Financial feasibility of fast pyrolysis plants in SW Oregon using forest residues as feedstock

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Overview

- Motivation
- Background
- Assumptions
- Financial Analysis Method
- Financial Performance & Sensitivity
- Conclusions
Forest biomass – waste product or energy feedstock?
Handling options

- Pile and burn or seek value-added end uses
- Open burning – emissions concerns and no value recovered
- Renewable energy feedstock – carbon neutral/negative, displaces fossil fuels
- Must be **financially feasible**

** OR **

- In-woods handling, transport
- Energy conversion

Pile and burn disposal

Photo: WFES
Bioenergy Conversion Methods

Biomass

Thermochemical
- Combustion
  - Heat, Steam, Electricity
- Gasification
  - Producer gas, Electricity
- Pyrolysis
  - Bio-oil, Biochar, Syngas

Biochemical
- Fermentation
  - Ethanol
- Anaerobic Digestion
  - Biogas

Source: McKendry 2002
Fast Pyrolysis

Rapid thermal degradation of biomass in the absence of oxygen

Bio-oil

Biochar

Syngas
Renewable Oil International® LLC
Fast Pyrolysis Process

- Biomass
- Gas & Vapor
- Heat Carrier
- Moving Bed Reactor
- Char
Study region for mobile and fixed pyrolysis

Forest Cover
- Non-forest
- Forest
- Roseburg
- Study region

Forest cover in Oregon based on a hybrid of NLCD (2001) land cover and ESLF (2008) land cover models. Forest cover includes standing forest, as well as regenerating harvested forest and recently burned forested land.

Source: Anderson 2010
Assumptions for both plants

- Products: 57% bio-oil, 27% biochar, 15% syngas, 1% tar
- 75% of thermal process energy supplied by syngas
- 60% capital investment borrowed @ 9% for 7 years
- Straight line depreciation
- Standard federal income taxes and Oregon excise taxes
- Energy content of #2 fuel oil = 0.139 MMBtu/gal
- Energy content of bio-oil = 0.08 MMBtu/gal
- Price #2 fuel oil = $2.64/gal (2-yr avg price Sep07-Aug09)
  - (Latest available weekly price from EIA = $3.09 as of Mar 2011)
- Price bio-oil (incl. 10% discount) = $1.36/gal
- Price bio-char = $136/ton
Contrasting assumptions

**Mobile 50 BDTPD**
- $3.46 million initial capital investment
- Operates 12 hours per day
- 87.5% utilization rate
- 6 FTE employees
- Delivered feedstock $20/BDT
- Consumes 7,128 BDT/yr
- Annual Production
  - 780,642 gallons bio-oil
  - 2,138 tons biochar
  - 79 tons tar
- All electrical process energy supplied by bio-oil
- Unit moves 2 times per year

**Fixed 200 BDTPD**
- $24.26 million initial capital investment
- 24-hour continuous operation
- 90% utilization rate
- 17.5 FTE employees
- Delivered feedstock $45/BDT
- Consumes 65,700 BDT/yr
- Annual Production
  - 8.32 million gallons bio-oil
  - 19,710 tons biochar
  - 730 tons tar
- All electrical process energy purchased from grid
Financial analysis method

- Discounted cash flow analysis
  - 7% real (net of inflation) discount rate
  - NPV of after tax cash flow and IRR determined for each plant
- Sensitivity analyses for multiple cost and revenue parameters
- Compare tradeoffs between mobile and fixed
## Baseline Financial Performance

<table>
<thead>
<tr>
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<th>Mobile</th>
<th>Fixed</th>
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<tbody>
<tr>
<td><strong>NPV ($1000s)</strong></td>
<td>36</td>
<td>9,681</td>
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<tr>
<td><strong>IRR (%)</strong></td>
<td>7.4</td>
<td>20.9</td>
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</table>
Financial Performance
Sensitivity Analysis

Mobile plant sensitivity to selected variable cost parameters

Breakeven labor cost is $29.84/hr/emp.

Breakeven feedstock cost is $21.43/BTD

Change in parameter level

NPV of after tax cash flows

- $500,000
- $400,000
- $300,000
- $200,000
- $100,000
- $0
- $100,000
- $200,000
- $300,000
- $400,000
- $500,000

-30%  -10%  Base case  +10%  +30%

Labor costs
Feedstock Cost
Bio-oil delivery cost to market (Portland, OR)
Biochar delivery cost to market
Financial Performance
Sensitivity Analysis

Mobile plant sensitivity to bio-oil and biochar prices

Break-even bio-oil price is $1.35/gal
Break-even bio-char price is $132/ton
Financial Performance Sensitivity Analysis

Fixed plant sensitivity to selected variable cost parameters

Breakeven labor cost is $92.93/hr/emp.

Breakeven feedstock cost is $80.69/BTD
Fixed plant sensitivity to bio-oil and biochar prices

- Break-even bio-oil price is $1.08/gal
- Break-even bio-char price is $16/ton
# Additional breakeven levels

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<thead>
<tr>
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<th>Mobile</th>
<th>Fixed</th>
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<tbody>
<tr>
<td>Scheduled operating days</td>
<td>322</td>
<td>223</td>
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<tr>
<td>Utilization rate (%)</td>
<td>86.8</td>
<td>55.0</td>
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<tr>
<td>Initial capital investment ($millions)</td>
<td>3.51</td>
<td>47.23</td>
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Conclusions

- Both mobile and fixed pyrolysis can be profitable
- Fixed plant exhibits superior returns under each financial performance measure
- Tradeoffs
  - Mobile plant has lower feedstock cost and ability to operate off-grid
  - Fixed plant exhibits economies of scale, especially with respect to labor costs
  - Both plants depend on developed markets for both bio-oil and biochar to be profitable
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