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BIOCHAR JOB ESTIMATING GUIDELINES

BASIC VALUES AND ASSUMPTIONS

Units and Conversion Factors Used in Biochar Estimating

1 cu yd = 27 cu ft
1 cubic foot = 7.5 gallons
1 kg = 2.2 lbs
1 US short ton = 2000 lb
1 metric tonne = 2205 lb

Density

Dry density of softwoods = 30 lb/cf
Dry density of oak = 37-56 lb/cf
Dry density of biochar = 230 lb/cy

Estimating feedstock volume, bulk density, mass

Standard Hand Pile:

- Dimensions of one standard forestry hand pile: 6 ft in diameter and 5 ft tall
- Dry mass of wood (douglas fir density) in standard forestry hand pile: 300 lbs

Cord of Wood:

- Envelope volume of 1 cord (4'x4'x8') = 128 cf = 4.7 cy
- Solid wood volume of 1 cord = 3.15 cy
- Conversion factor from cord envelope volume to wood volume – multiply by .67
- Dry mass of wood (douglas fir density) in one cord: 2,550 lb

Ring of Fire Kiln Specs

- Standard 6-panel kiln: 7.6 ft diameter, 5.6 cy volume
- Expanded 8-panel kiln: 10.2 ft diameter, 10 cy volume
- Expanded 10-panel kiln: 12.7 ft diameter, 15.7 cy volume
- Kiln Height: 40 in = 3.3 ft

Biochar Thermochemical Conversion Rubrics

- Conversion efficiency of dry wood to dry biochar in Ring of Fire Kiln: 17%
- Conversion time in Ring of Fire Kiln: 10 minutes to form 1 inch of biochar
- Time to accumulate 24 inches in Kiln: 240 minutes = 4 hours
- Volume of 24 inches of biochar in standard Ring of Fire Kiln: 3 cy

Feedstock required to yield 3 cy of biochar in the standard Ring of Fire

Feedstock amount based on a cord of wood:

- Biochar conversion of one cord (doug fir): $(2550 \text{ lb})(.17)=434 \text{ lbs biochar}$
- 3 cy biochar is 690 lb

Cords of wood required to make 3 cy biochar in kiln:

- $690 \text{ lb per 3 cy biochar} / 434 \text{ lbs biochar from one cord} = 1.6$
- 1.6 cords of doug fir density wood will make 3 cy biochar
- 1.6 cords times 2550 lb/cord is 4080 lbs or approximately 2 tons

Feedstock amount based on a standard hand pile:

- Biochar conversion of one standard hand pile (doug fir): $(300 \text{ lb})(.17)= 51 \text{ lbs biochar}$
- 3 cy biochar is 690 lb

Standard hand piles required to make 3 cy biochar in kiln:

- $690 \text{ lb} / 51 \text{ lbs biochar from one hand pile} = 13.5$
- 13.5 hand piles of doug fir density wood will make 3 cy biochar
- 13.5 hand piles is 4050 lbs, or approximately 2 tons

Water Requirements

- It takes 50 gallons of water to quench one cubic yard of biochar when raked thin
- Water to quench 3 cy of biochar: 150 gallons

Carbon

- Average % fixed carbon in flame cap kiln biochar = 85%
- Average H:C ratio: 0.3
- 1 ton of carbon = 3.67 tons of CO_2

Sample Estimating Exercise

Job Description

Two acres of forest thinning slash piled into standard hand piles on a mild slope with flat areas for setting up Ring of Fire Kilns

Piles per acre: 30

Fuel moisture: 25%

Objectives:

- Convert piles to biochar and rake out on site
- Capture data to verify biochar production volumes, bulk density and clean production

Resources Required

- Number of kilns available: 4 Ring of Fire Kilns
- Labor: 1 worker per kiln
- Supervisor: 1 person to oversee the job and manage carbon measurements
- Daily water requirements: 4 kilns x 150 gallons = 600 gallons
- Hand tools including shovels, fire rakes
- Crew and kiln transport: 1 crew cab pickup truck
- Water trailer with 600-gallon tank, pump, and 500-1000 feet of hose with nozzles

Daily Output

- Each kiln can process at least 13.5 piles and can stretch to 15 piles
- Four kilns can process all 60 piles on the two-acre site in one day
- Total biochar produced is 750 pounds per kiln or 1.5 tons

Work Day Hours

- Commute time: 1.5 hours
- Set up time at site: 1 hour
- Burn time (four hours plus an extra half hour to process 1.5 more piles per kiln): 4.5 hours
- Quenching: 1 hour
- Breakdown and packing up: 1 hour
- Total time including mobilization: 9 hours

COSTING EXERCISE

Fill in the hourly and daily cost for completing this job

- Worker hourly cost: Multiply by 4: Multiply by 9:
- Supervisor hourly cost: Multiply by 9:
- Mileage rate, crew transport truck: Multiply by # miles:
- Daily cost of water trailer:
- Total daily cost for labor and equipment operation:

Calculate the cost per ton of biochar produced

- Divide total cost by tons of biochar produced (1.5 tons biochar):
- Compare to bulk cost of biochar at \$650/ton, FOB
- Compare to retail cost of biochar at \$4.00/lb = \$8,000/ton, delivered
- Estimate carbon sequestered by multiplying by 2.5 = 3.75 tons CO₂
- Carbon payment if payment is \$100/short ton: \$375

ESTIMATING PROBLEM

Job Description

Nine acres of forest thinning slash piled into standard hand piles on a mild slope with flat areas for setting up Ring of Fire Kilns. This job is a little closer so daily commute time is only one hour.

Piles per acre: 40

Fuel moisture: 25%

Objectives:

- Convert piles to biochar and rake out on site
- Capture data to verify biochar production volumes, bulk density and clean production

Resources Required

- Number of kilns available: 3 Ring of Fire Kilns
- Labor: 1 worker per kiln. No Supervisor. Workers will manage all tasks including carbon measurements
- Daily water requirements: 3 kilns x 150 gallons = 450 gallons
- Hand tools including shovels, fire rakes
- Crew and kiln transport: 1 crew cab pickup truck
- Water trailer with 500-gallon tank, pump, and 500-1000 feet of hose with nozzles

Daily Output

- Each kiln can process at least 13.5 piles
- Total biochar produced is 690 pounds per kiln or 1.4 tons

Days to Complete the Job

Total # piles to process: piles/acre times number of acres:

Total biomass to process: (# piles x 300 lbs) / 2000 lb/ton:

Biomass processed per day: 13.5 x 300 lbs x 3 kilns = 6.1 tons

Days to process all biomass is total biomass/biomass processed per day:

Work Day Hours

- Commute time: 1.0 hour
- Set up time at site: 1 hour
- Burn time: 4 hours
- Quenching: 1 hour
- Breakdown and packing up: 1 hour
- Total time including mobilization: 8 hours

COSTING EXERCISE

Fill in the hourly and daily cost for completing this job

- Worker hourly cost: Multiply by 3: Multiply by 8:
- Mileage rate, crew transport truck: Multiply by # miles:
- Daily cost of water trailer:
- Total daily cost for labor and equipment operation:
- How many days will it take to process the piles on the nine-acre site:
- Total cost for the job is daily cost times number of days:
- How much biochar will be produced:
- Multiply by 2.5 to estimate the amount of CO₂ removed by biochar:
- If carbon payment is \$100/ton CO₂, how much is the carbon payment:
- Subtract the carbon payment from the job cost:

Questions for Further Study

1. How does your cost of biochar production as a wood disposal method compare with the alternatives?
2. Can you find someone to pay for the carbon sequestration value of biochar? How will that affect your profit?
3. How much will landowners pay for the benefits of biochar to forest soil, assuming that it will improve soil moisture and forest health and productivity over time?
4. Can you use machinery to move and load feedstock into kilns? How will that impact labor costs?
5. What is the cost of adding a loader or mini-excavator? Consider cost of renting vs owning plus cost of trailering equipment to job site.
6. How will that effect your labor productivity?
7. Could be more efficient if you deployed more kilns per day?
8. Can you reduce mobilization cost by leaving some equipment on site?

Quiz

1. How many cubic feet in a cubic yard?
2. Give the diameter and volume of an 8-panel Ring of Fire Kiln
3. How much water do you need to quench one cubic yard of biochar by spraying and raking thin?
4. What is the average conversion efficiency in the Ring of Fire Kiln of biomass to biochar on a dry mass basis?
5. How long does it take to form one inch of biochar in the Ring of Fire Kiln?
6. What is the dry density of Douglas fir?
7. What is the dry density of biochar?
8. What is the approximate weight of a hand pile that is 6 ft in diameter and 5 ft tall?
9. How much wood (by dry weight) does it take to produce 3 cubic yards of biochar in the Ring of Fire Kiln?
10. What is the average percentage of fixed carbon in biochar made in the Ring of Fire Kiln?