Exploring Biochar Production at the Bow Valley

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Abstract

This project assesses the techno-economic feasibility of biochar production from 316 hectares of post-harvest forest residues in Alberta's Bow Valley fireguard multi-year initiative. With an estimated biochar yield of 1,523 tonnes over a 3-phase period via slow pyrolysis, the study models three production scenarios: mobile (fully deployable), hybrid (mobile with centralized processing capabilities), and centralized (fixed-location facility). Each was evaluated for capital and operational costs, carbon credit potential, and profitability. A single, three- and five-year Net Present Value (NPV) analysis showed the hybrid system achieving the highest returns, while centralized systems offer long-term integration potential into municipal infrastructure networks, it faces higher capital barriers. Sensitivity analysis tested revenue changes from biochar and CORCs. The study recommends piloting a hybrid model for early adoption while monitoring policy and buyer trends. Further research is needed on full lifecycle emissions, coproduct utilization, and site-specific logistics.

Research Question

This project assesses the operational dynamics and economic profitability of biochar production from 316 hectares of post-harvest forest residues in Alberta's Bow Valley fireguard multi-year initiative.

Introduction

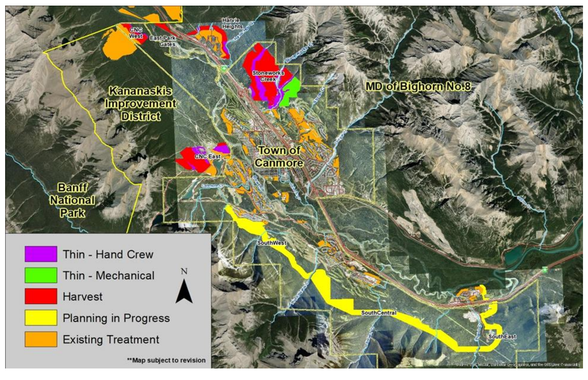
- The study investigates the economic viability and operational feasibility of biochar production specifically in the Bow Valley region of Alberta, situated in the eastern slopes of the Canadian Rockies.
- The fireguard's construction involves mechanical thinning and tree removal for wildfire mitigation and expected to span 3 to 5 years.

Figure 1: Fireguard Operation at StoneWork Creek

Source: Bow Valley Community Fireguard: Town of Canmore

- The project is spearheaded by the Biosphere Institute of the Bow Valley, a community-based environmental organization in Canmore. The Institute views biochar as a climate-positive intervention fitting within its low-carbon and nature-based solutions agenda

Figure 2: Complete overview of the Bow Valley Community Fireguard

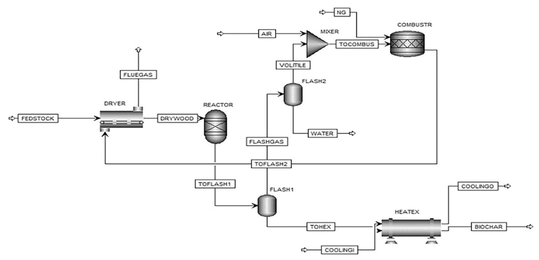


Source: Bow Valley Community Fireguard: Town of Canmore

Introduction(Continuation)

Pyrolysis has been identified as the process of convert forest biomass residue to biochar. It entails subjecting biomass to high temperatures in the absence of oxygen.

Figure 2: Pyrolysis Process



Source: IEA Bioenergy Task 43 ,2022

SUSTAINABLE DEVELOPMENT GOALS

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

13 CLIMATE ACTION

15 LIFE ON LAND

Methodology: Mixed Method Research Approach

Research Scope and Framework

- Technology Evaluation
- Operational Feasibility
- Market Trends
- Economic Analysis
- Policy Landscape

Data Collection

- Academic Literatures
- Industry Reports and Platforms
- Government and Institutional Sources
- Corporate Disclosures
- News and Public Databases

Finding and Analysis

Mobile

- This is a fully deployable unit used by technology like CharBoss to produce biochar on-site. It's an open system that rarely get certified for CORCs

Hybrid

- An in-between technology of Mobile and Centralized. A closed system that enables the capture of bio-oil and syngas. Takachar offers this technology. Process gets certified for CORCs

Centralized

- This is a fixed location facility with higher capacity, up to 10,000tonnes per yr. Capital Intensive. Production cost reduces with scale. Carbon credit feasible.

Assumptions and Result

Table 1: Biochar Production Cost Comparison

Description	Mobile Units	Mobile Cost (USD)	Hybrid Units	Hybrid Cost (USD)	Centralised Units	Centralised Cost (USD)
Loader/Feeder (CH906 front wheel loader, 25 hp;0.6 ton)	1	11,000	1	11,000	2	22,000
CharBoss Unit(Airburner Design)	1	153,326		-		
Torrefaction unit (Takachar reactor 2 ton /h;Airex Energy-CarbonFXTMfor Large Plant)	1	-	1	200,000	1	2,550,000
Tractor (John Deere 5E series, 100 hp)	1	-	1	75,000	1	75,000
Truck (Kenworth T80O, 425 hp)	1	90,000	1	90,000	1	90,000
Shed (as per fabricator)	2	20,000	2	20,000		-
Container (40 feet,63 m3)	3	15,000	3	15,000	3	15,000
Total Capital Cost		**289,326**		**411,000**		**2,752,000**
Labor at processing site (21 USD/h)	2	124,740	2	124,740	3	131,670
Tub grinder rental (Morbark 950; 225 hp, 12ton/h)	1	120,882	1	120,882	1	120,882
Consumables (utilities, spare parts, combustor)		9,906		9,906		19,812
Feedstock shipping (includes fuel and labor)						47,070
Repair and maintenance (15% of annual depreciation)		4,692		4,692		4,692
Insurance and miscellaneous (30% of labor costs)		37,422		37,422		39,501
Total Operating Cost		297,642		297,642		363,627
Total Cost		**586,968**		**708,642**		**3,115,627**

Adapted from Thengane et al. 2021

Assumptions for revenue generation are below:

- Biochar produced through the project: 1,523 tonnes
- Biochar market price: $171/tonne
- Carbon credit price: $129.65/tonne CO_2e
- Removal factor: 2.3 (i.e., each tonne of biochar is equivalent to 2.3 tonnes of CO_2e removed)
- Biochar yield = 20%, Bio-oil yield = 40% and syn gas yield = 40%
- Discount Rate = 5% (Martínez-Paz et al., 2016)

Table 2: Cost Benefit Summary Table for Biochar Production at Bow Valley

Metric (USD)	Mobile	Hybrid	Centralised
Total Cost	586,968.00	708,642.00	3,115,627.00
Total Revenue	260,433.00	714,630.95	3,039,034.15
Net Benefit	-326,535.00	5,988.95	76,592.85
Cost Benefit Ratio	-0.56	0.01	-0.02
ROI(%)	-55.63	0.85	-2.46
NPV 1st Yr	-310,033.33	5,703.76	-72,945.57
NPV 3rd Yr	-282,089.15	5,173.23	-66,202.89
NPV 5th Yr	-255,748.26	4,692.51	-60,009.63

Figure 3: NPV vs time

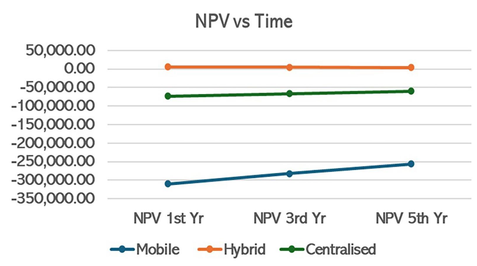
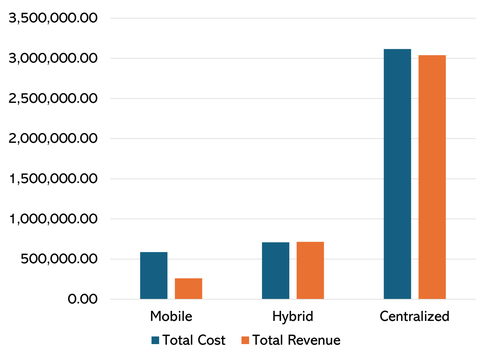


Figure 4: Cost and Revenue for three Models



Assumptions and Result (Continuation)

Table 3: Sensitivity Analysis of Biochar and Carbon Credit Price

Bio char Price ($/t)	Carbon Credit Price (S/tC02e)	Total Revenue ($)	Total Cost ($)	Net Profit ($)	ROI (%)	Benefit-Cost Ratio
100	75	415,017.50	682,760.00	-267,742.50	-39.21	0.61
100	130	607,677.00	682,760.00	-75,083.00	-11	0.89
100	200	852,880.00	682,760.00	170,120.00	24.92	1.25
171	75	523,150.50	682,760.00	-159,609.50	-23.38	0.77
171	130	715,810.00	682,760.00	33,050.00	4.84	1.05
171	200	961,013.00	682,760.00	278,253.00	40.75	1.41
250	75	643,467.50	682,760.00	-39,292.50	-5.75	0.94
250	130	836,127.00	682,760.00	153,367.00	22.46	1.22
250	200	1,081,330.00	682,760.00	398,570.00	58.38	1.58

Conclusion

- Hybrid system is the most viable near-term pathway for Bow Valley biochar (positive early returns, practical for pilot deployment).
- Centralized and mobile models face limitations from high capital costs, finite biomass, and low throughput.
- Opportunities exist in biochar and CORC markets, but regulatory and certification barriers must be addressed for scale-up.

Recommendation

The study recommends piloting a hybrid model for early adoption while monitoring policy and buyer trends.

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