

# Humboldt Biomass Alternative Analysis



## **Team Biomasssters**

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Prepared for RCEA

# Project Objective and Scope

- The objective of this project is to assess technical, economic, and environmental aspects of an alternative use of biomass feedstock in Humboldt County for the Redwood Coast Energy Authority (RCEA).
- The scope of this project does not include the analysis of how RCEA will make up for the energy lost if their biomass plant sources cease to exist.

# Criteria

Criteria	Weight
Environmental Criteria	
Greenhouse Gas (GHG) Emissions - CO2e/BDT % Reduction	4
Air Pollution - MT/Yr	4
Land Use Requirement - Acres	2
Social Criteria	
Employment - # of Jobs	3
Technology Maturity - TRL 1-9	2
Public Acceptance - % Acceptance	5
Economic Criteria	
Simple Payback Period - Years	10



## Constraints

- ▶ Must meet the local/regional air quality regulations (Title V if applicable).
- ▶ Primarily focused on: PM<sub>10</sub>, PM<sub>2.5</sub>, CO, NO<sub>2</sub>, CH<sub>4</sub>, and CO<sub>2</sub>
- ▶ The alternative must have the capacity to meet the current demand for biomass from both local power plants (DG Fairhaven, HRC Scotia)

# Alternative 1: Gasification

## Overview

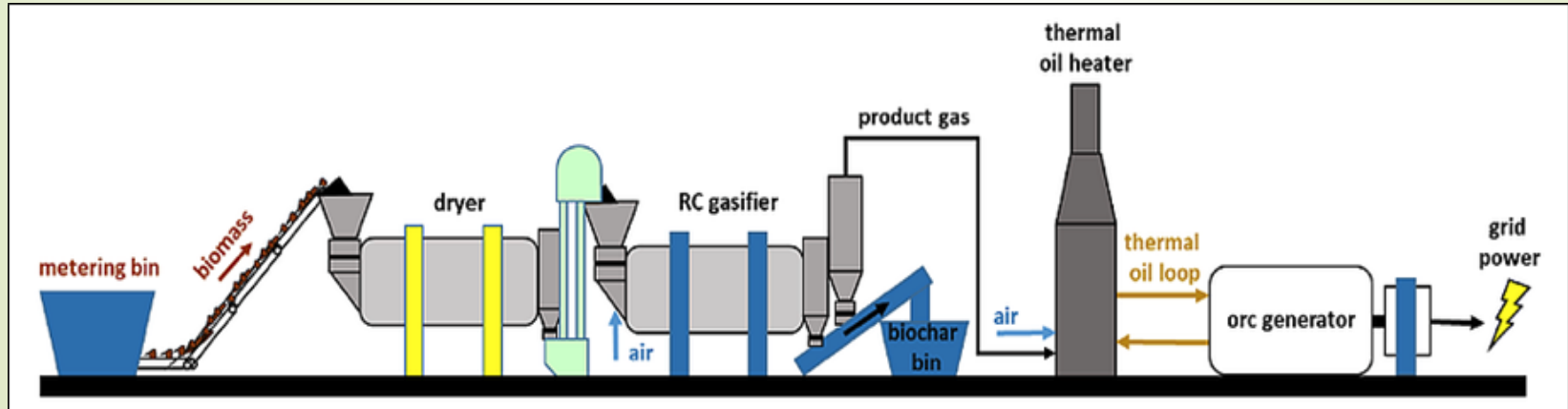
- Solids dryer
- Thermal oil heater
- Heat exchanger
- Organic Rankine Cycle

## Specifications

- Price of energy produced \$199/MWh
- Cost of biochar \$250/BDT (Westbiofuels 2018)
- 45% conversion rate

## Advantage/Disadvantages

- + Low air pollution
- + Marketable product (biochar)
- Relatively new (TRL 6.5)
- Low public acceptance (50%)
- Long payback period (14 year)



(WestBiofuels 2018).

# Alternative 2: Composting

## Overview

- Aerobic decomposition of organic matter mediated by micro-organisms to produce a soil amendment (David Boarder Composting Consultancy 2020)

## Specifications

- Windrow compost - faster conversion to soil amendment (Brodie et. al. 2000)
- 8,610 kg/wk nitrogen-rich material

## Advantages/Disadvantages

- + High Number Jobs (479)
- + TRL (9)
- Needs nitrogen-rich material (food waste, yard waste, cattle manure, grass clipping)
- Large Area (87 acres)



(SUEZ in UK. 2020)



# Alternative 3: Torrefaction

## Overview

- Thermochemical Process (mild form of Pyrolysis)

## Specifications

- 1 kg of torrefied wood for every 1.328 kg of woody biomass (NETL 2012)
- \$40 per ton of torrefied wood (Ortiz et al. 2011)

## Advantages/Disadvantages

- + Torrefied wood has properties similar to that of coal
- + There are many applications for the product
- + Emissions are lower
- Maturing technology (TRL 5)



(Bioresources 2017)

# Alternative 4: Biomass to Ethanol

## Overview

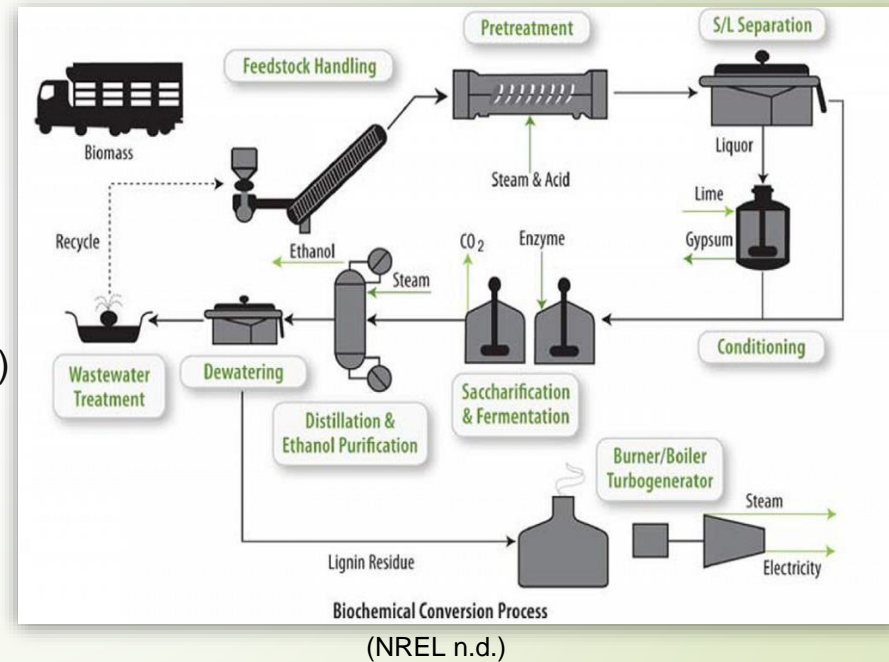
- Biochemical Process; sugars are extracted from biomass, fermented, then distilled to Ethanol

## Specifications

- 82 Gallons/ton feedstock
- Theoretical Yield: 37 Mgal
- \$2.20/gal of Ethanol (USDA 2020) (U.S. Code § 40A)

## Advantages/Disadvantages

- + Feedstock utilization (all @ current moisture)
- + Fossil-fuel replacement
- High capital and operating costs (>300 M\$)
- Maturing technology (TRL 6)





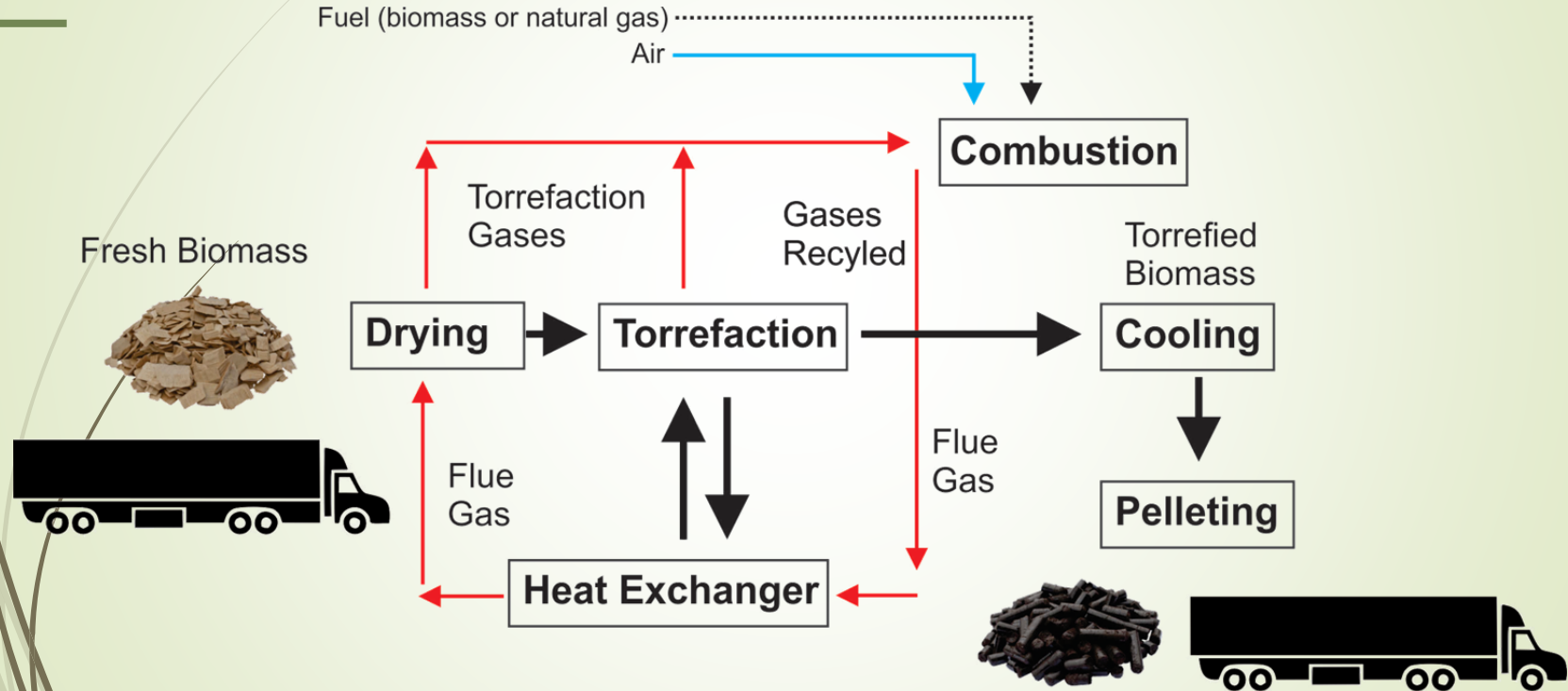
# Quantifiable Indicators

Criteria	Gasification	Compost	Torrefaction	Liquid Fuel
<b>GHG (MTCO<sub>2</sub>e/BDT) (% Change)</b>	~99.0%	-83.45%	-94.08%	-99.66%
<b>Air Pollution (MT/BDT)</b>	7x10 <sup>-6</sup>	6x10 <sup>-4</sup>	1.3x10 <sup>-4</sup>	2.9x10 <sup>-4</sup>
<b>Land Use (Acres)</b>	12.7	87	20.6	14
<b>Employment (Jobs)</b>	94	480	39	52
<b>Maturity (TRL)</b>	7	9	5	6
<b>Public Acceptance (%)</b>	50%	77%	>90%	62%
<b>Payback Period (Years)</b>	14	12	4	30

# Delphi Matrix

Criteria	Weight	Gasification		Composting		Torrefaction		Liquid Fuel	
		Allocated	Weighted	Allocated	Weighted	Allocated	Weighted	Allocated	Weighted
Environmental Criteria									
GHGs	4	10	40	4	16	8	32	9	36
Air Pollution	4	10	40	2	8	8	32	6	24
Land Use	2	8	16	1	2	4	8	6	12
Social Criteria									
Employment	3	9	27	10	30	5	15	6	18
Maturity	2	7	14	9	18	5	10	6	12
Acceptance	5	5	25	7	35	10	50	7	35
Economic Criteria									
Payback	10	6	60	10	100	9	90	1	10
Score	High	222		209		237		147	

# Preferred Alternative: Torrefaction



(modified from Cremers 2015).

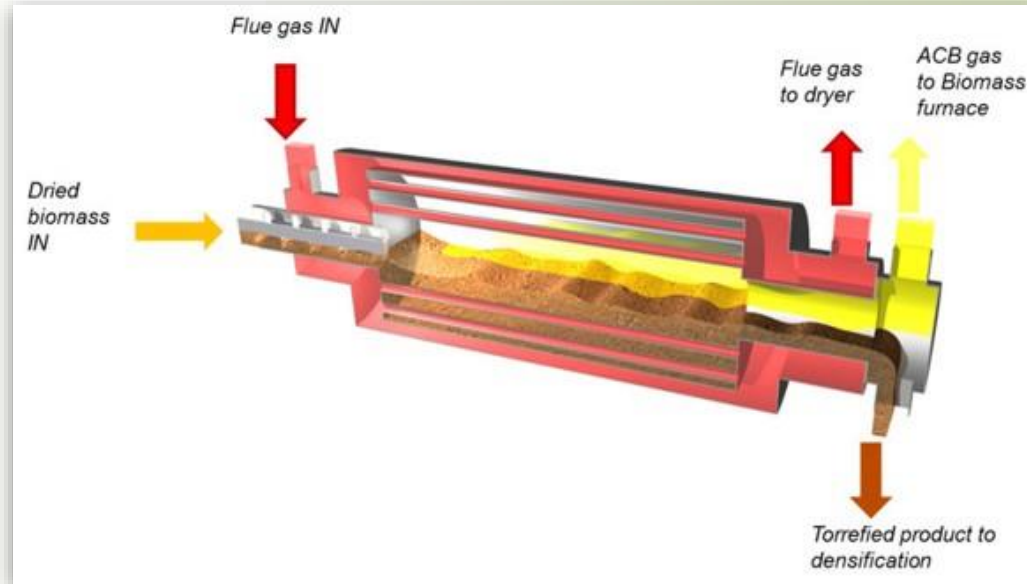
# Specifications

## Torr-Coal Rotary Torrefier

- Torrefied at a high Temperature (270°C)
- Individual reactor feedrate- 4500 kg/hr
- 7 parallel reactors to meet 561,600 MT/yr

## Torrefied Pellets

- Lower Heating Value 20-24 MJ/kg
- 1.47 kg of biomass for 1 kg of pellets
- Hydrophobic and resistant to biodegradation
- Reduced moisture content to 1-5%



(Shoulaifar 2015).

# Employment



(Canadian Biomass Magazine 2019)

Baseline			
Location	Direct	Indirect	Total
DG Fairhaven	22	19	41
HRC Scotia	25	30	55
Total Employment			96

(CBEA 2020a, CBEA 2020b, Randolph 2012)

Torrefaction (280,800 Dry MT Feed)		
Area	Jobs/1000 tons	Jobs
Harvesting	0.36	84
Operation	0.24	56
Construction	0.50	116
Total Employment		250

(Lambrecht et al. 2011)

# Total Emissions



(Magill 2016)

## GHGs

Facility	MW	CO <sub>2</sub> (MTCO <sub>2</sub> e/year)	CH <sub>4</sub> (MTCO <sub>2</sub> e/year)
HSC Scotia	32.5	282,000	2,200
DG Fairhaven	18.7	183,000	1,400
Alternative 3: Torrefaction	NA	125,200	3

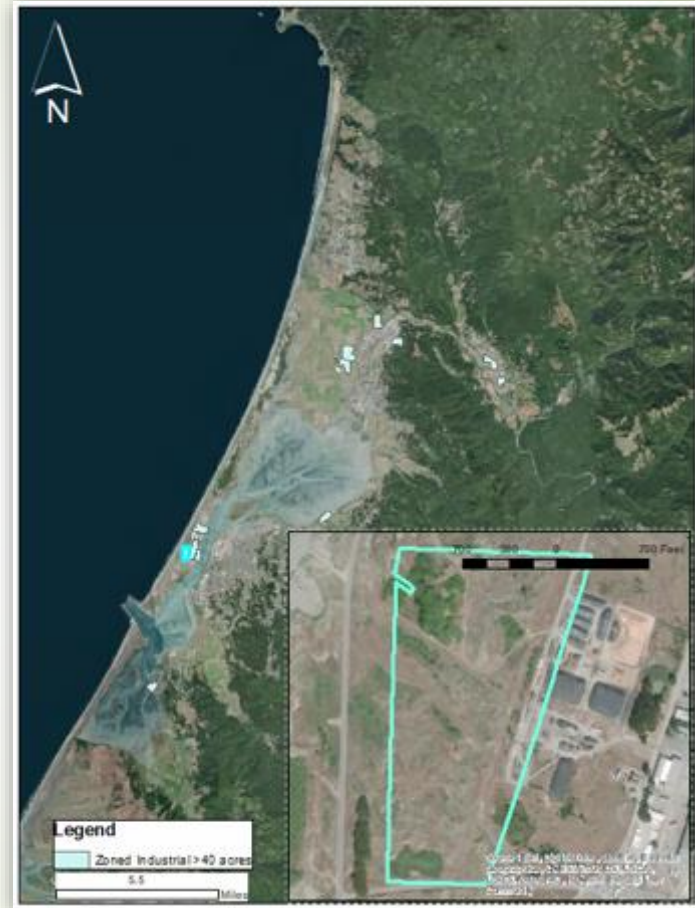
## Air Pollution

Facility	NO <sub>x</sub> (tons/year)	PM <sub>10</sub> (tons/year)	CO (tons/year)
HSC Scotia	160	36	640
DG Fairhaven	160	31	1,300
Alternative 3: Torrefaction	2	0.04	2



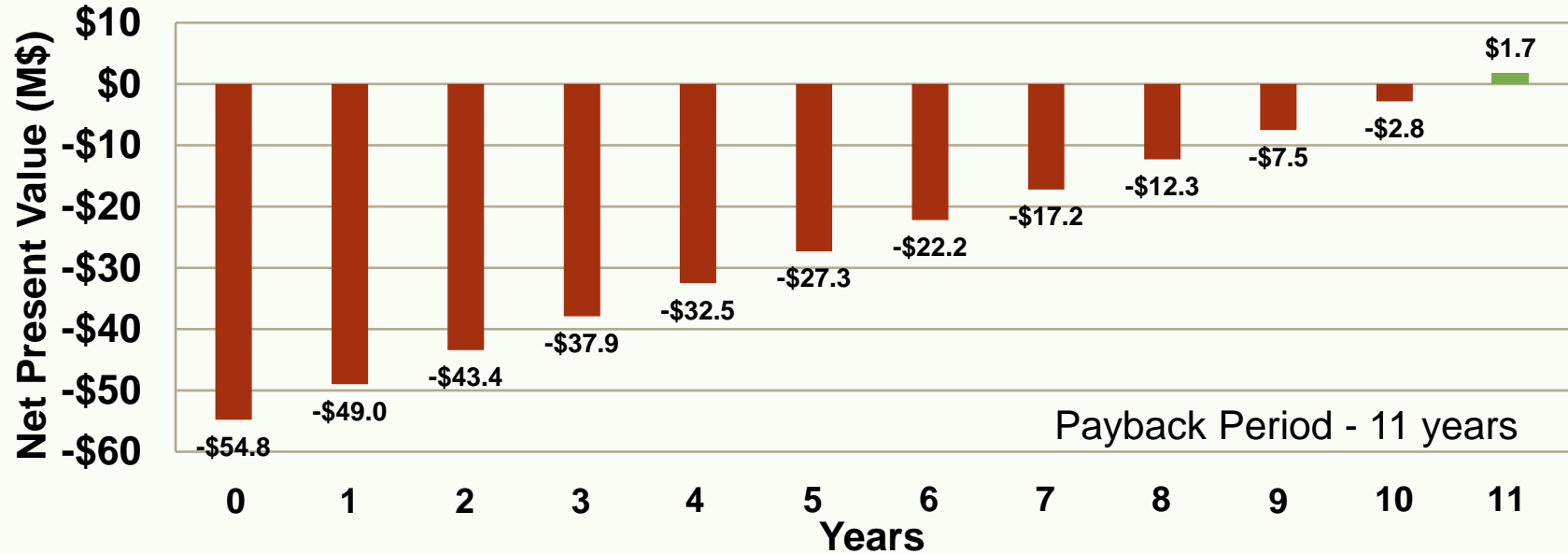
# Area

Area (Acres)		
Plant	15	(AFDP 1977) (CFDC 2006)
Storage/Expansion	40	(Carp 1987) (Mody 2012)
<b>Total</b>	<b>55</b>	



Possible 60 acre site for proposed torrefaction plant located on Samoa Peninsula

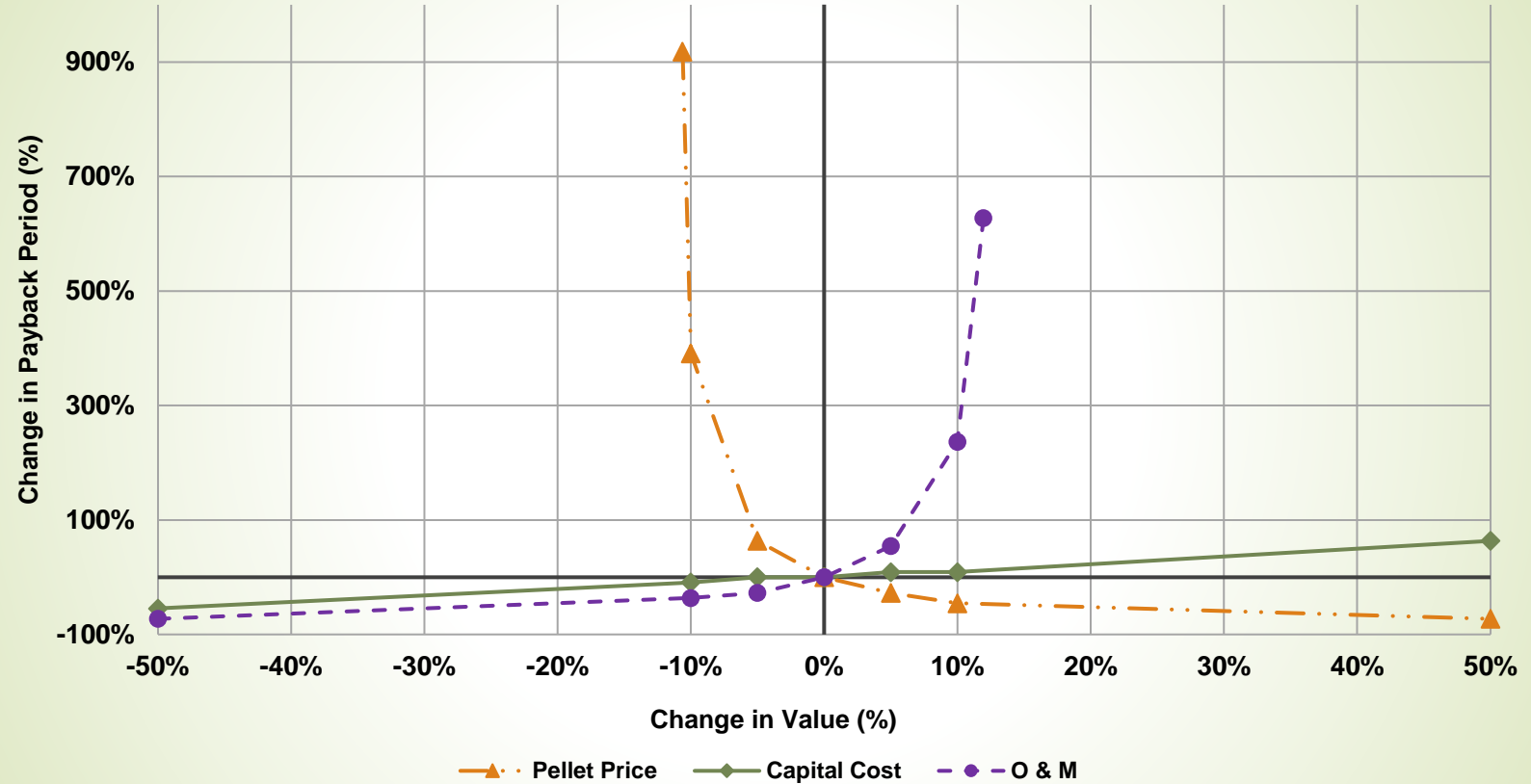
# Cost Analysis



Pellet Sell Price/ton - \$160 (Dovetail Partners, Inc 2013)

Nominal Interest Rate - 2.40% ( Lavappa et. Al. 2017)

# Sensitivity Analysis





## Conclusion and Recommendations

- Promising technology
- Find a market in California
- Perform full inventory of needed equipment, and their exact costs
- Create a detailed site plan for Humboldt location

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Thank you!  
Any Questions?





# Scoring Matrix

Scoring Matrix					
Criteria	Poor (1-2)	< Average (3-4)	Average (5-6)	> Average (7-8)	Excellent (9-10)
<b>GHG (MTCO<sub>2</sub>e/BDT) (% Reduction)</b>	<80%	80 - 85%	85% - 90%	90%-95%	>95%
<b>Air Pollution (Total MT/BDT)</b>	> 4x10 <sup>-4</sup>	4x10 <sup>-4</sup> - 3x10 <sup>-4</sup>	3x10 <sup>-4</sup> - 2x10 <sup>-4</sup>	2x10 <sup>-4</sup> - 1x10 <sup>-4</sup>	< 1x10 <sup>-4</sup>
<b>Land Use (Acres)</b>	>30	20 to 30	15 to 29	10 to 14	<10
<b>Employment (Jobs)</b>	<10	10-30	30-60	60-90	>90
<b>Maturity (TRL)</b>	TRL 1-2	TRL 3-4	TRL 5-6	TRL 7-8	TRL 9
<b>Public Acceptance (%)</b>	0-20%	20-40%	40-60%	60-80%	80-100%
<b>Payback Period (Years)</b>	30+	20 to 30	10 to 20	5 to 10	<5