Alternative Analysis for Mill Waste

Humboldt County, CA

Prepared for Redwood Coast Energy Authority

CAPSTONE

SPRING 2020

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Objective

Find alternative uses for the 560,000 MT/year of mill waste being combusted by DG Fairhaven and the Humboldt Sawmill Company that satisfy Economic, Environmental, and Social criteria

Times Standard (2016)

Criteria

Criteria	Weights
Economic	
Payback Period (years)	5
Operational Flexibility (range treated)	5
Environmental	
GHGs (MT CO_2-eq/BDT)	2
Particulate Matter (kg/BDT)	2
NOx (kg/BDT)	$1.\overline{3}$
SOx (kg/BDT)	$1.\overline{3}$
CO (kg/BDT)	$1.\overline{3}$
Carbon Sequestration (%)	0.5
Decentralized Utilization (km)	1
Ecological Impact (km^2)	0.5
Social	
Employment (# of people)	6
Public Concern	4

Pyrolysis

Input:

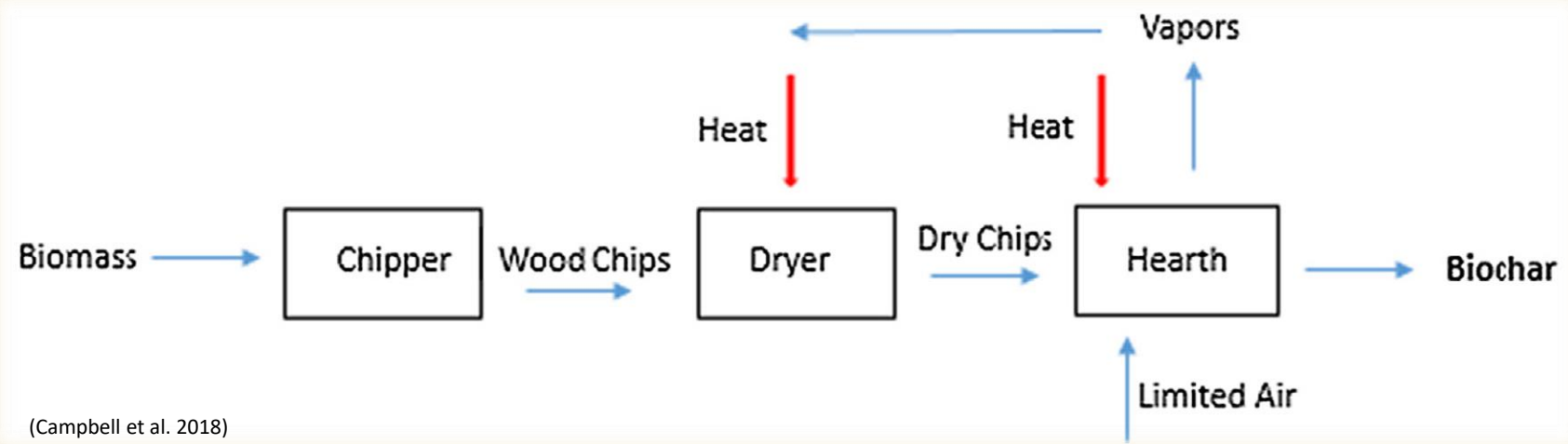
- Biomass Feedstock – 562,000 MT/year (wet)

Output:

- Biochar – 75,600 MT/yr ~ 27 wt%
- CO_2-eq – 18,500 MT/yr

Unit: 1 ton/hr feedstock

System: 43 units in parallel



(Campbell et al. 2018)

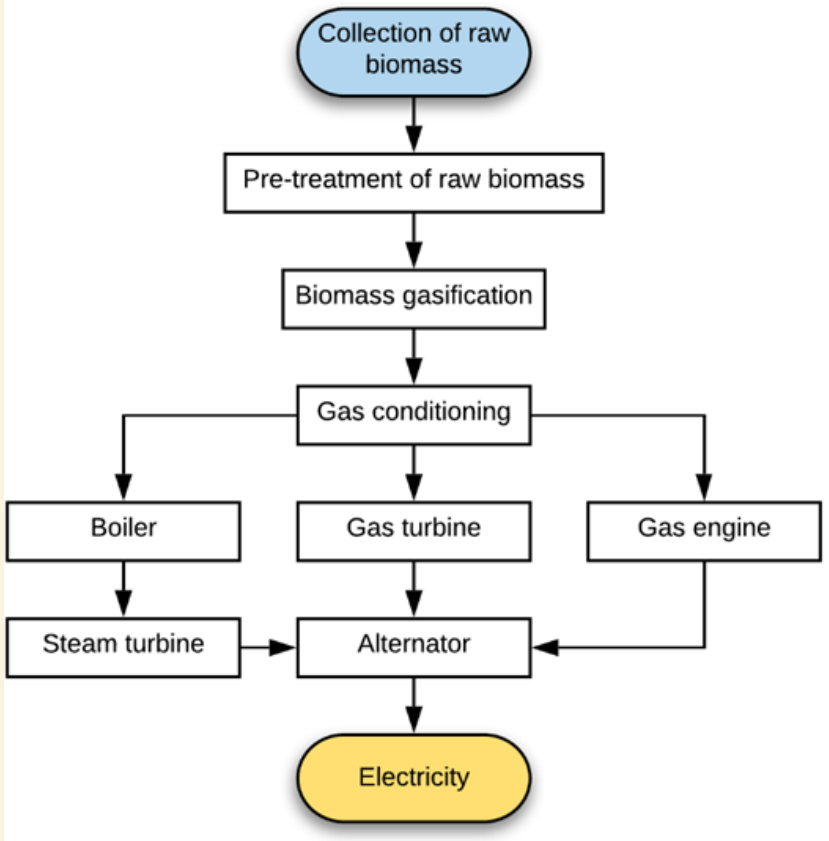
Gasification

Inputs:

- 562,000 MT/year feedstock (wet weight)

Outputs:

- 48 MW electricity produced
- 42,000 MT/year biochar production



Gasification Flow Chart (Adapted from Sansaniwal et al. 2017)

Tissue Manufacturing

Introduction
Alternatives
Preferred Alternative
Conclusion
Pyrolysis
Gasification
Tissue Manufacturing
Organic Mulch
Summary

Inputs:

- 115k MT-wood & 158k MT-recycled paper
  - 50/50 pulp mixture
- 6.2 – 8.6 L-water/kg-tissue
- 13.6 – 50.2 g-chemical/kg-tissue
  - Soda, OC, Resin, CO_2-liquid, Urea, H_3PO_4, O_2

Outputs:

- 210,000 MT of tissue
- CO_2-eq of 865 MT/year

Toilet paper manufacturing process, before packaging (Zagorsky 2020).

Organic Mulch

Introduction
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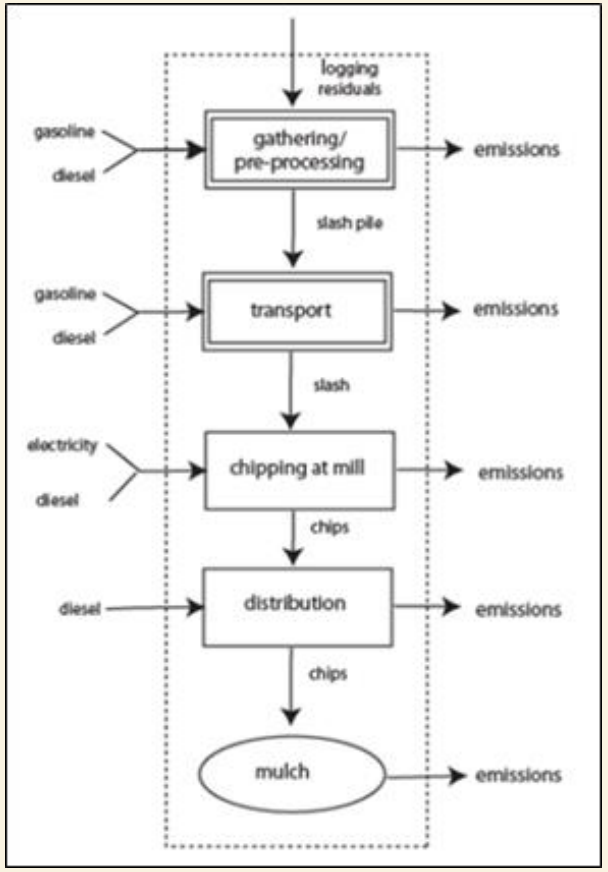
Summary

Inputs:

- 562,000 MT/year feedstock (wet weight)

Outputs:

- 4,218 MT/year of mulch for commercial/agricultural use
- 51,942 MT/year of mulch as ADC and Non-ADC at the HWMA
- 2.0 MT CO_2-eq/BDT processed



Organic Mulch Flow Chart (Lee et al. 2010)

Summary

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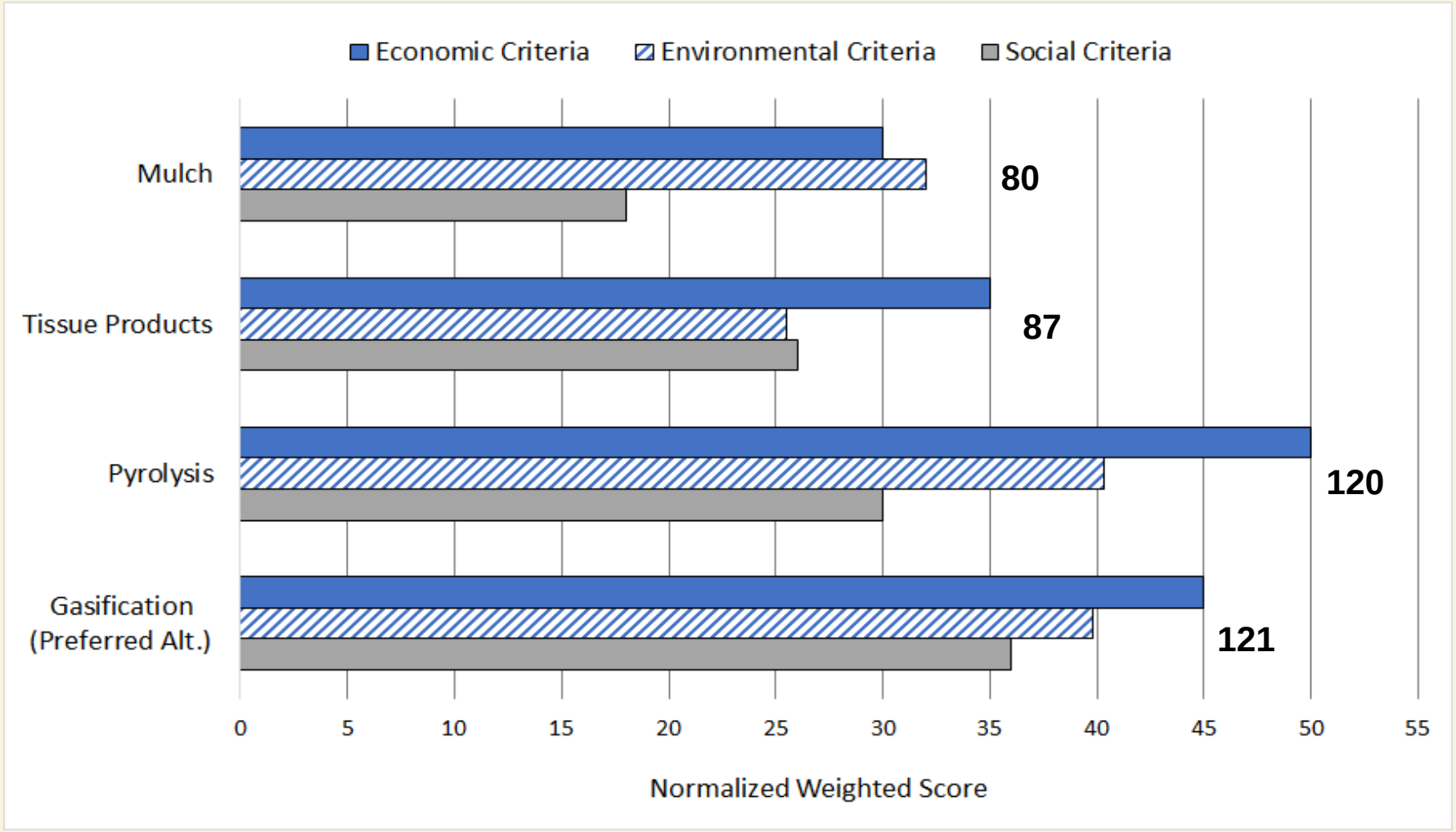
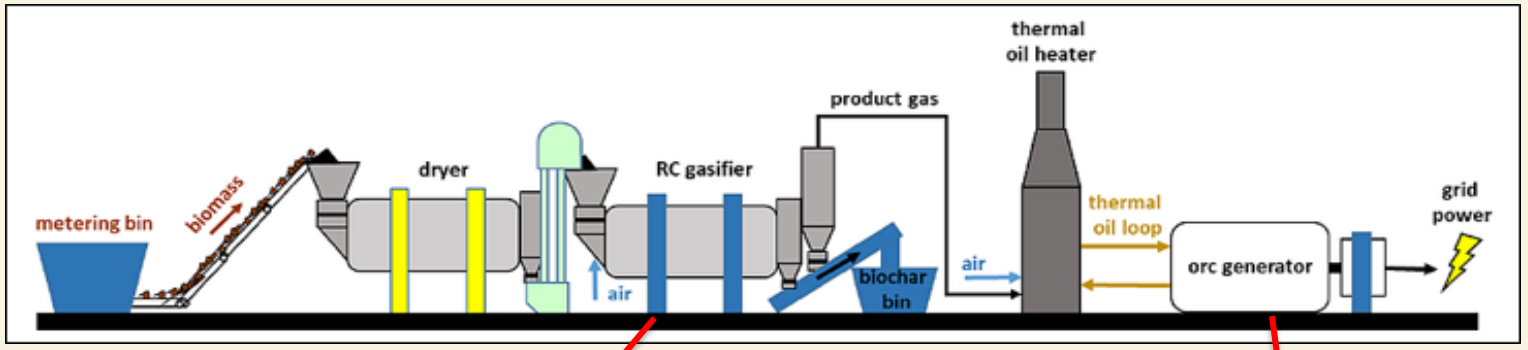


Preferred Alternative - Modular Gasification



(CEC 2019)

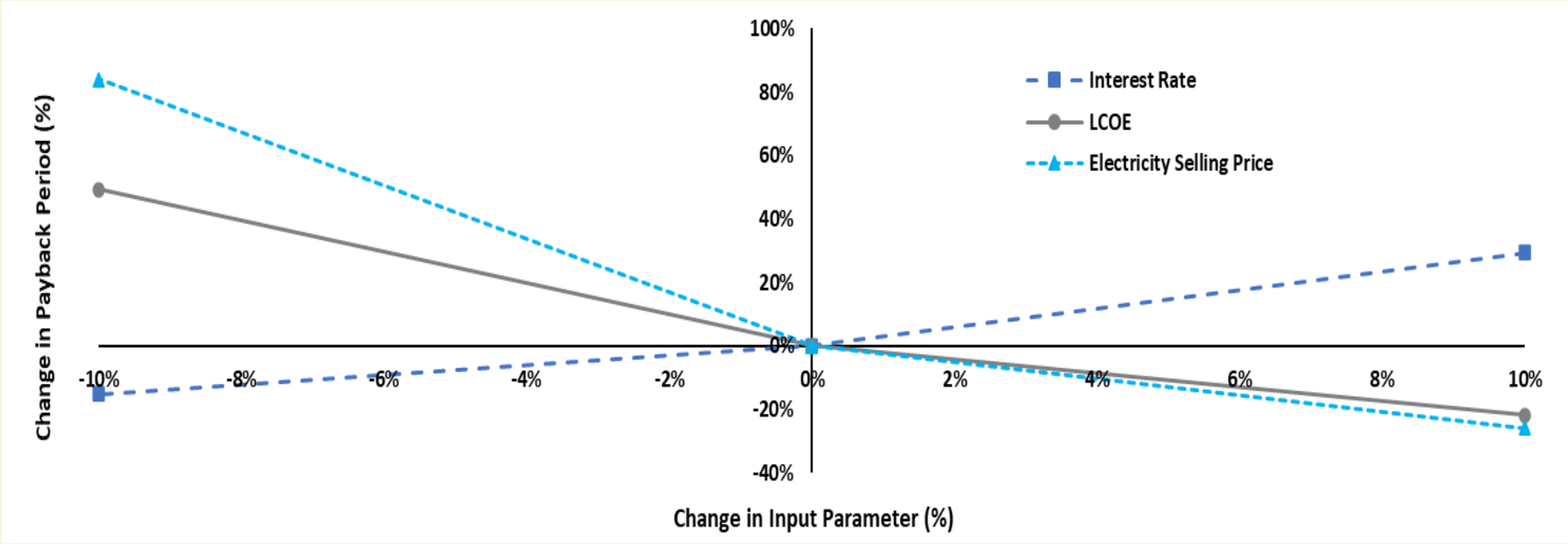
Modular Rotary Gasifier (WestBiofuels 2020)

Commercial 3 MW Organic Rankine Cycle (ORC) Generator (CEC 2019)

Preferred Alternative - Modular Gasification

Discounted Payback Period	
Lifespan (years)	30
Interest Rate (%)	8.0
Capital Costs ($M)	270.2
Annual Costs ($M)	32.8
Net Annual Revenue ($M)	58.5
Net Annual Income ($M)	25.6
LCOE ($/MWh)	-61
Electricity Selling Price ($/MWh)	78
Discounted Payback Period (years)	24.1

Preferred Alternative - Modular Gasification



Interest rate, levelized cost of electricity (LCOE), and electricity market price all have significant effects on discounted payback period and success of project

Conclusion

- Use of DG Fairhaven as the site because of proximity to PG&E substation
- The need for a biochar market in Humboldt County (42,000 MT/year)
- Cost of Electricity and LCOE
- Optimize location to reduce costs and emissions from transportation
- Identify loans, grants, and incentives to reduce capital costs

Location of DG Fairhaven parcel number 40112111

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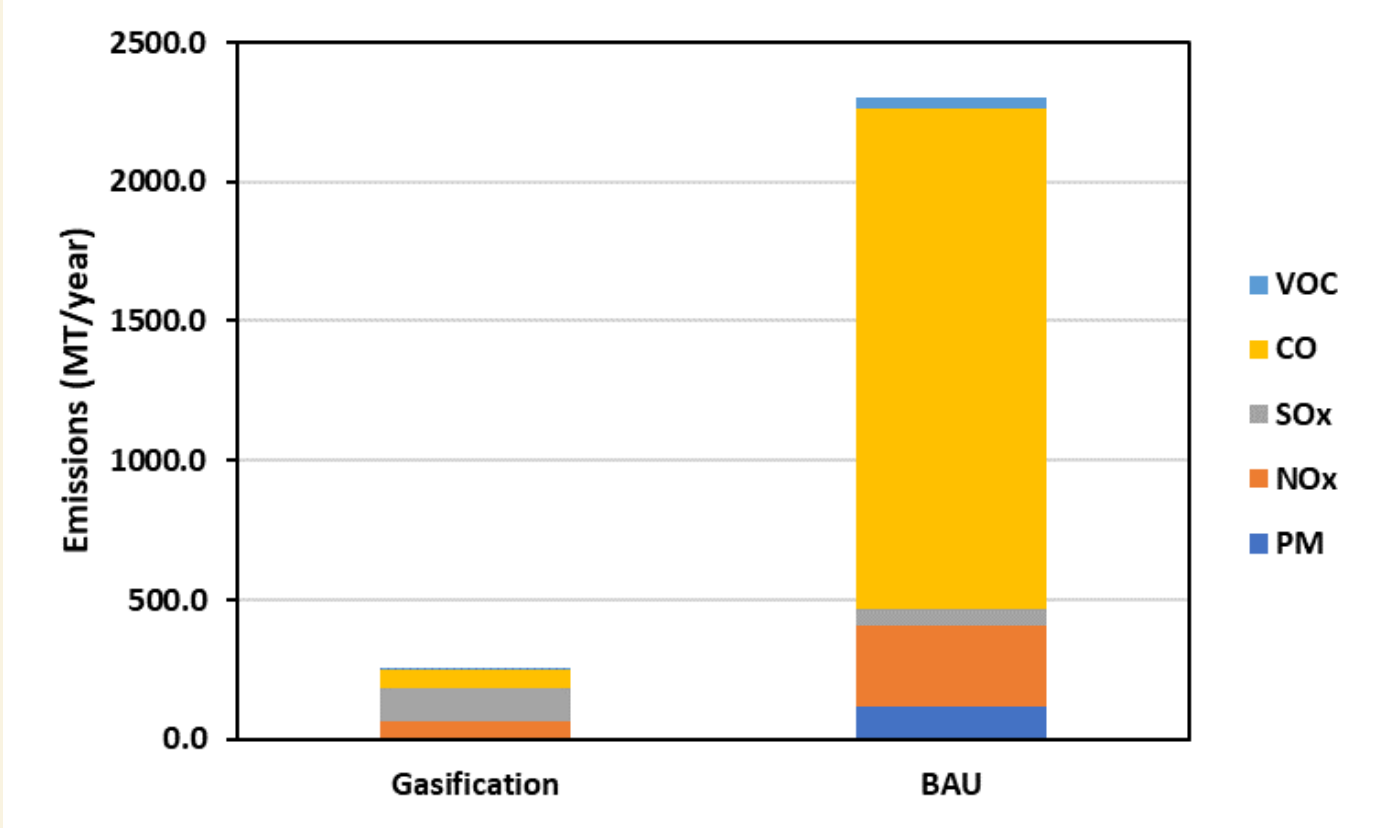
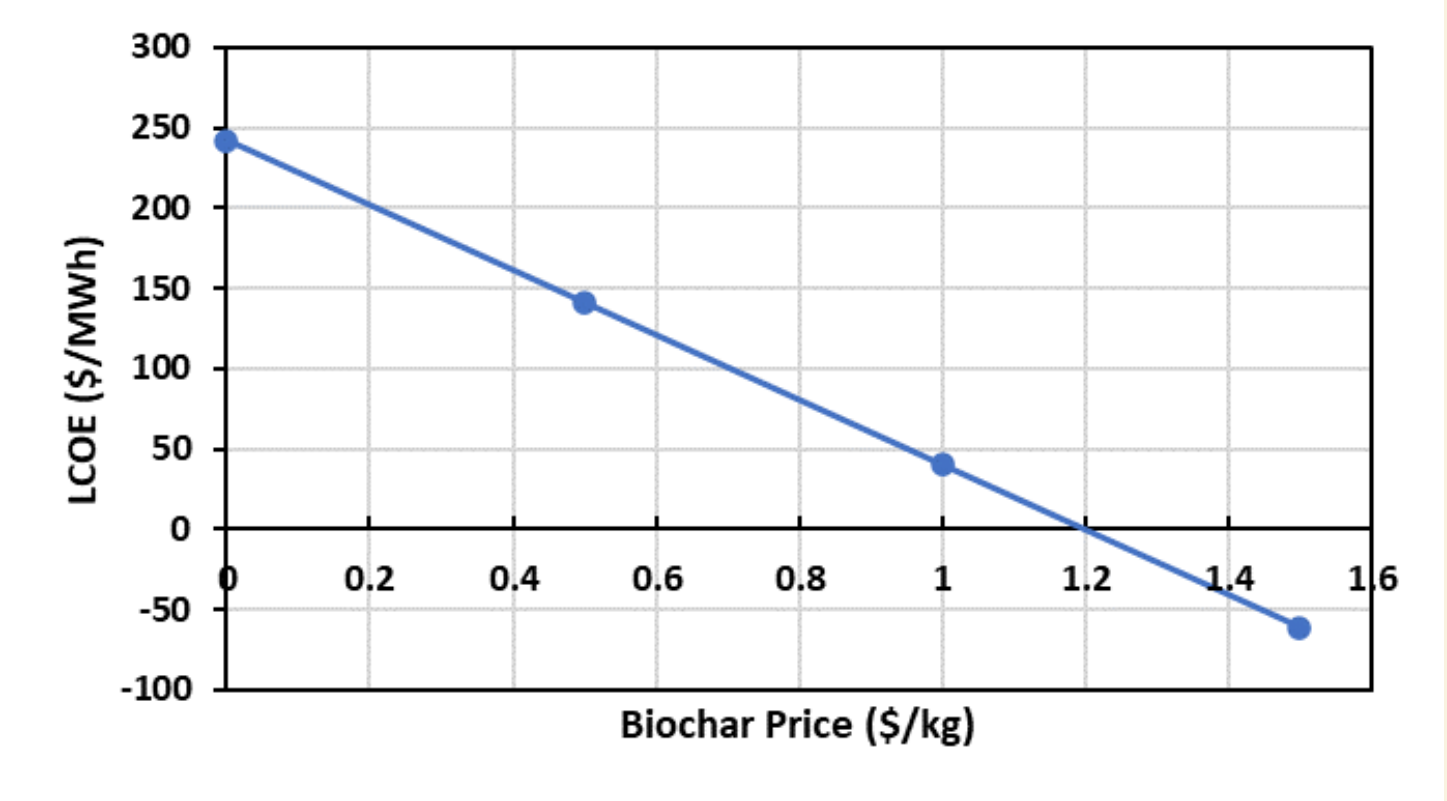
Emissions Comparison with BAU



Comparison of emissions for gasification and BAU case (CARB 2020)

Emissions Comparison with BAU



Impacts of biochar price on the levelized cost of energy (CEC 2019)

Alternative's Scoring

	Gasification	Pyrolysis	Tissue Products	Mulch
Economic				
Payback Period (years)	13.4	6.0	125	22
Operational Flexibility (range treated)	Very High	Very High	Low	High
Environmental				
GHGs (MT CO2-eq/BDT)	1.13	0.07	0.00	2.00
Particulate Matter (kg/BDT)	0.06	0.06	0.90	0.02
NOx (kg/BDT)	0.25	2.21	0.60	0.00
SOx (kg/BDT)	0.23	0.25	0.85	0.00
CO (kg/BDT)	0.11	0.20	2.60	0.20
Carbon Sequestration (%)	37	55	46	20
Decentralized Utilization (km)	<1	<1	10.5	161
Ecological Impact (km^2)	0.02	0.14	0.42	0.06
Social				
Employment (# of people)	235	106	171	22
Public Concern	Average	Average	High	Average

Delphi Matrix

Criteria	Normalized Weight of Criteria	SCORE			
		Gasification	Pyrolysis	Sanitary Tissue	Mulch
Payback Period (years)	5	20	25	25	10
Operational Flexibility (range treated)	5	25	25	10	20
GHGs (MT CO2-eq/BDT)	2	6	10	10	2
Particulate Matter (kg/BDT)	2	8	6	2	8
NOx (kg/BDT)	1.3	5	5	1	7
SOx (kg/BDT)	1.3	5	7	5	7
CO (kg/BDT)	1.3	7	5	1	7
Carbon Sequestration (%)	0.5	1	2	1	1
Decentralized Utilization (km)	1	5	4	4	1
Ecological Impact (km^2)	0.5	3	2	1	1
Employment (# of people)	6	24	18	18	6
Public Concern	4	12	12	8	12
Weighted Score		**121**	**120**	**87**	**80**