wood heat as its primary source of warmth. Drivers of this trend include favorable economics, increased familiarity with commercial scale wood energy, and continued interest in sustainability and renewability, as supported by government incentives.

Power Production From Wood faces an uncertain future. There is potential to co-fire wood in existing coal-fired power plants, and torrefaction of wood is an attractive option for making that possible. However, significant amounts of co-firing would require additional wood production in the state - perhaps in the form of fast growing Short Rotation Woody Crops. Federal mandates for clean power may encourage this sector, but policy uncertainty coupled with competition from other renewable power sectors make this a risky proposition unless developments in technology can make wood based power more attractive.

Liquid Fuel Production also faces an uncertain future, largely due to policy uncertainty at the federal level and high risks associated with high expenses of constructing biorefineries. The size of the market, however, is large.

In summary, the most likely growth areas for wood energy in Pennsylvania are small to medium sized projects whose economic and other sustainability aspects tend to be favorable.

10. How you can help

The sustainable growth of wood energy in Pennsylvania ultimately depends on the understanding and interest of its lawmakers, energy professionals, and especially its citizens. There are several ways that people can help encourage the use of wood energy in Pennsylvania:

1. Use wood energy in your home - with a high efficiency stove or boiler. If you have a wood stove, operate it well so that it burns clean and hot.
2. Encourage local schools, hospitals, and businesses to consider wood energy for their facility. Often, this idea hasn’t occurred to people who could benefit most.
3. Participate in the State Wood Energy Team - this statewide group works together to promote sustainable use of wood energy resources in a way that improves the lives and livelihoods of the Commonwealth’s citizens.
4. Encourage public support of wood energy through federal, state, and local programs that incentivize renewable and sustainable use of wood energy.

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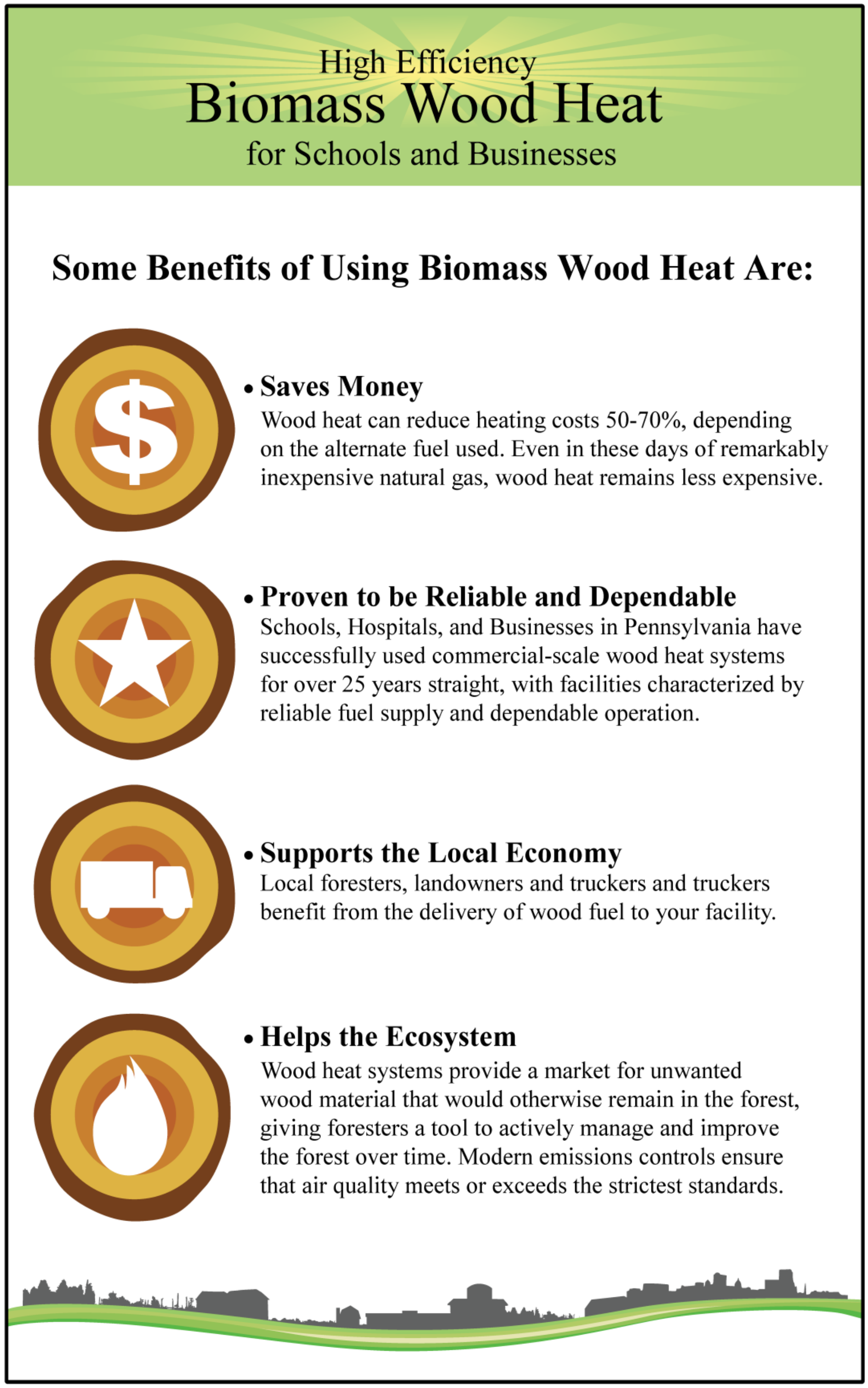
Appendix

Wood Energy Promotional Brochure, from the PA State Wood Energy Team.



What Type of Facilities Are Suitable for Wood Heat?

The ideal candidate facility for wood heat is one with a central boiler system, a winter heat load, adequate road access for fuel deliveries, and available staff to carry out occasional maintenance on the system.

For More Information:

Several groups can help answer questions or provide assistance as you consider wood energy. Contact one of the following groups:

- the PA State Wood Energy Team (Ed Johnstonbaugh, exj11@psu.edu or Mike Palko, mipalko@outlook.com).
- Penn State Extension (www.energy.extension.psu.edu)
- the PA Biomass Energy Association (http://www.supportpabiomass.org)
- PA Fuels for Schools and Communities (http://www.pafuelsforschools.psu.edu/default.asp)

The Pennsylvania State Wood Energy Team

is a USDA Forest Service funded collaborative effort of

PennState Extension

along with over 40 organizations and companies.

AFS Energy
Allegheny Hardwood Utilization Group
Allegheny National Forest
Biomass Thermal Energy Center
Blue Ridge School District
East Lycoming School District
Energex
Energy Management Concepts
Kane Area Schools
Laird Design and Graphic Services
McClure Corporation
Messersmith Manufacturing
NEWBio Bioenergy Consortium
Northern Tier Hardwood Association
PA Biomass Energy Association
PA Department of Environmental Protection
PA Fuels For Schools and Communities Working Group
PA Game Commission
PA State Representative Kathy Rapp
Penns Valley School District
Pennsylvania Hardwood Development Council
PennTAP
Sustainable Energy Fund
USDA NRCS (Pennsylvania)