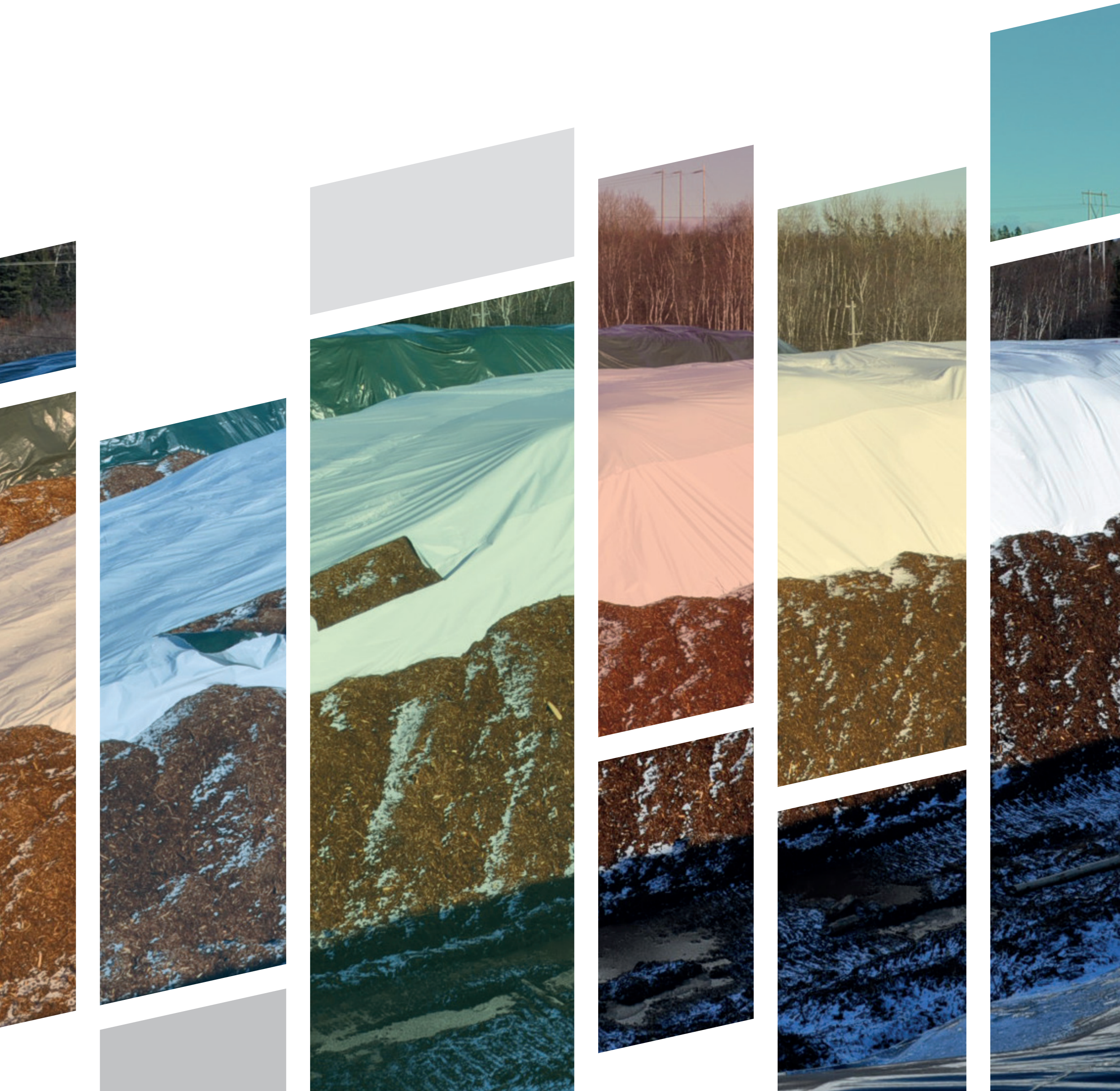
FPInnovations

Best Management Practices Guide for

# Access to Quality Forest Feedstocks



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# Access to Quality Forest Feedstocks

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This guide is based on the publication ***Biomass Management: Effective Management Techniques for Biomass Piles to Secure Access to Quality Feedstock* (Technical Report no. 8 – January 2017)**, where a full list of references can be found.

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## Current situation

As forest-origin biomass use has increased, logistics of supply and storage become more complex and innovative solutions are required to improve feedstock quality for the growing bioenergy industry. The variety of feedstocks available is quite complex, with multiple feedstocks coming from different streams (at-the-stump, roadside, transfer yard, mill) and accessible under different formats (wood chips, bark, fines, tops, and branches or low-grade logs). The quality of biomass is critical for many bioenergy processes and best management practices (BMPs) are required to guarantee access to quality feedstocks at any given time.

A priority in the supply chain is the need to improve the business and policy environment for biomass and biomass heat markets by developing better understanding and best practices for storage of forest biomass.

## Objectives

The general objective of this guide is to assess the economic benefits of BMPs on feedstock quality and process improvement for the bioenergy sector. This guide is based on the publication *Biomass Management: Effective Management Techniques for Biomass Piles to Secure Access to Quality Feedstock* (Technical Report no. 8 – January 2017), a summary of published literature focusing on characteristics and management of comminuted (hogged) and roundwood forest biomass. Previous studies undertaken and some of the practical experience of FPInnovations staff have been incorporated.

The specific objectives are to:

- Compile field data and literature review on storage trials done with forest biomass
- Measure the financial implications of innovative storage practices with a cost-benefit analysis

Biomass feedstocks used to supply the bioenergy sector need to meet the quality standards set forth by the facilities that utilize these feedstocks and their various bioenergy processes.

# Critical attributes

The critical attributes of biomass monitored closely by the industry for both quality assurance and payment purposes are the following:

- Moisture content (MC):
  - Main attribute for boiler efficiency
  - Wood is hygroscopic and moisture content varies seasonally
- Particle size:
  - Oversize>100 mm may clog delivery infeed systems of small-scale boilers
  - Fine<3 mm will increase fly ash
- Bulk density:
  - Low bulk densities increase transport costs
  - High bulk densities reduce necessary storage area
- Contamination level:
  - Soil/sand/gravel cause slag fouling of boiler systems
  - Rocks and metal can harm comminution equipment
  - Chemicals (e.g., paint, wood preservatives, salt/chlorine) create harmful emissions and ash

# Sampling procedures

Standards used to sample and measure biomass quality attributes are published by the International Organization for Standardization (ISO) under the TC-238 Solid Biofuels series of standards started in 2007. Basic procedures for biomass sampling and analysis are listed below in a straightforward and easy-to-implement way.

- Sampling source:
  - Performed at locations where material is representative of where it was originally retrieved
  - i.e., Trucks, barges, storage piles, conveyor belts
- Sampling frequency:
  - Depends on the quality consistency of the delivered product. New suppliers (each delivery)/Long-time suppliers (1/5 deliveries)
  - Sample stored material over time for moisture content and temperature (once per week)
- Sampling size:
  - Moisture content = 2 L
  - Particle size = 10 L
  - Bulk density = 50 L
- Number of replicates per sampled load:
  - Moisture content = 3
  - Particle size = 3
  - Bulk density = 2

The moisture content of forest biomass is the number one factor influencing boiler efficiency. The efficiency of burning biomass drops rapidly once the moisture content rises above 30% (Figure 1). Using FPJoule, we can estimate that an industrial boiler consuming just over 800 000 green metric tonnes (gmt) of biomass per year at 55% moisture content could save $4 million per year by burning 100 000 gmt less (biomass delivered at $40/gmt), if biomass consumed had a moisture content of 50%.

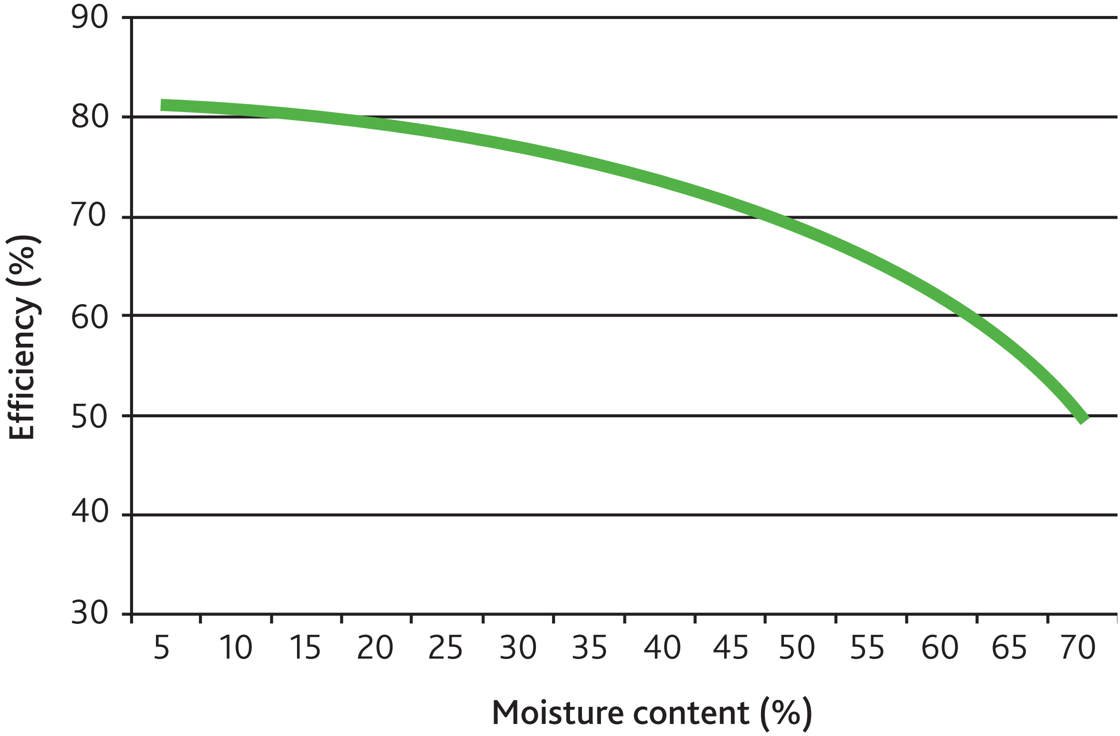



Figure 1. Boiler efficiency according to biomass moisture content.

The biomass quality management challenges differ for each type of biomass. Bioenergy processes will most often use the following four types of forest-origin biomass:

- Roundwood
- Wood chips (clean or dirty)
- Sawmill bark (including hog fuel)
- Legacy bark piles

Gaps most often identified by the industry are related to:

- Pile volume and mass estimates
- Use of wet and dirty biomass
- Payment method
- Quality standards

# Legacy bark piles

There is an opportunity to recover legacy bark piles which will require proper screening and washing of the material to remove contaminants (Figure 2). Windrow piling during summer months is also crucial to remove excess water. Trommel screeners can be used to remove oversize wood pieces (>9 cm), rocks, and other debris from contaminated biomass for a cost ranging from $6 to $17/dry tonne depending on screen size used, particle size distribution, and levels of contamination of the feedstock. Hog fuel washing using rock-wood separators is also an increasingly popular method used in western Canada to clean log yard waste.

Proper volume estimation of piles is important to allow users to measure the opportunities of recovering the biomass source.

**Volume estimate** of comminuted biomass piles is challenging due to various piling methods used throughout the industry: Pile shapes are irregular and not always easy to measure, and usually need some site-specific adjustments. Estimates can be made using:

- On-ground measurements (height × width × length) + geometry formula
- Aerial imagery via drones (3D point cloud)
- GPS of multi-layer cross-sections around and across piles (using X, Y, Z coordinates)

**Mass estimate** in green metric tonnes (gmt) of a softwood bark pile of 150 000 $m^3$ (apparent or bulk volume) requires the following example input:

- Oven-dry basic density of solid wood = 440 kg/$m^3$ (specific to species)
- Pile moisture content (MC) = 55%
- Bulking factor = 37% (specific to the feedstock type)
- Compaction factor = 1.3 (specific to the feedstock type)

Green bulk density =
$(440\ kg/m^3/(1-55\%)) \times 37\% \times 1.3 = 530\ kg/m^3$

Pile weight =
$530\ kg/m^3 \times 150\,000\ m^3/1\,000 = 79\,500$ gmt


Figure 2. Biomass preparation through screening (A) and washing (B).

# Marginal forest stands

There is an opportunity to create value from marginal forest stands with innovative harvesting and recovery techniques to access small-diameter roundwood.

Observations made in eastern Canada have shown that small-diameter roundwood (<10 cm) has a 7 p.p. (percentage point) lower moisture content compared to larger-diameter roundwood (>20 cm) for wood harvested from June to September. This makes a strong case that small-diameter roundwood should be the focus of a fuelwood procurement strategy.

Economic availability of small-diameter bio-logs is the main challenge. Integration of biomass recovery (small-diameter roundwood along with tops and branches) with traditional harvesting of roundwood (sawlogs and pulpwood) is crucial to access these volumes and to develop a supply chain that makes this type of fibre available.

Marginal forest lands can be targeted for biomass production using sound operational planning strategies and access to more accurate forest inventory data via LiDAR and other advanced techniques. Maximizing fibre recovery from these sites is crucial for financial viability; otherwise, there will be poor utilization when marginal stands are solely targeted for higher-quality products (e.g., lumber).

Potential sources of biomass may also become available from thinnings, FireSmart treatments, right-of-ways, road sites, stand conversion, energy crops, disease, fire-affected stands, and urban forestry.

# Wet biomass

There is an opportunity to value wet biomass (>50% moisture content) with innovative storage practices and efficient mechanical dewatering systems.

Trials have shown that storage of biomass in solid wood form (i.e., roundwood) has the greatest potential to reduce moisture content, by 3% per month during drying season (May to September) and limit dry matter losses to 0.05–0.1% per month of storage.

Long-term storing of comminuted biomass, although not desirable, is performed by most bio-energy facilities and innovative methods are needed to better manage the moisture content variability during storage to secure access to quality biomass when called upon. Here are some key items to follow when piling comminuted biomass:

- Build windrow shape piles
- Limit pile height<7 m
- Limit pile storage time<4 months
- Tarp during winter storage
- Use passive ventilation
- Build the piles in drained, paved locations so that excess water from inside the pile and precipitations gets quickly evacuated from the storage area

Mechanical dewatering systems have also been investigated. Compression drying does show some potential in reducing biomass moisture content by 15–25 p.p while using very little mechanical energy compared to heat energy used by thermal drying systems (i.e., rotary drum dryers, belt dryers). The compression method still faces the challenge of scaling up to industrial size.

# Payment system

There is an opportunity to develop a payment system that creates incentives for biomass suppliers to deliver high-quality biomass.

The variety of feedstocks available to the emerging bio-resource industry is quite complex: roundwood, wood chips, sawdust, shavings, bark, tops and branches, short-rotation energy crops (SREC), and municipal solid waste (MSW). The quality of biomass is critical for many bio-refinery processes. There's a need to harmonize procurement and trading practices between the emerging bio-resource industry and the traditional forest industry. Setting clear guidelines through a set of quality standards used throughout the industry is a must.

ISO Solid Biofuels standards cover a wide range of items from terminology to sample preparation to more specific fuels specifications and classes for different feedstocks. Methods described can sometimes be onerous, and classes used to define quality would prove to be labourious to implement as a first step. This is why FPInnovations is currently developing a simple and easy-to-use biomass classification system (hog fuel classifier) to help the industry establish monitoring and controlling practices to assess the quality of incoming biomass through shipping, receiving, and storage. A statistical biomass quality control system is also to be developed by FPInnovations.

An innovative payment system based on energy value can be created with the help of FPJoule (Figure 3). FPJoule is a web platform that calculates the energy value in biomass based on species group, tree component, and moisture content. The energy value and other attributes such as particle size and contamination are far better parameters on which to base the price of biomass rather than on a single green-metric-tonne basis.

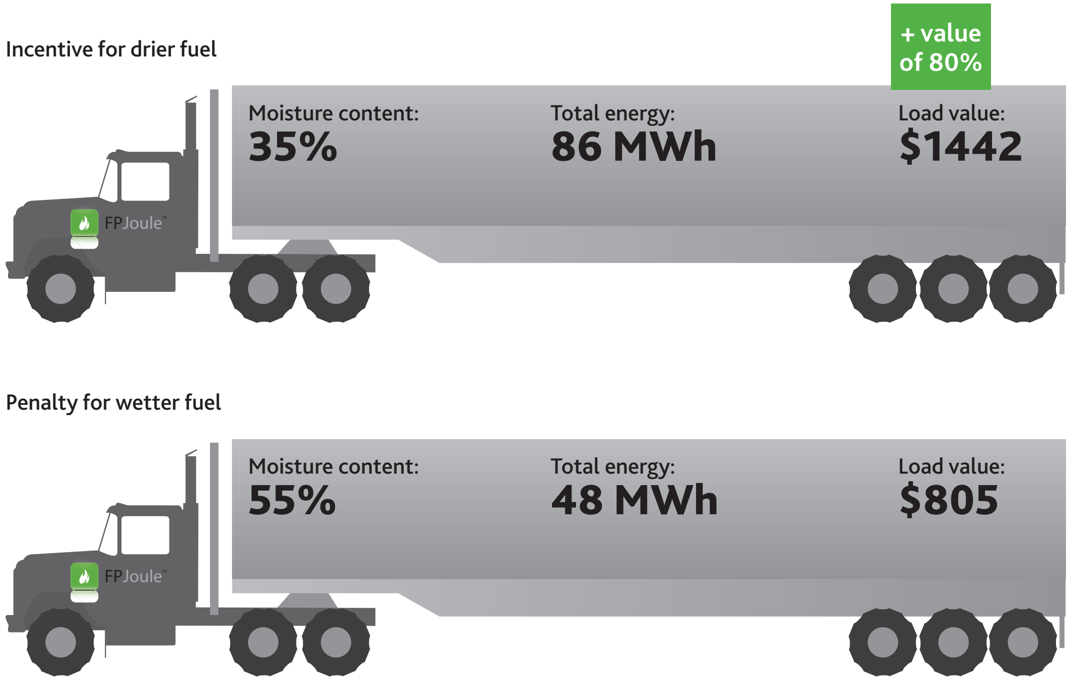



Figure 3. Incentive for delivering high-quality biomass using innovative payment method. Calculated using FPJoule for softwood bark and energy value of $16.77/MWh ($4.66/GJ).

Common drivers in the forest and bioenergy industries are the need to demonstrate sustainable forest management and harvesting with reduced environmental impacts of operations. Supply analytics management and modelling using weather prediction to support low-impact harvesting as well as improve biomass quality is part of the supply chain of the future. Operational planning improvements can help achieve such goals.

This section will cover items and tools that have potential to use  to help improve the supply chain of the future.

- Weather impacts
- Operational planning
- Trading (FPJoule)
- Quality monitoring (Hog fuel classifier)

## Weather impacts

The use of weather prediction data to support low-impact harvesting as well as wood and fuel quality is a main area of interest for collaborative research of the Boreal Forest Research Alliance (FPInnovations, Skogforsk, LUKE).

The use of weather data has already been adopted in many storage trials throughout the world. The relationship between measured weather data and drying curves of biomass storage trials helps to develop prediction tools for moisture management of biomass feedstocks.

Cooperation with local weather services could eventually lead to real-time operational planning of the supply chain. Some existing systems already show promise in using  to help better manage the supply chain of the future.

MHG Systems' Biomass Manager platform is being used to track and manage feedstocks from stump to boiler in New Brunswick through a forestry management company, ACFOR.

FPJoule has been developed through multiple storage trials done in recent years in Canada in order to build a database of drying curves for multiple feedstocks stored in different conditions for varied storage periods.

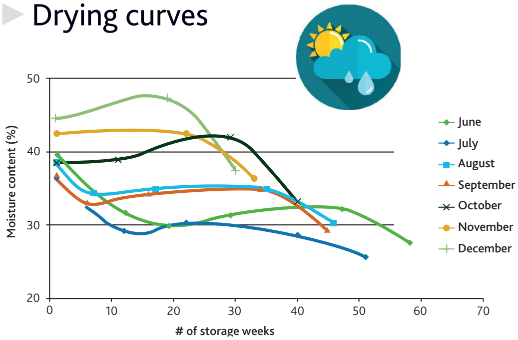
## Operational planning

Improvements in operational planning can be achieved using mobile tools and integrated systems that would allow fibre procurement managers to better schedule deliveries throughout the year in order to optimize the storage of biomass and to achieve higher quality.

Logistical planning of the supply and storage of biomass used in bioenergy facilities is complex (Figure 4). This is where  can be useful via inputs from meteorological agencies, enhanced forest inventories, fuel classification systems, real-time tracking of supply volumes, and storage strategies. FPInnovations can assist in developing such platforms by providing some usable insight on how to implement the use of these various tools and data streams.

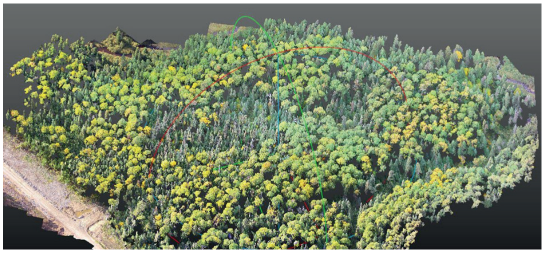
## Meteorological prediction:

▶ Drying curves




## Enhanced forest inventories:

▶ Fibre densities (species)

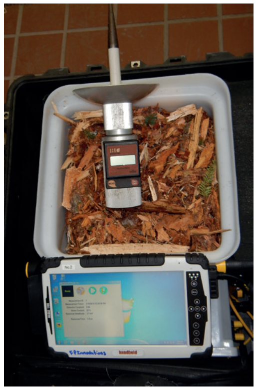


## Supply schedule:

▶ Harvest season and load tracking

## Fuel classification system:

▶ Contamination, sizing, and MC



## Storage strategy:

▶ Layout, pile shape, and seasoning

Figure 4. Operational planning options for a better supply chain.

# FPJoule

FPJoule is a web-based tool that can be used to evaluate the amount of energy contained in biomass based on its origin and moisture content. The tool can also be used to quantify the financial advantages of using biomass as a fuel source compared to conventional fossil fuels. A more comprehensive spreadsheet model is also available to FPInnovations members. The latter version can be modified to match the attributes of a particular facility, such as boiler efficiency, storage strategy, and transport configurations.

FPJoule is an ideal platform to develop an innovative payment system based on quality attributes such as energy content (Figure 5). provided by systems tracking fuel quality throughout the supply chain could be useful in the creation of an integrated quality/payment mobile platform.

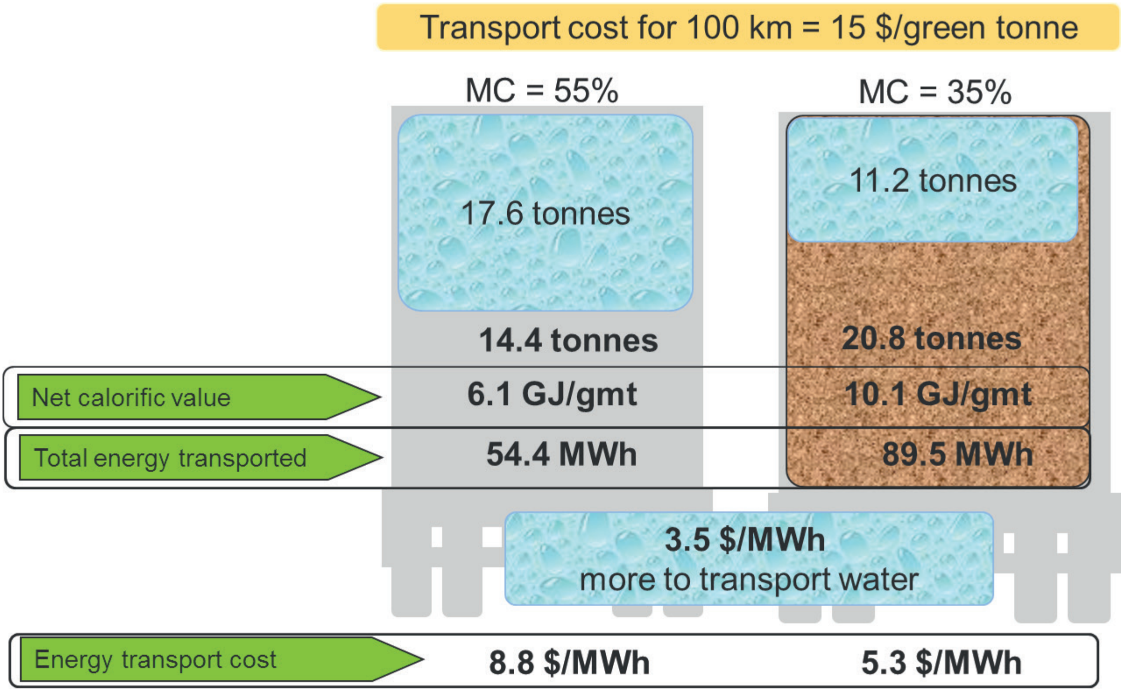



Figure 5. Payment system based on energy content delivered to end-user.

# Biomass classification system

A biomass classification system is currently being developed by FPInnovations in response to interest from the forest industry to quickly identify the biomass quality delivered to their doorstep.

The goal of this labelling system is to quickly determine biomass quality using a system of simple classes defined by easy-to-identify visual and touch quality indicators. These procedures are inspired by the ISO Solid Biofuels standards, yet are more straightforward and easier to implement as a first step of quality standards throughout the Canadian bioresource industry.

The FPInnovations classifier procedures use five sets of parameters to define quality classes printed on the product description label (Figure 6).

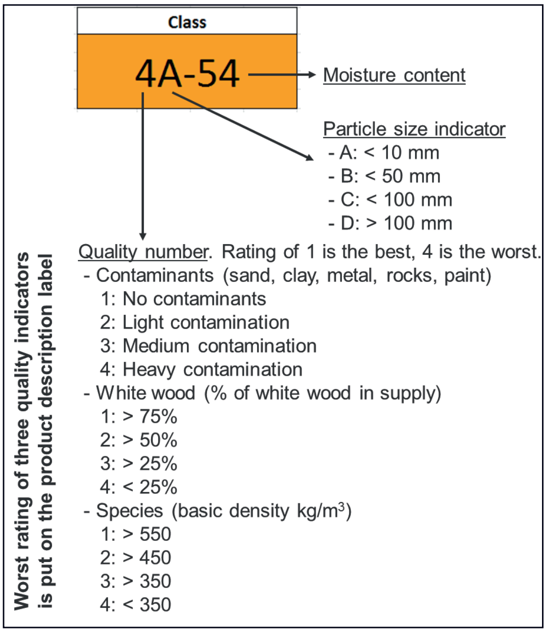



**Figure 6. FPInnovations' biomass classification system.**

# Statistical biomass quality control system

FPInnovations' objective is to implement quality monitoring practices to assess fuel quality purchases through the development of a statistical quality control tool. This tool will help in monitoring and controlling the quality (moisture content, particle size, and contamination) of biomass that is both incoming (shipping and receiving) and in storage (Figure 7). This statistical quality control tool will be designed to be integrated into an existing biomass quality monitoring platform. An investigation of the use of statistical quality control tools in other sectors for collecting pulling all that expertise into an adapted framework designed for the bio-resource industry. The quality control tool will:

- Propose methods on where and how to measure fibre characteristics
- Identify required sampling procedures for each critical quality attribute (aligned with current ISO standards)
- Be validated throughout the industry
- Use FPInnovations' hog fuel classifier as a model to build from

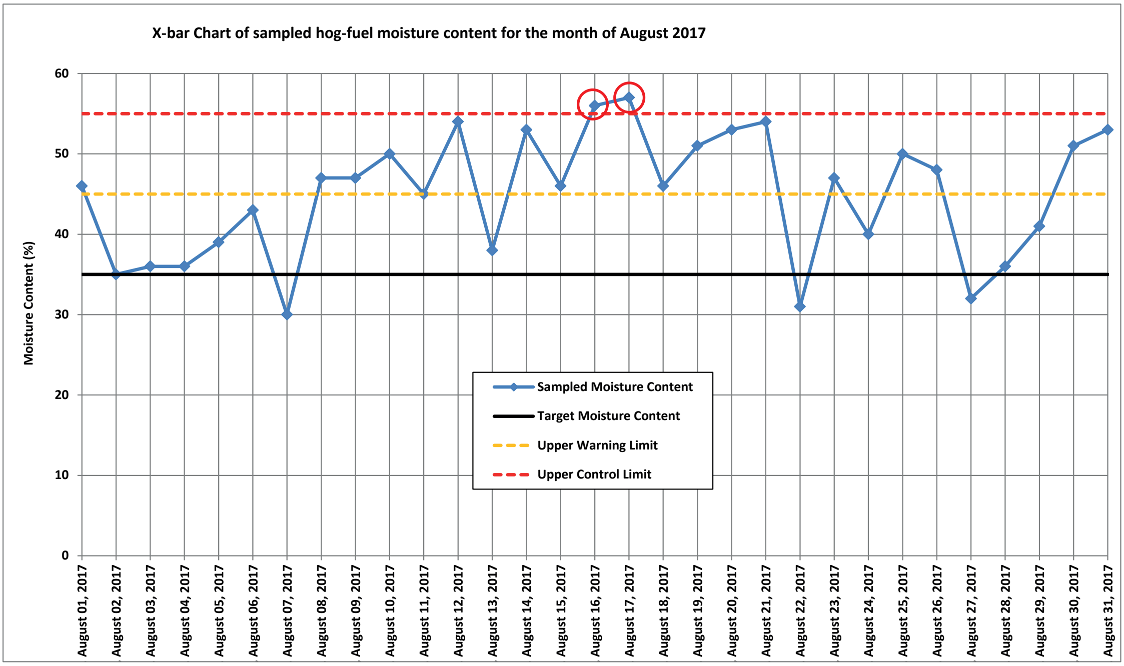



**Figure 7. Potential output from quality control tool to be developed by FPInnovations.**
***Disclaimer: This graph displays fictitious data merely for demonstration purposes.***

Best management practices for storage are outlined in this section for various types of biomass in order to increase feedstock quality throughout the supply chain (Figure 8).

For each type of biomass:

- Roundwood
- Wood chips (clean/dirty)
- Sawmill bark
- Legacy bark piles

Tackling the critical biomass attributes:

- Moisture content (MC)
- Particle size
- Bulk density
- Contamination level

Key parameters influencing biomass quality during storage:

- Storage period
- Origin of biomass (stump, roadside, or mill)
- Weather
- Pile shape and compaction


Figure 8. Biomass storage for roundwood (A), wood chips (B), and bark (C and D).

# Roundwood biomass

Roundwood biomass supply is easy to handle and manage in regard to moisture control.

### Supply and storage practices

- Covering:
  - Single layer on top of piles (paper-based tarp 250 g/m$^2$) starting in early fall
  - Simple-to-use solutions with large impacts by protecting pile from direct rainfall
  - Moisture content reductions ranging from 4 to 8 p.p. (percentage point) compared to uncovered logs
- Delivery schedule:
  - Seasonal harvest targeting standing timber with low moisture content (May to August)
  - Log diameters<20 cm will provide drier biomass which will lower pressure on supply (lower moisture content means less biomass is required to provide equivalent energy output)
  - Focus on higher basic density species like tolerant hardwoods, which also tend to have lower moisture content at harvest
- Storage period:
  - Storage period is not a limiting factor for roundwood as dry matter losses are only between 0.1% and 1%/month and seasoning of roundwood is effective with moisture losses of 3%/month during drying season (May to September)
- Pile shape:
  - Pile in long windrows parallel to prevailing winds in 3 to 4 m high piles
- Storage layout:
  - Keep a 4–5 m corridor for machine circulation between piles. Do not stack more than two piles back to back. This item is important for safety reasons, general access to inventory, and ventilation.

### Quality assessment

Roundwood biomass can be effectively seasoned and is not prone to spontaneous combustion (like bark). Quality assessment during receiving and storage should consider:

- Moisture content:
  - Gate: for one in five truckloads, collect three logs/truckload/point of origin (cutblock of same supplier)
  - Yard: three logs/1 000 odt/month
  - Method: Three cut points (2-inch discs) along each log (end, quarter, and middle) (Figure 9). Wood discs are dried at 105°C for 24–48 hours until weight stabilizes
- Temperature:
  - not an issue
- Particle size:
  - not an issue
- Bulk density:
  - not an issue

Figure 9. Roundwood sampling in the mill yard.

# Wood chips

Wood chip supply can be delivered in a variety of formats and from multiple sources. Pulp quality clean chips (<6% bark) supplied from local sawmills can be used as well as dirty chips (i.e., fuel chips) from chipped roundwood (9–15% bark) or tops and branches (25–50% bark/foliage).

## Supply and storage practices

- Covering:
  - Tarp top to bottom of pile (reinforced polyethylene 340 g/m$^2$)
  - Shelters should also be used whenever possible, but are expensive to build for very large quantities
  - Use passive ventilation between tarp and pile to eliminate condensation (Figure 10)
  - Covering reduces ice build-up on outside of piles during winter storage and moisture content by 10–13 p.p.
- Delivery schedule:
  - Inventory build-up during dry summer months
- Storage period:
  - ≤6 months
- Pile shape:
  - 1:3 maximum height to width ratio
  - Pile height≤7 m
- Storage layout:
  - Maintain a clean, paved, and well-drained storage surface. Avoid shovelling into piles during winter to prevent snow/ice and rocks being thrown into the piles

## Quality assessment

Wood chip biomass is less prone to fire than bark and moisture content tends to stay relatively stable under cover, but moisture content can easily vary by more than 4 p.p. within a single load. Samples at the mill gate should be taken during unloading to provide an accurate representation of the load average value. Quality assessment during receiving and storage should consider:

- Moisture content:
  - Gate: for one in five truckloads, collect three 2 L samples/truckload/point of origin (cutblock of same supplier/sawmill origin).
  - Yard: three 2 L samples/1 000 odt/month
  - Method: Chip samples are dried at 105°C for 24–48 hours until weight stabilizes (ISO 18134-2:2015)
- Temperature:
  - Less of an issue than hog fuel, but temperature monitoring should still be done on a monthly basis with manual probing at 1 to 2 m depths on all sides of the pile
  - 5 probes/1 000 odt/month

Figure 10. Recommended storage practices for fuel chips.

- Particle size:
  - Gate: for one in five truckloads, collect three 10 L samples/truckload/origin
  - Yard: three 10 L samples/1 000 odt/2 months
  - Method: Sieving with vibrating screener (ISO 17827-2:2016)
- Bulk density:
  - Gate: for one in five truckloads, collect two 50 L samples/truckload/origin
  - Yard: two 50 L samples/1 000 odt/2 months
  - Method: 50 L stainless bin (ISO 17828:2015)

# Sawmill bark

Sawmill bark is mostly delivered from local softwood lumber mills and moisture content varies according to season from 45% to 65%.

## Supply/storage practices

- Covering:
  - Tarp top to bottom of pile (reinforced polyethylene 340 g/m²)
  - Secure tarp tightly at the bottom and cover with residues to prevent the wind from blowing under the tarp (prevent tarps from ripping)
  - Use passive ventilation between tarp and pile to eliminate condensation
  - Covering along with internal passive ventilation is successful in evacuating some moisture from the piles during storage by 4–6 p.p.
- Delivery schedule:
  - Inventory build-up during dry summer months
- Storage period:
  - ≤4 months
- Pile shape:
  - 1:3 maximum height to width ratio
  - Pile height<7 m
- Storage layout (Figure 11):
  - Maintain a clean, paved, and well-drained storage surface. Avoid winter shovelling into piles during winter to prevent snow/ice and rocks being thrown into the piles.
  - Reduce the amount of fines (<12% as per ISO standards) to reduce pile compaction and limit temperature build-up.

**Figure 11. Recommended storage practices for bark.**

## Quality assessment

Sawmill bark is prone to spontaneous combustion and moisture content tends to vary considerably within a given pile. Quality assessment is especially important to mitigate fire risks and minimize dry matter losses. Samples at the mill gate should be taken in the upper third of the load. Items to consider during receiving/storage:

- Moisture content:
  - Gate: for one in five truckloads, collect three 2 L samples/truckload/point of origin
  - Yard: three 2 L samples/1 000 odt/month
  - Method: Samples are dried at 105°C for 24–48 hours until weight stabilizes (ISO 18134-2:2015)
- Temperature:
  - Monitoring should be done in regular intervals with manual probing at 1 to 2 m depths on multiple spots per pile
  - 5 probes/1 000 odt: every 2 weeks<50°C, weekly 50–70°C, daily>70°C

- Particle size:
  - Gate: for one in five truckloads, collect three 10 L samples/truckload/origin
  - Yard: three 10 L samples/1 000 odt/2 months
  - Method: Sieving with vibrating screener (ISO 17827-2:2016)
- Bulk density:
  - Gate: for one in five truckloads, collect two 50 L samples/truckload/origin
  - Yard: two 50 L samples/1 000 odt/2 months
  - Method: 50 L stainless bin (ISO 17828:2015)

# Legacy bark piles

Legacy bark supply is recovered from sawmill landfill sites. These piles are often capped, or covered, with sand, and contaminated with various kinds of mill waste. Dewatering via natural air drying or mechanical methods, along with screening via trommel screeners, are required to make it a useful feedstock (Figure 12). Once treated, it is delivered to end users where it is mixed with sawmill bark. Quality assessment at delivery and throughout storage is the same as for sawmill bark (described in the previous section).


Figure 12. Recommended recovery steps for legacy bark piles.

# Roundwood case study

The roundwood case study is based on a trial done in Nova Scotia with random-length, low-grade hardwood logs not suitable for pulp but valuable for energy in a facility requiring 135 000 odt/yr or 270 000 gmt at a target moisture content of 50% using both roundwood and bark.

## Costs of seasoning roundwood

- Handling – $3.80/odt:
  - Pile size = 100 m long × 5.4 m wide × 4 m high = 315 odt
  - Loader + Operator = $130/hr
  - Handling and piling productivity = 34 odt/hr
  - TOTAL = $1 200/pile or $3.80/odt
- Tarping – $2.35/odt:
  - Material = $0.75/m$^2$ for paper-based tarps = $400/pile
  - Installation = 2 hours to cover
  - Equipment = Excavator + Operator + Helper = $160/hr = $320/pile
  - TOTAL = $720/pile or $2.35/odt
- Tied-up inventory (capital) – $1.85/odt:
  - Average monthly volume stored annually = 21 000 odt
  - Purchase price of roundwood biomass = $91/odt = $1.9 M
  - Annual interest rate = 2%
  - TOTAL = $40 000/year or $1.85/odt

## Benefits of seasoning roundwood

A seasoning strategy, with fall/winter tarping, produces biomass roundwood with a 12 p.p. lower average annual moisture content compared to a just-in-time supply scenario. The improved burning efficiency from drier material means a reduced pressure on feedstock supply by more than one-third (Tables 1 and 2). In this particular case study, this means 32 000 odt less roundwood is required and the facility requiring 135 000 odt annually can increase its purchases of lower quality/lower price bark for that amount. A decrease in roundwood supply (at $91/odt) compensated by an increase in bark purchases (at $75/odt) yields annual savings of $2.16 million or $16/odt.

## Net savings of seasoning roundwood

Benefits of a seasoning/tarping storage strategy ($16/odt) outweigh the cost ($8/odt) of such a strategy compared to a just-in-time supply scenario. Net annual savings provided by better biomass management in this case are $8/odt for annual savings of $1.1 million.

## Table 1. Just-in-time strategy for fuel logs stored in mill yard

| Schedule | Consumption | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Woodroom bark[a] | | Purchased hog | | Fuel logs[b] | | Total | | Stockpile woodroom bark |
| | gmt | MC (%) | gmt | MC (%) | gmt | MC (%) | gmt | MC (%) | |
| April | 7 500 | 56 | 4 500 | 56 | 10 500 | 44 | 22 500 | 50.4 | |
| May | 7 500 | 54 | 7 000 | 54 | 8 000 | 44 | 22 500 | 50.4 | |
| June | 7 500 | 52 | 10 500 | 52 | 4 500 | 44 | 22 500 | 50.4 | |
| July | 7 500 | 52 | 10 500 | 52 | 4 500 | 44 | 22 500 | 50.4 | |
| August | 7 500 | 50 | 15 000 | 50 | 0 | 44 | 22 500 | 50.0 | |
| September | 7 500 | 50 | 15 000 | 50 | 0 | 44 | 22 500 | 50.0 | |
| October | 7 500 | 53 | 6 500 | 53 | 8 500 | 46 | 22 500 | 50.4 | |
| November | 5 500 | 55 | 2 000 | 55 | 15 000 | 48 | 22 500 | 50.3 | 2 000 |
| December | 5 500 | 58 | 0 | 58 | 17 000 | 48 | 22 500 | 50.4 | 2 000 |
| January | 1 000 | 58 | 0 | 58 | 21 500 | 50 | 22 500 | 50.4 | 6 500 |
| February | 1 000 | 58 | 0 | 58 | 21 500 | 50 | 22 500 | 50.4 | 6 500 |
| March | 1 000 | 58 | 0 | 58 | 21 500 | 50 | 22 500 | 50.4 | 6 500 |
| **Total** | **66 500** | **53** | **71 000** | **52** | **132 500** | **48** | **270 000** | **50.3** | **23 000** |

[a] Woodroom produces 200 to 300 gmt of softwood bark per day.
[b] Chipped just-in-time

## Table 2. Seasoning strategy for fuel logs stored in mill yard

| Schedule | Consumption | | | | | | | | Fuel logs inventory | | Fuel logs harvest schedule | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Woodroom bark[a] | | Purchased hog | | Fuel logs[b] | | Total | | | | | |
| | gmt | MC (%) | gmt | MC (%) | gmt | MC (%) | gmt | MC (%) | gmt | MC (%) | gmt | MC (%) |
| April | 7 500 | 56 | 4 500 | 56 | 10 500 | 44.0 | 22 500 | 50.4 | 4 500 | 44.0 | 15 000 | 44.0 |
| May | 7 500 | 54 | 8 500 | 54 | 6 500 | 41.2 | 22 500 | 50.3 | 13 000 | 43.0 | 15 000 | 44.0 |
| June | 7 500 | 52 | 12 000 | 52 | 3 000 | 40.0 | 22 500 | 50.4 | 25 000 | 42.4 | 15 000 | 44.0 |
| July | 7 500 | 52 | 12 750 | 52 | 2 250 | 36.0 | 22 500 | 50.4 | 37 750 | 40.8 | 15 000 | 44.0 |
| August | 7 500 | 50 | 15 000 | 50 | 0 | 32.0 | 22 500 | 50.0 | 52 750 | 38.0 | 15 000 | 44.0 |
| September | 7 500 | 50 | 15 000 | 50 | 0 | 30.0 | 22 500 | 50.0 | 52 750 | 34.3 | | |
| October | 7 500 | 53 | 12 250 | 53 | 2 750 | 30.5 | 22 500 | 50.3 | 50 000 | 33.0 | | |
| November | 7 500 | 55 | 10 500 | 55 | 4 500 | 32.0 | 22 500 | 50.4 | 45 500 | 33.0 | | |
| December | 7 500 | 58 | 8 250 | 58 | 6 750 | 32.0 | 22 500 | 50.2 | 38 750 | 33.2 | | |
| January | 7 500 | 58 | 8 250 | 58 | 6 750 | 32.0 | 22 500 | 50.2 | 32 000 | 33.4 | | |
| February | 7 500 | 58 | 7 500 | 58 | 7 500 | 35.0 | 22 500 | 50.3 | 24 500 | 33.8 | | |
| March | 7 500 | 58 | 7 500 | 58 | 7 500 | 35.0 | 22 500 | 50.3 | 17 000 | 34.6 | | |
| **Total** | **90 000** | **54.5** | **122 000** | **53.7** | **58 000** | **36.5** | **270 000** | **50.3** | | **35.8** | **75 000** | |

[a] Woodroom produces 200 to 300 gmt of softwood bark per day.
[b] Seasoned + tarping

# Bark case study

The bark case study is based on a trial done in Nova Scotia with softwood sawmill bark valuable for energy in a facility requiring 150 000 odt/yr or 300 000 gmt at a target moisture content of 50%.

## Costs of seasoning bark

- Pile shaping – $2.50/odt:
  - Pile size = 100 m long × 21 m wide × 7 m high = 2 000 odt
  - Excavator + Bulldozer = $250/hr
  - Handling and piling productivity = 100 odt/hr
  - TOTAL = $5 000/pile or $2.50/odt
- Ventilation – $3.00/odt:
  - Material = 1 m diameter, 6 m long culvert pipes (reused 10 times) = $3 000/pile
  - Installation of pipes in middle of pile along the length = 10 hours
  - Excavator + Bulldozer + 2 Labour = $300/hr = $3 000/pile
  - TOTAL = $6 000/pile or $3.00/odt
- Tarping – $3.50/odt:
  - Material = $1.70/m2 for reinforced polyethylene tarps = $2 500/pile
  - Installation = 10 hours to cover + 5 hours to uninstall
  - Excavator + Loader + 2 Labour = $300/hr = $4 500/pile
  - TOTAL = $7 000/pile or $3.50/odt

## Benefits of seasoning bark

A seasoning strategy, with ventilation and tarping, produces bark with a 6 p.p. lower average annual moisture content compared to a larger pile storage scenario without tarping. The improved burning efficiency from drier material means a reduced pressure on feedstock supply. In this particular case study, this means 10 000 odt less bark is required; therefore, the facility can reduce its bark purchase. A decrease in bark supply (at $70/odt) yields annual savings of $700 000 or $4.70/odt.

Reducing storage length and pile height will limit dry matter losses. Even a single point reduction in dry matter loss – from a 3% loss to a 2% loss per month – would mean annual savings of $180 000 or $1.20/odt.

## Net savings of seasoning bark

Only the material stored in the yard in the fall needs to be tarped and ventilated (in this case, about 76 500 odt at a cost of $690 000). Benefits of a ventilation/tarping storage strategy outweigh the cost of such a strategy compared to building larger uncovered piles. Net annual savings provided by better biomass management in this case are $190 000 or $1.25/odt. This doesn't take into account the reduced risk of spontaneous combustion which also greatly improves the conditions and potential savings.

Bark inventory is built in windrows during the summer which is better to control moisture content. Building large piles with heights above 7 m is discouraged because they will accelerate dry matter losses and are more prone to fire and moisture content increase.

Tarping and ventilation is done on bark piled in the yard during the fall to secure access to drier biomass during the high-demand winter months. A seasoning strategy compared to a just-in-time supply scenario can help save about 21 500 gmt per year which reduces the pressure on fibre supply by 6% (Table 3).

**Table 3. Year-round bark storage strategies**

| Months | Boiler consumption | Status quo (large piles/untarped) | | New strategy (windrows/tarped/ventilated) | |
|---|---|---|---|---|---|
| | odt | MC | gmt | MC | gmt |
| January | 17 500 | 58 | 41 667 | 54 | 38 043 |
| February | 17 500 | 60.7 | 44 529 | 54 | 38 043 |
| March | 15 000 | 59.2 | 36 765 | 54 | 32 609 |
| April | 10 000 | 59.5 | 24 691 | 54 | 21 739 |
| May | 10 000 | 55.2 | 23 952 | 54 | 21 739 |
| June | 10 000 | 55.1 | 22 272 | 54 | 21 739 |
| July | 10 000 | 54.1 | 21 786 | 54 | 21 739 |
| August | 10 000 | 53 | 21 277 | 53 | 21 277 |
| September | 10 000 | 50.1 | 20 040 | 50.1 | 20 040 |
| October | 10 000 | 52 | 20 833 | 52 | 20 833 |
| November | 15 000 | 54 | 32 609 | 54 | 32 609 |
| December | 15 000 | 56 | 34 091 | 54 | 32 609 |
| **Total** | **150 000** | **56.5** | **344 512** | **53.6** | **323 020** |

Biomass Procurement and Yard Managers are strongly encouraged to follow the preventative measures and recommendations in this Best Management Practices guide.

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