

# Humboldt State University Undergraduate Presentation

Spring 2020

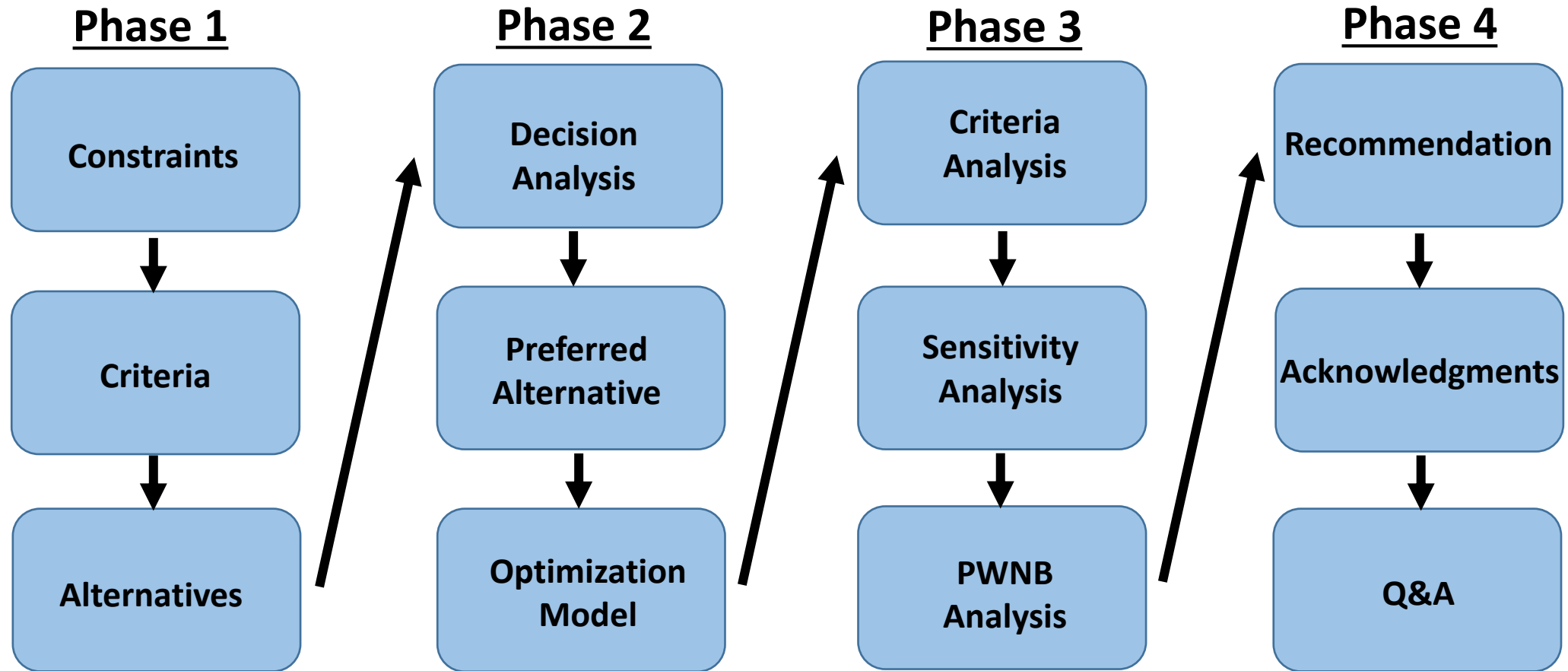
Wilfredo Cervantes | Terry Franklin | Lowen Hobbs | Kevin Isacson



REDWOOD COAST  
**Energy**Authority

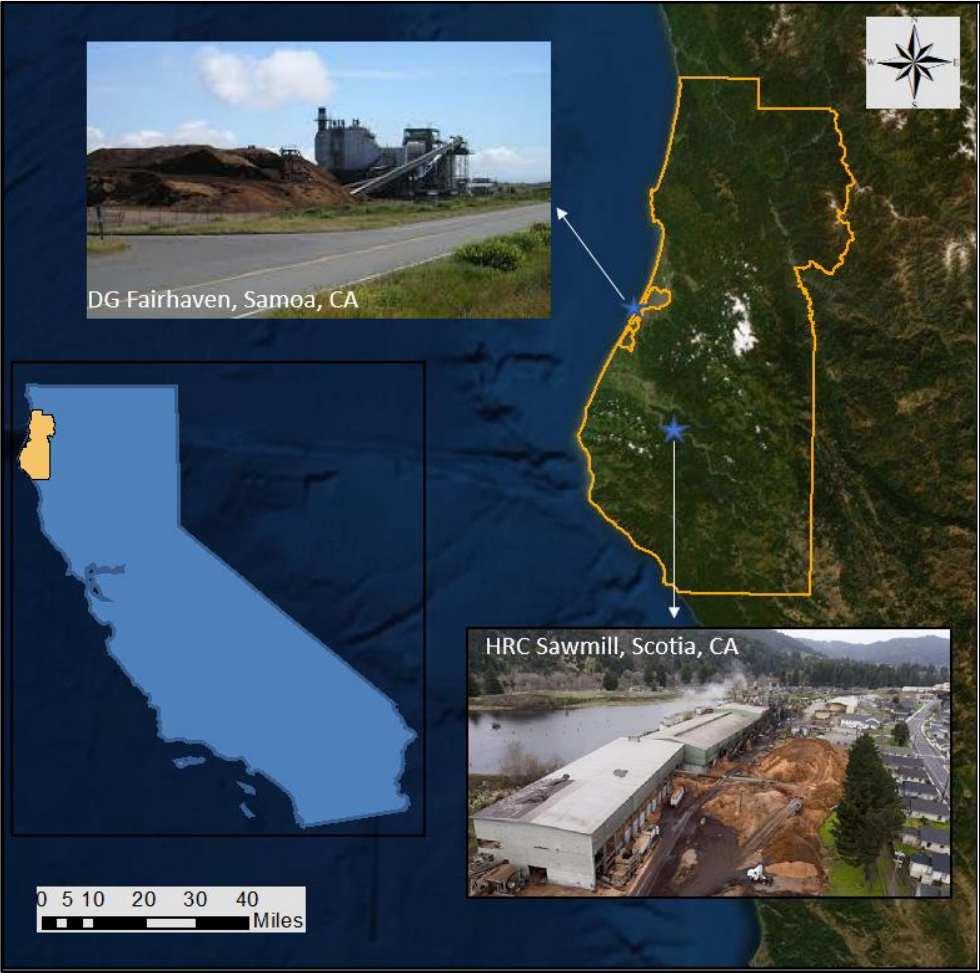
**Capstone Project:  
Alternative Biomass Utilizations in  
Humboldt County**

# Presentation Outline



# Constraints

Phase 1	Constraints
Phase 2	Criteria
Phase 3	Alternatives
Phase 4	



Constraints	Description		
Regulations	Must meet all local, state, & federal regulations		
Employment Opportunities	Jobs provided from an alternative must be greater than or equal to existing biomass energy facilities		
Facility	Direct	Indirect	Total
DG Fairhaven	22	19	41
HRC Scotia	25	30	25

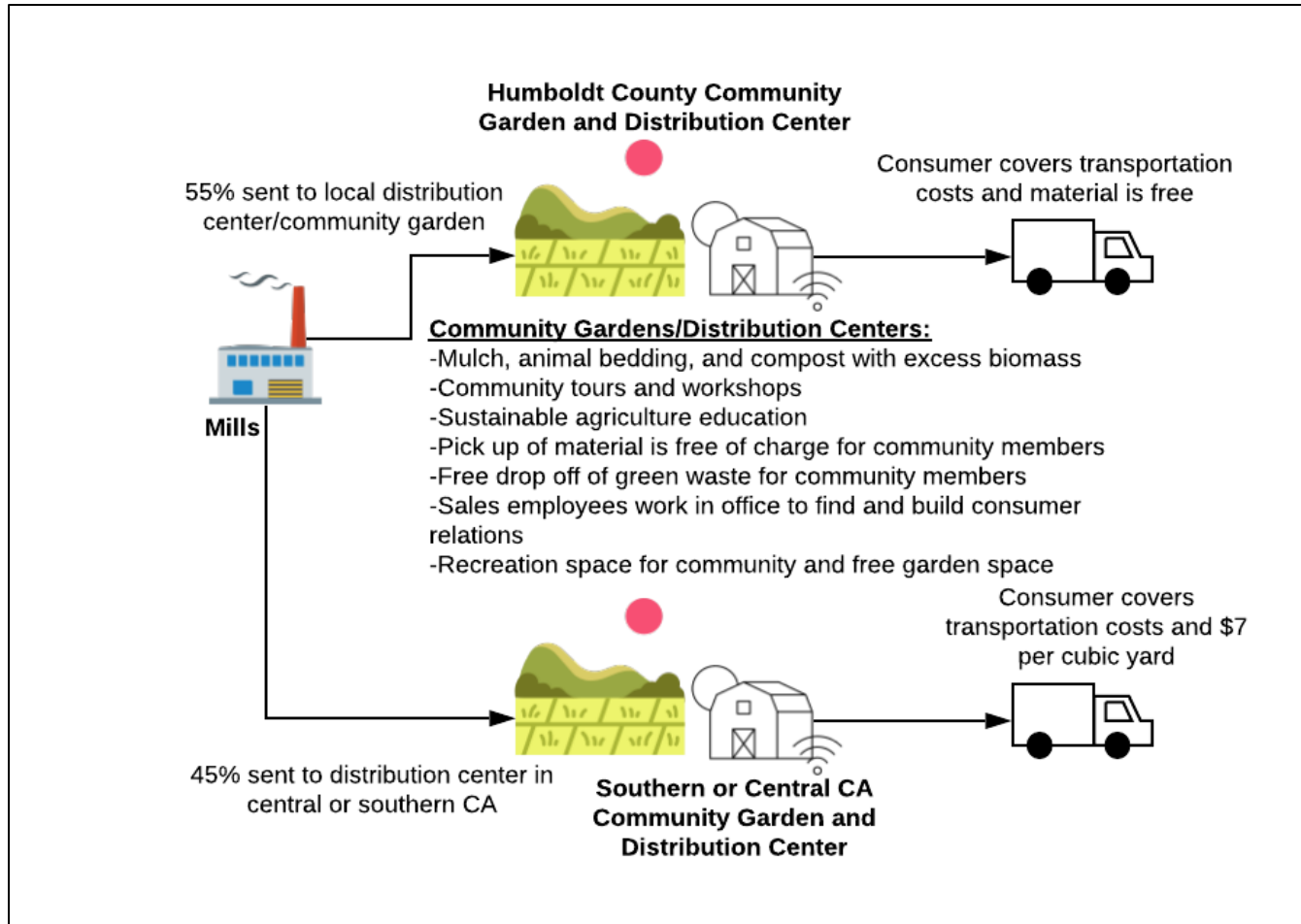
# Criteria

- Phase 1
- Constraints
- Phase 2
- Criteria
- Phase 3
- Alternatives
- Phase 4

Criteria	Description	Quantification
Social		
Aesthetics	Minimize change in visual effects to surrounding environment	Volume of unnatural structures (ft³)
Community Support	Maximize public approval	The percentage of the people who approve the project (%)
Economic		
Payback Period	Minimize time until a project begins making a profit	The number of years before a project begins to make a profit (years)
Employment Opportunities	Maximize job opportunities	Number of job opportunities that the project would produce or preserve (#)
Project Implementation	Maximize ability for implementation of project at the federal, state, and local level	Time required from approval to beginning operation of alternative (months)
Environmental		
Air Quality	Minimize air quality impacts	Amount of NAAQS pollutants (PM <sub>10</sub> , NO <sub>x</sub> , SO <sub>x</sub> , CO) (US tons/year)
Carbon Sequestration	Maximize sequestration of carbon	Amount of 20-year equivalent CO <sub>2</sub> sequestered per year (US tons eq. CO <sub>2</sub> /yr)

# Distribution Network

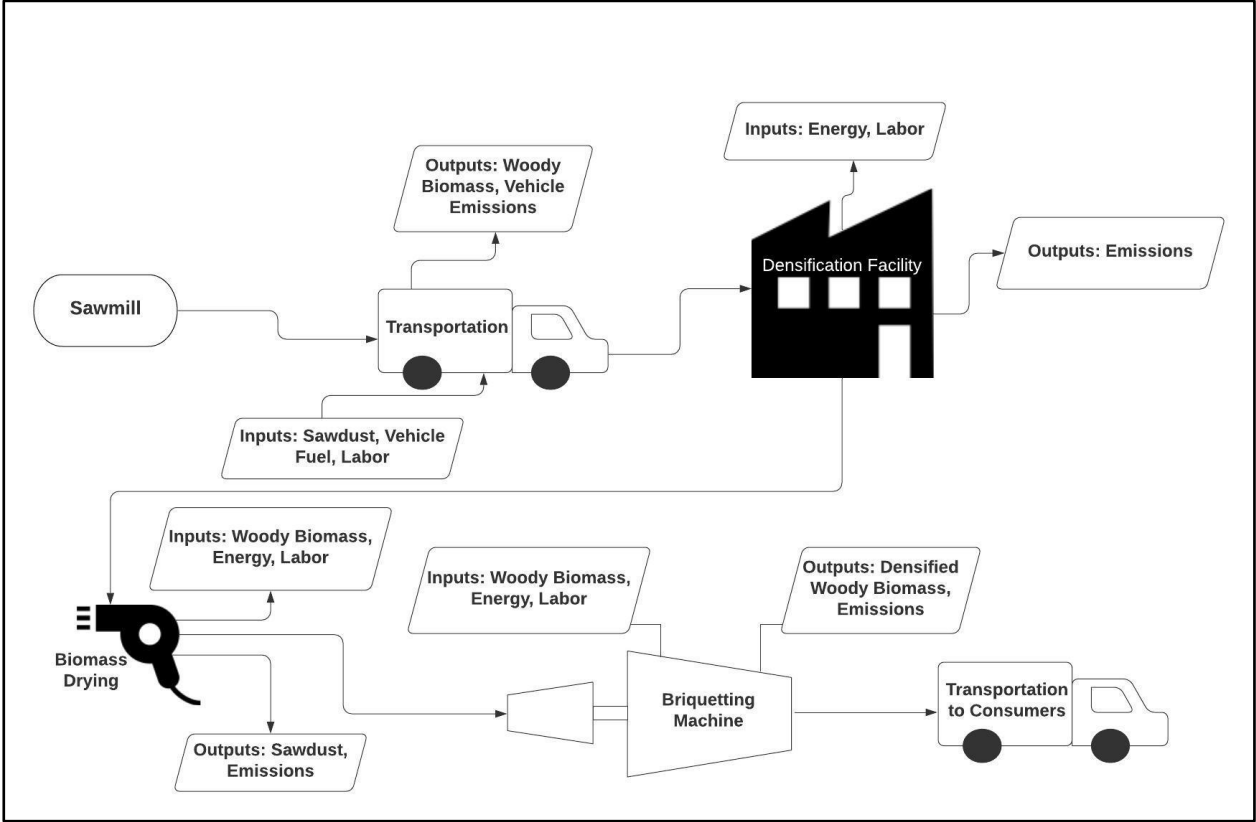
Phase 1 Constraints  
Phase 2 Criteria  
Phase 3 **Alternatives**  
Phase 4





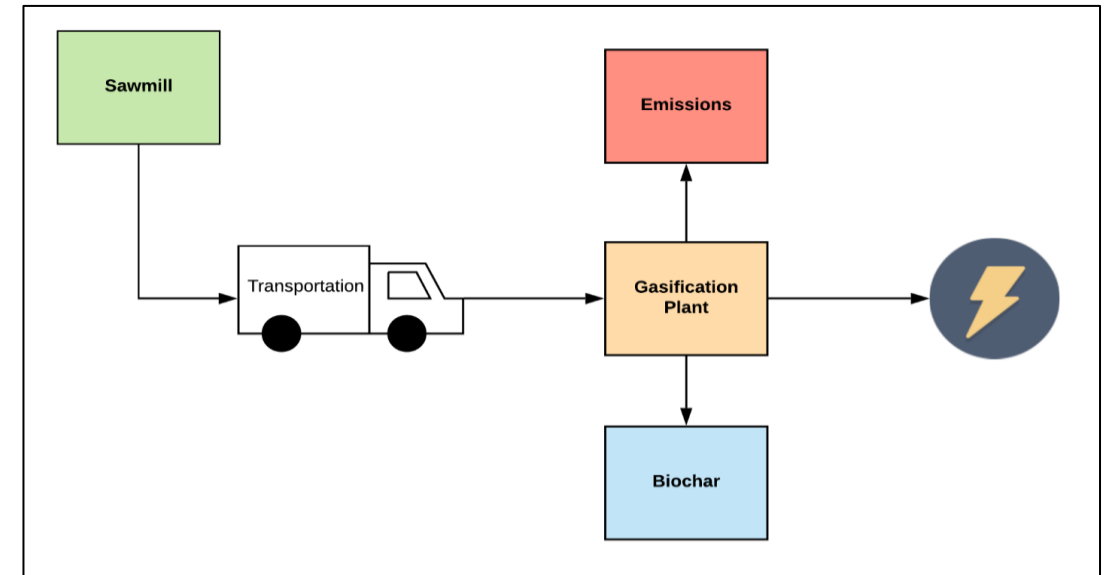
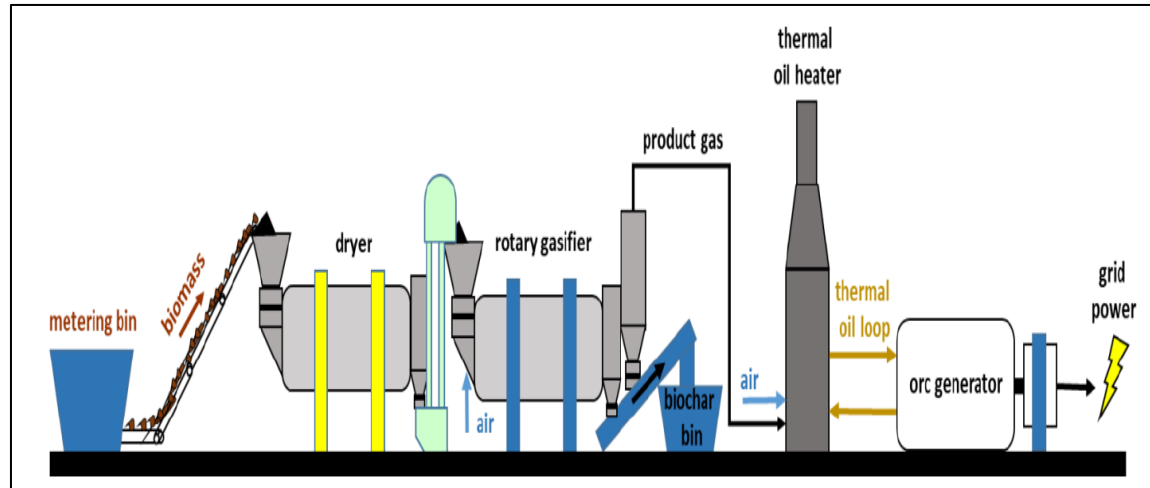
# Densification Facility

Phase 1	Constraints
Phase 2	Criteria
Phase 3	Alternatives
Phase 4	



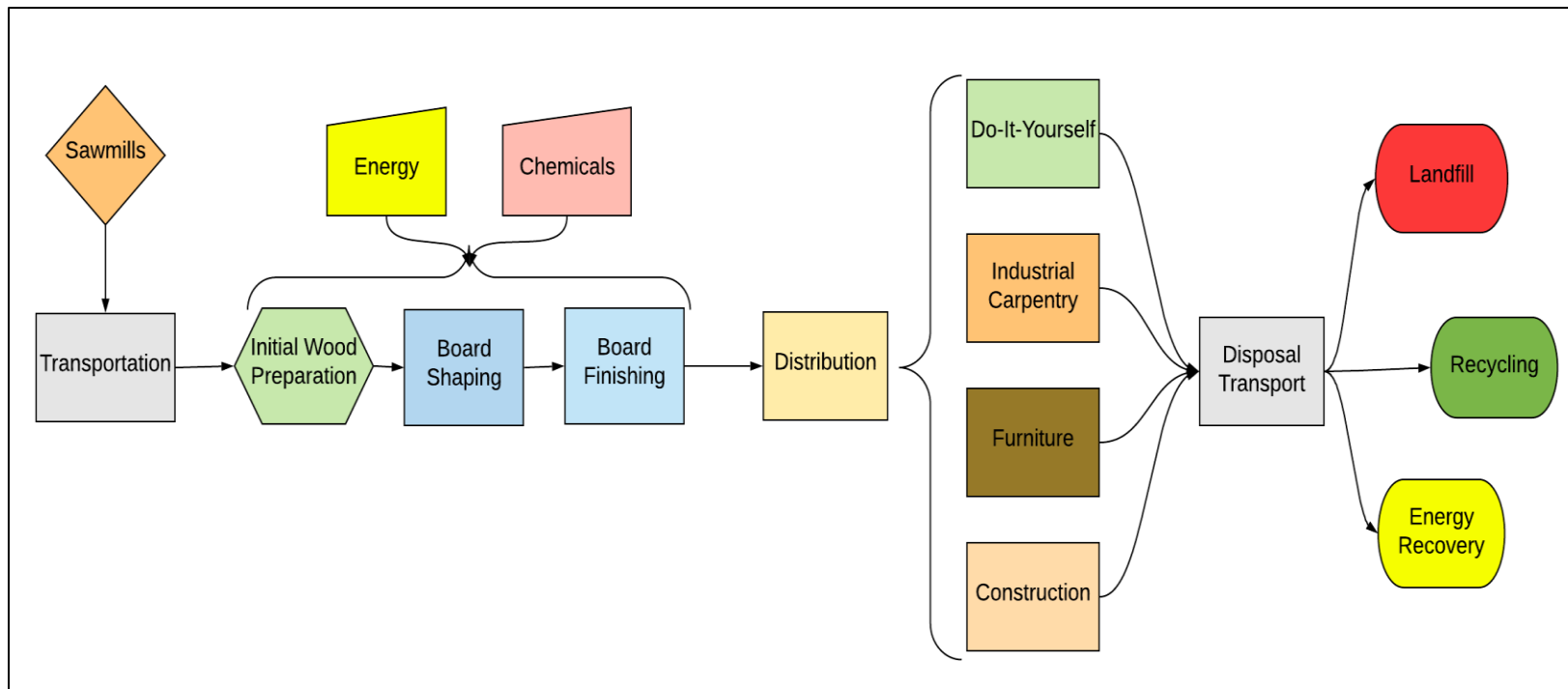
# Community-Scale Gasification

Phase 1 Constraints  
Phase 2 Criteria  
Phase 3 **Alternatives**  
Phase 4



# Particleboard Facility

**Phase 1** Constraints  
Phase 2 Criteria  
Phase 3 **Alternatives**  
Phase 4





# Client Weights

Criteria	Description	Quantification	Client Weight (1-10)
Social			
Aesthetics	Minimize change in visual effects to surrounding environment	Volume of unnatural structures (ft <sup>3</sup> )	2
Community Support	Maximize public approval	The percentage of the people who approve the project (%)	5
Economic			
Payback Period	Minimize time until a project begins making a profit	The number of years before a project begins to make a profit (years)	4
Employment Opportunities	Maximize job opportunities	Number of job opportunities that the project would produce or preserve (#)	4
Project Implementation	Maximize ability for implementation of project at the federal, state, and local level	Time required from approval to beginning operation of alternative (months)	2
Environmental			
Air Quality	Minimize air quality impacts	Amount of NAAQS pollutants (PM <sub>10</sub> , NO <sub>x</sub> , SO <sub>x</sub> , CO) (US tons/year)	5
Carbon Sequestration	Maximize sequestration of carbon	Amount of 20-year equivalent CO <sub>2</sub> sequestered per year (US tons eq. CO <sub>2</sub> / yr)	5

# Delphi Matrix

- Phase 1 Client Weights
- Phase 2 Delphi Method
- Phase 3 Pugh Method
- Phase 4 Preferred Alt.  
Opt. Model

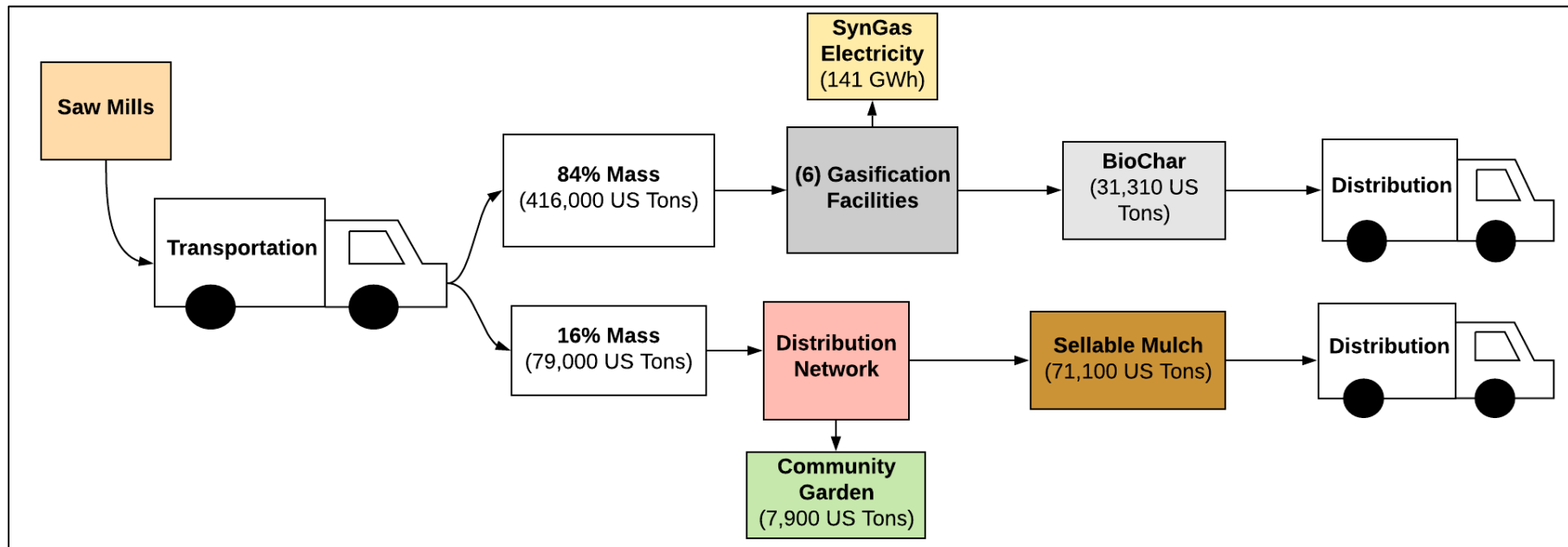
Criteria	Weight of Criteria	Alternative Scores (1-5)			
		Biomass Fuel Densification Facility	Particleboard Facility	Distribution Network	Community-Scale Biomass Gasification
Social Criteria					
Aesthetics	3	4	3	5	4
Community Support	7	4	1	5	2
Economic Criteria					
Payback Period	4	5	1	5	3
Employment Opportunities	4	2	2	2	2
Project Implementation	2	3	4	4	4
Environmental Criteria					
Air Quality	5	1	5	5	5
Carbon Sequestration	5	1	3	1	5
Overall Weighted Score		84	76	116	104

# Pugh Method

- Phase 1 Client Weights
- Phase 2 Delphi Method
- Phase 3 **Pugh Method**
- Phase 4 Preferred Alt.  
Opt. Model

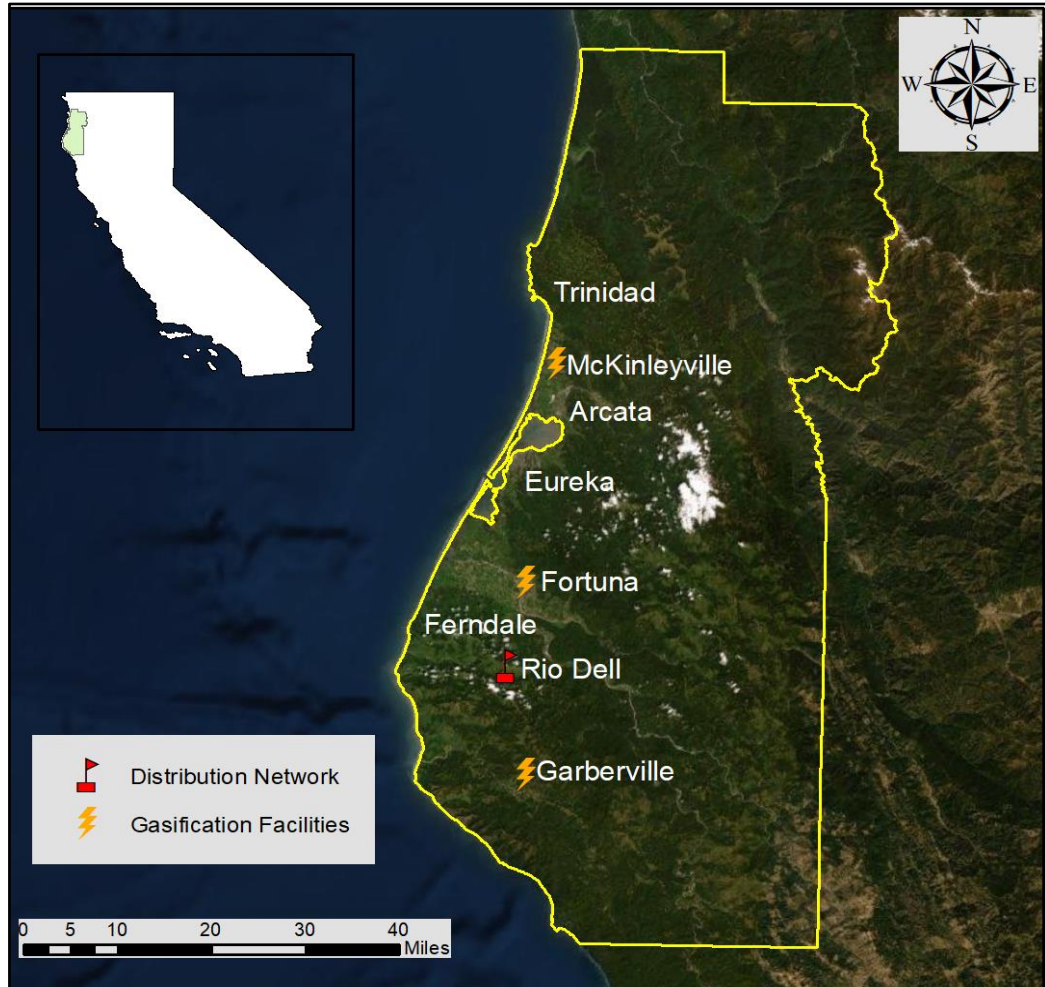
Constraint	Distribution Network and Community-Scale Gasification	Distribution Network and Particle Board Facility	Distribution Network and Fuel Densification Facility
Social			
Aesthetics	-	-	-
Community Support	-	-	-
Economic			
Payback Period	-	-	+
Employment Opportunities	+	+	+
Project Implementation	-	-	-
Environmental			
Air Quality	+	-	-
Carbon Sequestration	+	+	-
Net Scores			
Net Negatives	4	5	5
Net Positives	3	2	2

## Community-Scale Gasification and Distribution Network



# Optimization Model

Phase 1	Client Weights
<b>Phase 2</b>	<b>Delphi Method</b>
Phase 3	Pugh Method
Phase 4	Preferred Alt.
	<b>Opt. Model</b>

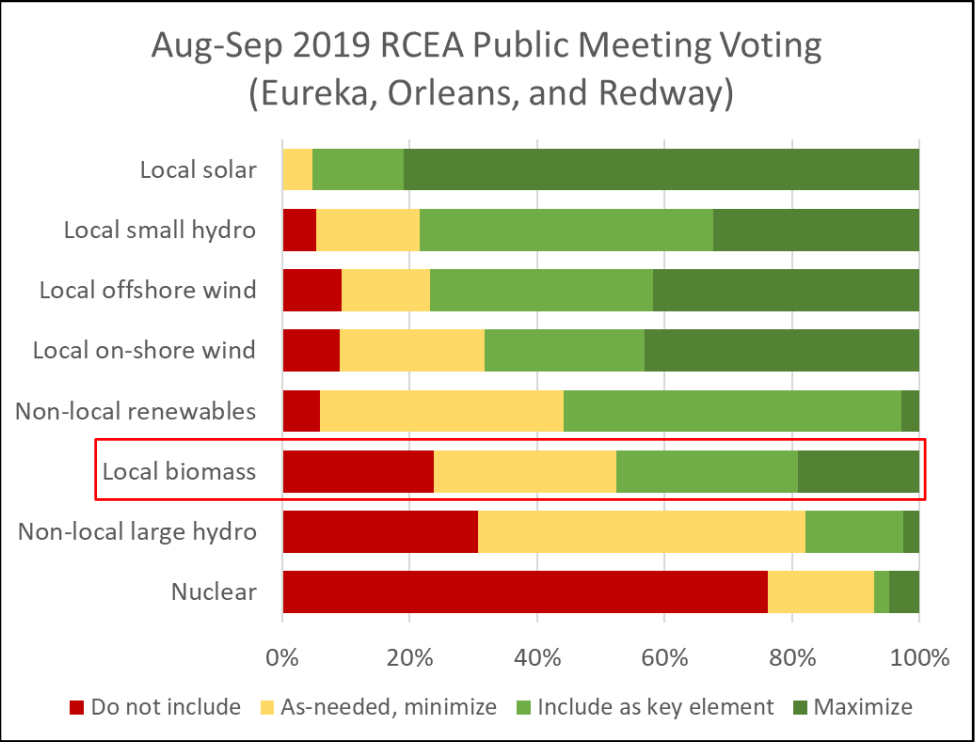


- A genetic algorithm was utilized to minimize the maximum distance between each shown city and the alternative sites.
  - Important to help minimize transportation of the biomass.
- Six total gasification units (two in each chosen city).
  - Determined cities are McKinleyville, Fortuna, and Garberville.
- One distribution network center in Rio Dell.



# Social Criteria Analysis

- Phase 1
- Criteria Analysis
- Phase 2
- Sensitivity Analysis
- Phase 3
- PWNB analysis
- Phase 4



Criteria	Distribution Network	Gasification	Total/Average
Aesthetics (ft <sup>3</sup> )	14,900	1,842,000	1,856,900
Community Support (%)	85	33	59

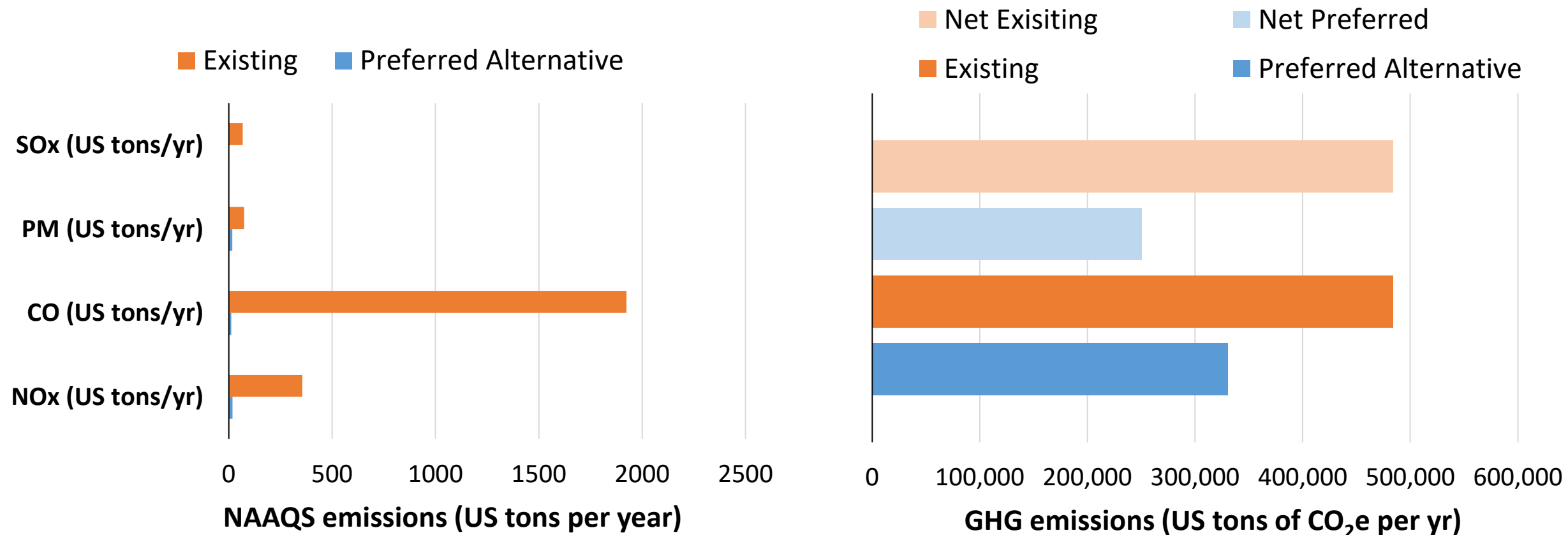
Project Implementation expected to be 48 months.

Employment Type	Distribution Network	Gasification	Total
Direct	15	200	215
Indirect	20	16	36

	Distribution Network	Gasification	Total
Capital Cost (\$)	4,070,000	101,250,000	105,320,000
Annual Revenue (\$)	2,354,000	37,183,000	39,537,000
Annual O&M Cost (\$)	1,418,000	12,312,000	13,730,000
PBP (years)	---	---	4

# Environmental Criteria Analysis

Phase 1 **Criteria Analysis**  
Phase 2 Sensitivity Analysis  
**Phase 3** PWNB analysis  
Phase 4

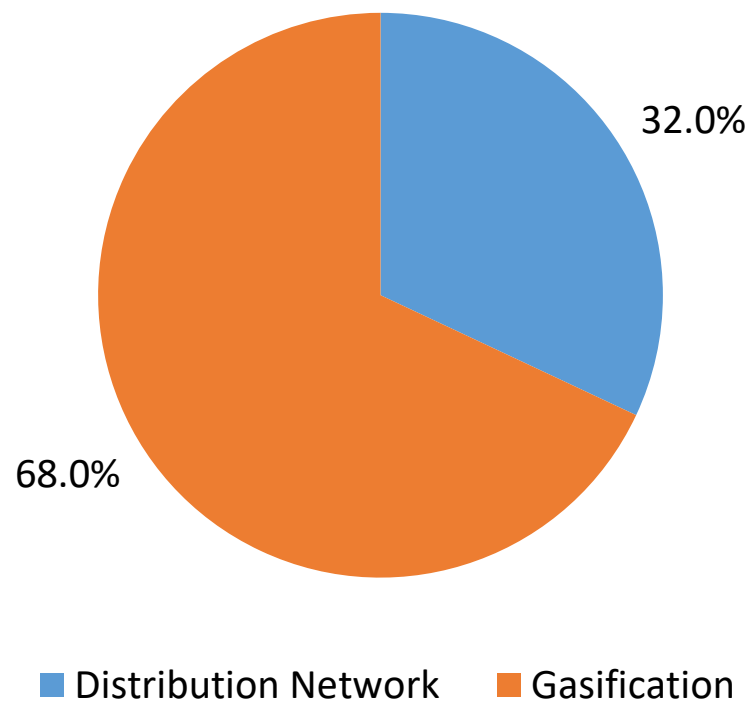


**\*Note: PM is PM<sub>10</sub> and GHG emissions are just process emissions.**

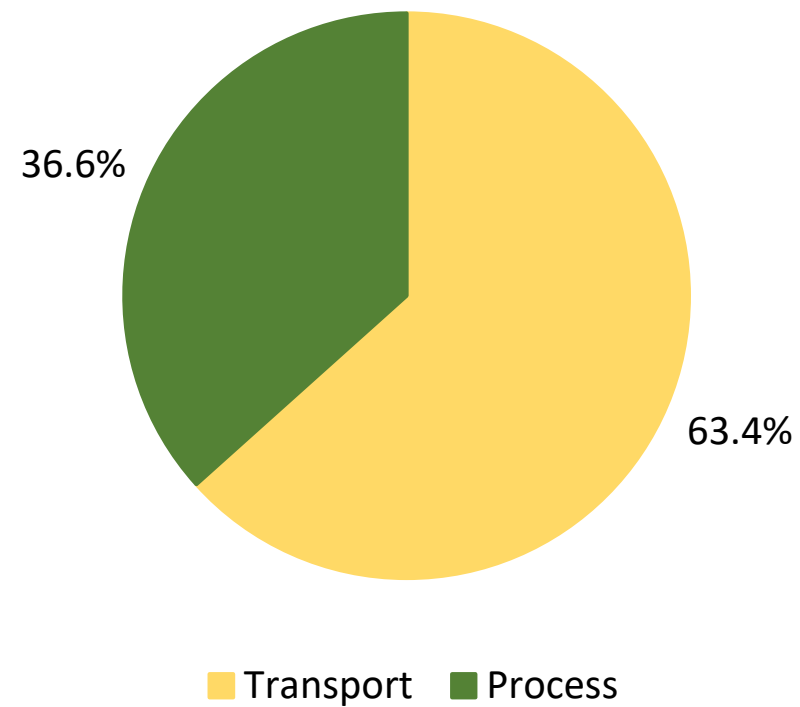
# Environmental Criteria Analysis

Phase 1	<b>Criteria Analysis</b>
Phase 2	Sensitivity Analysis
<b>Phase 3</b>	PWNB analysis
Phase 4	

NAAQS Emissions by Alternative

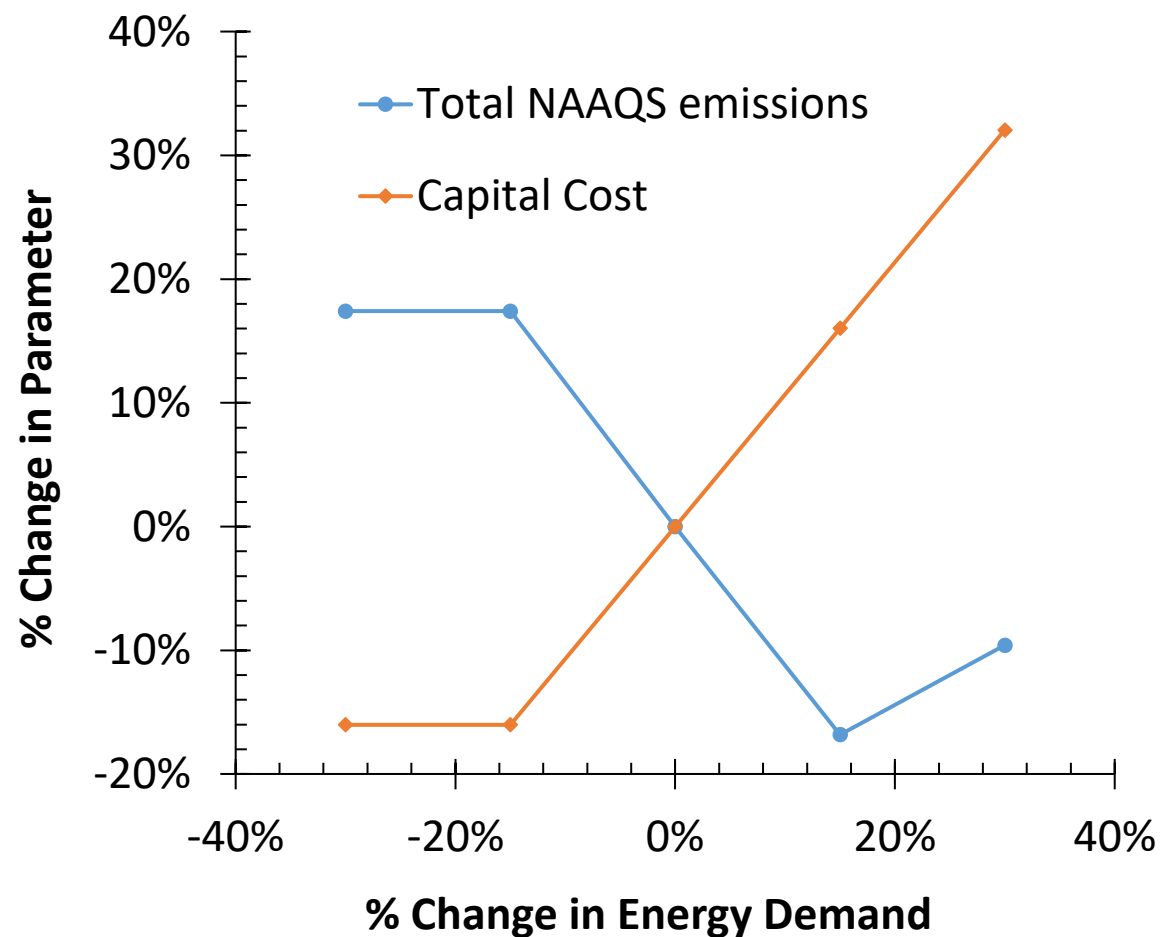


NAAQS Emissions by Process



# Energy Demand

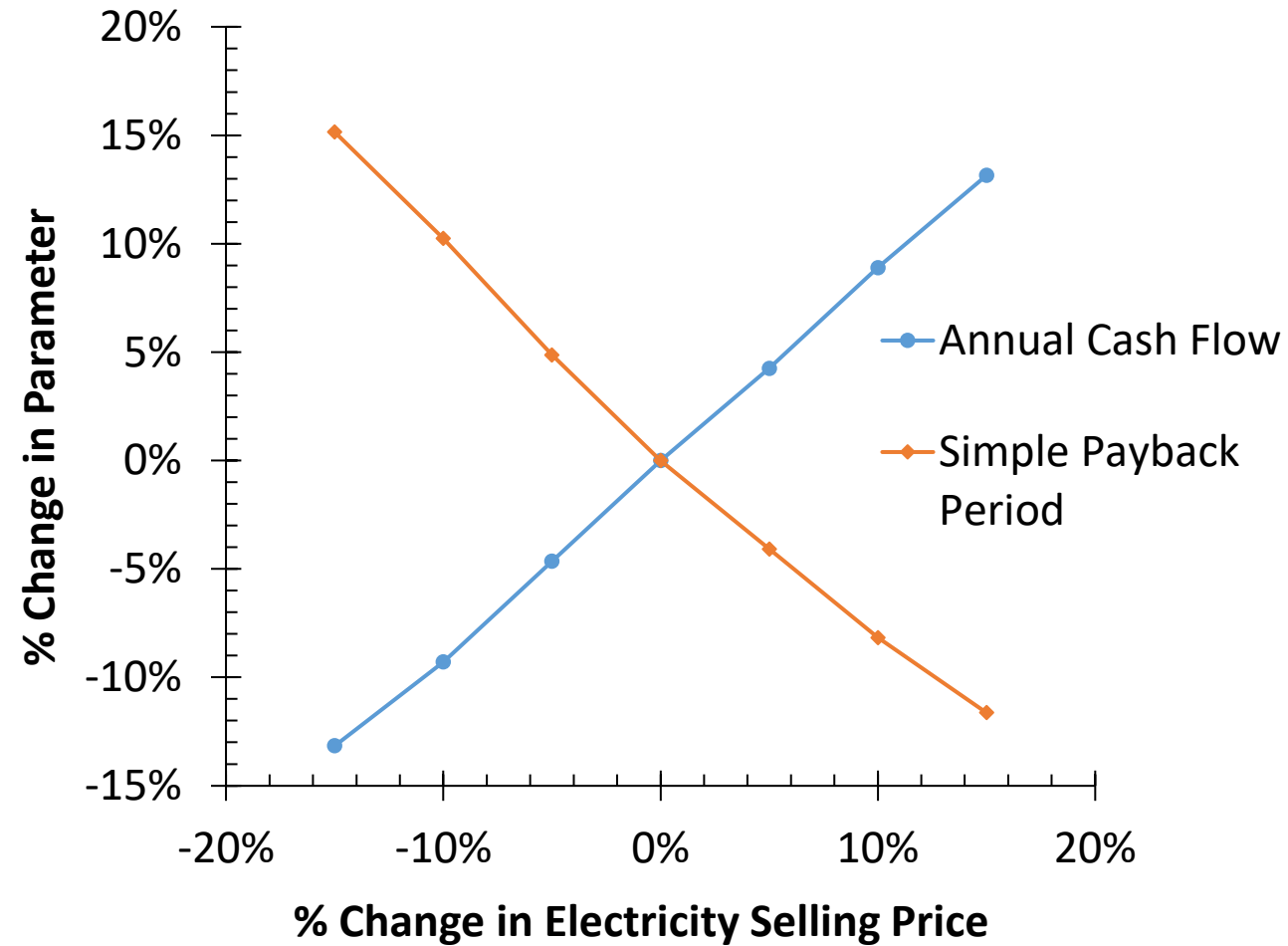
Phase 1 Criteria Analysis  
Phase 2 **Sensitivity Analysis**  
Phase 3 PWNB analysis  
Phase 4





# Electricity Selling Price

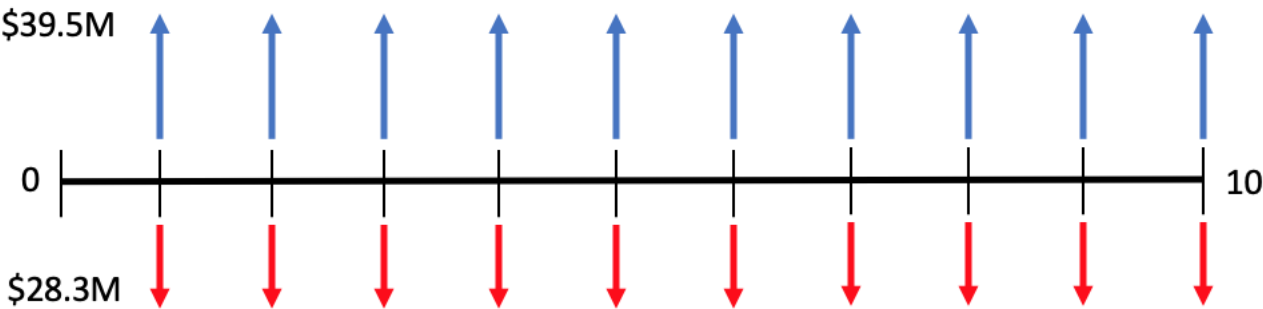
Phase 1 Criteria Analysis  
Phase 2 **Sensitivity Analysis**  
Phase 3 PWNB analysis  
Phase 4



# PWNB Analysis

- Phase 1 Criteria Analysis
- Phase 2 Sensitivity Analysis
- Phase 3 PWNB analysis**
- Phase 4

Interest rate	6.4%
Inflation rate	1.7%
Present Worth Cost	\$123,320,000
Present Worth Benefit	\$360,970,000
Present Worth Net Benefit	\$237,650,000



## Alternative Recommendation –

- Use distribution network and gasification facilities for the waste woody biomass.
- Optimized the city location of the distribution network and gasification facilities within Humboldt County.

## Future Work –

- Research grant funding and partner opportunities to help implement the project.

Advantages	Disadvantages
Balance of social, economic, and environmental criteria	Low demand for non-combustive uses of waste woody biomass and biochar
Low NAAQS pollutant and GHG emissions	Large capital cost
Helps meet RCEA 2030 goal for local renewable energy sources	Decentralized with 4 different locations
Large benefits for the community	Public perception

- Dr. Sintana Vergara and Dr. Tesfayohanes Yacob
- Richard Engel and Anamika Singh at RCEA
- Bob Marino and the crew at DG Fairhaven
- RUF Briquetting Systems

# Questions

Phase 1 Recommendation  
Phase 2 Acknowledgements  
Phase 3 **Q&A**  
**Phase 4**





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# Optimization Model Results

## Gasification Facilities –

	Index	Cities	Garberville	Rio Del	Fortuna	Ferndale	Eureka	Arcata	McKinleyville	Trinidad
	1.0	Garberville	0.0	41.5	49.8	57.0	67.0	74.5	80.4	90.0
	2.0	Rio Del	41.5	0.0	8.4	15.6	25.7	33.2	39.0	48.4
	3.0	Fortuna	49.8	8.4	0.0	7.5	17.5	25.0	30.9	40.3
	4.0	Ferndale	57.0	15.6	7.5	0.0	19.6	27.1	32.9	42.0
	5.0	Eureka	67.0	25.7	17.5	19.6	0.0	7.7	13.5	23.0
	6.0	Arcata	74.5	33.2	25.0	27.1	7.7	0.0	5.8	15.3
	7.0	McKinleyville	80.4	39.0	30.9	32.9	13.5	5.8	0.0	10.0
	8.0	Trinidad	90.0	48.4	40.3	42.0	23.0	15.3	10.0	0.0
			1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
Site Placement	Changing Variables	Cities	Garberville	Rio Del	Fortuna	Ferndale	Eureka	Arcata	McKinleyville	Trinidad
Garberville	1.0	Garberville	0.0	41.5	49.8	57.0	67.0	74.5	80.4	90.0
Fortuna	3.0	Rio Del	49.8	8.4	0.0	7.5	17.5	25.0	30.9	40.3
McKinleyville	7.0	Fortuna	80.4	39.0	30.9	32.9	13.5	5.8	0.0	10.0
	5.0	Ferndale	67.0	25.7	17.5	19.6	0.0	7.7	13.5	23.0
	4.0	Eureka	57.0	15.6	7.5	0.0	19.6	27.1	32.9	42.0
	8.0	Arcata	90.0	48.4	40.3	42.0	23.0	15.3	10.0	0.0
	2.0	McKinleyville	41.5	0.0	8.4	15.6	25.7	33.2	39.0	48.4
	6.0	Trinidad	74.5	33.2	25.0	27.1	7.7	0.0	5.8	15.3
		Minimum	0.0	8.4	0.0	7.5	13.5	5.8	0.0	10.0
						Max	13.5	Notes: *All values are in miles *Assumed placement of 3 gasification locations across the county.		

## Distribution Network –

Index	Cities	Garberville	Rio Del	Fortuna	Ferndale	Eureka	Arcata	McKinleyville	Trinidad
1.0	Garberville	0.0	41.5	49.8	57.0	67.0	74.5	80.4	90.0
2.0	Rio Del	41.5	0.0	8.4	15.6	25.7	33.2	39.0	48.4
3.0	Fortuna	49.8	8.4	0.0	7.5	17.5	25.0	30.9	40.3
4.0	Ferndale	57.0	15.6	7.5	0.0	19.6	27.1	32.9	42.0
5.0	Eureka	67.0	25.7	17.5	19.6	0.0	7.7	13.5	23.0
6.0	Arcata	74.5	33.2	25.0	27.1	7.7	0.0	5.8	15.3
7.0	McKinleyville	80.4	39.0	30.9	32.9	13.5	5.8	0.0	10.0
8.0	Trinidad	90.0	48.4	40.3	42.0	23.0	15.3	10.0	0.0

			1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
Site Placement	Changing Variables	Cities	Garberville	Rio Del	Fortuna	Ferndale	Eureka	Arcata	McKinleyville	Trinidad
Rio Dell	2.0	Garberville	41.5	0.0	8.4	15.6	25.7	33.2	39.0	48.4
	5.0	Rio Del	67.0	25.7	17.5	19.6	0.0	7.7	13.5	23.0
	4.0	Fortuna	57.0	15.6	7.5	0.0	19.6	27.1	32.9	42.0
	6.0	Ferndale	74.5	33.2	25.0	27.1	7.7	0.0	5.8	15.3
	7.0	Eureka	80.4	39.0	30.9	32.9	13.5	5.8	0.0	10.0
	3.0	Arcata	49.8	8.4	0.0	7.5	17.5	25.0	30.9	40.3
	1.0	McKinleyville	0.0	41.5	49.8	57.0	67.0	74.5	80.4	90.0
	8.0	Trinidad	90.0	48.4	40.3	42.0	23.0	15.3	10.0	0.0

Minimum	41.5	0.0	8.4	15.6	25.7	33.2	39.0	48.4
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Max48.4

Notes:  
\*All values are in miles.  
\*Assumed placement of one distribution network in the county.

# PWNB Analysis Results

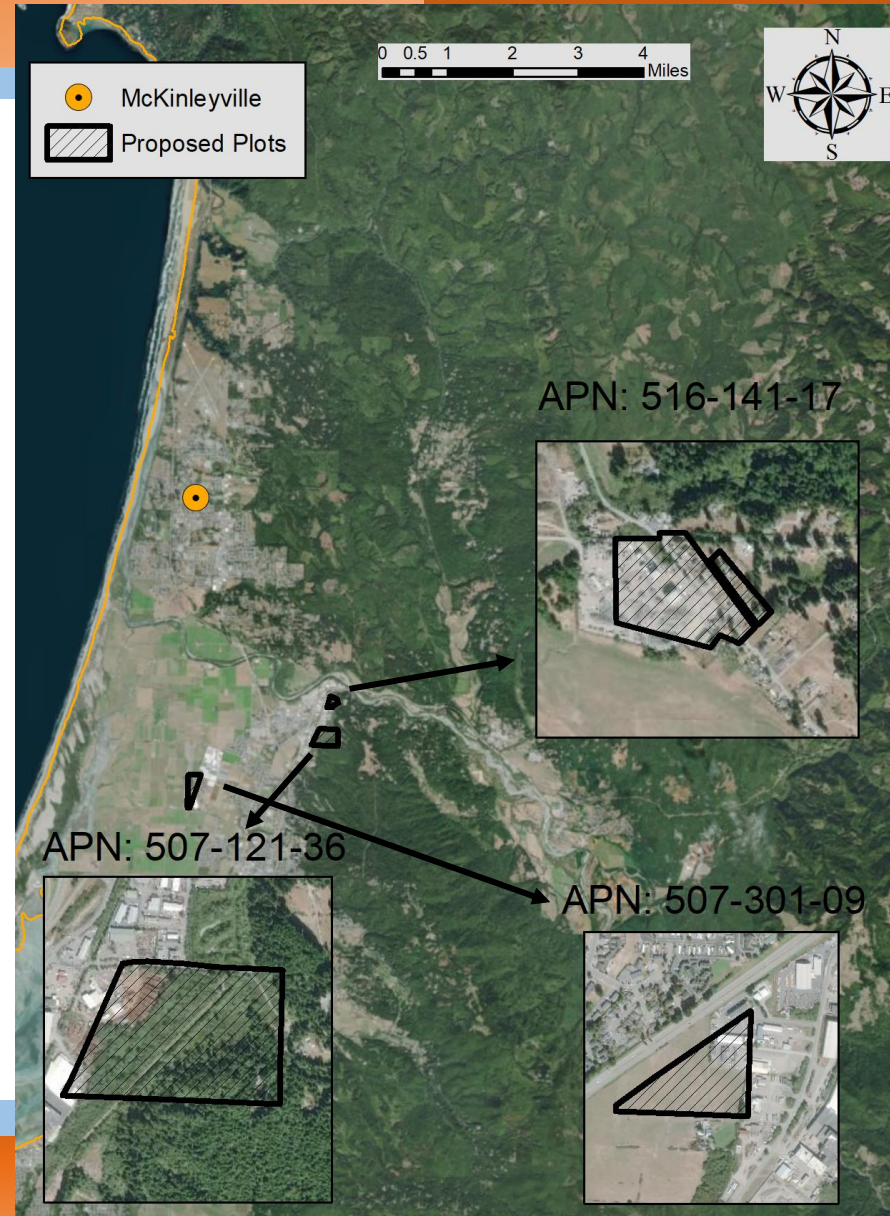
n (yrs)	10
Capital Cost (\$)	\$105,320,000
Annual Costs (\$)	\$13,730,904
Annual Revenue (\$)	\$39,536,601
interest rate	0.064
annual O&M	\$13,730,904.5
Annual Interest payment (\$)	\$9,478,800
Total annual cash flow (\$)	\$16,326,896
Total loan payment	\$145,820,218.68
Annual interest payment	\$14,582,022
Capital Costs	\$105,320,000.000
total interest paid	\$40,500,218.68
PWC (P/F, i=1.69%, n=10)	\$123,320,498.56
inflation rate	0.0169
Total Annual Costs	\$28,312,926.3
Total future costs	\$145,820,218.68
PWB (P/A, i=1.69%, n=10)	\$360,970,734.25
PWNB= PWB- PWC	\$237,650,235.68



# Scoring Rubric

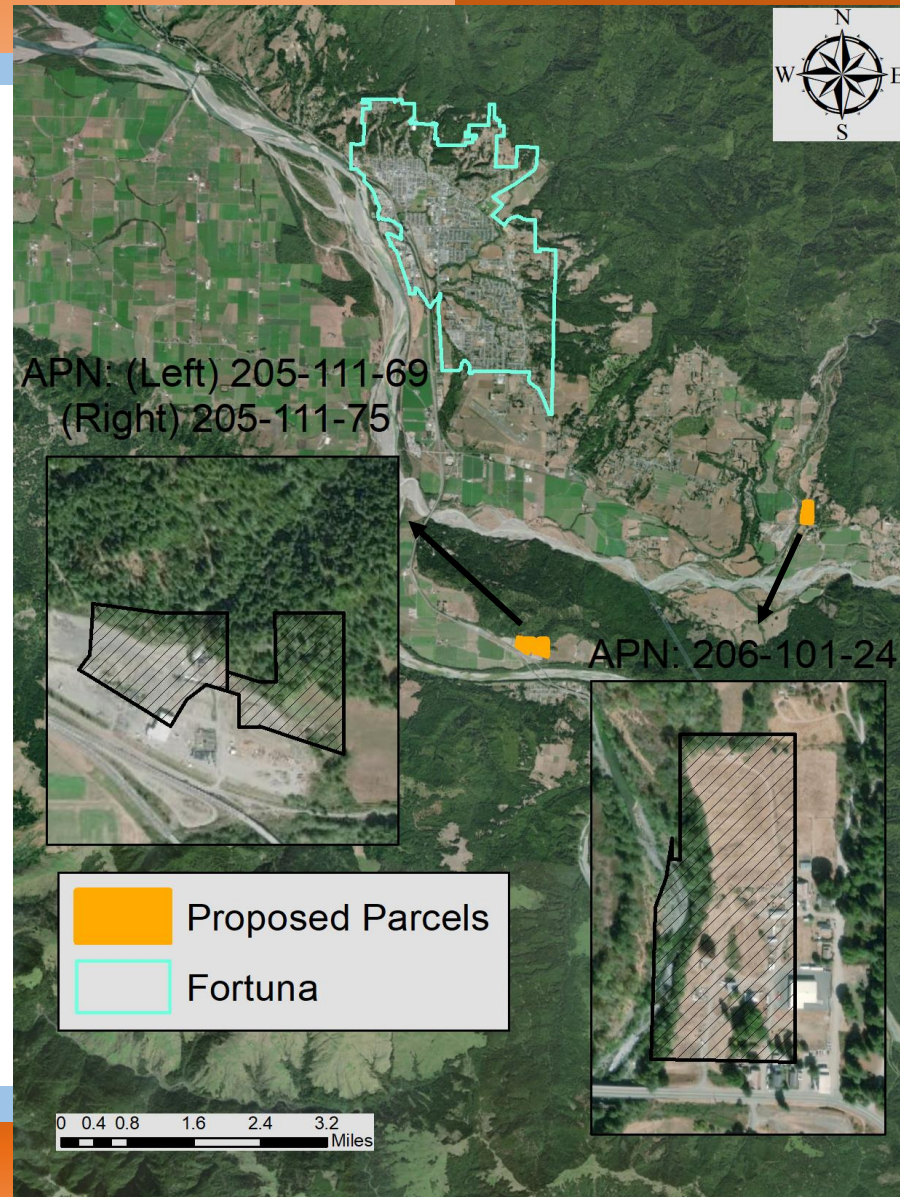
		1	2	3	4	5
Criteria	Quantification	Poor	Below Average	Average	Fair	Exceptional
Social						
Aesthetics	Volume of unnatural structures (ft <sup>3</sup> )	> 15 million	10 < x ≤ 15 million	5 < x ≤ 10 million	1 < x ≤ 5 million	≤ 1 million
Community Support	The percentage of the people who approve the project (%)	≤ 20%	20 < x ≤ 40%	40 < x ≤ 60%	60 < x ≤ 80%	> 80%
Economic						
Payback Period	The number of years before a project begins to make a profit (years)	> 8	6 < x ≤ 8	4 < x ≤ 6	2 < x ≤ 4	≤ 2
Employment Opportunities	Number of job opportunities that the project would produce or preserve (#)	< 100	100 < x ≤ 200	200 < x ≤ 300	300 < x ≤ 400	> 400
Project Implementation	Time required from approval to beginning operation of alternative (months)	> 84	60 < x ≤ 84	36 < x ≤ 60	12 < x ≤ 36	≤ 12
Environmental						
Air Quality	Amount of NAAQS pollutants (PM <sub>10</sub> , NO <sub>x</sub> , SO <sub>x</sub> , CO) (Total US tons/year)	> 4,000	3,000 < x ≤ 4,000	2,000 < x ≤ 3000	1,000 < x ≤ 2000	≤ 1,000
Carbon Sequestration	Amount of 20-year equivalent CO <sub>2</sub> sequestered per year (US tons eq. CO <sub>2</sub> per yr)	≤ -200,000	- 200,000 < x ≤ - 100,000	- 100,000 < x ≤ 0	0 < x ≤ 100,000	> 100,000

# McKinleyville – Gasification





# Fortuna – Gasification





# Garberville – Gasification



# Rio Dell – Distribution Network

