Module 1 – Biomass Basics

Common Language, Conversions, Moisture Content

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May 30th, 2018

Topics for this morning

- Common biomass language
- Common units of measure
- Conversions
- Moisture content

Common Biomass Language

Common language

- Why do we need to clarify the language?

Common language

- Why do we need to clarify the language?
  - Different units of measure

Common language

- Why do we need to clarify the language?
  - Different units of measure
  - Different machinery

Common language

- Why do we need to clarify the language?
  - Different units of measure
  - Different machinery
  - Different products

Common biomass / woody debris language

Biomass

- Organic matter, especially plant matter, that can be converted to fuel and is therefore regarded as a potential energy source.
- Usually we include pulp and OSB chips as well
- Covers far more than just the forestry world

Common biomass / woody debris language

Woody debris

- No set definition but for our purposes can include fibre residues from logging, sortyards, log storage yard, pulp mills and sawmills.
- Can include bark, needles and whitewood
- Large variety of particle sizes and forms

Common biomass / woody debris language

Comminution

- The action of reducing a material to minute particles or fragments.
- Why?
  - To reduce transportation and storage costs by increasing bulk density
  - To produce an acceptable biomass fuel or a feedstock for other processes (e.g., wood chips for combustion in boilers or material for pellets and briquettes)

Common biomass / woody debris language

Grinding

- Reducing the particle size of woody debris using a grinder
- Grinders typically use brute force to smash debris into smaller pieces (we'll talk about grinders this afternoon)

Common biomass / woody debris language

Hog fuel

- Hog fuel is the result derived from the grinding process
- ‘Hog fuel’ also covers a huge diversity of products with variance in particle size, species, bark content, moisture content, etc
- Ask me about my hog fuel classifier when we have a break!

Common biomass / woody debris language

Cogeneration or ‘cogen’

- The generation of electricity and other energy jointly, especially the utilization of the steam left over from electricity generation to produce heat
- Many pulp and saw mills have co-generation plants to offset energy costs. Most consume hog fuel, mill residues, some can consume black liquor

Common biomass / woody debris language

Pellet feedstock

- Falls under the hog fuel umbrella, but instead of burning for co-generation, ground up to an even smaller particle size and turned into pellets
- Microchips can also be used for pellet feedstock
- Typically needs to be dry and have a low bark content.

Common biomass / woody debris language

Chipping

- Comminution form where knives are applied to wood to create chips for pulp or for energy (called energy chips)
- Pulp chips are usually debarked, energy chips are cut with the bark still on

Common biomass / woody debris language

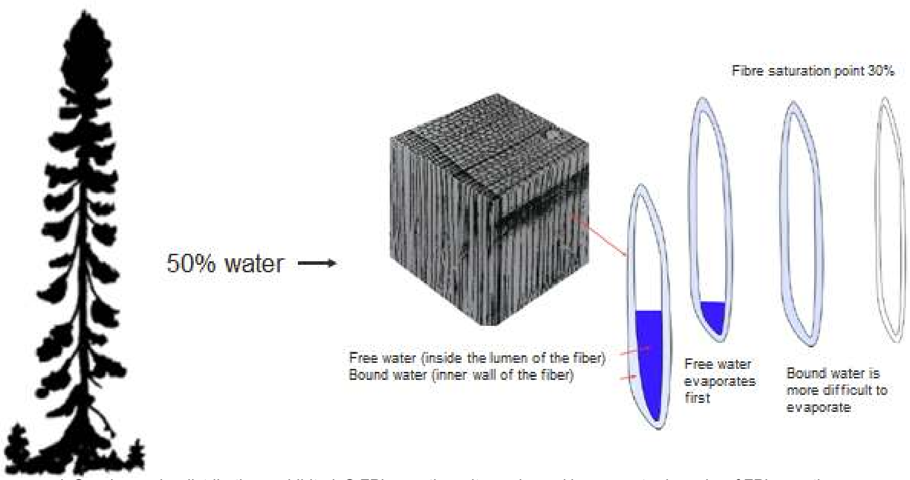
Particle size

- Refers to the size of the pieces created by grinding or chipping
- Important in the chip pulping process as well as small scale heat and power facilities

Common biomass / woody debris language

Moisture content

- The relationship between the mass of water and the mass of the woody fibre.
- Two measures of moisture content (wet basis, which we will use, and the dry basis)



Units of Measure

Common units of measure

- Why is understanding units of measure important?

Common units of measure

- Why is understanding units of measure important?
  - Improve communication and prevent confusion

Common units of measure

- Why is understanding units of measure important?
  - Improve communication and prevent confusion
  - Improve accuracy in calculations

Common units of measure

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  - Help us understand what questions to ask when discussing biomass with other professionals

Common units of measure

- Why is understanding units of measure important?
  - Improve communication and prevent confusion
  - Improve accuracy in calculations
  - Help us understand what questions to ask when discussing biomass with other professionals
  - Supports fairer and more accurate biomass trade/payment systems (between suppliers and users of biomass--> nobody feels cheated)

Cubic metres

- Cubic metres (solid)
  - Standard metric measure of volume in forestry for solid wood before milling
- Cubic metres (loose)
  - A measure of volume used to describe the volume of a truck, barge or storage pile of chips or hog fuel. Note: this measure contains air space!

Tonnes (and Tons)

- Measures of weight
  - Tonne (metric) = 1000 kg (2205 lbs)
    - Two forms of tonne used in BC, green tonnes and oven dry tonnes.
  - Ton (US) = 907 kg (2000 lbs)
    - Not much used in BC unless cross border buying or selling, but can often be found in the literature.

Tonnes (and Tons)

- Oven dry tonnes vs green tonnes
  - Oven dry tonne = 0% moisture content (also referred to as a bone dry tonne)
  - Green tonne = 0.1 to ~ 70% moisture content. Moisture content is variable (and so is the amount of water you may be hauling, buying or selling)

Volumetric units

- Volumetric unit (VU’s)
  - Measure of volume rather than weight
  - 200 cubic feet (equivalent to 5.66 cubic metres)
  - Preferred unit of measure in barging, some trucking
  - Consistent payment for seller, but product may be different in each load or barge due to variance in moisture, piece size, species (ie weight can be very different for each VU)

Basic wood density

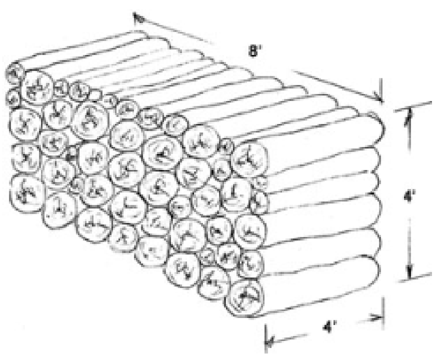
- Mass per unit of volume
- Kilograms per cubic metre at MC = 0% is a common measure
- We'll use wood density in some of our conversion calculations in a few minutes (Table 1 in the handout)

Bulk density

- Mass per unit of volume

$$\text{Bulk density (BD)} = \frac{\text{Mass of biomass fuel}}{\text{Volume of biomass fuel}} \quad [kg/m^3]$$

- Wood density is mostly consistent within species, bulk density can be highly variable and dependant on piece size and moisture content



Logs stacked (20% mc): 350 - 500 kg/m3 (green)

Wood chips: 250-450 kg/m3 (green)

Bulk density

- Why is bulk density important?
  - Bulk density → to transport and store 1,000 ODt of biomass

Number of 32 t trucks	63	46	34	31	31
Storage Area (m^2)	2,100	1,500	1,100	990	700

Order of magnitude: ice rink = 1,600 m^2

Bulking factors

- Dependant on particle size
- Usually expressed as a percentage, loose kg/m^3 per solid kg/m^3
- Percentage decreases as air space is increased
- Using the bulking factor for chips, this means that if you had a 10 m^3 box, you could place 10 m^3 of solid wood inside it (no airspace), but only the equivalent of 3.7 m^3 (solid) in chip form.

Energy content and density

- Energy content and energy density
- Energy content: GJ/ODt, kWh, ….
- Energy density: GJ/m^3

Tree components	Calorific value (GJ/ODt)	
	Balsam fir	White birch
White wood	20.0	19.8
Bark	21.1	22.9
Needles/Leaves	21.6	21.5
GJ/m^3 solid	7	11

→ **Energy density** differs with species

Fuels	GJ/tonne
Heavy fuel oil (HFO)	43
Natural gas	53
Propane	50
Coal	29

Energy content does not differ with species

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Good questions to ask

- If dealing with cubic metres (solid),what species?
- Green tonnes or oven dry tonnes. If it’s green, what is the moisture content?
- If cubic metres, solid or loose. If loose, what is the particle size?

Common conversions

Common conversions

- Why is it important to know how to do biomass conversions?

Common conversions

- Why is it important to know how to do biomass conversions?
  - The information you may need is not always in the units you desire

Common conversions

- Why is it important to know how to do biomass conversions?
  - The information you may need is not always in the units you desire
  - So Stu doesn't have to answer emails asking him to convert cubic metres to oven dry tonnes ☺

Common conversions

- Cubic metres (solid) to oven dry tonnes
- Oven dry tonnes to cubic metres (solid)
- Cubic metres (solid) to cubic metres (loose)
- Volumetric units to odt
- Green tonnes to odt

Cubic metres to oven dry tonnes

1. Determine wood density for chosen species (see Table 1 in handout)
2. Multiply cubic metres by density of wood to get total oven dry kilograms
3. Divide total oven dry kilograms by weight of one oven dry tonne (1000kg).
4. Result is in oven dry tonnes

Let's try the example on the next slide…..

Cubic metres to oven dry tonnes

Example 1

Your nickname is ‘Marginal Manny’ and you have hauled and scaled approximately 500 m^3 of western hemlock. Unfortunately, it has been attacked by escaped hyper aggressive wood borers developed in the Canadian government’s biowarfare facility located next door to your log yard and is no longer appropriate for lumber manufacture. You would like to get at least some return on your investment and decide to try and sell the fibre to the local pulp company ‘Harmlyst’. The pulp mill manager ‘Bold-face Bobby’ asks ‘How many oven dry tonnes is that?’

Cubic metres to oven dry tonnes

Example 1

Your nickname is ‘Marginal Manny’ and you have hauled and scaled approximately 500 m^3 of western hemlock. Unfortunately, it has been attacked by escaped hyper aggressive wood borers developed in the Canadian government’s biowarfare facility located next door to your log yard and is no longer appropriate for lumber manufacture. You would like to get at least some return on your investment and decide to try and sell the fibre to the local pulp company ‘Harmlyst’. The pulp mill manager ‘Bold-face Bobby’ asks ‘How many oven dry tonnes is that?’

Step 1 - Look up density of western hemlock…..

Cubic metres to oven dry tonnes

Example 1

Your nickname is ‘Marginal Manny’ and you have hauled and scaled approximately 500 m^3 of western hemlock. Unfortunately, it has been attacked by escaped hyper aggressive wood borers developed in the Canadian government’s biowarfare facility located next door to your log yard and is no longer appropriate for lumber manufacture. You would like to get at least some return on your investment and decide to try and sell the fibre to the local pulp company ‘Harmlyst’. The pulp mill manager ‘Bold-face Bobby’ asks ‘How many oven dry tonnes is that?’

Step 1 - Look up density of western hemlock…..

$$423 \text{ kg/m}^3$$

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Cubic metres to oven dry tonnes

Example 1

Your nickname is ‘Marginal Manny’ and you have hauled and scaled approximately 500 m^3 of western hemlock. Unfortunately, it has been attacked by escaped hyper aggressive wood borers developed in the Canadian government’s biowarfare facility located next door to your log yard and is no longer appropriate for lumber manufacture. You would like to get at least some return on your investment and decide to try and sell the fibre to the local pulp company ‘Harmlyst’. The pulp mill manager ‘Bold-face Bobby’ asks ‘How many oven dry tonnes is that?’

Step 1 - Look up density of western hemlock (423 kg/m^3)

Step 2 - Multiply cubic metres by density……

Cubic metres to oven dry tonnes

Example 1

Your nickname is ‘Marginal Manny’ and you have hauled and scaled approximately 500 m^3 of western hemlock. Unfortunately, it has been attacked by escaped hyper aggressive wood borers developed in the Canadian government’s biowarfare facility located next door to your log yard and is no longer appropriate for lumber manufacture. You would like to get at least some return on your investment and decide to try and sell the fibre to the local pulp company ‘Harmlyst’. The pulp mill manager ‘Bold-face Bobby’ asks ‘How many oven dry tonnes is that?’

Step 1 - Look up density of western hemlock (423 kg/m^3)

Step 2 - Multiply cubic metres by density

$$500\ m^3 \text{ X } 423\ kg/m^3 = 211500 \text{ oven dry kg}$$

Cubic metres to oven dry tonnes

Example 1

Your nickname is ‘Marginal Manny’ and you have hauled and scaled approximately 500 m^3 of western hemlock. Unfortunately, it has been attacked by escaped hyper aggressive wood borers developed in the Canadian government’s biowarfare facility located next door to your log yard and is no longer appropriate for lumber manufacture. You would like to get at least some return on your investment and decide to try and sell the fibre to the local pulp company ‘Harmlyst’. The pulp mill manager ‘Bold-face Bobby’ asks ‘How many oven dry tonnes is that?’

Step 1 - Look up density of western hemlock (423 kg/m^3)

Step 2 - Multiply cubic metres by density (500 m^3 X 423 kg/m^3 = 211500 oven dry kg)

Step 3 - Divide oven dry kg by weight of one oven dry tonne………

Cubic metres to oven dry tonnes

Example 1

Your nickname is “Marginal Manny’ and you have hauled and scaled approximately 500 m^3 of western hemlock. Unfortunately, it has been attacked by escaped hyper aggressive wood borers developed in the Canadian government’s biowarfare facility located next door to your log yard and is no longer appropriate for lumber manufacture. You would like to get at least some return on your investment and decide to try and sell the fibre to the local pulp company ‘Harmlyst’. The pulp mill manager ‘Bold-face Bobby’ asks ‘How many oven dry tonnes is that?’

Step 1 - Look up density of western hemlock (423 kg/m^3)

Step 2 - Multiply cubic metres by density (500 m^3 X 423 kg/m^3 = 211500 oven dry kg)

Step 3 - Divide oven dry kg by weight of one oven dry tonne

211500 kg / 1000 kg = 211.5 oven dry tonnes

$ per cubic metre to $ per oven dry tonnes

- To convert \$/m^3 to \$/odt, divide cost per m^3 by the wood density (Note: there are multiple m^3 in an odt so price per unit will be higher)
- Using western hemlock and \$25/m^3:
  - Step 1 - Look up density of western hemlock (423 kg/m^3)
  - Step 2 – Convert density to oven dry tonnes per m^3 (423 kg / 1000 kg = .423 odt/m^3)
  - Step 3 – Divide cost per m^3 by wood density (\$25/m^3 / .423 odt/m^3 = \$59.10/odt)

Oven dry tonnes to cubic metres

1. Determine wood density for chosen species. (see Table 1 in handout)
2. Convert kg/m^3 to odt/m^3
3. Divide total oven dry tonnes by odt/m^3.
4. Result is in cubic metres

Let’s try the example on the next slide….

Oven dry tonnes to cubic metres

Example 2

You are “Hammermill Huey”, the owner of the local biomass procurement company “The Daily Grind”, exploring contract options for grinding the logging residues of a large licensee “West Island Timber Forest Products”. You tell the regional forester, “Tailhold Tommy” you can potentially grind 250 odt per day. Tommy tells you that it’s mostly Douglas-fir and asks ‘How may cubic metres of wood is that per day?’.

Step 1 – Look up density of Douglas-fir…….

Oven dry tonnes to cubic metres

Example 2

You are "Hammermill Huey", the owner of the local biomass procurement company "The Daily Grind", exploring contract options for grinding the logging residues of a large licensee "West Island Timber Forest Products". You tell the regional forester, "Tailhold Tommy" you can potentially grind 250 odt per day. Tommy tells you that it's mostly Douglas-fir and asks 'How may cubic metres of wood is that per day?'.

Step 1 – Look up density of Douglas-fir…..

$$450\ kg/m^3$$

Oven dry tonnes to cubic metres

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Step 1 – Look up density of Douglas-fir (450 kg/m^3)

Step 2 – Convert density to tonnes per m^3......

Oven dry tonnes to cubic metres

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Step 1 – Look up density of Douglas-fir (450 kg/m^3)

Step 2 – Convert density to tonnes per m^3

$$450 \text{ kg} / 1000 \text{ kg} = .45 \text{ odt/m}^3$$

Oven dry tonnes to cubic metres

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Step 1 – Look up density of Douglas-fir (450 kg/m^3)

Step 2 – Convert density to tonnes per m^3 (450 kg / 1000 kg = .45 odt/m^3)

Step 3 – Divide total odt by density………

Oven dry tonnes to cubic metres

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Step 1 – Look up density of Douglas-fir (450 kg/m^3)

Step 2 – Convert density to tonnes per m^3 (450 kg / 1000 kg = .45 odt/m^3)

Step 3 – Divide total odt by density

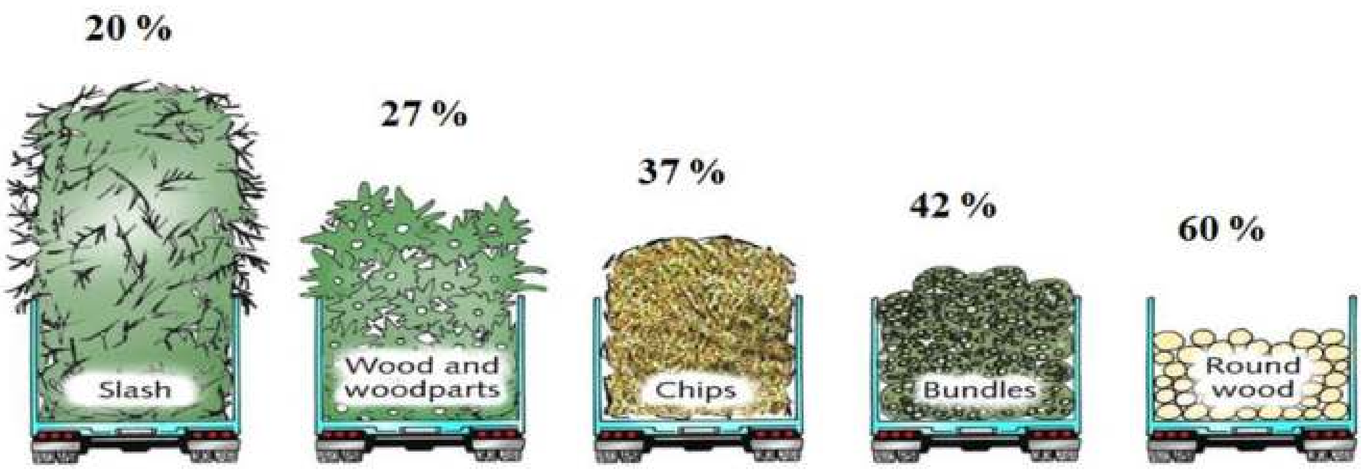
$$250 \text{ odt} / .45 \text{ odt/m}^3 = 555.6 \text{ m}^3$$

$ per oven dry tonne to $ per cubic metre

- To convert \$/odt to \$/m^3, multiply cost/odt by the wood density (Note: there are multiple m^3 in an odt so price per unit will be lower)
- Using the Douglas-fir and \$50/odt:
  - Step 1 – Look up density of Douglas-fir (450 kg/m^3)
  - Step 2 – Convert density to tonnes per m^3 (450 kg / 1000 kg = .45 odt/m^3)
  - Step 3 – Multiply \$/odt by density (\$50 per odt * .45 odt/m^3 = \$22.50/m^3)

Solid cubic metres to loose cubic metres

1. Divide solid cubic metres by the bulking factor found on Table 2 in handout (also below).



Solid cubic metres to loose cubic metres

Example 3

You are “Fuel chip Frieda” and have a solid 500 m^3 that you purchased from your buddy “Marginal Manny”. You need to grind up the solid wood and transport it to the local co-gen plant. You need to try and arrange for trucks but to do that you need to determine how many. Each truck can carry 185 m^3 (loose). How many trucks do you need?

Step1: Divide 500 m^3 by the bulking factor for chips…….

Solid cubic metres to loose cubic metres

Example 3

You are “Fuel chip Frieda” and have a solid 500 m^3 that you purchased from your buddy “Marginal Manny’. You need to grind up the solid wood and transport it to the local co-gen plant. You need to try and arrange for trucks but to do that you need to determine how many. Each truck can carry 185 m^3 (loose). How many trucks do you need?

Step1: Divide 500 m^3 by the bulking factor for chips

$$500\ m^3 / (37\% \text{ or } .37) = 1351 \text{ loose } m^3$$

Solid cubic metres to loose cubic metres

Example 3

You are “Fuel chip Frieda” and have a solid 500 m^3 that you purchased from your buddy “Marginal Manny’. You need to grind up the solid wood and transport it to the local co-gen plant. You need to try and arrange for trucks but to do that you need to determine how many. Each truck can carry 185 m^3 (loose). How many trucks do you need?

Step1: Divide 500 m^3 by the bulking factor for chips (37% or .37) = 1351 loose m^3

Step 2: Divide 1351 loose m^3 by the truck volume………

Solid cubic metres to loose cubic metres

Example 3

You are “Fuel chip Frieda” and have a solid 500 m^3 that you purchased from your buddy “Marginal Manny’. You need to grind up the solid wood and transport it to the local co-gen plant. You need to try and arrange for trucks but to do that you need to determine how many. Each truck can carry 185 m^3 (loose). How many trucks do you need?

Step1: Divide 500 m^3 by the bulking factor for chips (37% or .37) = 1351 loose m^3

Step 2: Divide 1351 loose m^3 by the truck volume…….

1351 m^3 / 185 m^3 = 7.3 trucks → round up to 8

Warning: This method assumes that the chips are dry (<40% MC) and the weight limit for the truck is not exceeded. Always check weight allowances for trucks!

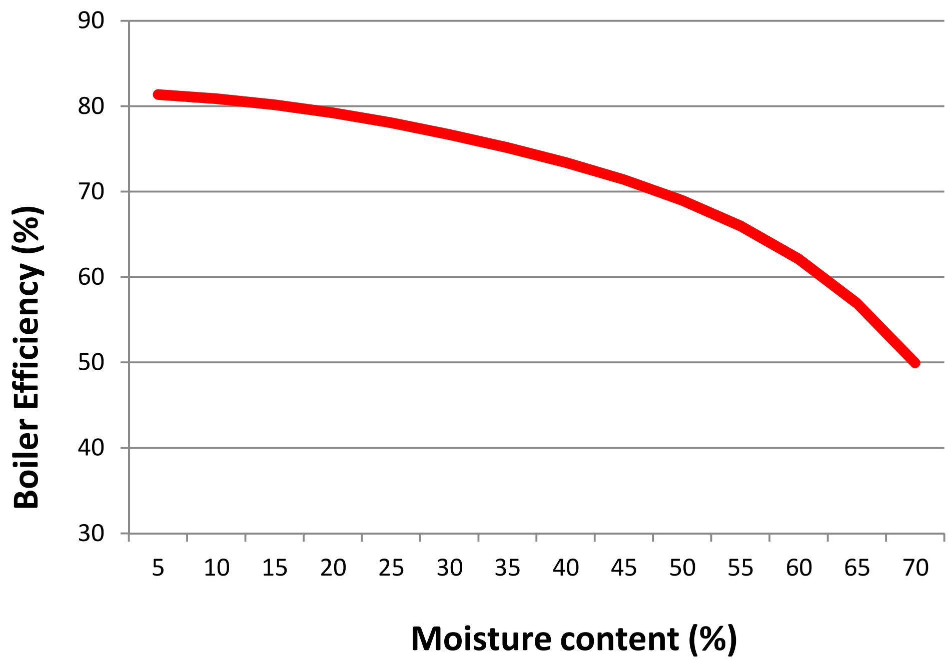
Volumetric units to oven dry tonnes

1. Convert VU's to cubic feet (1VU = 200 ft^3 loose)
2. Convert cubic feet to cubic m^3 (200 ft^3 loose = 5.66 m^3 loose)
3. Convert loose m^3 to solid m^3 (5.66 m^3 X .37 = 2.1 m^3 solid)
4. Multiply solid m^3 by species density (2.1 m^3 X 450 kg/m^3 = 945 kg)
5. Convert kg to tonnes (945kg / 1000kg = .945 odt)

Moisture Content

Moisture content

- Why is moisture content important with biomass?



Combust more wood, evaporate less water!

MoISTURE content

- Why is moisture content important with biomass?

Load 1

Price per green tonne = $30/gt

Price per oven dry tonne = $66.67/odt

GJ per truckload = 236.8 GJ

Load 2

Price per green tonne = $30/gt

Price per oven dry tonne = $46.15/odt

GJ per truckload = 377.6 GJ

Deliver more wood (energy!) less water!

Average Canadian household uses around 105 GJ per year!

Moisture content

- Weight versus volume in transport
  - As hauled materials grow wetter, it becomes more likely that a loaded truck may reach maximum weight before the truck is physically full.
  - Conversely, when loading dry materials, operators may reach max volume of the truck before weight is reached.
    - This usually means fuel savings (truck doesn't have to work as hard).
    - Also, the drier material will have a higher energy density so cost per GJ of energy is lower.

Moisture content

- How do we calculate moisture content?
  - Two methods – wet basis and dry basis
- Most biomass users use the wet basis but it's always good to ask.

- Moisture content (wet basis):

$$mc\ (\%,\ \text{w.b.}) = \frac{m_{wet} - m_{dry}}{m_{wet}} \times 100$$

m_{wet} = mass of wet biomass

m_{dry} = mass of oven-dry biomass

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Moisture content

- See moisture content determination methodology in your handout package explains how to dry biomass (ie how to determine the m_{dry} in the equation below)
  - Moisture content (wet basis):

$$mc\ (\%,\ \text{w.b.}) = \frac{m_{wet} - m_{dry}}{m_{wet}} \times 100$$

m_{wet} = mass of wet biomass

m_{dry} = mass of oven-dry biomass

Moisture content determination

Example 4

You are a fibre supply manager, “Hog Pile Hank” and you want to determine average moisture content of the hog fuel pile in your yard. You take a 1kg sample (green) and place it in the oven for 24 hours. After drying, the sample weighs 0.6kg (oven dry). What is the moisture content?

1. Subtract the oven dry weight from the green weight to determine the amount of water in sample……..

Moisture content determination

Example 4

You are a fibre supply manager, “Hog Pile Hank” and you want to determine average moisture content of the hog fuel pile in your yard. You take a 1kg sample (green) and place it in the oven for 24 hours. After drying, the sample weighs 0.6kg (oven dry). What is the moisture content?

1. Subtract the oven dry weight from the green weight to determine the amount of water in sample……..

$$1.0 \text{ kg} - 0.6 \text{ kg} = 0.4 \text{ kg water}$$

Moisture content determination

Example 4

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1. Subtract the oven dry weight from the green weight (1.0 kg – 0.6 kg = 0.4 kg water).
2. Divide the weight of water by the weight of the green sample……

Moisture content determination

Example 4

You are a fibre supply manager, “Hog Pile Hank” and you want to determine average moisture content of the hog fuel pile in your yard. You take a 1kg sample (green) and place it in the oven for 24 hours. After drying, the sample weighs 0.6kg (oven dry). What is the moisture content?

1. Subtract the oven dry weight from the green weight (1.0 kg – 0.6 kg = 0.4 kg water).
2. Divide the weight of water by the weight of the green sample…….

0.4 kg / 1.0 kg = 40% moisture content

Green tonnes to oven dry tonnes

1. Multiply green tonnes by moisture content to determine weight of water in tonnes
2. Subtract water weight from green tonnes to determine woody fibre weight in oven dry tonnes

Green tonnes to oven dry tonnes

Example 5

You are a fibre supply manager, “Boiler Bart”, for the local co-heat and power plant “Whistle Clean Energy Corporation”. You are concerned about the high moisture content in your feedstock pile and want to figure out how many oven dry tonnes you have in your pile so you can determine energy content. You know you have approximately 25,000 green tonnes in your pile and you have completed a moisture content analysis and determined average moisture content to be 60% (not unusual for the coast).

1. Multiply green tonnes by the moisture content………

Green tonnes to oven dry tonnes

Example 5

You are a fibre supply manager, "Boiler Bart", for the local co-heat and power plant "Whistle Clean Energy Corporation". You are concerned about the high moisture content in your feedstock pile and want to figure out how many oven dry tonnes you have in your pile so you can determine energy content. You know you have approximately 25,000 green tonnes in your pile and you have completed a moisture content analysis and determined average moisture content to be 60% (not unusual for the coast).

1. Multiply green tonnes by the moisture content…..

0.6 * 25,000 tonnes = 15,000 tonnes (water)

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Green tonnes to oven dry tonnes

Example 5

You are a fibre supply manager, "Boiler Bart", for the local co-heat and power plant "Whistle Clean Energy Corporation". You are concerned about the high moisture content in your feedstock pile and want to figure out how many oven dry tonnes you have in your pile so you can determine energy content. You know you have approximately 25,000 green tonnes in your pile and you have completed a moisture content analysis and determined average moisture content to be 60% (not unusual for the coast).

1. Multiply green tonnes by the moisture content (.6 * 25,000 tonnes = 15,000 tonnes)
2. Subtract water from green tonnes……….

Green tonnes to oven dry tonnes

Example 5

You are a fibre supply manager, “Boiler Bart”, for the local co-heat and power plant “Whistle Clean Energy Corporation”. You are concerned about the high moisture content in your feedstock pile and want to figure out how many oven dry tonnes you have in your pile so you can determine energy content. You know you have approximately 25,000 green tonnes in your pile and you have completed a moisture content analysis and determined average moisture content to be 60% (not unusual for the coast).

1. Multiply green tonnes by the moisture content (.6). This number indicates how much of your pile is water (15,000 tonnes).
2. Subtract water from green tonnes…….

25,000 green tonnes – 15,000 tonnes water = 10,000 oven dry tonnes of fibre

For more information please contact:

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