RENEWABLE WOOD ENERGY

A Tool for Decarbonization & Forest Resilience

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As ski areas and the communities in which they operate aim to decarbonize, no single renewable energy source, energy efficiency approach or other strategy can be the sole solution. It takes pursuit of any and all options. One of the key segments for decarbonization in the U.S. is thermal energy, as facility owners often have major portions of their greenhouse gas (GHG) emissions associated with heating and cooling buildings, laundry, water heating and other on-site processes.

Using wood for energy can be a smart choice for mountain towns and resorts. Reducing the carbon intensity of operations with an energy source that displaces fossil fuels and promotes forest restoration demonstrates a commitment to broad environmental stewardship year round.

Renewable Thermal Energy Options

As facility owners attempt to decarbonize, they can choose between a variety of options for thermal energy. One energy source option is forest management residue — the tree stems, tops and limb byproducts from forest treatments. This option typically has low energy costs and GHG emissions, especially when sourced from residues that would otherwise meet an alternate fate that has poor environmental outcomes, such as wildfire, open pile burning and landfilling.

Without a stable market demand, woody material generated from forest management activities is often piled and burned, contributing to poor air quality and high management costs. Instead, this material can be used in a clean, efficient wood energy system, reducing the use of fossil fuels. The low energy cost and high decarbonization potential from this residue makes its use a beneficial option worth considering.

How It Works

In a wood energy system, wood residues run through a boiler or furnace system to provide space heat, hot water, cooling and/or electricity. Typical wood residues available are byproducts from forestry activities and include: wood chips, mill residues, wood pellets and cordwood. The wood residue type that's recommended is generally determined by what's locally available, scale of heat demand, space available and the level of automation desired. Wood is often a lower-cost heating option, especially compared to fuel oil, propane and electric resistance.

The graph shows forest management residues at an average cost of heat delivered at $4.63 per million Btu (British thermal units), wood pellets at $19.05, fuel oil at $26.51, and higher with propane and electric resistance. The further processing required to manufacture wood pellets from byproducts compared to just chipped/ground wood adds cost to this option. Variability also exists in the cost of forest residues depending on whether you are sourcing material from your own lands, chipping or grinding it yourself, or if you work with an outside contractor to manage a portion or all of that material harvest, processing and delivery for you.

Wood energy can be easily scaled. Fully automated wood chip or pellet systems are a good option for larger heat demands to provide hot water, space heating, and ice melting for base lodges and entire resort districts and communities. Larger-scale systems can also include co-generation of electricity. Smaller advanced cordwood boilers are an option for smaller facilities that have staff capacity to manage hand feeding the wood with the benefit of a lower investment cost.

Wood product manufacturers have been the humble frontrunners of zero waste and renewable wood energy in our forest communities for decades. Many generate renewable heat and power for their operations and communities with byproducts from their milling operations (i.e., bark, sawdust, chips and shavings). This practical and economical approach of directing wood residues to a beneficial use translates to a variety of scales and has been broadly adopted by the commercial, industrial and institutional sectors with more than 600 systems operating in the U.S.

Wood to the Wise: Leaders in Their Field

In 2014, Gundersen Health System in La Crosse, Wis., became the first hospital in the U.S. to generate more energy than it uses with a suite of renewable energy improvements, including a wood energy system, wind turbines, biogas digesters, landfill gas and geothermal. The wood energy system accounts for 38% of Gundersen's energy independence goal and reduced the hospital's net GHG emissions by more than 9,500 metric tons per year.

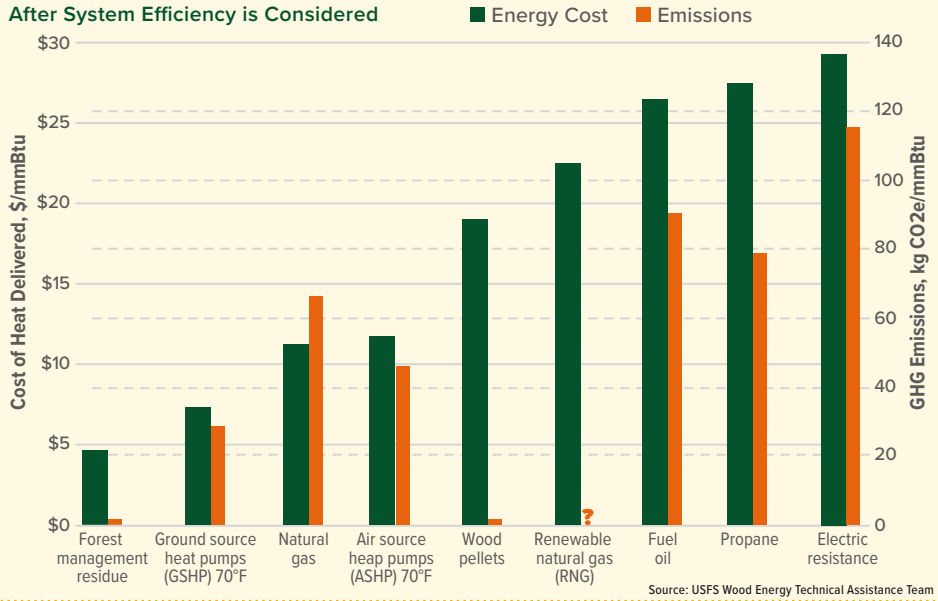
"We set out to make the air better for our patients to breathe, control our rising energy costs and help our local economy," said Dr. Jeff Thompson, Gundersen chief executive officer emeritus. "We believe we have made more progress on all three than anyone else in the country,"

The Wild Center in the Adirondacks, the first LEED certified museum in New York, integrated a dual-source renewable energy heating plant that employs a wood pellet boiler and solar array to heat their 54,000 square foot complex.

Four out of the 10 colleges and universities that have achieved their goal of carbon neutrality under the Climate Leadership Network — higher education institutions whose president/chancellor have made a formal commitment with respect to climate leadership on their campus — did so with wood energy systems. This includes Bates College and Colby College in Maine, Colgate University in New York, and Middlebury College in Vermont. These are just a few of the several colleges with wood energy systems across the country.

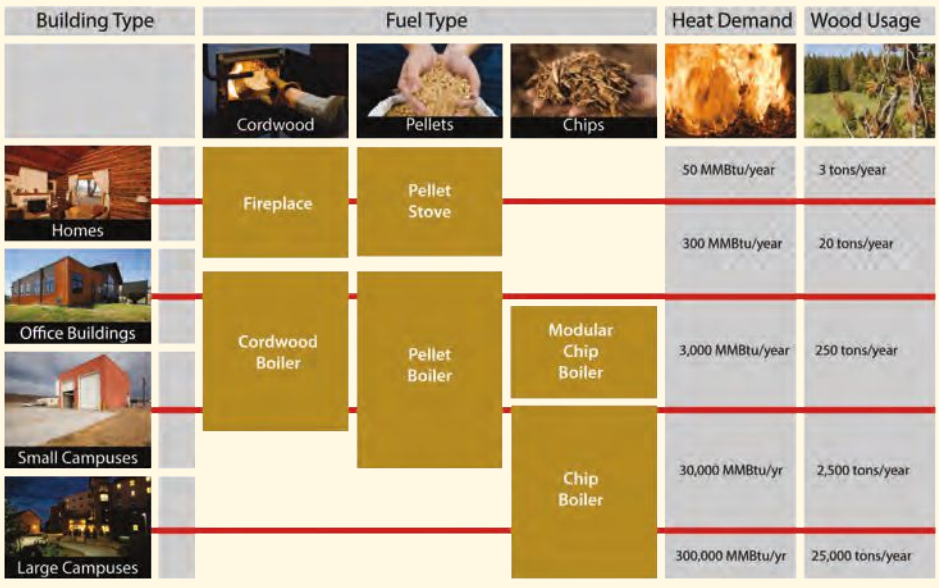
Cost & Level of GHG Emissions from Thermal Energy Options

After System Efficiency is Considered



Source: USFS Wood Energy Technical Assistance Team

Considerations for Scope of Wood Energy System



Ski Areas Are Catching On

Bridger Bowl, Mont., operates a small indoor cordwood boiler that uses dead and dying trees from their forest management operations to heat the lift operations building and vehicle maintenance shops through radiant floor heating.

"Most of our logging operations are over the snow in the spring," said Jason Prasek, mountain manager. "We fell the trees by hand, sorting out more marketable logs to go to local mills and then firewood for our own use."

Their woodshed holds 18 cords, and they try to cut, split and stack that over the course of a few weeks.

"It is work," said Prasek. "With grooming operations running through the night, there's staff available to run the boiler 24/7 and feed the wood in about every three to five hours."

Following suit, Red Lodge Mountain, Mont., has a cordwood boiler on order that will be installed in 2023. The ski area received a grant from the USDA Forest Service (USFS) to purchase and install the system. They're going in with eyes wide open on the work required to manage the firewood and boiler system. The owners and staff are excited about the project, the idea for which came from a forester with the state.

"We're not into it for the cost savings. However, it seems from right now a wash with energy costs," said Jeff Schmidt, GM. "We'll always be doing forest management,

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Wood chip district heating system, Burns, Oregon.

and this is a better use of the fuel that we're otherwise stacking and burning up into the sky. The burner is very efficient with less emissions than open burning."

Northstar Community Services District (NCSD), Calif., is planning installation of a 2-megawatt wood energy system with project support from the USFS Wood Energy Technical Assistance Team and a recent grant from CALFire. NCSD is a municipal government entity that provides public services to the community surrounding the Northstar California ski resort. They provide services of forest fuels management and fire protection in addition to water, sewer, solid waste, snow removal, road maintenance and recreational trails. The proposed district wood energy system will complement NCSD's fuels management and defensible space programs that generate about 800 bone dry tons per year of forest residues.

"Outlets for [their] byproducts from forest fuels management are diminishing and becoming further away and more expensive," according to Mike Staudenmayer, NCSD GM. "This material now costs more to dispose of than municipal solid waste at the dump. We want to close the loop on those management activities so we can be more efficient with the limited resources we have with the goal of increasing the pace and scale of forest remediation to reduce the wildfire threat."

NCSD's planning for the project includes getting an air permit from the local air pollution control district.

"The air district is a proponent of the project because it's an opportunity to reduce emissions from pile burning," Staudenmayer said. "In addition to reducing emissions from some of the open pile burning, we would rather the wood burn on our terms versus during a wildfire event. By burning chips in a highly controlled environment with the best available technologies, we can greatly reduce particulate matter and potential greenhouse gases and offer a competitive alternative to burning fossil fuel for our constituent's heating needs."

NCSD plans to work with the landfill as a fuel supplier to supplement their self-generated residues with other material from the area to heat about 14 buildings from a central boiler plant, replacing natural gas currently imported from out of state. Buildings proposed to be served by the new district wood energy system include NCSD's administrative building, a fire station and various buildings in the Northstar Village, including mixed residential and commercial buildings and two recreation centers with outdoor pools and spas.

Mt. Bachelor, Ore., is planning an installation of a larger automated wood energy system to serve four buildings with byproducts from forest restoration treatments on the Deschutes National Forest that will be chipped or ground. The ski area is slated to replace 150,000 gallons of propane with an estimated 720 dry tons of forest residues per year. They will displace 90% of their propane usage in those four buildings, with an estimated carbon emissions reduction of 88%.

"This is the biggest thing we could do toward our sustainability goals," said John McLeod, GM. "We have done ▶

SUPPORT & FINANCING

The USFS Wood Innovations Program provides technical assistance and grants to support the scoping and development of wood energy at public and private facilities across the U.S.

- **Wood Innovations Program and funding opportunities are at *https://go.usa.gov/xSWw9*. Ski areas interested in exploring wood energy should visit this link to find the regional Wood Innovations program coordinator for your state. They'll connect you with the National Wood Energy Technical Assistance Team who can answer any questions you have and work with you on a preliminary feasibility study.**
- **Another contact is Lew McCreery, National Wood Energy Technical Assistance Team, USFS *Lew.mccreery@usda.gov***

As your vision progresses to design, engineering and installation, USFS Wood Innovation and Community Wood Energy grants are available. The request for proposals for these grants is advertised annually in mid-October.

In our work, the USFS believes that managing forests and using wood products sustainably provide a great synergy of nature- and market-based solutions to forest resilience and climate change — not to mention simply providing for basic needs in our daily lives and the health of our communities. In addition to wood energy, the USFS Wood Innovations program supports innovation and project development in the use of wood and biomass for green building, sustainable biofuels, and other bio-based products like biochar (see sidebar, page 32).


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some other work, including small-scale solar, installing more efficient HVAC controls and LED lighting, but nothing at this scale of positive environmental benefit."

As part of POWDR's network of ski areas, Mt. Bachelor takes part in the operator's Play Forever program that dedicates a portion of their revenues to sustainability through environmental and philanthropic action. Mt. Bachelor will use those funds to finance the wood energy project. POWDR itself is part of the Climate Collaborative Charter in partnership with Alterra Mountain Company, Boyne Resorts and Vail Resorts that is committed to combatting climate change by "aggressively pursu[ing] renewable energy sources to be carbon neutral" and "be[ing] responsible stewards of the environment — the land, forests, watersheds, and habitats that provide the pristine locations where we live, work and host guests," according to a 2021 news release.

McLeod said their fuel supply will come from contractors who are implementing NEPA-approved forest management activities within the Deschutes National Forest where the resort is located.

"It will be a change in operations for those contractors where they can bring the material that would otherwise be

BIOCHAR
BURNING WITH BENEFITS

Managing wood residues, generated from fuels reduction and forest management activities, can be a challenge. In a good scenario, removed trees can be sold to mills with the revenue helping to cover the cost of the treatments. However, there are commonly a lot of small diameter trees, limbs and tree tops that don't have a market outlet and are managed at a cost to ski areas. Some of these residues can be used in a wood energy system to heat a ski resort. However, lower quality material may require other options, and this often defaults to disposal through open pile burning.

Technologies are available to manage wood residues in a more controlled environment that reduce the negative impacts of open burning while offering co-benefits, including biochar production. Biochar is essentially a charcoal-like substance produced when wood or other bio-material is heated (cooked) at high temperatures in the absence of oxygen. Under a microscope, biochar reveals a stable and highly porous structure that has beneficial applications in improving soil conditions and remediating pollution.

Forest landowners and managers are finding benefits in producing and consuming biochar. By redirecting forest residues from open pile burning into a purpose-built system, particulate emissions and the risk of fire spread are reduced while producing some quantities of biochar. These systems may also allow you to extend your limited outdoor burning windows. What's more, by containing the fire in an insulated elevated unit, the impacts of pile burning on the ground, which can scorch the soil and make it vulnerable to weeds, are reduced.

Biochar is used as a soil amendment to reduce soil compaction and increase its capacity to hold water and nutrients. It can also enhance erosion and sediment control to remove unwanted nutrients or other pollutants before runoff or absorb those that are already in a waterbody. Applying biochar to forest and agricultural soils to enhance plant growth, mitigate climate change, and sequester carbon have shown positive results in short-term preliminary trials, but there is still a lot to learn about particular benefits of biochar under various production and application scenarios over longer periods of time.

Beyond forest applications, biochar is showing promise in other sectors with properties that make it a desirable biologically-based filler, or replacement material, in a number of applications — plastic, concrete and asphalt industries, in metallurgical applications (metal extraction and mineral processing), and in climate mitigation. Biochar's unique structure resists biological and chemical degradation, and its presence can lower the environmental impact of products and industries that commonly use non-renewable resources and are energy intensive.

A January 2022 report by Washington State University, Biomass to Biochar: Maximizing the Carbon Value, provides a good summary of current opportunities, barriers and recommendations for the biochar sector in the Pacific Northwest. The report explains that the climate change mitigation potential of biochar technology depends on a number of factors: primarily, the supply of biomass that is harvested; but also the fraction of the carbon in the original biomass that ends up in the biochar (i.e., the carbon efficiency); the alternative fate of the biomass carbon (i.e., natural decay, wildfire, landfilling, etc.); the stability of the biochar after conversion (i.e., resistance to decomposition when applied to soil and ability to remain as stable carbon over time); the native fertility of the soils to which biochar is applied; and whether heat is also generated and used to offset fossil-carbon sources of energy.

piled and burned to a collection yard at the resort," according to McLeod. "It's a total win-win scenario. A win for our partnership with the Forest Service — we're literally surrounded by Forest Service land. A win from an emissions standpoint. A win from a leadership standpoint."

McLeod noted that the project was really catalyzed this spring when they were awarded a $1.5 million Community Wood Energy grant from the USFS. The system is fully designed and master development and NEPA approved. In pulling together their financing for the project, Mt. Bachelor received a $1 million grant from the county and is seeking another $1 million grant through the Oregon state energy office. They hope to break ground next spring and are anticipating operating the wood energy system in winter 2024–25.

"It's natural for ski areas to take a lead on wood energy," added McLeod.

Powering Up

Wood energy systems can be scaled and designed to provide power as well. The most efficient and cost-effective way to produce power with wood is with a thermally-led combined heat and power (CHP) system. CHP technologies produce ▸

The USFS is working with AirBurners Inc. to develop and test a relocatable air curtain burner that will produce biochar.

Biochar is a charcoal-like substance, with a stable and highly porous structure that has beneficial applications in improving soil conditions and remediating pollution, produced when wood or other bio-material is cooked at high temperatures in the absence of oxygen.

For any of these biochar markets to mature and grow, more research and proven demonstration of these applications will be required along with production of biochar at much larger and economical scales.

In seeking to fill knowledge gaps and explore the market, the USFS is working with the US Biochar Initiative *(biochar-us.org/welcome-biochar-learning-center),* providing grants to biochar related projects, and working with AirBurners Inc. to develop and test a relocatable air curtain burner that will produce biochar. An air curtain burner is an engineered, open-topped firebox with an active air blower that is used to reduce wood waste to ash in a more controlled burn that emits less smoke and particulates. These are commonly used in forestry, agriculture and disaster recovery to dispose of whole logs, limbs and brush. The cost of owning and operating these systems does come at a higher expense than open-pile burning but provides environmental benefits, including a small amount of biochar. The systems have portability where they can be towed and set up at different sites in a treatment area.

"A lot of people are excited about the prospect of biochar — producers, forest landowners and potential consumers alike — and there is a lot of energy going into advancing the research and testing to get us there," says Charlie Becker, natural resource specialist with the USDA Forest Service.

Some of these engineered technologies are simply wood destroyers that burn wood and reduce it into ash with the potential for a small amount of biochar. Others are more specifically engineered to produce larger amounts of biochar and/or heat. In seeking alternatives to open pile burning, many small forest landowners are experimenting with biochar production at a small scale, employing small, low-tech portable open metal boxes where wood is continuously added by hand or machine, tended to, then quenched with water. There is no active air blower on these systems, but rather piles are built in the container in a way that promotes a passive air flow that draws the flames downward in the unit. These low-tech units vary in size from as small as a backyard fire pit.

"For the forest landowner or ski area with small volumes of forest residues, the opportunity to do on-site biochar production with low- to intermediate-tech kilns is there," according to Becker.

These options have varied input requirements related to feedstock preparation, operations and the outputs or benefits desired. Higher-tech systems also exist that focus on the co-production of both biochar and heat that result in larger quantities of biochar. These can work well at industrial sites like sawmills that have the equipment and labor available to manage the feedstock, production process and marketing of the biochar. In contrast to a wood energy system that integrates more easily with the daily operations of a ski area, a biochar system like this is a more labor-intensive industrial add-on to existing operations.

MARCUS KAUFFMAN, OREGON DEPARTMENT OF FORESTRY

Where Wood Energy Works Best

- Expensive fossil fuel source
- Buildings connected to a centralized heating system
- Nearby wood fuel source
- At businesses with climate-smart goals

Wood Energy Benefits

- Local
- Clean
- Efficient
- Lower energy costs
- Climate smart
- Mitigates wildfire
- Supports sustainable forest management

electric and thermal energy at high efficiencies using a heat engine or turbine.

In many operating CHP systems, power is the priority objective with the heat produced as a byproduct of the power generation. In contrast, thermally-led CHP is designed to meet the thermal energy demands of a facility as the priority objective, then generate power at a level that matches how much heat is needed so that efficiency is maximized. This results in a system that can meet the thermal energy demands of a facility, and typically generates electricity for a cost of around 1 to 2 cents per kWh. The catch is that the system will typically not provide all the electric needs of a facility since power production is dependent on how much heat is needed in the facility.

Climate Smart

The co-benefits of wood energy that support people, planet and profit are compelling.

The use of byproducts from forest management activities displaces fossil fuels and supports proactive treatment of forests that are far beyond their ability to be resilient and resistant to drought, catastrophic wildfires, and insect and disease infestations. Forest treatments can enhance the forests' capacity to continue to sequester carbon and reduce the risk of stand-replacing fires that compromise our water sources and livelihoods. Further, wood energy provides an outlet for otherwise non-sellable byproducts and supports a diversified economy that includes forestry professionals who provide valuable expertise and services.

Converting wood to energy recycles carbon that is already in a short-term carbon cycle. Carbon dioxide is absorbed by trees through photosynthesis, and then released through decay in a continuous carbon cycle. Whether wood from trees naturally decomposes or is burned, carbon dioxide is released into the atmosphere. That carbon will continue to cycle within the new growth and decay of wood in trees.

When forests are managed in a way that stimulates the capacity to continue to grow more wood and sequester carbon, there is no new carbon dioxide added to the atmosphere.

No single strategy can be the solution to the challenges that our forests and communities face, but wood energy provides a place-based holistic solution worth considering.

Scan the QR code with your phone's camera to read more about these and other wood and biomass projects and find the Forest Service Regional Program Coordinator in your state, as well as Forest Service Wood Innovations Program and Funding opportunities.