Waste to Wisdom:
Environmental and Economic Analysis of Biomass Conversion Processes

Demand Side Perspective of W2W Products
Economic Impact Analysis of W2W Operations

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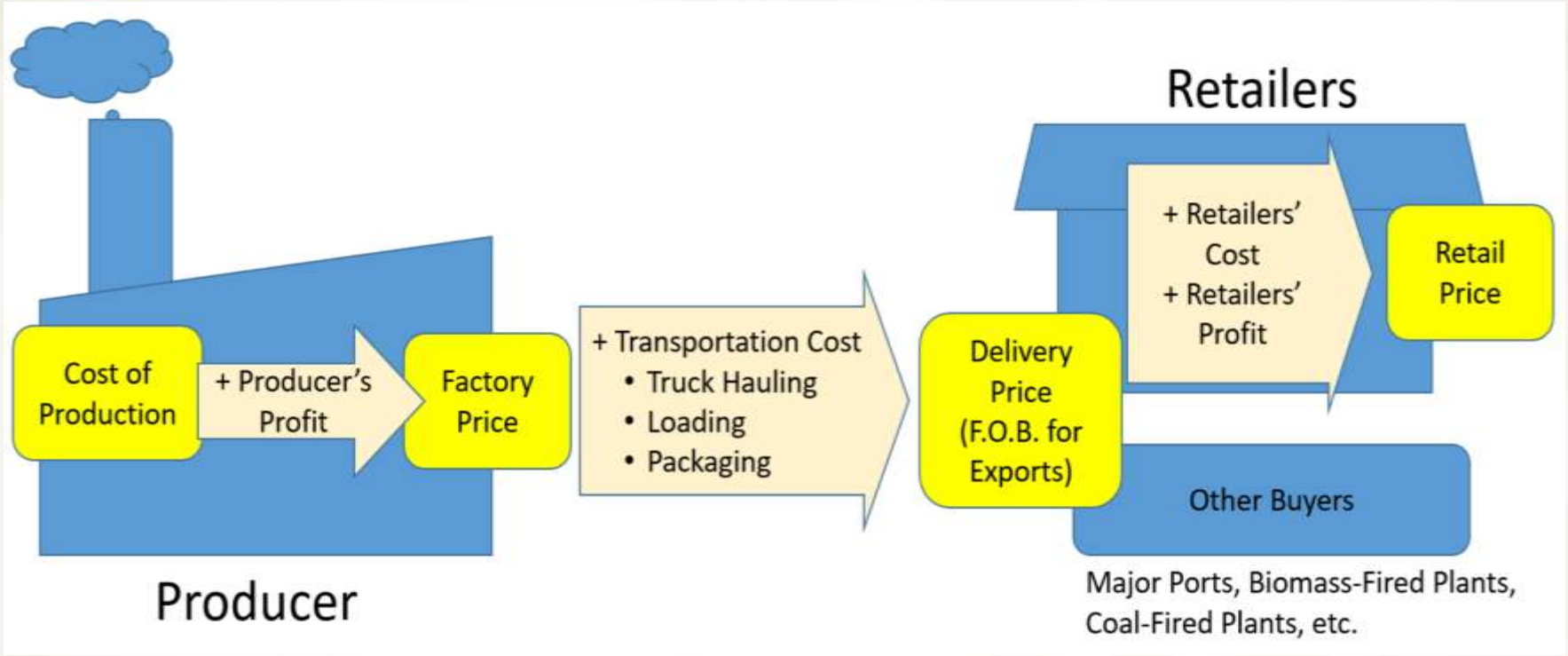
1. Demand-Side Perspective of W2W Products

Objective:

To develop bench-mark demand curve models

Customers buy “benefit” not “features” of the products.

Different "Prices" along Supply Chain



Delivery Price – Transportation Cost = Factory Price
(delivery price is fixed because of the competition)

Bioenergy Products: Wood Briquettes

Local Residential Heating Market

- US HHs generated 580 trillion BTU from woody biomass in 2014 (2.7% of total residential sector)
- The annual average consumption of wood for heating (wood briquettes equivalent) per person was estimated to be 0.068 ton (CA), 0.174 ton (WA) and 0.281 ton in (OR).
- Residential usage has +20% premium.

→ $143/ST (Delivery Price)

Local Commercial Biomass Energy Market (CHP …)

- Commercial Energy: 0.7% from biomass
- The average annual biomass consumption per capita within the commercial sector was to be 0.027 ton (CA), 0.022 ton (WA) and 0.037 ton in (OR) [wood briquettes equivalent].

→ $119/ST (Delivery Price)

Bioenergy Products: Torrefied Briquettes

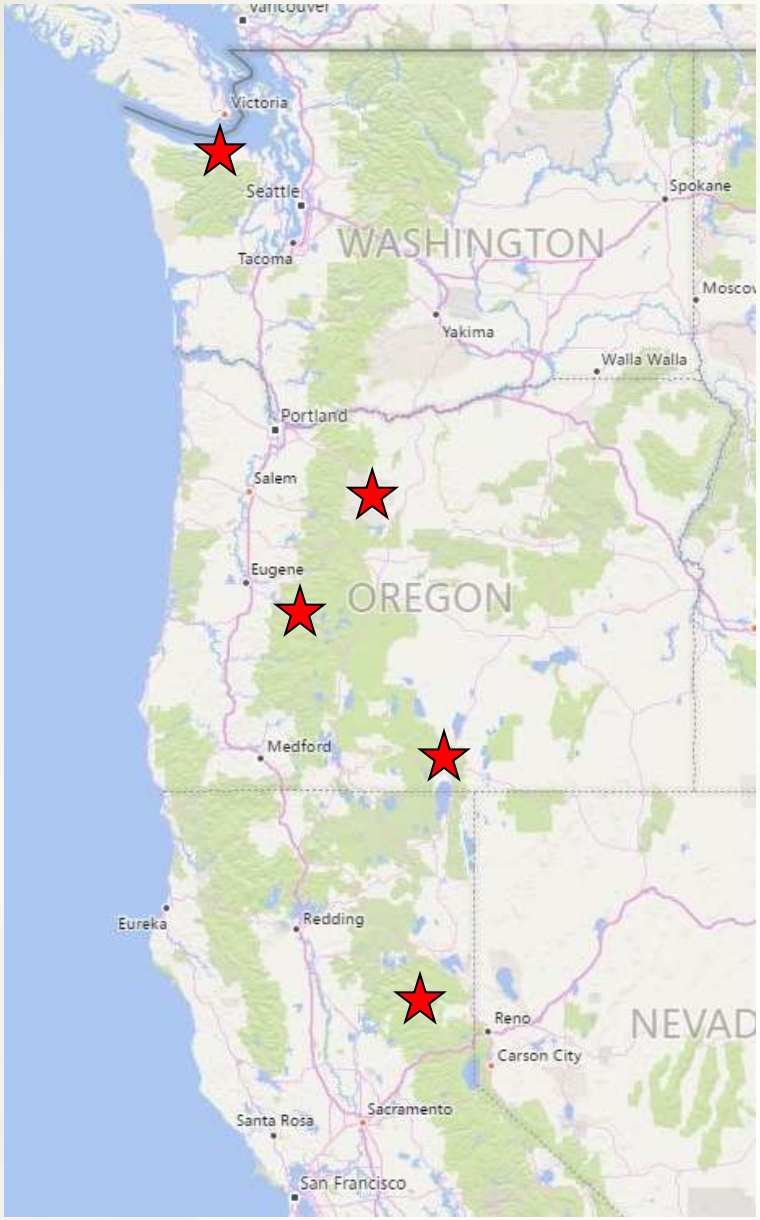
- Torrefied briquettes can be co-fired with coal.
- Zilkha Biomass in Alabama supplied “black pellets” to the French power company CPCU. First shipment in 2015.
- In 2015, black pellets to France was about 38.4% premium over the average price for wood pellet. Though, most market experts expect that the price premium for black or torrefied pellets will converge towards about 25% over time.

  → **$148/ST**

- Asian power plants would like to buy black or torrefied pellets to reduce coal consumption.
- Assume that there will be adequate demand once torrefied briquettes reach the market (*i.e.*, coal plants, major ports)
- Residential market: possible but difficult

Soil Amendment Products: Biochar

- An immature but potentially lucrative market
- The price of biochar varies depending on the target market
  → Price Skimming Strategy
- Small market: Oversupply → Profitability Erosion
- The delivery price for biochar used in gardening and landscaping applications is between **$4,950/ST** at the high-end and **$250/ST** at the low-end. The willingness to pay may go down as low as $100/ST.
- Annual compost consumption per capita is 0.01 ton



Five Locations for Case Study

Port Angeles, WA

Warm Springs, OR

Oakridge, OR

Lakeview, OR

Quincy, CA

Market size depends on population:

Population estimation with respect to distance from the site locations

$d \rightarrow$ distance (miles) from the plant

$11{,}411 \times \exp(0.0685 \times d)$ in Port Angeles, WA
$2{,}600 \times \exp(0.0739 \times d)$ in Warm Springs, OR
$128{,}643 \times \exp(0.0230 \times d)$ in Oakridge, OR
$13{,}684 \times \exp(0.0226 \times d)$ in Lakeview, OR
$83{,}728 \times \exp(0.0300 \times d)$ in Quincy, CA

Demand Curve for Wood Briquettes

$$Q_{WB}^{R} = g(d)\, a_{WB}^{R}\, p_{WB}^{R},$$

$$FP_{WB}^{R} = DP_{WB}^{R} - TCF_{WB}^{R} - d\, TCV_{WB}^{R},$$

$$Q_{WB}^{C} = g(d)\, a_{WB}^{C}\, p_{WB}^{C},$$

$$FP_{WB}^{C} = DP_{WB}^{C} - TCF_{WB}^{C} - d\, TCV_{WB}^{C}.$$

$$Q_{WB} = Q_{WB}^{R} + Q_{WB}^{C}$$

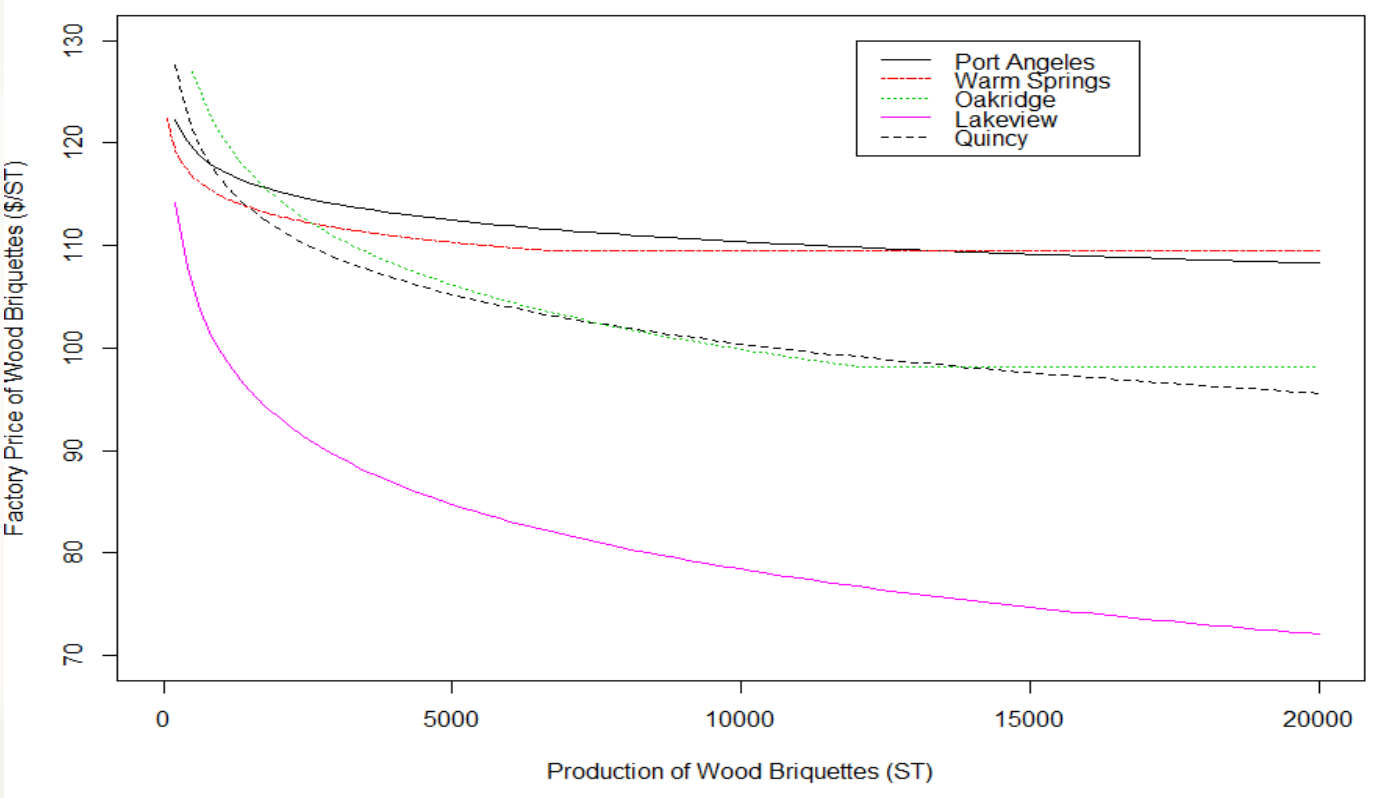
$$= g\left(\frac{DP_{WB}^{R} - TCF_{WB}^{R} - FP_{WB}}{TCV_{WB}^{R}}\right) a_{WB}^{R}\, p_{WB}^{R} + g\left(\frac{DP_{WB}^{C} - TCF_{WB}^{C} - FP_{WB}}{TCV_{WB}^{C}}\right) a_{WB}^{C}\, p_{WB}^{C}$$

Wood Briquettes: Factory Price vs Production Quantity

Assume W2W wood briquettes can take;

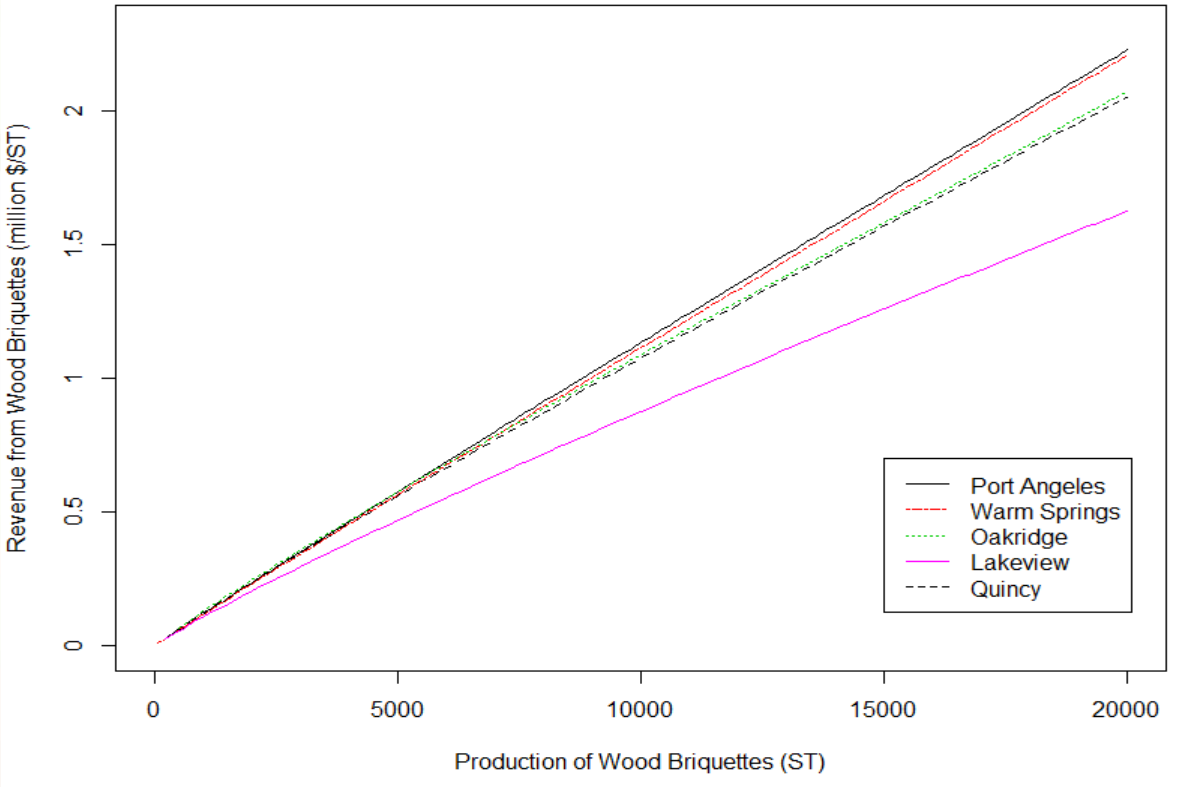
1% of residential firewood market

2% of commercial biomass market



Wood Briquettes: Sales Revenue vs Production Quantity

$$R_{WB} = \int_0^{Q^*_{WB}} f(Q_{WB}) dQ_{WB}$$



Factory Price of Torrefied Briquettes

Coal plants: Centralia WA, Boardman OR, and Valmy, NV

$$FP_{TB} = DP_{TB} - TCF_{TB} - d\,TCV_{TB}$$
$$R_{TB} = Q_{TB}\,(DP_{TB} - TCF_{TB} - d\,TCV_{TB})$$

Locations	Closest Market	Distance	Factory Price	Revenue
Port Angeles	Port of Tacoma	110 mile	**$125.44/ST**	125.44 x Q_{TB}
Warm Springs	Port of Portland	102 mile	**$127.03/ST**	127.03 x Q_{TB}
Oakridge	Port of Portland	154 mile	**$116.68/ST**	116.68 x Q_{TB}
Lakeview	North Valmy	250 mile	**$ 97.58/ST**	97.58 x Q_{TB}
Quincy	Port of Richmond	220 mile	**$103.55/ST**	103.55 x Q_{TB}

Biochar Demand Curve and Revenue

$$DP_{BC} = \exp\{\frac{\ln\left(DP_{BC}^{low} - DP_{BC}^{min}\right) - \ln\left(DP_{BC}^{high} - DP_{BC}^{min}\right)}{p_{BC}\, a_{BC}\, g(d) - 1}(Q_{BC} - 1)\} + DP_{BC}^{min}$$

$$FP_{BC} = h(g(d), Q_{BC}) - TCF_{BC} - d\, TCV_{BC}$$

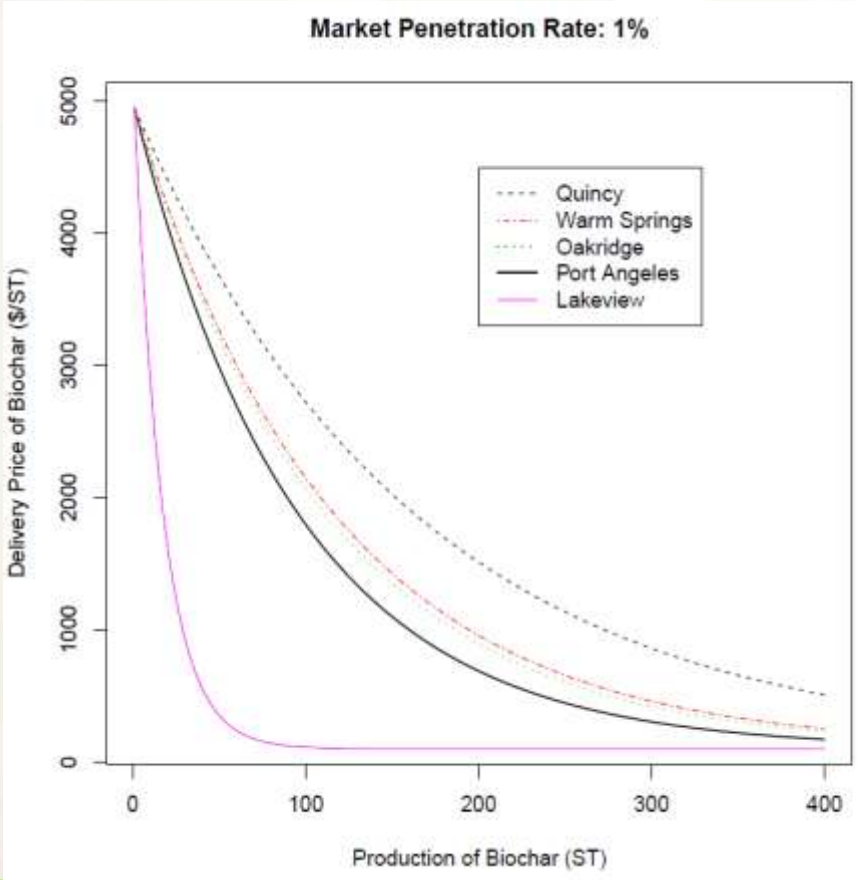
$$R_{BC} = \int_0^{Q_{BC}^*} \{h(g(d), Q_{BC}) - TCF_{BC} - d\, TCV_{BC}\} dQ_{BC}$$

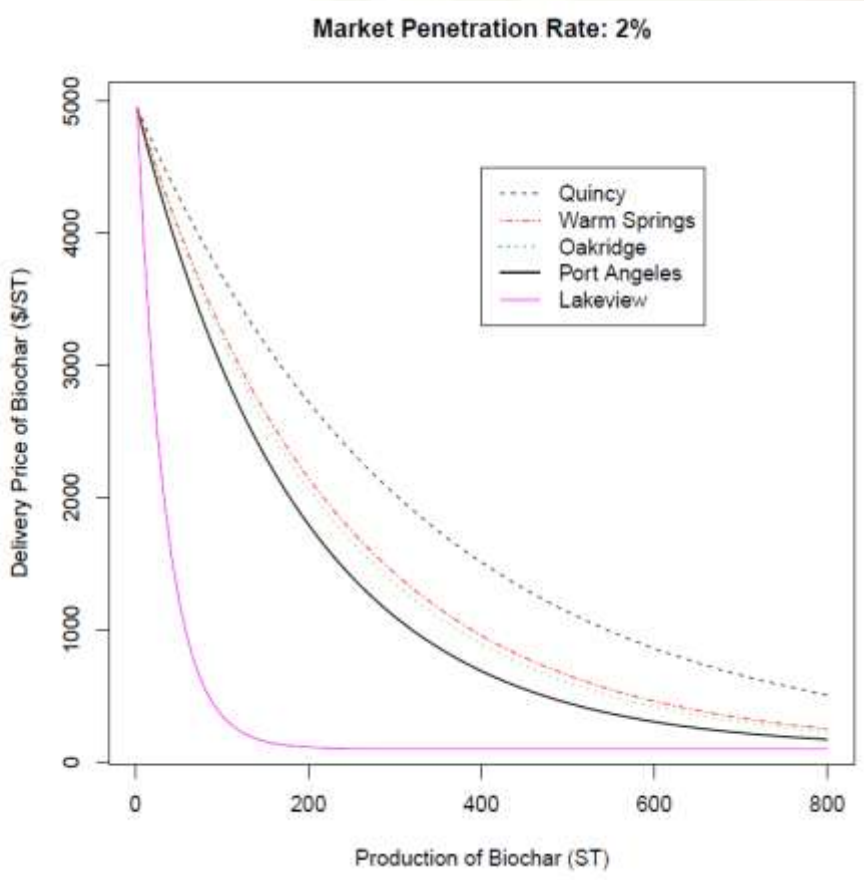
Biochar: Factory Price vs Production Quantity

Assume W2W biochar can take;

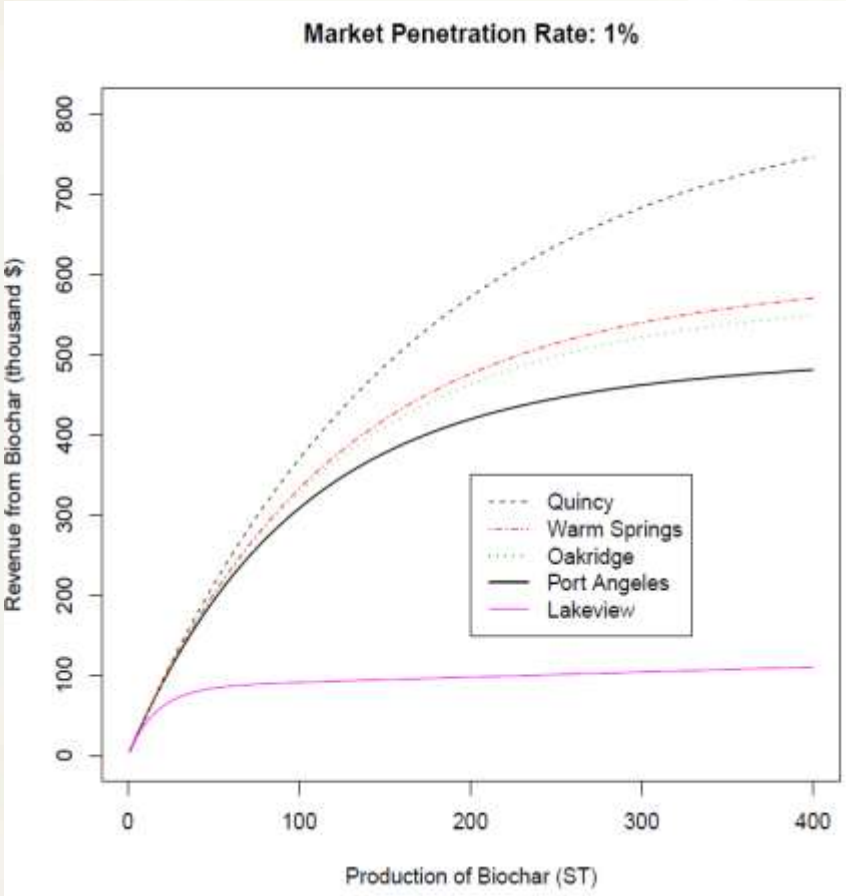
1% or 2% of compost market

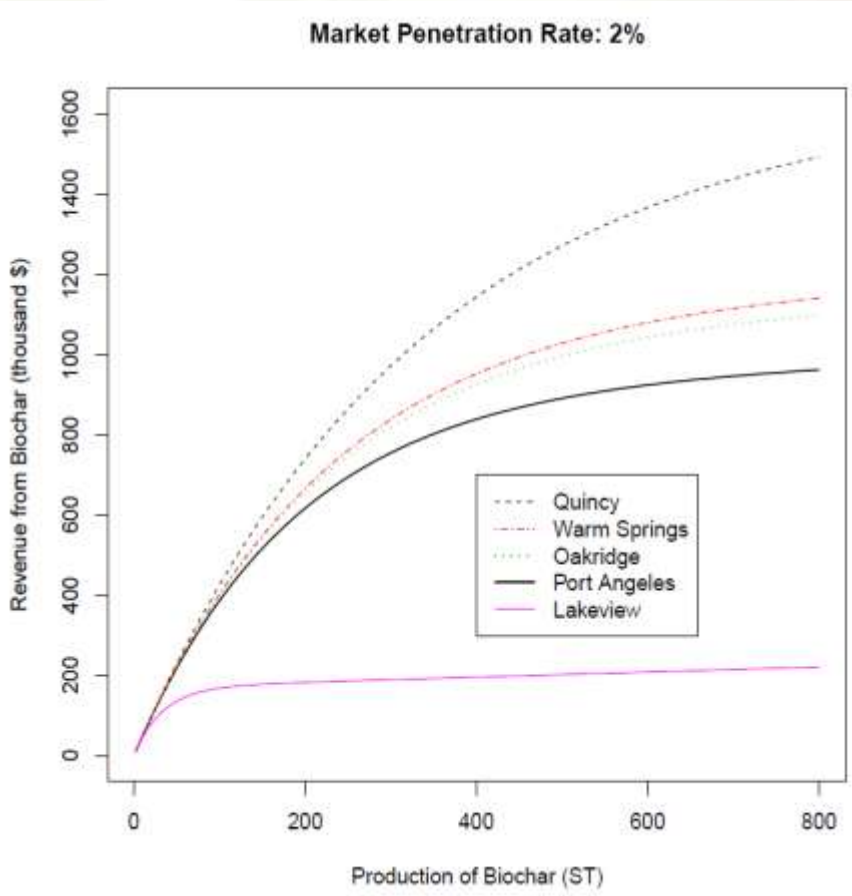
the range of the market is 150 miles





Biochar: Sale Revenue vs Production Quantity





2. Economic Impact Analysis of W2W Operations

Objective:

To identify the total economic impacts.

W2W project is important for rural economic development.

Scenario in Quincy CA

Producing Wood Briquettes (50,000 BDT)

Production: 49,000 BDT (53,719 ST @ 9.63% MC) of Wood Briquette

→ Sales Revenue: $143/ST * 53,719 ST = $7,681,817

→ Factory Price per Unit: $143 - $89.4/ST

→ Factory Revenue: $5,140,518

→ Transportation (Quincy to Retailers): $2,541,299

→ Production Cost Estimation per Unit: $74.67/BDT → $81.86/ST

→ Production Cost → $4,397,437

→ Profit of Factory, Forestry Operators and Forest Owner

$743,081 (14.5%)

Summary Economics in Quincy CA

Truck Transportation
From Quincy to Markets
$ 2.54 Million

Biomass Collection
Wood Briquettes Production
$ 5.14 Million

Profit:
$743,081

Total Sales Revenue
$ 7.68 Million

Direct Effects

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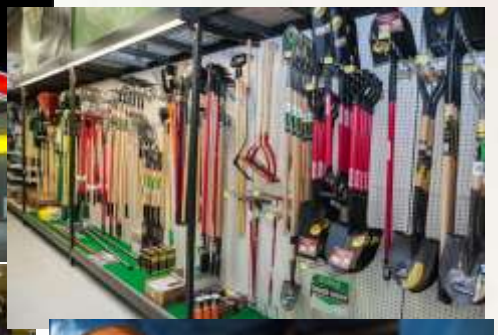
Purchase Materials /Service

Suppliers in the County



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Induced Effects

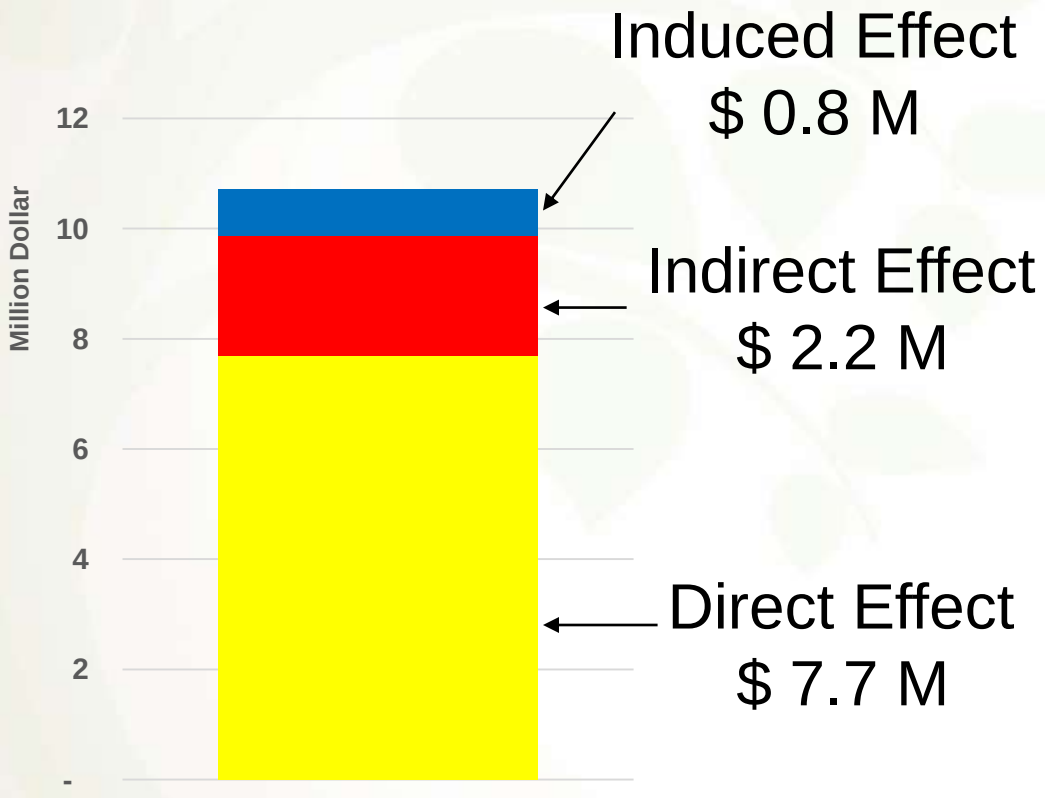
Employees

Indirect Effects

Community Impact Assessment in Plumas County, CA

	Data in 2014		Multipliers	
	Output	Jobs	Type I	Type SAM
Total	$ 1,404 M	9,761		
Logging	$ 4.7 M	44	**1.102**	**1.273**
Wood Products	$ 94.7 M	345	**1.292**	**1.380**
Truck Transportation	$ 16.7 M	116	**1.272**	**1.423**

Scenario in Plumas County (Quincy) CA
Economic Impacts by BCT



BCT / Biomass Collection
$ 5.14 M
Truck Industry
$ 2.54 M

Total Economic Impacts in Plumas County
$10.7 Million
0.8% of County Output

Conclusion

- We modeled demand side perspective:

  Demand Side + Production Cost + Supply Side

- Demand is limited by population and market penetration. The distance from market (i.e., population center) is a critical factor to be considered in locating a bioenergy production facility. There are a lot of innovative ways to overcome the above limitation. Increasing market penetration rate can increase profitability. However, market development and market penetration require appropriate marketing investment.
- Producing same products at different locations will likely result in cannibalization.
- BCT operations can generate considerable economic contribution to rural counties in western states.
- This is a short-run bench mark. Market may change in the long-run.

Thank you!

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