Economic Analysis and Profit Potential of a Mobile Air Curtain Biochar Processor

Trent A. Morton, Corey M. Kichler, and H. Allen Torbert [1]
USDA-ARS-National Soil Dynamics Laboratory, Auburn, AL, USA

Abstract

Agricultural and forestry waste is typically disposed of using open burn piles. However, this method usually creates a lot of ash and destroys most of the available carbon. Burning waste in low oxygen environment, called pyrolysis, creates biochar material which leaves most of the carbon in the biochar residue, resulting in a biproduct that has economic value. An inventive method to achieve pyrolysis while burning organic materials is the use of an air curtain inside of the firebox. Blowing a steady flow of air over the fire pit can remove air mixed in the burning material, resulting in a very low oxygen environment in the burning zone. Recently, commercially available equipment that uses air curtain technology has been developed that is also portable so that it can be moved to remote sites where the waste is generated. This technical report provides an economic evaluation of using this type of equipment in silvicultural operations typical of the Southeastern US. Results show for the particular cost assumptions and equipment choice, the potential total yearly profit of $89,133 could be attained including operating cost for the Charboss ($64,325.88/yr) and an excavator ($22,660.97) to load material at a biochar sales price of $350/ton.

Introduction

There is continued interest in developing new methods to improve the soil quality of soils used in silviculture and agriculture operations. Soil quality is greatly reduced in these soils due to the depletion of organic carbon (OC) due to long term use, and methods to retore organic carbon are being developed. One method currently under study is the addition of biochar to these OC depleted soils.

Agricultural and forestry waste is typically disposed of using open burn piles. However, this method usually creates a lot of ash and burns up most of the available carbon. However, if this waste can be converted to biochar instead of simply burning it, then a potential beneficial soil amendment to increase soil OC levels can be created. Burning waste in low oxygen environment (called pyrolysis) is a method that will leave most of the carbon in the biochar material that is produced. Equipment that uses pyrolysis to create biochar from organic waste would not only allow a means for producers to handle their waste but also to produce a valuable byproduct for their operations. Therefore, transportable pyrolysis equipment that can be used by producers to create biochar from waste is needed.

An inventive method to achieve pyrolysis while burning organic materials is the use of an air curtain inside of the firebox. By blowing a steady flow of air over the fire pit, air near the burning material is almost entirely removed, resulting in a very low oxygen environment around the burning material. One specific example of equipment that uses this principle is the AirBurners CharBoss® Model T26. The machine is a pyrolysis air curtain burner mounted on a

---

[1] Use of a company or product name by the U.S. Department of Agriculture or agency does not imply approval or recommendation of the product to the exclusion of others that may also be suitable.

triaxle trailer so that it can be moved to different locations. The utilization of this type of equipment presents the possibly of generating biochar from organic waste without having to relocate the waste from the point of origination. Since biochar has resale value, a profit could potentially be made by retaining this machine to produce biochar for use by a landowner or to sell on the open market. An economic evaluation of using this equipment in a silvicultural operation typical for the Southeastern US was conducted to examine the potential profitability of using a CharBoss in these operations.

Silviculture Operations in the Southeast US

The primary region for loblolly pine (*Pinus taeda*) production is the southeastern United States on privately owned land (Little, 1971). Since the largest land use in the region is forest, pine production is an important industry and critical part of the local economies. Pine plantations, both large and small, are intensively cultivated to produce large trees resulting in products such as sawtimber, utility poles, and paper (Wahlenberg, 1960). Plantations are thinned at a regular schedule when trees are small to make room for the remaining trees to grow larger. The smaller trees are used for paper production and larger tree produce sawtimber and utility poles.

During harvest operations, pine trees are hauled to designated landing sites within the harvest area and then passed through a "total tree harvesting machine". These machines de-limbs and de-barks the trees for transport to a paper mill or lumber mill. Residual materials from the harvesting of pine plantations are the limbs, tops, and cull portions of the merchantable and nonmerchantable trees. Sometimes this residual material can be sold for paper mill boiler fuel (after chipping). More commonly, this material is treated as a waste material and is simply burned or left to rot on the landing site (Stokes et al., 1989).

This waste product that is left at the landing sites provides no benefit to the land, whether it was left to rot or was burned, extensively removing all the organic carbon through the resulting ash. However, if this material was converted to biochar, it could potentially provide an additional income stream for loggers or landowners. Equipment such as the CharBoss provides a practical way of producing biochar at the landing sites of the tree harvest.

Economic Evaluation

The potential profit generated from using an AirBurners CharBoss® Model T26 for biochar creation can be estimated by applying a standard economic evaluation and using basic economic operating assumptions to calculate the total ownership (fixed) and operational (variable) costs of the machine. Moreover, the possible revenue created by the machine can be projected by examining the price received from the production and subsequent selling of biochar. This potential profit can be used by loggers and land managers to justify the cost of a CharBoss operation. Also, even if the landowner does not sell the biochar, but chooses to use it on his own property, the economic evaluation can be seen as an investment of the landowner in maintaining the productivity of his property by recycling the waste produced into a useful material.

For purposes of this study, it was assumed that the machine will be utilized for a total of 213 workdays (or 1,700 work hours) per year in 8-hour workdays. This is calculated by first taking 365 days, then subtracting weekends and federal holidays. Next, an assumed -10% for inclement weather and -5% for travel time to and from the worksite is subtracted from the total. (See formula calculations: *"1. Working Days"*). Next, the ownership or fixed costs (depreciation and capital recovery, taxes, insurance and housing) of the machine were calculated using the known purchase price, estimated salvage value (the machines worth at the end of economic life), assumed economic life, accumulated hours, financing interest and U.S. inflation rates, and annual hourly use.

CharBoss® Model T26 (Ownership/Fixed Costs)
The purchase price is $152,121 (AirBurners – Palm City, FL---As of June/2024). Using an assumed economic life of 8 years and a salvage value of 40% of a new machine. The machine is new, so there are zero accumulated hours. An assumed interest (Finance Cost % - Inflation %) equivalent to 5% and annual hourly use (calculated above) of 1,700 hours. By using this information, the depreciation was calculated to be $91,272 over the useful life of the machine. The capital recovery (the return of the initial investment over time) was $17,190 and taxes, insurance, and housing costs are $1,065 yearly. Thus, the total fixed costs are $18,254 per year or $10.74 per hour (See formula calculations: *"2. Ownership Costs"*).

In addition to the costs associated with owning the CharBoss® T26, operational costs must be included such as loading debris into the firebox. Manual loading is not very feasible when it comes to maximizing revenue, so using a small excavator with a grapple attachment would be the ideal way to load the firebox. Lifting heavy timber by hand into the firebox would be unsafe, exhaustive, and inefficient. For the purpose of this examination, a Bobcat® E40-R2 compact excavator is used as a representation for calculating the associated fixed and variable costs. It is small enough for rough terrain maneuverability, yet it has enough power to handle most waste that would be loaded into the CharBoss® T26.

Bobcat® E40-R2 Compact Excavator (Ownership/Fixed Costs)
By using the same formulas, the total fixed or ownership costs of the excavator can be calculated. The purchase price is $65,271 (from Doosan Bobcat Company – North America). Using an assumed economic life of 10 years and a salvage value of 40% of a new machine. The machine is new, so there are zero accumulated hours. Interest (Finance Cost % - Inflation %) is equivalent to 5%. Furthermore, the annual hourly use (estimated to be 30% of the CharBoss® T26) is 510 hours. By using this information, the depreciation was calculated to be $39,163 over the useful life of the machine. The capital recovery is $6,397 and the taxes, insurance, and housing costs are $457 yearly. Thus, the total fixed costs are $6,853 per year or $13.44 per hour.

The variable or operational costs (repair and maintenance, fuel, lubrication, and labor) of the machines can be calculated using the known purchase price, the assumed economic life and total accumulated hours, the estimated accumulated repair costs, the labor rate, the fuel cost, and the engine horsepower of the machine.

CharBoss® Model T26 (Operational/Variable Costs)
The total accumulated hours at the end of economic life are 13,600; the total accumulated repairs are assumed to be 49% of the purchase price of a new machine; the labor rate is $15.00 per hour; the fuel costs are $4.00 per gallon (diesel); and the machine has a 25-horsepower engine. When using this information, the total repair costs are $74,539 over the life of the machine or $5.48 per hour of operation; the fuel costs are $4.40 per hour of operation; the lubrication costs are $0.66

per hour of operation; and the labor costs are $16.50 per hour of operation. Combined, the total variable costs are $27.04/hour of operation (See formula calculations: *"3. Operational Costs"*).

Bobcat® E40-R2 Compact Excavator (Operational/Variable Costs)

Likewise, the variable or operational costs for the compact excavator are calculated with the same formulas. The total accumulated hours at the end of economic life are 5,100; the total accumulated repairs are assumed to be 50% of the purchase price of a new machine; the labor rate is $15.00 per hour; the fuel costs are $4.00 per gallon (diesel); and the machine has a 40-horsepower engine. When using this information, the total repair costs are $32,636 over the life of the machine or $6.40 per hour of operation; the fuel costs are $7.04 per hour of operation; the lubrication costs are $1.06 per hour of operation; and the labor costs are $16.50 per hour of operation. Combined, the total variable costs are $31.00 per hour of operation.

Total Costs for the CharBoss® T26

The total (sum of fixed and variable) costs for the CharBoss® T26 are $37.78 per hour of operation. In addition, the CharBoss® T26 uses 100 gallons of water per day (for biochar quenching) which is equivalent to 12.5 gallons per hour. Thus, water use costs are $0.06 per hour of operation based on the Alabama Department of Environmental Management (ADEM) average water usage price data quoted for the city of Auburn, Alabama. Therefore, the actual total costs for the CharBoss® T26 are $37.84 per hour, which is equivalent to $64,326 per year. Additionally, the total (sum of fixed and variable) costs for the Bobcat® E40-R2 compact excavator are $44.43 per hour which is equivalent to $22,661 per year.

Potential Profit

After calculating the total costs for both machines, the potential profit can be estimated by examining the conceivable prices received from selling biochar on an open market and the effective field capacity of the machine. The effective field capacity is the production potential of the machine in a given time. Prices received will probably vary dramatically depending on the state or region and the biochar properties, but there is a price point potential of up to $350 per metric ton of biochar sold (*based on data from Utah Extension*). By using $350 per metric ton, a yearly gross revenue of $176,120 can be attained. This is based on the metrics set forth in the *CharBoss® Lifecycle Assessment conducted by USBI and the U.S. Forestry Service in February of 2024*. This assessment cited that the CharBoss® T26 can yield 0.296 metric tons of biochar per hour. This extrapolates out to be 503 metric tons of biochar produced per year based on our operating assumptions. Therefore, a yearly profit of $89,133 (See formula calculations: *"4. Potential Biochar Sales Profit"*) is calculated by subtracting the total yearly costs of the CharBoss® T26 ($64,326) and then the total yearly costs for the Bobcat® E40-R2 Compact Excavator ($22,661) from the yearly gross revenue of $176,120.

In addition to the biochar sales revenue, another plausible possible income could be from charging customers for the elimination of remaining forestry and agricultural waste. The effective field capacity that is applied to the Bobcat® E40-R2 Compact Excavator is equivalent to the burn rate of the CharBoss® T26. The machine can burn 1.72 metric tons of throughput per hour (from *CharBoss® Life Cycle Assessment by USBI and U.S. Forest Service 2024*). This extrapolates out to be 2,924 metric tons of waste eliminated per year.

Formula Calculations:

1.) Working Days:

- [Days per Year (365) – Weekend Days (104) – Federal Holidays (11)] = 250 workdays.
- Workdays (250) x [100% - Inclement Weather (10%) - Travel to Worksite (5%)] = 213 workdays.
- (250 workdays) x (8 hours per day) x 85% = 1,700 yearly work hours.

2.) Ownership Costs:

- Remaining Value ($60,848.28) = [Purchase price ($152,120.69) x Salvage Value (40%)].
- Depreciation ($91,272.41) = [Purchase Price ($152,120.69) - Remaining Value ($60,848.28)].
- Capital Recovery ($17,189.64) = [Depreciation ($91,272.41) x Capital Recovery Factor[1] (0.155)] + [Interest Rate[2] (5%) x Remaining Value ($60,848.28)].
- Taxes/Insurance/Housing ($1,064.84) = 0.01 x [(Purchase Price ($152,120.69) + Remaining Value ($60,848.28)) / 2].
- Total Fixed Costs per Year ($18,254.48) = [Capital Recovery ($17,189.64) + Taxes/Insurance/Housing ($1,064.84)].
- Total Fixed Costs per Hour ($10.74) = [Total Fixed Costs per Year ($18,254.48) / Annual Hourly Use (1,700)].

Footnotes

[1]Capital recovery factor was retrieved from The American Society of Agricultural and Biological Engineers (ASABE).
[2]Interest rate is calculated by using: [Cost of financing (8%) - U.S. Inflation Rate (3%)].

3.) Operational Costs:

- Total Accumulated Hours at end of life (13,600) = Economic Life (8 years) x Annual Hourly Use (1,700 hours).
- Accumulated Repairs ($74,539.14) = [End of Life Total Repairs[*] (49%) - Current Repairs (0%)] x Purchase Price ($152,120.69).
- Average Repair Costs per Hour ($5.48) = [Accumulated Repairs ($74,539.14)] / [Total Accumulated Hours at End of Life (13,600)].
- Fuel Costs per Hour ($4.40) = [0.044[**] x Engine Horsepower (25) x Fuel Price per Gallon ($4.00)].
- Lubrication Costs per Hour ($0.66) = [0.15 x Fuel Costs per Hour ($4.40)].
- Labor Costs per Hour ($16.50) = [1.1[***] x Wage Rate per Hour ($15.00)].
- Total Variable Costs per Hour ($27.04) = [Average Repair Costs per Hour ($5.48) + Fuel Costs per Hour ($4.40) + Lubrication Costs per Hour ($0.66) + Labor Costs per Hour ($16.50)].

Footnotes

[*]The "End of Life" Total Repairs figure was retrieved from the American Society of Agricultural and Biological Engineers (ASABE).
[**]The factor for calculating diesel fuel costs was retrieved from the American Society of Agricultural and Biological Engineers (ASABE).
[***]A factor of 1.1 is used to account for a worker driving/re-fueling/setting up/etc. the machine.

4.) **Potential Biochar Sales Profit:**

- Metric Tons per Year of Biochar (503.2) = Metric Tons per Hour of Biochar (0.296) x Annual Hourly Use (1,700).
- Biochar Yearly Sales Revenue ($176,120.00) = Price per Metric Ton of Biochar ($350.00) x Metric Tons per Year of Biochar (503.2).
- Biochar Yearly Sales Profit ($89,133.15) = Biochar Yearly Sales Revenue ($176,120.00) - Total CharBoss® T26 Annual Costs ($64,325.88) – Total Bobcat® E40-R2 Compact Excavator Annual Costs ($22,660.97).

References

Bobcat® E40-R2 Overview https://www.bobcat.com/na/en/equipment/excavators/compact-excavators/e40

CharBoss® Overview https://airburners.com/files/specifications/charboss.pdf

Gudmundur, Johannesson. (2024). GHG Life Cycle Assessment of CharBoss® Biochar Production and Potential Use for CDR Certificate Generation. USDA Forest Service and US Biochar Initiative. https://biochar-us.org/sites/default/files/presentations/USFS_USBI-CharBoss-LCA-Report-FEB-29-2024-FINAL.pdf

Little, E.L., Jr. 1971.Atlas of United States trees. Vol. 1. Conifers and important hardwoods. U.S. Dept. Agr. Misc. Publ. 1146.

Stokes, B.J.,D.L. Sirois, and W.F. Watson. 1989. Recovery of forest residues in the southern United States, p. 32–43. In: B.J. Stokes (ed.). Harvesting small trees and forest residues: Proceedings of the 1989 International Energy Agency, task 6, activity 3 symposium. U.S. Dept. Agr. For. Serv., Southern For. Expt. Sta., Auburn, AL.

Wahlenberg, W.G. 1960. Loblolly pine: Its use, ecology, regeneration, protection, growth, and management. Duke Univ., School of Forestry, Durham, NC.

Yost, M., Holt, J., Austin, J., Creech, E., McAvoy, D., Winward, D., & Allen, N. (2021, April). Biochar Impacts on Crop Yield and Soil Water Availability [Fact sheet]. Utah State University Extension. https://extension.usu.edu/crops/research/biochar-impacts-on-crop-yield-and-soil-water-availability