Biochar: Linking Forest Residues to Agricultural Solutions

Presentation

• Overview of biochar and bio-oil
• Economics of biochar – feedstock challenges
• Biochar production potential in New Zealand
• Commercialisation and deployment
• Shape of biochar research

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1. Biochar and Bio-oil

What is biochar?
- A fine-grained charcoal high in organic carbon and largely resistant to decomposition
- Slow pyrolysis: the thermal decomposition of organic feedstocks at slow heating rates under oxygen-limited conditions

1. Biochar – Production Techniques

Major techniques:
- Slow, flash or fast pyrolysis
- Hydrothermal carbonization
- Microwave conversion
- The process yields bioenergy - syngas and bio-oil.
- Maximization of biochar at the expense of bioenergy
1. Biochar: Potential Uses

Sequester carbon
- Wood carbon content 50%, biochar carbon content 70–80%

Reduce nitrous oxide emissions and nitrate leaching
- Reduce nitrous oxide emissions and nitrate leaching from soils.
- One-off cost with a permanent benefit.

Biochar to lift soil and crop productivity
- Improve soil structure and water retention and enhances nutrient availability - productivity gains depend on soil, crop type, char concentrations, and nutrient levels

1. Biochar and Bio-oil

Bio-oil
- With existing technology, bio-oil is best used directly as process heat and in stationary engines.

- Challenges: low volatility, high viscosity, coking, corrosiveness, and instability.

- Bio-oil can be used as a basis for higher-value extracts and by-products
### 2. Biochar: Economic Challenges

<table>
<thead>
<tr>
<th>Overview</th>
<th>Attributes</th>
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</thead>
<tbody>
<tr>
<td>• Carbon storage</td>
<td>• Bioenergy and carbon store</td>
</tr>
<tr>
<td>• Research activity</td>
<td>• a nutrient-retaining substance</td>
</tr>
<tr>
<td>• Profitability</td>
<td>– boost crop yields</td>
</tr>
<tr>
<td>• Government interest</td>
<td>– lower fertiliser costs;</td>
</tr>
<tr>
<td>• Commercialisation efforts</td>
<td>• Utilise waste, retain soil moisture, and remediate contaminants.</td>
</tr>
<tr>
<td>• Future research</td>
<td></td>
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</tbody>
</table>

### 2. Biochar: Economics - Application

- Biochar: increased yields and reduced fertiliser costs?
- Biochar and abated N2O and nutrient leaching
- Biochar and Carbon Storage
- Biochar and Carbon Markets
  - Estimated to be viable when carbon prices reach US$47/t CO2e, current prices hovering at US$20/t
  - Not going to be generating huge profits.
2. Biochar: Economics – Prod^n Scenarios

- Provision of feedstock
  - Forestry company
  - Wastewater / sewage disposal company
  - Municipal waste contractor
  - Sawmill

- Provision of pyrolysis
  - Customised pyrolysis unit
  - Existing pyrolysis unit e.g. used in steel mill; sawmill; for bioenergy

- Provision of land for biochar application
  - New Zealand-based farmer / agricultural cooperative
  - Council – municipal land (parks, construction sites or landfill)
  - Developing country farmer

<table>
<thead>
<tr>
<th>Harvesting costs (net of waste management fee)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
</tr>
<tr>
<td>Capital, running and labour costs</td>
</tr>
<tr>
<td>Transportation</td>
</tr>
<tr>
<td>Distribution: e.g. by a fertiliser company</td>
</tr>
<tr>
<td>Aggregation of carbon credits: e.g. by carbon trading company</td>
</tr>
</tbody>
</table>

Aggregation of these stages by a domestic or overseas company / investor

2. Biochar: Economics - Feedstocks

<table>
<thead>
<tr>
<th>Material</th>
<th>Costs* (AU$/t char)</th>
<th>Income** (AU$/t char)</th>
<th>Net cost (AU$/t char)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest residues</td>
<td>330</td>
<td>35-90</td>
<td>240-295</td>
</tr>
<tr>
<td>Saw mill waste</td>
<td>270</td>
<td>35-90</td>
<td>180-235</td>
</tr>
<tr>
<td>Poultry litter</td>
<td>160</td>
<td>NA</td>
<td>160</td>
</tr>
<tr>
<td>Agricultural waste</td>
<td>&gt;500</td>
<td>NA</td>
<td>&gt;500</td>
</tr>
</tbody>
</table>

Figure 1 – Costs of different biochar feedstocks. CSIRO in Australia
2. Biochar: Economics - Feedstocks

- Forestry residues
- Wood processing residues
- Purpose-grown forests and crops
- Agricultural residues
- Municipal solid waste
- Waste rubber tyres
- Poultry litter/animal effluents
- Sewage sludge

2. Biochar: Production Potential

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Biomass wet tonnes / year</th>
<th>Biomass dry tonnes / year</th>
<th>Tonnes Carbon</th>
<th>Tonnes Char</th>
<th>Gas/energy</th>
<th>Char focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest residues a</td>
<td>2,420,000</td>
<td>1,210,000</td>
<td>605,000</td>
<td>242,000</td>
<td>205,700</td>
<td>284,350</td>
</tr>
<tr>
<td>Forest residues b</td>
<td>1,496,000</td>
<td>748,000</td>
<td>374,000</td>
<td>149,600</td>
<td>127,160</td>
<td>175,780</td>
</tr>
<tr>
<td>Wood processing residues a</td>
<td>2,501,000</td>
<td>1,250,500</td>
<td>625,250</td>
<td>250,100</td>
<td>212,585</td>
<td>293,868</td>
</tr>
<tr>
<td>Wood processing residues b</td>
<td>799,000</td>
<td>399,500</td>
<td>199,750</td>
<td>79,900</td>
<td>67,915</td>
<td>93,883</td>
</tr>
<tr>
<td>Other</td>
<td>2,725,700</td>
<td>1,196,950</td>
<td>574,623</td>
<td>272,570</td>
<td>231,685</td>
<td>270,167</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>9,941,700</strong></td>
<td><strong>4,804,950</strong></td>
<td><strong>2,378,823</strong></td>
<td><strong>994,170</strong></td>
<td><strong>845,045</strong></td>
<td><strong>1,118,047</strong></td>
</tr>
</tbody>
</table>

Notes:
- Forest residues a: Easily accessible residues
- Forest residues b: Hard to access residues
- Wood processing residues a: Residues currently with markets
- Wood processing residues b: Residues currently without markets

Residues to Revenues 2009
2. Biochar: Production Potential

New Zealand Biochar potential - available feedstocks, total carbon storage capacity

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Carbon Storage (t)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest residues a</td>
<td>121,000</td>
<td>25%</td>
</tr>
<tr>
<td>Municipal solid waste, putrescible</td>
<td>20,400</td>
<td>4%</td>
</tr>
<tr>
<td>Straw</td>
<td>3,995</td>
<td>8%</td>
</tr>
<tr>
<td>Horticultural wood</td>
<td>2,040</td>
<td>4%</td>
</tr>
<tr>
<td>Municipal wood waste</td>
<td>2,040</td>
<td>4%</td>
</tr>
<tr>
<td>Wood processing residues a</td>
<td>125,050</td>
<td>27%</td>
</tr>
<tr>
<td>Wood processing residues b</td>
<td>74,800</td>
<td>16%</td>
</tr>
</tbody>
</table>

3. Biochar: Commercialisation

Three broad categories:

- Biofuel companies that investing in pyrolysis technology, and looking to commercialise the char co-product;
- Companies focused on maximising yields of biochar, targeting climate change and soil fertility.
- NGOs - biochar deployment in developing countries, stressing biochar’s credentials as an ‘alternative technology’
3. Biochar: Commercialisation

- 1. Biofuel companies branching out into bio-oil and biochar
- 2. Companies focused on biochar
- 3. Biochar non-profits

Companies focused on biochar: e.g.
- New Zealand’s own CarbonScape
- The Carbon Char Group
- NaturePlus
- Carbon Gold

3. Biochar: Commercialisation –Carbon Markets

- Currently not eligible for carbon credits under any market mechanisms.
- Efforts underway to have it included in almost all the existing carbon markets.
- Various trends in the development of carbon markets are causing biochar to be viewed with increasing interest by markets.
  - Clean Development Mechanism (CDM)
  - Voluntary Carbon Markets
4. Biochar: Research

Key questions remain:
- Do certain chars actually retard plant growth when applied to certain soils, or damage them?
- Does biochar actually store C in soils long term, for how long; and how does this change in different soils?
- Does biochar really retain nutrients (N, P, K) in soils and thereby reduce need for application of artificial fertilisers / boost crop yields?
- What feedstocks produce appropriate chars for different soils and different purposes, in a cost-effective manner?

Some ways of finding answers may include:
- **Economic analysis** – developing scenarios or ‘platforms’ for biochar production in specific countries and locales.
- **Classification** of chars to support trails
- Long-term **field trials** of biochar (rather than simply laboratory trials), using different New Zealand soils.
- **Life Cycle Assessment** (LCA) of the biochar production process
Conclusions: Key Challenges

Competing for forest residues:
• optimising feedstock production, harvesting, drying and grinding
• optimising production processes and end products
• finding the best R&D paths to upgrade biochar/bio-oil products
• validation and fine-tuning of the environmental and agricultural productivity benefits of biochar.

Further Information

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