Montana
Woody Biomass Utilization Strategy

PART I. ASSESSMENT OF WOODY BIOMASS UTILIZATION OPPORTUNITIES

PART II. STRATEGY FOR SUSTAINING AND ENHANCING UTILIZATION

Vision

Ecologically and economically sustainable woody biomass harvest and utilization can be used to manage for resilient forests, reduce wildfire threats to communities, improve air quality, diversify rural economies, provide renewable, bio-based products, energy and other opportunities including reduced net greenhouse gas emissions.

November 2011

About the Montana Biomass Working Group

In order to better understand current woody biomass inventory and opportunities, and to coordinate and focus current utilization efforts within government agencies, academia, biomass producers and end users; as well as identify ways to sustain and create new utilization opportunities; the Montana Biomass Working Group (BWG) was established in Winter 2009 as an advisory group to the State Forester. The BWG is comprised of state and federal government partners, economic development groups with strong knowledge of the forestry sector, academicians and extension foresters from Montana's University System. Private industry, as well as non-industry, state, tribal, and federal forest management perspectives and expertise are also represented.

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EXECUTIVE SUMMARY

Both need and opportunity suggest that forest biomass utilization can play an important role in providing a number of ecological, social and economic benefits to Montana. Limited markets for woody biomass exist in Montana and new markets have been slow to develop. Given this, the Montana Biomass Working Group was established as an advisory group to the State Forester—convened in 2009-2010 to assess current utilization opportunities and challenges, and provide recommendations for enhancing utilization in Montana in ways that are ecologically and economically sound.

PART I. ASSESSMENT OF WOODY BIOMASS UTILIZATION OPPORTUNITIES

The Assessment contains a broad look at the varied opportunities and challenges associated with resource concerns and priority issues for Montana forests, current biomass utilization and infrastructure, available and under-utilized biomass supply, markets and socio-political factors.

Key Findings and Considerations

Montana State Assessment and Forest Action Plan
The Montana State Assessment of Forest Resources identified five priority issues for Montana forests: 1) forest biodiversity and resiliency; 2) wildfire and public safety; 3) forest products and biomass utilization; 4) sustainable urban forest landscapes; and 5) changing forest ownership patterns. The Assessment model employed GIS analytic techniques to create a map that identifies areas in the state with viable and high potential for biomass availability and utilization integrated with forest health management. The Montana Forest Action Plan directs programming and project development in those high priority areas of the state.

Forest Resource Values of Concern
There is public concern regarding the impacts that increased market demand for woody biomass, especially for energy, will have on the forest. Resource concerns commonly aired related to biomass removal include soil function and productivity, water quality, biodiversity, and wildlife habitat. In an effort to address these concerns, the Biomass Working Group reviewed existing state and federal rules, regulations and guidance for forest management practices on state, federal, and private lands, and determined that these mechanisms were sufficient to address concerns related to biomass harvest practices.

Social Acceptance
The development of a woody biomass industry fed, at least in part, by forest material from public lands, will depend critically upon the wide-spread acceptance of a broad group of stakeholders and the public. Members of the public hold varied, and at times, competing beliefs about the benefits and perceived risks and uncertainties associated with biomass utilization. Social acceptance may be better achieved through public education and improved monitoring and reporting on the economic and ecological effects of biomass utilization.

Climate Change
There is much public discourse over the life-cycle of greenhouse gas emissions as it relates to forest biomass harvest and utilization. The quantification of this life-cycle varies according to multiple factors and depending on varied scales. Those who see a role for the use of woody biomass-based products to mitigate the causes of climate change cite a number of benefits including displacing fossil fuel emissions, providing bio-based alternatives to other energy-intensive and petroleum based materials, and supporting healthy forest management that enhances the ability of the forests to sequester carbon.

Woody Biomass Supply and Demand

Woody Biomass Inventory

The Montana DNRC – Forestry Division recently commissioned the University of Montana Bureau of Business and Economic Research (BBER) to compile a report examining forest-based biomass supply and use in Montana. This assessment examined live trees, standing dead trees, logging residue, and primary mill residue as available woody biomass inventory. Accounting for social, economic and logistical constraints, the potentially available biomass supply from Montana forestland was estimated to be 40.3 million bone dry tons. Available volumes of logging residue are dependent on forest treatment and commercial timber harvest activities on private and public lands. In-state production and consumption of mill residues is dependent on mill capacity, timber harvest volumes, and milling efficiencies.

Characteristics of Supply Sources

Not all biomass is created equal. Physical characteristics, available markets and relative costs of production have traditionally segregated woody biomass sources into two broad categories: "mill residuals" and "woods-direct". The most economical source of biomass is that which is associated with traditional saw log harvest and saw milling operations. Woods-direct biomass is the most under-utilized and abundant resource, and there are a number of challenges associated with its collection and use.

These challenges include:

- the relatively low value of end products,
- forest roads that are not designed and built to accommodate the use of trucks/trailers capable of hauling biomass,
- access to the forest is seasonal,
- difficulty in estimating the amount of residual biomass produced from harvest activities,
- hauling costs can be high dependant on diesel fuel prices and distance from site to end user, and
- increased potential for contaminants such as dirt and rocks.

Market Opportunities and Challenges

Improving local markets for biomass residuals from both mills and harvest activities would help bolster the economic viability of existing forest products manufacturing facilities, as well as proposed timber and/or forest restoration treatments. Existing and potential market opportunities include traditional roundwood products, engineered lumber and composites, landscape and agricultural products, energy—thermal, combined heat and power, liquid fuels, and densified fuels such as pellets and briquettes, bio-chemicals and bio-plastics. Developing new markets for woody biomass does not necessarily mean developing competition for existing users, and will be more successful when integrated with existing timber harvesting and product infrastructure.

Retaining and developing new market opportunities in Montana requires meeting certain challenges such as:

- understanding the characteristics and limitations of local biomass materials,
- ensuring utilization of biomass in quantities that are economically and ecologically sustainable over the long-term,
- the relatively high cost of collection and transportation,
- the relatively low value of most end products,
- designing forest management activities where sawlog volume from vegetative and restoration treatments will carry the cost of low value material,

- keeping costs in line with potential revenue from product sales,
- the high capital cost associated with wood-to-energy projects,
- the price of biofuels and bioenergy compared to other energy sources, and
- incentive programs for renewable energy that focus on electricity and transportation sectors, with lesser incentives for thermal energy.

Optimal markets and/or users should have the following characteristics:

- scaled to use a sustainable supply of locally available woody biomass,
- utilize material that is under-utilized and abundant,
- capable of efficiently producing end-products of sufficiently high value to cover the production and transport cost of biomass material,
- co-located with, or in near proximity to, other forest product manufacturing sites,
- integrated with, and complementary to, existing timber harvesting and wood product infrastructure, and
- social acceptance.

PART II. STRATEGY FOR SUSTAINING AND ENHANCING UTILIZATION

The strategy identifies three focus areas and recommends action items in support of the goal to sustain and enhance biomass utilization in Montana—with opportunities for improvements in programmatic services, partnerships, and state and federal policies.

Focus Areas:

1. Support and enhance biomass market and project development
2. Provide reliable and sustainable supply of woody biomass
3. Support advancements in science, engineering and technology

Recommended Action Items

Focus Area 1: Support and Enhance Biomass Market and Project Development

Programs

- Focus time and financial resources on most viable market opportunities. This currently includes thermal energy generation particularly at facilities outside of natural gas distribution areas, and combined heat and power generation at forest product mills.
- Provide incentive/funding assistance to assess, design, and implement biomass utilization and energy projects.
- Lead by example: encourage state agencies to integrate wood products and wood energy in state buildings.
- Engage in public information campaign to address public concerns related to biomass harvest and utilization.
- Maintain State program that provides a clearinghouse for biomass utilization information and activities, and provides financial and technical assistance for project development.

Partnerships

- Engage economic development organizations and agencies to identify and support viable business and project opportunities in biomass.
- Support education and marketing campaigns that promote wood products to the building sector, businesses and consumers.
- Continue collaboration with multi-agency, multi-stakeholder groups such as the Montana Biomass Working Group and Montana Forest Restoration Committee's Forest Products Retention Roundtable.

Focus Area 2: Provide Reliable and Sustainable Supply of Woody Biomass

Programs

- Continue to promote active management on state, federal and private forestlands.
- Continue to provide outreach to non-industrial private landowners on the value of harvesting traditional and non-traditional products as a tool to achieve good forest stewardship.
- Enhance education and curriculum on sustainable forest management practices for foresters and landowners to highlight resources of particular concern related to biomass harvest (i.e. soil health, alternative slash management, benefits of biomass retention, etc.).

Partnerships

- Engage the Montana State Assessment stakeholders in prioritizing landscape-level biomass supply planning.
- Develop collaborative multi-agency, multi-stakeholder projects incorporating programs such as forest restoration and stewardship, hazardous fuels treatments, pest management and urban forestry.
- Work with local collaborative stakeholder groups to develop and/or recommend forest restoration projects.
- Coordinate with state and federal land agencies in maintaining the Western Montana Coordinated Resource Offering Protocol web tool as a reliable, up-to-date clearinghouse of information for biomass supply from agency projects and timber sales.

Focus Area 3: Support Advancements in Science, Engineering and Technology

Programs

- Support research, development and deployment of technologies that provide for high efficiencies and minimized environmental impacts in biomass harvest, transport, processing, and end use.
- Enhance efficiency in recovery of biomass from harvest operations including techniques for reducing contaminants of dirt and rocks.
- Direct research programs to study air emissions and carbon life-cycle analyses for various utilization options.
- Support vocational training and college-to-business exchange programs specific to biomass sectors.
- Support research and development programs and projects that lead to development of new biomass products.
- Support research, monitoring, and reporting of the ecological, economic and social impacts and benefits of woody biomass harvesting and utilization. Include the economic benefits to communities, effects on air quality and fire suppression and forest management costs, and net effects on fossil fuel use.

Partnerships

- Work with The Montana University System, research institutions and the private sector to identify and explore research and technology capacity, needs and shortfalls.
- Identify and engage with engineering and technology programs and partners.
- Continue to work with state regulatory agencies to ensure compliance with applicable regulations, and to inform development of regulations that are not overly burdensome and that recognize positive attributes of biomass utilization and the impacts its use displaces.
- Engage in technology transfer between public and private entities.

Guiding Principles for Policy

State and federal policies have the capacity to create varied incentives and supports or barriers to biomass utilization developments. There are a few guiding principles for policy development in support of biomass utilization.

Policies should:

- be carefully constructed to avoid unintended consequences and major market distortions,
- facilitate increased use of biomass in a way that is compatible with and complementary to existing forest product industries;
- recognize the value and social and environmental co-benefits that can be derived from biomass utilization;
- reward all forms of energy produced from biomass including thermal, combined heat and power, and liquid fuel;
- coordinate with other state, regional and national policy initiatives and efforts; and
- provide supportive business and investment tax structures for biomass developments.

INTRODUCTION AND BACKGROUND

This strategy has been developed under the premise that enhancing and expanding markets for woody biomass has the potential to provide ecological, social and economic benefits to Montana. Through the assessment of Montana's biomass supply, infrastructure, markets and policies—existing and potential—we have a better understanding of the opportunities and challenges throughout the biomass supply and use chain. With this, we are better able to formulate a way forward that:

1. is scaled appropriately to ecologically and economically accessible biomass material,
2. doesn't compromise forest resource values of concern,
3. capitalizes on existing infrastructure and available resources,
4. encourages innovation and diversification, and
5. affords an adaptive approach.

This strategy was created as an advisory document for the Montana State Forester and is built from the collective research, expertise and contributions of a diverse group of stakeholders and technical advisors that make up the Montana Biomass Working Group.

Part 1, the *Assessment* identifies the opportunities and challenges for utilization including priority issues for Montana forests, resource values of concern, current biomass supply, use and infrastructure and socio-political factors. The findings and discussions from this assessment informed the development of Part 2, the *Strategy*, which identifies three focus areas and recommends action items for sustaining and enhancing utilization through various programmatic services, partnerships and policies. Just as forest ecosystems, biomass markets, scientific findings, and socio-political factors are dynamic and ever-evolving, so is the Strategy.

Montana Forest Conditions and Trends

The Montana Statewide Assessment of Forest Resources conducted by DNRC in 2009-2010 examined current conditions and trends affecting Montana forestlands. The assessment identified several key issues for Montana forests:

- Past forest and wildfire management practices have resulted in uncharacteristic change and loss in diversity of stand composition, size, density and patterns—reducing the resiliency and ecosystem functionality of our forest stands and landscapes.
- 75% of the more than 9 billion live trees on Montana forestland is less than seven inches diameter at breast height.
- 30% of Montana's forests have been impacted by insects, disease, and uncharacteristic wildfire in the last 10 years.
- Montana's wildland-urban-interface boundaries currently contain more than 350,000 structures and two-thirds of those are homes.
- Large, contiguous blocks of private industrial forestlands are being divested to recreational and residential properties, public land agencies and conservation organizations which shifts land management objectives aimed more at forest restoration and silvicultural treatments that provide for a diverse suite of values beyond just commercial timber harvest.

These trends have significant implications for Montana's social and environmental future. Management activities aimed to mitigate risks and impacts associated with these forest conditions will invariably include treatments that generate a large volume of small-diameter trees and biomass. Having marketable end-uses for that biomass material can increase the cost efficiency of those treatments, allowing more acres to be treated.

Forest treatments have costs that in Montana can range from $400 to $3,500 per acre, averaging $1,000 per acre. Not all landowners can afford these costs. Revenues gained from the sale of sawlog and non-sawlog material can be the deciding factor as to whether or not a forest treatment will occur on their property. This is the case for all landowners—from homeowners in the wildland-urban-interface to family forest owners; federal, state, tribal and conservation land managers, and industrial timber land owners—be it for hazardous fuels reduction; enhancing wildlife habitat or recreational attributes; improving forest resiliency against wildfire, insects and disease;

commercial timber harvest or other values. As it pertains to forest stands where management objectives require the thinning and removal of a large proportion of small-diameter trees and biomass, without a commercial value for the forest material, either 1) the forest treatment will not occur at all, or 2) the woody material (slash) generated from the treatment is likely to be burned in open piles on the forest site. There are additional economic costs and environmental impacts associated with that slash-burning that could be avoided if markets for biomass existed.

In addition to being a supportive tool for continued management of Montana forests, sustainable biomass utilization can provide for a number of other benefits.

Shared Vision of the Biomass Working Group

Biomass utilization can provide the following benefits:

- support ecosystem management and restoration projects that promote healthy and resilient forests,
- reduce risks of catastrophic wildfire to wildlife habitat and communities,
- enhance forests' capacity for long-term carbon sequestration,
- sustain and strengthen Montana's forest products infrastructure and rural economies,
- reduce uncontrolled emissions from open burning of forest residues,
- utilize woody biomass as a local, renewable bio-based product (including energy) which retains direct benefits to local communities and economies, and
- reduce energy expenditures in manufacturing and importing non-biobased building materials such as steel and concrete.

Definitions

Biomass is defined in this document as above-ground non-sawlog, woody material from trees such as tops, branches, needles, leaves, bolewood and small-diameter trees commonly generated as by-products of commercial timber harvest, hazardous fuels and silvicultural treatments, and forest restoration and pre-commercial thinning; and also includes wood by-products from wood processing facilities such as chips, sawdust, shavings, and bark.

Biomass utilization is defined in this document as the harvest, sale, offer, trade or use of wood biomass to produce a full range of wood products including bioenergy, engineered lumber, pulp and paper, fence posts and poles, shavings, furniture, housing components, landscaping products, cellulosic ethanol, etc.

PART I. ASSESSMENT OF WOODY BIOMASS UTILIZATION OPPORTUNITIES

KEY FINDINGS AND CONSIDERATIONS

This strategy begins with an assessment of the varied opportunities and challenges associated with resource concerns and priority issues for Montana forests, current biomass utilization and infrastructure, available and under utilized biomass supply, markets and socio-political factors.

State Assessment and Forest Action Plan

In 2009-2010, Montana Department of Natural Resources and Conservation (DNRC), in collaboration with a consortium of over 40 interested stakeholders, conducted a Statewide Assessment of Forest Resources with the purpose of providing a foundation to assist the DNRC in prioritizing forested areas of greatest need and opportunity for stewardship and sustainable management, and developing a comprehensive long term strategy to address these needs and opportunities (Montana DNRC 2010). The assessment examined current conditions and trends affecting forest lands in Montana, confirming that land use change, insects and disease, invasive species, and large-scale wildfires have resulted in the fragmentation and degradation of vast acreages of forestlands. Additionally, the increasingly volatile and global nature of the forest products industry continues to put pressure on local, state and regional economies.

This assessment resulted in development of a strategy, Montana's Forest Action Plan, which directs the future deployment of State and Private Forestry Programs in Montana focused on five priority issues for Montana forests in critical landscapes. The five priority issues identified by the Statewide Assessment Working Group are:
1) forest biodiversity and resiliency;
2) wildfire and public safety;
3) forest products and biomass utilization;
4) sustainable urban forest landscapes; and
5) changing forest ownership patterns.

Using geographic information system (GIS) analytic techniques, GIS data layers were weighted and integrated into an Assessment model. The model identified viable and high potential landscapes with combined opportunities for biomass utilization where land management can significantly mitigate forest health risk factors such as insects and disease, as well as the risk of catastrophic wildfire; and where there is real, near-term potential to access and supply material to forest product and biomass markets (See Figure 1).

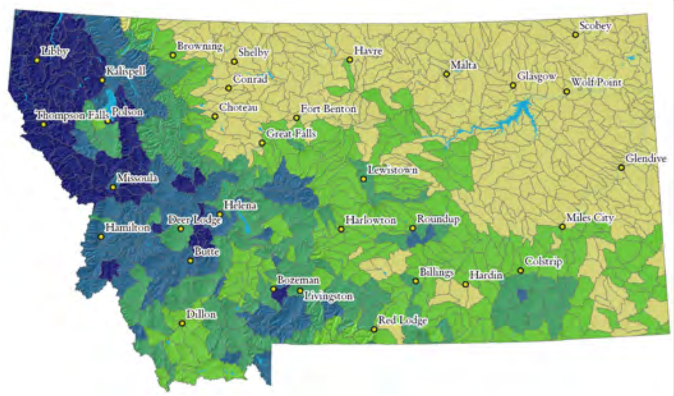


Figure 1. State Assessment model output identifying areas with high potential for biomass availability and utilization integrated with forest health management. (Darker colors denote watersheds with higher potential to meet objectives).

Forest Resource Values of Concern

The Biomass Working Group discussed the role of biomass in forest resource values of greatest concern and the associated impacts of aboveground removal. Resources of concern identified included soil function and productivity, water quality, biodiversity, and wildlife habitat. In an effort to address these concerns, the Biomass Working Group formed a subcommittee tasked with developing biomass harvest and retention guidelines for Montana forests. During this development process, it was made apparent to the subcommittee that because biomass harvest is most-often integrated with traditional forest operations of sawlog and pulpwood harvest, it can be difficult to isolate the effects of biomass removal.

The Biomass Working Group reviewed existing state and federal regulations and guidance

for forest management practices on state, federal, and private lands, and determined that these mechanisms were sufficient to address concerns related to biomass harvest practices (See Appendix A). With this, the Working Group decided not to continue to develop harvest guidelines specific to biomass. However, the Working Group did recommend that provisions for concerns related to biomass harvest impacts be included in Montana's Water Quality Best Management Practices (BMPs) for Forests. These provisions have been approved and incorporated into revised BMPs for Montana Forests (Montana State University Extension Service 2011).

There is limited research focused solely on the ecological impacts of forest biomass harvests. A review of existing research found that only three of 26 known studies examined the effects of biomass removal on biodiversity in ponderosa pine stands, and there were no studies of mixed conifer and lodge pole pine stands which characterize much of Montana's forestlands.

Social Acceptance

The development of a woody biomass industry fed, at least in part, with forest material from public land, will depend critically upon wide-spread acceptance from a broad group of stakeholders and the public. Social acceptance is rooted in the beliefs, perceptions and opinions held by a population, and it is subject to change as new information is acquired.

Why public support is important to the success of biomass utilization developments:

- Prior to investments in biomass product manufacturing and bio-energy facilities, project developers require assurance of stable and long-term availability of woody biomass supply. Given that 60% of the forestland base in Montana is publically-owned National Forest Systems lands comprising a large volume of available biomass, **public support for timber harvesting as a tool in forest stewardship** and health management is key.

- Because it is difficult for wood biomass energy to compete with the comparatively low market rates and imbalanced investment incentives for fossil fuels and other renewables, **public support for policies, initiatives and subsidies that support and incentivize development of woody biomass** are needed.

- The public includes **potential consumers and investors** in biomass products and projects.

Members of the public hold varied, and at times, competing beliefs about the benefits and perceived risks and uncertainties associated with biomass utilization. A survey of articles related to wood biomass energy published in Montana newspapers between 2008 and 2010 day-lights some commonly-heard public perceptions of biomass energy specifically, but also represents views of biomass harvest and utilization in general. (See Figure 2, Todd 2010).

Public views on the benefits and percieved risks and uncertainties associated with biomass utilization.

Expectations of Benefit	Perceived Risks and Uncertainties	
Cost-effective energy source	**Economic feasibility**	Competing Views
Environmental benefit	**Environmental degradation**	
Climate change mitigation	**Compounding climate change**	
Improve air quality	**Reduce air quality**	
Sustaining livelihood	Policy constraints	
Fire mitigation	Sustainability of supply and scale of development	
Energy security		
Enhance forest aesthetics	Logistical limitations	
	Lack of science	
	Trust between stakeholders	

Figure 2. Public views on the benefits and perceived risks and uncertainties associated with biomass utilization. First four listed in table are competing views. Qmspac8 Rmbb 0./.,

There are varied end-uses for woody biomass, and social acceptance for each of these end-products may vary depending on factors such as product type, technology employed, and scale and siting of developments.

Social acceptance may be better attained through:

- Monitoring and reporting on the economic and ecological effects of biomass removals and utilization at various scales and locations.
- Public outreach, information and demonstrations of forest harvest and management practices, existing biomass users in the state, and alternative outcomes/impacts associated with not using biomass (i.e. hazardous fuel loads, open slash-pile burning).

Climate Change

There is much public discourse over the life cycle of greenhouse gases emissions resulting from biomass harvest and utilization. The quantification of these effects varies according to multiple factors including forest type, silvicultural treatments, carbon release and uptake rates of varied forests and wood products, time, and the end-use and associated emissions of a particular wood/biomass product and the alternative product or activity it may be displacing.

Those who see a role for the use of woody biomass-based products to mitigate the causes of climate change cite the following benefits:

- replacing fossil fuels with a local, renewable energy source that reduces net gain in greenhouse gas emissions;
- providing bio-based products that replace petroleum-based and other energy intensive products;
- providing structural building materials that sequester carbon and displace other energy-intensive building materials such as steel and concrete, and
- supporting forest restoration, stewardship, and hazardous fuels reduction treatments that enhance the forests ability to sequester carbon and reduce air quality impacts of open wood burning from slash piles and wildfire.

WOODY BIOMASS SUPPLY & DEMAND

Inventory and Available Supply

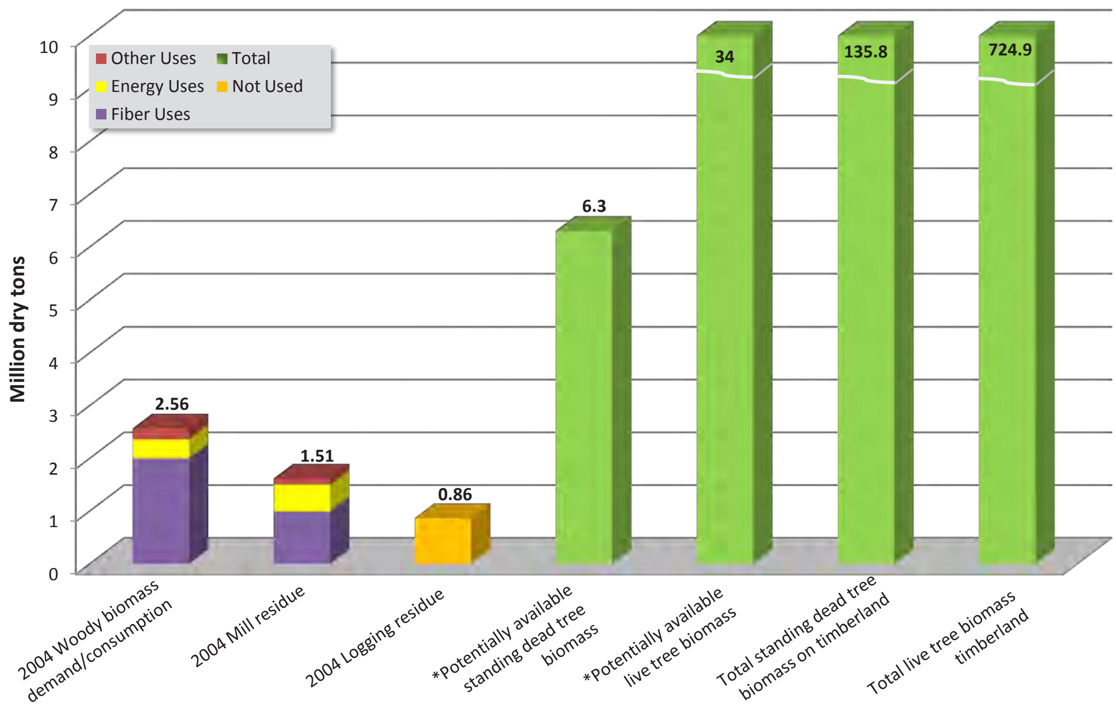
The Montana DNRC – Forestry Division recently commissioned the University of Montana Bureau of Business and Economic Research (BBER) to compile a report examining forest-based biomass supply and use in Montana (Morgan 2009). This assessment examined live trees, standing dead trees, logging residue, and primary mill residue as available woody biomass inventory. Putting the inventory information through various filters such as proximity to roads, slope and age class, estimates indicate there is an ample supply of woody biomass to meet the needs of existing and new woody biomass users for several decades. These data filters were used to provide more reasonable approximation of available volumes by accounting for logistical and social constraints affecting the accessibility of biomass from forest harvests. Adjusting for these constraints, these filters provide very conservative (i.e. low) volume estimates (See Figure 3).

Findings

Forest Inventory

- There is 860.7 million dry tons (MDT) total live and standing dead tree biomass across all Montana forestlands.
- About 74% of the live tree volume, and 85% of the standing dead tree volume is on national forests.
- Approximately 75% of the volume of live trees on Montana forests have a diameter at breast height (dbh) of less than seven inches.
- Filtered estimates indicate there are 93.1 million dry tons (MDT) of live and standing dead tree above-groundwoody biomass on the 3.59 million non-reserved acres of Montana timberland that is 0.5 mile or less from a road, on slopes of 0 to 40%, and in stands with ages from 0-100 years. Using the same filters and applying an additional filter to include only trees that are 5.0-10.9" dbh, shows a potential available supply of 40.3 MDT.
- The 40.3 MDT of potentially available

Figure 3. **Montana Woody Biomass Supply Use**



*"Potentially available" is confined to material that is < 0.5 miles from road, 0 - 40% slope, age 0 - 100 years, for tree dbh 5.0 - 10.9. Source: Morgan 2009

smaller-tree woody biomass represents 5% of the current 860.7 MDT total live and standing dead tree biomass across all Montana timberlands.

Logging Residue

- Private lands account for the majority of timber harvested in Montana, and consequently account for the majority of logging residues generated.
- Logging residue that could be recovered for biomass produced from commercial timber harvest in 2004 was estimated at 860,641 BDT and 520,000 BDT in 2008. Timber harvest volume in 2010 is estimated to be 43% of the 2004 levels, projecting 370,075 BDT of recoverable biomass.

Mill Residue

- Utilization of mill residue in the state has been over 90% since the 1980s.
- Mill residue produced by Montana sawmills was estimated to be 1.51 MDT during 2004. Approximately 71% of the residue was used as raw material by the pulp and reconstituted board industry. This utilized volume has changed due to the recent closure of Smurfit-Stone pulp plant.

Current Biomass Users

- Current woody biomass users in Montana (MDF/particleboard plants, bark/wood pellet plants, Fuels for Schools biomass energy facilities) together consume approximately 700,000-1,200,000 dry tons annually.

Because of various economic, logistic and socio-political factors, not all of the woody biomass inventory described in BBER's report would necessarily be available to users. Additional supply information can be obtained from the Western Montana Coordinated Resource Offering Protocol (CROP) - an interactive web tool that provides broad level information on planned timber sales and forest material offerings on state and federal lands in regions of Western Montana in the near term. Other resources include current Forest Inventory and Analysis

(FIA) data from the USDA Forest Service and the U.S. Department of Energy's "Billion Ton" report (USDA Forest Service, Perlack et. al. 2005).

Forest Restoration and Thinning Projects

There are thousands of tons of small diameter trees available annually in Montana from managing forestlands. These trees are cut during pre-commercial thinning, hazardous fuel reduction and forest restoration projects, across all land ownerships. The left-over slash/biomass created from these activities is typically considered a fire hazard and the cost of the project can quickly over-take the benefits returned to the landowner.

Collaborative forest restoration projects in Montana could potentially produce additional woody biomass as a by-product of restoration efforts. As an example, the Southwest Crown of the Continent Collaborative Forest Landscape Restoration Project proposes to treat 199,140 acres over ten years. Of these, roughly 73,000 acres will receive vegetative treatments, and 36,500 acres will have commercial wood products removed. The estimated woody biomass produced from these treatments is 1.27 million bone dry tons (BDT) over ten years, or 127,000 BDT per year (Southwestern Crown of the Continent Landscape Restoration Strategy 2010).

The U.S. Forest Service Northern Region projects annual non-sawlog removals of 61 – 70 million board feet (190,000,000 BDT – 218,000,000 BDT) (Northern Region projections 2010) from federal forest lands in Montana, including 3 long-term, landscape-scale, stewardship contracting projects. However, the removals and availability of woody biomass from federal lands is not guaranteed.

Current efforts to remove invasive tree species such as russian olive and salt cedar, particularly along the waterways of eastern Montana, provide additional opportunities.

Urban Wood Waste

While this strategy is focused on forest biomass, it is recognized that there is opportunity for improved collection, sorting and use of wood waste from urban areas including tree trimmings and clean construction debris. Some communities in Montana have collection points for these materials where it is used for various end products including salvaged building materials, wood pellets, compost and landscaping materials.

Characteristics of Supply Sources

Not all biomass is created equal. Physical characteristics, available markets and relative costs of production have traditionally segregated woody biomass sources into two broad categories: "Mill Residuals" and "Woods-Direct".

Mill Residuals

Mill residuals are by-products left over from the manufacture of traditional wood products and includes materials such as clean wood chips, sawdust, shavings, peelings, bark and dirty chips. These residuals can be viewed either as an asset or disposal liability to the manufacturing process depending upon the availability and value of markets.

Mill residuals in the form of clean wood chips traditionally have the highest value and generally supply pulp/paper, medium-density fiberboard (MDF) and particleboard producers. Sawdust, shavings, bark and other mill residuals have traditionally been delivered to the most advantageous available market. Uses range from landscape bark, fiber for particleboard or MDF, fuel pellets, animal bedding, and landscaping/soil amendment products. The lowest value mill residuals are often burned as "hog fuel" for energy use on-site or delivered and sold to other energy users.

Mill residuals are relatively inexpensive to produce because: 1) they are a by-product of an existing wood use where the raw fiber and processing costs are shared with multiple products; 2) production of the residuals occurs at centralized locations (mills); and 3) efficiency of mill residual transportation systems to end users is generally higher due to the location of mill infrastructure generally near rail and highway transportation corridors.

Woods-Direct

Woods-direct biomass is comprised of above-ground, non-sawlog woody material such as small or defective trees and logging residue. There are generally three classifications of woods-direct biomass products: 1) clean chips, and 2) slash grindings and 3) hog fuel, which are sub-classes of logging residue.

Clean Chips

Clean chips are produced from small logs or non-sawlog material, historically referred to as "pulp logs". Clean chips are produced using a chipper that employs sharp knives to produce a smooth, consistently-sized chips. Woods-direct clean chips are generally more expensive to produce than mill residual chips since all costs, including stumpage, logging, transportation, debarking and chipping costs, must be borne by the value of the clean chip. Most clean chips are produced at centralized chip yards with access to transportation infrastructure such as rail or highway rather than in the woods at dispersed locations.

Logging Residue

Logging residue, commonly referred to as "slash" is a by-product of timber harvesting comprised of the un-merchantable tree tops, limbs, needles, and small trees remaining from a traditional timber harvest or other silvicultural treatment. Following a harvest, some biomass material is retained on the forest site for ecological considerations, but the remaining excess of slash/biomass is considered a hazard and is either machine- or hand-piled and burned on site, lopped and scattered across the site, or moved to the roadside for chipping or grinding. This disposal and/or removal of excess slash is required by the Montana Control of Timber Slash and Debris Law (MCA 2011).

When logging residues are viewed as no/low-value waste, they are commonly handled as waste—driven on, moved around the harvest site, and piled with a dozer collecting dirt and rocks. If an off-site use or market is identified for these residues, the raw, dirty material is commonly ground using a horizontal or tub grinder that employs a "hog mill" with hammers and teeth to break apart the woody material. This is the origin of the term "hog fuel."

Logging residues processed into slash grindings and hog fuel have historically been the most challenging to produce and deliver economically, despite their relative abundance. Raw fiber costs are often low, but the cost of accumulating and grinding the biomass across a sometimes widely distributed area, and high transportation costs pose an impediment to their utilization.

Slash grindings may be produced in varied scales of quality depending on their end use. At their lowest quality, hog fuel is produced by a single grinding of slash that is comprised of bark, needles, limbs and bolewood with allowance for higher amounts of irregularly sized material, dirt and fines. Due to the nature of the product (dirty, moist, inconsistently sized), hog fuel has traditionally been limited to use as a combustion fuel for generation of heat for large-scale industrial uses and as a component of manufactured soil amendments and compost.

Slash grindings may be processed and/or screened in a way that creates a more refined energy fuel for smaller-scale biomass boiler systems like those installed at public schools. These smaller systems generally have less robust fuel conveyance and combustion systems than those at industrial scales. The smaller systems have a lower tolerance for dirty, moist, inconsistently sized material that contains high proportions of needles and bark. Through methodical harvest, processing and screening, slash grindings can produce a good quality energy fuel, but at a higher cost than hog fuel.

Cost Assessment of Supply Sources

Calculating the delivered cost of biomass material to a facility has many components. For each operation, the different components need to be appraised individually to develop an overall delivered cost. Woody biomass generated as a residual from a commercial harvesting operation usually covers cutting and skidding costs. The grinding or chipping, as well as loading and hauling of the material, is often an additional cost. Operational conditions are dependent upon where the

slash/biomass is located, such as in large landings where the chipper/grinder can be set up once or along the roads, requiring frequent equipment relocation. The more moving and setting up of the equipment, the more time it takes and more it costs.

Another consideration is whether the material can be blown directly into chip vans or trailers for delivery, or if it is deposited on the ground for later loading with another machine. Again, the more times the material is handled the more operational cost you have in the product.

Hauling costs to the end-user is dependent on distance or the time involved in a round trip. Other factors influencing haul costs can be the price of diesel fuel for the trucks and whether road reconstruction is necessary to permit the use of roads. These road costs may also need to be considered in the overall price of the delivered product.

Harvesting forest biomass is generally most economical as part of a mechanical logging or thinning operation that harvests commercial sawlogs during the same operation. Depending on the landowners' objectives, additional costs can be incurred when handling other non-sawlog material. When a mechanical thinning operation includes removal of commercial size trees, the cut and skid cost components of the biomass harvest can usually be covered by the value of the commercial timber. Under current market conditions, the additional costs associated with moving the biomass to the landing, and chipping and loading it into a trailer can quickly reach the price point a user facility is willing to pay on a delivered basis. Usually there is sufficient positive value in the commercial size logs to overcome the transportation cost of moving the biomass to a facility. Carefully designed mechanical thinning projects often carry the entire cost of removal of the biomass. If not, work can still be done if the receiving facility or landowner is willing to pay the additional costs.

Costs, Values and Current Market Outlets

When considering the delivered cost/value of woody biomass, it is useful to think of three different product classes: 1) mill residuals, 2) slash grindings, and 3) non-sawlog solid wood fiber.

- *mill residuals* – chips, shavings, bark, and sawdust.
- *slash grindings* – woody by-products of sawlog harvest (slash) processed with a grinder (i.e. trees, tops, limbs, needles), possibly urban waste.
- *non-sawlog solid wood fiber* – small diameter, non-commercial trees that were cut for reasons other than economic value (e.g., fuel reduction, stocking manipulation, salvage, and insect and disease control).

Mill Residuals

Costs and values are generally established by alternate market value and availability. In some parts of the state, residuals have good value for alternate uses such as medium density fiberboard, paper chips, particleboard, and other products—providing a revenue stream to manufacturers. In other parts of the state, these items are viewed as a liability and disposed of at a cost due to lack of markets. These products are a true "by-product" after the cost of production is factored in. Fiber disposal cost is generally borne by the primary product such as lumber.

Out of necessity, most mill residuals currently have a market outlet. Roughly 99% of mill residue is utilized by the pulp reconstituted board industry, burned as energy fuel, or for other purposes. Woody biomass users in Montana consume between 2.2 and 2.7 million BDT per year (Morgan 2009). As market options constrict or are further from the manufacturing facilities, residuals become a decreasing source of income and in some cases, are an expense to the manufacturing process. It is economically advantageous for mill residuals to be available to more local markets.

Slash Grindings
If the ground material is produced at the mill, there may be an opportunity cost associated with not utilizing the fiber to produce heat or steam at the mill. The cost of getting the slash to the landing is borne by the higher value product it is attached to when whole tree harvesting systems are used. When there is no higher value product attached, which is the case in many restoration or hazard fuel reduction activities; you still have to pay for the grinding, loading, hauling, storing and drying of the material.

Current markets for slash grindings in Montana are primarily as combustion heat for industrial uses and raw material for composting facilities. The higher the value and contract price for slash, the more material will be removed and utilized. Otherwise, most of these logging residues are disposed of through piling and burning in the forest.

Woods-direct biomass is the most under-utilized and abundant resource, but there are a number of challenges associated with its collection and use.

These challenges include:

- the relatively low value of end products,
- forest roads that are not designed and built to accommodate the use of trucks/trailers capable of hauling biomass,
- access to the forest is seasonal,
- difficulty in estimating the amount of residual woody biomass material produced from harvest activities,
- hauling costs can be high dependant on diesel fuel prices and distance from site to end user, and
- increased potential for contaminants such as dirt and rocks.

Non-Sawlog Solid Wood Fiber
The solid "pulp log" or "biomass energy log" is the most expensive type of fiber as it has to carry all the costs, (e.g., cost = stumpage + cutting + skidding + processing + chipping/grinding + loading + transportation). Smaller trees also have a higher per unit cost because more stems must be handled by people and equipment to yield the same amount of wood (i.e., one bone dry ton (BDT) of wood from trees < 6" dbh is more expensive to produce than one BDT of wood from trees > 10" dbh).

Infrastructure

Biomass utilization is directly integrated with Montana's existing forest industry infrastructure--employing the same workforce and harvest, processing and transportation equipment. Given that biomass harvest and utilization is most economical when associated with traditional sawlog harvest and milling operations, the viability of a biomass sector is dependant on maintaining Montana's current forest products infrastructure.

Montana's existing forest products industry includes foresters, loggers, equipment operators, and other contractors that work in the forest (e.g., log and chip haulers), primary timber processors (e.g., sawmills, log home manufacturers, post & pole facilities, plywood mills), and mill residue users (e.g., medium density fiberboard (MDF), particleboard plants, woody biomass energy producers, and wood pellet producers).

Montana's primary and secondary forest products industry employed roughly 6,800 people with labor and income exceeding $250 million dollars in 2010. Total sales value of Montana's primary and secondary wood and paper products exceeded $700 million dollars in 2010. The annual capacity to process timber into solid wood products like lumber and plywood was nearly 500 million board feet Scribner in 2010. Satisfying the current wood fiber demand for reconstituted products (MDF, particleboard) and energy fuel would require approximately 840,000 bone dry tons (BDT) of mill residue and other wood fiber annually.

MARKET OPPORTUNITIES AND CHALLENGES

The conventional view is that biomass is a by-product of traditional logging operations and the cost of removal generally exceeds market price. As such, biomass and related small diameter material is considered a low-value product with insufficient markets and therefore commonly burned in the forest after harvest activities in either slash piles or broadcast over the harvest area. Improving local markets for biomass residuals from both mills and harvest activities can help bolster the economic viability of existing forest products manufacturing facilities, as well as proposed timber and/or forest restoration treatments.

Markets for biomass may be improved through increasing product demand, creating more value-added products, and improving efficiencies in biomass collection, transportation and processing that, in turn, reduce production costs.

Developing new markets for woody biomass does not necessarily mean developing competition for existing users. Price signals generally guarantee that sawlogs, roundwood, and forest and mill residues will be directed to their highest-value uses. The location of new markets, product specifications and relative value will dictate what types and volumes of woody biomass are utilized.

Optimal markets and/or users should have the following characteristics:

- scaled to utilize a sustainable supply of locally available woody biomass,
- utilize material that is under-utilized and abundant,
- integrated with and/or complementary to existing infrastructure,
- capable of efficiently producing end-products of sufficiently high value to cover the production and transport cost of biomass material,
- co-located with, or in near proximity to, other forest product manufacturing sites, and
- social acceptance.

Existing and potential market opportunities include traditional roundwood products, engineered lumber and composites, landscape and agricultural products, energy—thermal, combined heat and power, liquid fuels, and densified fuels such as pellets and briquettes, bio-chemicals and bio-plastics.

Roundwood and Small-Diameter Wood

Montana is well established as a manufacturer of roundwood and small-diameter wood products such as: engineered structures, fence posts and poles, railings, split rails, tree stakes, lathe stakes, hops and vineyard poles, shavings, log and rustic furniture, and specialty products for home and landscape accents. There are currently 21 post and pole plants and 19 log furniture manufacturers in Montana. Figures for other small roundwood manufacturers are not readily available.

Engineered Lumber, Composite Construction Materials, Pulp and Paper

Engineered lumber and wood composites are products made from wood that have been bound or glued together to make a different product than solid manufactured lumber. Wood composites, including particleboard and medium density fiberboard (MDF), are manufactured primarily using mill residues of clean chips, sawdust and planer shavings. There is currently one MDF, and one particleboard plant in Montana. Finger joint boards, glue-laminated (glulam) and cross-laminated timbers (CLT) are strong structural products that may be made from piecing together several smaller pieces of lumber that may have come from smaller diameter trees. There is currently one finger joint plant in Montana.

Other potential markets for wood pulp include liner board, paper, newsprint, absorbent products such as diapers and wipes, rayon and wood plastic composites.

Thermal Energy

Thermal energy represents approximately one-third of the total energy consumption in the United States. Thermal energy includes space and process heating and air conditioning, domestic water heating, and the thermal portion of combined heat and power. The conversion of woody biomass to thermal energy is up to 90% efficient, compared to up to 40% efficiency for electricity, and 15% for transportation fuels.

Existing biomass thermal energy users in Montana include eight wood product mills, several public schools, one university campus and numerous residential applications. In 2009, the eight mills consumed a total of 219,000 green tons of biomass (mostly comprised of their own milling residues) while public schools consumed an estimated 10,000 total green tons.

Wood pellet silo and boiler room at Troy School

With funding support from the USDA State and Private Forestry program, the Montana DNRC Fuels for Schools and Beyond Program has provided grant assistance for the assessment and construction of woody biomass energy projects at public facilities. Of the 58 feasibility assessments conducted, 15 facilities have moved forward with installations aided by a DNRC grant (11 in operation and 4 in design). The four Montana projects currently in design include: 1) the Montana State Prison in Deer Lodge, 2) the University of Montana, Missoula, 3) a hospital in Superior, and 4) a hospital in Plains.

Additional opportunities at varied scales across the state have been identified in two reports, which warrant revisiting by interested project developers and facilities. A 2004 assessment titled, *"Potential for Expanding the Fuels for Schools Concept to other Institutions and Industries"* analyzed the state database of registered boilers, their respective owners, ages, fuel type, size, location, proximity to forest resources, and estimated payback period if converted to wood (Emergent Solutions 2004). A 2006 assessment titled, *"Biomass Boiler Market Assessment"* expanded on the 2004 assessment and identified 91 fossil-fuel fired boilers in the state that, if converted to wood-fired, would see a simple payback on their investment in less than 10 years. Facilities identified include healthcare, state and public buildings, wood and industrial manufacturing plants, refineries, schools, hotels, and laundry facilities with boilers ranging in size from 1.5 to 72 million BTUs/hour (CTA Architects Engineers 2006).

There are additional opportunities for wood heat in residential and small building applications using cordwood or pellet stoves and indoor/outdoor wood furnaces and boilers. Given advancement in stove efficiencies and emission ratings, and state and federal tax credits available for wood-burning devices, there may be opportunities to engage in wood stove change outs in targeted communities. With assistance from the Environmental Protection Agency and Montana Department of Environmental Quality, a wood stove change out in Libby, Montana in 2005 – 2007 successfully reduced both indoor and outdoor pollutant emissions in that airshed (Hearth, Patio and Barbeque Association 2008).

Pellets

Wood pellets are manufactured by drying and pulverizing the wood material and then squeezing it through a die which creates pressure causing the lignin in the wood to plastify and hold the cylindrical pellet together. The U.S. bag pellet industry has steadily grown since the mid-1980s when efficiencies improved in residential pellet stoves. The pellet industry has been stable, not requiring subsidies that have been awarded to wind, solar and ethanol development. In addition, pellet technology is mature, and the manufacturing customer base is established.

Pellet systems have emerged as an economically viable choice for factories and schools. There is one major commercial pellet manufacturer in Montana with two mill locations, producing pellets at varied grades for both residential and industrial uses. However, Montana does import bagged pellets from other states. While there are state and federal tax credits available for the purchase of pellet stoves, sales are slow and may be attributed to current low costs of natural gas. This highlights opportunities for focusing development of residential and community-scale thermal energy projects in areas outside of natural gas distribution where higher cost heating fuels of propane and fuel oil are common and biomass fuel can be more cost-competitive.

Key challenges for thermal biomass energy developments in Montana:

- As a solid fuel, wood-fired systems require more complex fuel conveyance and burner components than liquid or gas fuel-fired systems, and thus carry a higher initial capital equipment cost (particularly at the smaller scale); and
- Government energy policies and incentive programs for renewable energy are focused on the electricity and transportation sectors, leaving lesser support for renewable thermal energy options and biomass.

Electricity and Combined Heat and Power

Electricity from woody biomass must compete with energy produced from other sources, including coal, natural gas, hydropower, wind and solar. Wood-based electricity, when produced as part of a combined-heat and power operation, is estimated to cost 7-10 cents per kWh. The range in costs per kWh is heavily influenced by the size of the facility, available government subsidies and financing rates, the required return on investment, and the delivered cost of woody biomass (Anderson, R. 2010, McNeil Technologies 2005). Stand alone electricity, in which there is no financial benefit associated with recovering and using waste heat from the project is more costly to produce, in addition to being a far less efficient use of the biomass fuel.

Conventional power generation converts only about 1/3 of the fuel energy into electricity. Higher energy conversion efficiencies can be achieved if a plant generates not only one form of energy, electric power or heat, but a combination of the two (cogeneration/combined heat and power), or even three, if cooling is included (tri-generation). While electricity can be transported long distances with relatively little transmission loss, heat cannot. This makes the case for district combined heat and power plants in a de-centralized energy framework.

In comparison to a stand-alone electricity plant, combined heat and power (CHP) appears to be the most appropriate and economical option for electricity generation from woody biomass. Combined heat and power is best suited for facilities or districts with large demands for both electricity and thermal energy (steam, heating, cooling, hot water). CHP facilities provide the advantage of high efficiency, often achieving nearly 70 percent energy conversion efficiencies. Strong CHP applications include the industrial and utility scale, larger public facilities, business and residential complexes, and district energy systems. Combined heat and power systems may be owned by the facility that needs both the thermal and electrical power, or may have split ownership between thermal/steam load need and power production.

Currently, Montana sawmills provide the best prospects for biomass CHP because a portion of the generated electricity can be utilized for operations as they produce their own heat and steam (including using waste steam for lumber drying), they have access to on-site biomass fuel, and sawmills employ experienced boiler operators.

Feasibility studies for industrial biomass CHP applications in Montana were conducted in 2010

for NorthWestern Energy and Porter Bench Energy, LLC. The study prepared for NorthWestern Energy explored the feasibility of developing woody biomass-fired CHP plants to be co-located at six existing sawmills in western Montana to supply a portion of NorthWestern Energy's renewable portfolio (Anderson R. 2010). The study for Porter Bench Energy, LLC analyzed nine candidate sites that included both operational and shuttered mills (Porter Bench 2010).

The study commissioned by NorthWestern Energy identified a prototypical plant would be an 18MW plant, requiring 121,000 bone dry tons of biomass per year, and would have an estimated capital cost of $53.6 million. The study also pointed to opportunities at larger economies of scale with capital costs per MWh declining sharply from $8.7 million per MWh for a 1.1 MWh plant to $2.9 million for a 17 MWh plant (Anderson, R. 2010).

Woody biomass, used in combined-heat and power applications, may play a role in Montana's power markets for three reasons: 1) Montana's Renewable Portfolio Standard (RPS) requires regulated electric utilities produce 15 percent of their electricity from renewable resources by 2015; 2) government programs provide grants and low cost financing for biomass energy facilities; and 3) woody biomass can provide utilities with a source of firm renewable power, unlike power production from other renewable sources like wind and solar which are conditional and intermittent.

Another market opportunity for Montana CHP projects is the potential sale of renewable energy credits (RECs) to other states. California has the most aggressive RPS in the nation, allowing 25 percent of the standard to be met by tradable RECs from out-of-state. The state of Washington also allows the purchase of out-of-state RECs. Their current demand for RECs is low, but their Renewable Portfolio Standard (RPS) requirement is 3 percent by 2012, and increasing to 9 percent by 2016, and 15 percent by 2020. Washington also allows the purchase of RECs from small projects at double their valuation; which beginning in 2016 would be a significant incentive for projects sized at 5 MW or smaller.

Rural Electric Cooperatives

Beginning in 2011, cooperatives located west of the continental divide and served by Bonneville Power Administration (BPA) – a federal power marketing agency – will face a first-ever limitation on their access to cost-based federal power. This typically below-market priced power will be restricted to the cooperatives' current power needs. Any additional need to service growth in power demand will have to come from some type of market-based supply; obtainable either through BPA or another source.

This need for additional power creates potential opportunities for woody biomass energy development. Adding to this potential is the reality of basic organizational structure and ownership of Montana's electric cooperatives. These are electric utilities locally owned by the customers they serve with governance provided by boards of directors, democratically elected by the customers. Local ownership in these communities has historically kept electric cooperatives highly sensitive to the need to do all it can to help promote local economic development. In addition, opportunity for electric cooperatives is further aided by the co-op's eligibility to obtain federal Clean Renewable Energy Bonds (CREBs). These bonds – provided the co-op holds power plant ownership – offer what amounts to a zero-interest loan to capitalize plant construction. CREBs are available only to not-for-profit entities such as electric cooperatives.

Renewable energy credit opportunities are tempered in no small degree by a significant challenge – current market prices. Weak regional and national economies have resulted in sharply depressed power market prices and regional prices are currently well below the projected average cost of woody biomass energy for western Montana (Anderson R. 2010).

Co-Firing with Coal

Co-firing biomass with coal has been identified as a potential key contributor to near-term greenhouse gas reductions, due in part to the fact that existing coal plants are often paid off, fully permitted, and have existing connections to transmission and freight lines. Co-firing can be applied at the power plant scale or in industrial factory boilers. Trials show co-fired biomass can replace up to 15% of the total energy input of a coal power plant while reducing emissions of sulfur dioxide, nitrogen oxide and greenhouse gases. Retrofitting coal plants to co-fire biomass includes modifications to the burners and feed-intake systems with retrofit costs ranging from $150-$300/kW of biomass generation. As an example, a 100 MW coal plant with 10% biomass substitution would require an estimated investment of $1.8 million (Interlaboratory Working Group 1997).

There are eight active coal-fired electricity generating plants located in eastern Montana and one currently inactive plant in Thompson Falls designed to burn both wood waste and coal. The eight active plants range in generation capacity from 41.5MW – 740 MW. The average price of coal in Montana in 2010 was $1.46/MMBtu (Energy Information Administration). The comparative price for woody biomass at $1.46/MMBtu is equal to about $20/BDT (USDA Forest Service 2004). At this rate, investment in co-firing with biomass both domestic and abroad will likely be driven by emissions regulations, the price placed on carbon, and/or subsidies for biomass fuel, and not the market alone.

Challenges for biomass-generated electricity at the utility- and industrial-scale include:

- Given that coal and hydropower can wholesale electricity at 3-5 cents per kWh, it may be difficult for power produced from woody biomass to be competitive.
- Incomplete information regarding supply and demand conditions and its availability to all buyers and sellers.
- Uncertain and unreliable volumes of biomass available from federal lands.
- Relative prices are more volatile than contractual relationships. Inflexible, long-term supply agreements, while serving useful business purposes, may impede wood products moving to their highest-value uses.
- Price structures can be distorted by government policies and incentives.
- Market demand for woody biomass fuel as a non-greenhouse gas (GHG) contributor may be impeded by lack of consensus on the GHG emissions life cycle of wood energy.
- Limited transmission and distribution capacity of existing power lines.
- Combined heat and power markets may be challenged if a nearby demand for waste steam from the generating process is not available. Efficiencies and resulting cost savings will be lost.

Other Products and Emerging Markets

Landscape, Agricultural Products and Animal Bedding

A number of sawmills use or sell their mill and logging residue as value added products such as landscape bark, mulch, compost and soil amendments. There are six producers of these landscape products in Montana.

Beetle-killed and small diameter trees are finding market opportunities in erosion control products and animal bedding. There is one animal bedding manufacturer in Montana. There are several new erosion and sediment control products emerging. Wood fiber-based erosion control products provide a good alternative to straw-based erosion control products which can be less-desirable because of predation by livestock and other animals. With increased activities in oil and gas development and impact remediation/restoration in the region, there may be strong demand for erosion control products.

Biochemicals

Biochemical products may be used directly as fuels or further processed to produce higher value chemicals and gases that can replace petroleum-based chemicals in the flavor, fragrance, and cosmetic industries. There is increasing demand from natural and personal care sectors seeking re-

newable, non-petroleum based chemicals. There is one small bio-refinery currently in development in Montana that will produce these high value chemicals from woody biomass.

Algae
Woody biomass can be integrated into an algae bio-refinery to produce biofuels and organic soil amendments. In this process, woody biomass acts as a medium for algae growth. The algae production system can be designed in a closed loop system that produces a number of high value by-products, and thus additional revenue streams, including, but not limited to heat, electricity, nitrogenous fertilizer, organic soil amendments, and biodiesel. There is one algae bioprocessor currently in development that is co-located with a wood products mill in the Flathead Valley.

Advanced Composites and Bio-plastics
Wood plastic-composites (WPC) are composite materials made of a combination of wood fiber and/or flour and plastics. The most widespread WPC products on the market include decking, building materials, and furniture, offering enhanced durability and easy maintenance. With consumer demand growing for renewable and recyclable products, there are growing opportunities for bio-plastics. Bio-plastics containing wood flour can be injection molded to a variety of consistencies and shapes for varied product sectors, including consumer/industrial packaging, appliances, automotive, furniture, personal care and toys. Wood plastic-composite technologies also promote value-added uses for post-consumer and/or post-industrial waste materials.

Briquettes
Wood briquettes are produced through densification of dry residuals by compressing dry, shredded woody biomass under heat and pressure. The result is a densified long-burning, low-emission heating fuel. Briquettes can be produced in several shapes depending upon end-market demand, (e.g., bricks, pucks and cylinders). Bricks and cylinders are valued for wood stoves and fireplaces. Pucks are high quality fuel for all commercial boilers.

Pyrolysis and Biochar
Through the pyrolysis process, organic materials, such as woody biomass, are transformed into gases, liquid, and a solid residue containing carbon and ash. These three products all have distinct potential uses and relative values. The synthetic gas may be used in processes similar to those that use natural gas. The liquid called pyrolysis oil (or bio-oil) can be used as a liquid energy product much like biodiesel. The solid product created can either be biochar or activated carbon depending on the process. Activated carbon manufactured to particular specifications is used in a variety of medical and industrial applications, including water filtration, chemical production and municipal waste treatment. The ability to make multiple products from biomass through pyrolysis provides for diverse value streams which may aid in overcoming some of the economic barriers that currently exist in biomass utilization.

Advancements in process control, scalability and portability may make this process more applicable in utilizing biomass in Montana in the future. While the mobile capacity of pyrolysis units presents a good option for processing forest residues in-woods; there needs to be improvements in the system design that makes it robust enough to handle transport on rough forest roads without compromising the machinery in transit (Anderson, N. 2010).

There is very limited, but developing research on the potential benefits of applying biochar as a soil amendment and carbon-sequestration tool. Research is still in progress to manufacture activated carbon from forest biomass into a high-grade water filtration product.

Cellulosic Ethanol
The June 23, 2010, "USDA Biofuels Strategic Production Report", provides a regional roadmap to meet the U.S. Department of Agriculture's biofuels goals of the Renewable Fuel Standard. The strategy proposes to create new market opportunities for American agriculture to help fulfill the 36 billion gallons of renewable transportation fuel per

year by 2022; including 2.8 billion gallons derived from woody biomass (USDA 2011).

It takes roughly one green ton of woody biomass to produce 43 gallons of cellulosic ethanol (Pinchot Institute and Heinz Center 2010). A prototypical ethanol plant produces 30 million gallons per year of biofuels, requiring approximately 700,000 green tons of wood biomass annually.

Technologies for efficiently converting woody biomass to cellulosic ethanol have been slow to develop.

PART II. STRATEGY FOR SUSTAINING AND ENHANCING UTILIZATION

STRATEGY

The discussions and findings that came out of the assessment informed the development of Montana's Woody Biomass Utilization Strategy. The strategy identifies three focus areas in support of the goal to sustain and enhance biomass utilization in Montana—all of which may benefit from improvements in state and federal policies, partnerships, and programmatic services.

Focus Areas:
1. Support and enhance biomass market and project development
2. Provide reliable and sustainable supply of woody biomass
3. Support advancements in science, engineering and technology

Recommended Action Items

Focus Area 1. Support and Enhance Biomass Market and Project Development

Programs

- Focus resources on most viable market opportunities. (For example, for thermal energy projects, focus on large heat/energy users like hospitals, universities, industrial complexes; areas with high-heating costs due to no access to natural gas and reliance on more expensive fuel oil and propane; combined heat and power generation at forest product mills; and new construction projects with district heating opportunities).
- Provide incentive/funding assistance to assess, design, and implement biomass utilization and energy projects.
- Lead by example: encourage state agencies to integrate wood products and wood energy in state buildings.
- Host demonstrations of existing biomass products and projects.
- Engage in public information campaign to address public concerns related to biomass harvest and utilization.
- Maintain State program that provides a clearinghouse for biomass utilization information and activities, and provides financial and technical assistance for project development.

Partnerships

- Engage economic development organizations and agencies to identify and pursue viable business and project opportunities in biomass.
- Support education and marketing campaigns that promote wood products to the building sector, businesses and consumers such as "Local Wood Is Good" and "Made in Montana"
- Continue collaboration with multi-agency, multi-stakeholder groups such as the Montana Biomass Working Group and Montana Forest Restoration Committee's Forest Products Retention Roundtable.

Focus Area 2: Provide Reliable and Sustainable Supply of Woody Biomass

Programs

- Continue to promote active management on state, federal and private forestlands.
- Continue to provide outreach to non-industrial private landowners on the value of harvesting traditional and non-traditional products as a tool to achieve good forest stewardship.
- Enhance education and curriculum on sustainable forest management practices for foresters

and landowners to highlight resources of particular concern related to biomass harvest (i.e. soil health, alternative slash management, benefits of biomass retention, etc.).
- Expand state agency web sites to include more technical information on biomass utilization.
- Create web source to link biomass material producers to users.

Partnerships
- Engage the Montana State Assessment stakeholders in prioritizing landscape-level biomass supply planning.
- Develop collaborative multi-agency, multi-stakeholder projects incorporating programs such as forest restoration and stewardship, hazardous fuels, pest management and urban forestry.
- Work with local collaborative stakeholder groups to develop and/or recommend forest restoration projects.
- Coordinate with state and federal land agencies in maintaining the Western Montana Coordinated Resource Offering Protocol web tool as a reliable, up-to-date clearinghouse of information for biomass supply from agency projects and timber sales.

Focus Area 3: Support Advancements in Science, Engineering and Technology

Programs
- Support research, development and deployment of technologies that provide for high efficiencies and minimized environmental impacts in biomass harvest, transport, processing, and end use.
- Enhance efficiency in recovery of biomass from harvest operations particularly in small-diameter, low-value forest stands, including techniques for reducing contaminants of dirt and rocks.
- Direct research programs to study air emissions and carbon life cycle analyses for various utilization options.
- Support vocational training and college-to-business exchange programs specific to biomass sectors.
- Support research and development programs and projects that lead to development of new biomass products.
- Support research, monitoring, and reporting of the ecological, economic and social impacts and benefits of woody biomass harvesting and utilization. Include the economic benefits to communities, effects on air quality and fire suppression and forest management costs, and net effects on fossil fuel use.

Partnerships
- Identify and engage with engineering and technology programs and partners.
- Work with The Montana University System and other research institutions to identify and explore research and technology capacity, needs and shortfalls.
- Continue to work with state regulatory agencies to ensure compliance with applicable regulations, and to inform development of regulations that are not overly burdensome and that recognize positive attributes of biomass utilization and the impacts its use displaces.
- Engage in technology transfer between public and private entities.

Guiding Principles for Policy

State and federal policies have the capacity to create varied incentives and supports or barriers to biomass utilization developments. There are a few guiding principles for policy development in support of biomass utilization.

Policies should:

- be carefully constructed to avoid unintended consequences and major market distortions,
- facilitate increased use of biomass in a way that is compatible with and complementary to existing forest product industries,
- recognize the value and social and environmental co-benefits that can be derived from biomass utilization,
- reward all forms of energy produced from biomass including thermal, combined heat and power, and liquid fuel,
- coordinate with other state, regional and national policy initiatives and efforts, and
- provide supportive business and investment tax structures for biomass developments.

Appendix A

Montana Forest Management Regulations and Guidelines

State Lands
State Trust Lands, Montana Dept. of Natural Resources and Conservation
- Forest Management Administrative Rules.
- State Forest Land Management Plan.

Montana Fish, Wildlife and Parks
- Administrative Rules and Laws.
- Conservation and Management Plans.

Federal Lands
Forest Service
- Laws, Regulations, Policies.

Bureau of Land Management
- Laws, Regulations, Policies.

Private Lands
Montana Forest Practices Regulations and Guidelines
- Streamside Management Zone Law
- Timber Debris and Slash Law
- Forest Practice Notification Law
- Water Quality Best Management Practices for Forestry
- Voluntary Wildlife Guidelines for Streamside Management Zones

Continuing Education Programs for Loggers and Landowners

Accredited Logging Professional Program, Montana Logging Association—a voluntary educational program for loggers with a timber harvesting curriculum related to forest stewardship and sustainability, ethical and regulatory compliance, and operational efficiencies.

Montana Forest Stewardship Program, DNRC—state program that provides Family Forest landowners with a learning experience that allows them to make informed decisions about the management and conservation of their forestlands.

Forest Stewardship Planning Workshops, MSU Extension Forestry—education program for non-industrial private forest landowners.

Montana Tree Farm- a non-profit organization affiliated with the National Tree Farm System and American Forest Foundation. Their purpose is to help private forest landowners manage their lands with the goals of conserving forests, water, and wildlife while promoting natural resources based recreational opportunities.

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Western Montana Coordinated Resource Offering Protocol

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Montana Woody Biomass Utilization Strategy

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November 2011

For more information, visit
www.dnrc.mt.gov/Forestry/Assistance/Biomass