Enabling a Regional Bioeconomy: A Developing Australian Biomass Supply Chain Case Study
Biomass Supply Chain Project Suite Overview

High Level Project Deliverables:

• **Goal** – Work with Stakeholders to Develop & Initiate A Viable Supply Chain by 2020

• **Focus** – Enable Sustainable Supply of Biomass to Enable the Emerging Bio-Economy in Queensland

Project Collaborator(s):

• HQPlantations - Southern Pine plantation resource in south-east Queensland, Australia

• Laminex Australia

• Altus Renewables
Overview

4 Projects – 4 Key Research Question(s):
1. What is the current biomass availability and composition?
2. What are the operational considerations and site preparation implications of biomass removal?
3. What are potential recovery options & costs?
4. What is the optimal supply chain?

Regional Context: High Energy Costs | Local Co-Gen Interest | Emerging Pellet Market
Question: What is the current biomass availability and composition?

Study: Post Harvest Residue Assessment

2 - Systems (CLT & WT)

5 - Sites (Varying Biomass Conditions)

3 - Evaluation Techniques (CRC Method, Line Intersect, Pile Decomposition)
Project 1 - Biomass Assessment

Composition and Volume of Forest Harvest Residues depend on Harvesting Technique and local markets.

• Cut to Length Harvesting

<table>
<thead>
<tr>
<th>Site</th>
<th>2016 ND</th>
<th>113 SD</th>
<th>114SD</th>
<th>15 RR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Residue (GMt/ha)</td>
<td>56.3</td>
<td>97.6</td>
<td>100.4</td>
<td>51.5</td>
</tr>
<tr>
<td>Recovery (%)</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>Extractable Biomass (GMt/ha)</td>
<td>11.3</td>
<td>19.5</td>
<td>20.1</td>
<td>10.3</td>
</tr>
<tr>
<td>Residues Left on Site (GMt/ha)</td>
<td>45.0</td>
<td>78.1</td>
<td>80.3</td>
<td>41.2</td>
</tr>
</tbody>
</table>

What is truly Recoverable?

Recoverable Biomass likely 10-20 GMt/ha

• Whole Tree Harvesting

Composition of Recoverable Residues

- Pulp: 3.40, 23%
- Waste: 5.18, 34%
- Biscuit: 0.01, 1%
(Assume: Recovery > 1m length)

Lost Value Considerations

Roadside Biomass

In-Field Biomass
Question: What are the operational considerations and site preparation implications of biomass removal?

Study: (2) Harvest Systems

1 - Mimic Biomass Recovery (WT)
2 - In-Field Biomass Dispersal (No Recovery) (CLT)
3 - Evaluate Operational & Site-Preparation Costs
**Cut-to-Length**

<table>
<thead>
<tr>
<th>Harvesting Method</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut to Length (CTL)</td>
<td>Harvester/ Processor - Komatsu 951 with Komatsu S172 Head</td>
</tr>
<tr>
<td></td>
<td>Forwarder - Komatsu 8903</td>
</tr>
<tr>
<td>Whole Tree (WT)</td>
<td>Feller Buncher - Tigercat 860C with Hotsaw Tigercat Head model 5702</td>
</tr>
<tr>
<td></td>
<td>Processor - Komatsu PC 270LC with Waratah 620L Head</td>
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<tr>
<td></td>
<td>Grapple Skidder - Tigercat model 632E</td>
</tr>
</tbody>
</table>

**Whole-Tree Harvesting**

- (left) Harvester/ Processor (right) Forwarder
- (left) Feller Buncher, (Centre) Processor, (right) Grapple Skidder

**Operational Analysis**

- Roadside Biomass
- In-Field Biomass

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**Est. Cost ($/PMH)**

- Harvester/ Processor - Komatsu 951 with Komatsu S172 Head: 275.55
- Forwarder - Komatsu 8903: 275.55
- Feller Buncher - Tigercat 860C with Hotsaw Tigercat Head model 5702: 275.55
- Processor - Komatsu PC 270LC with Waratah 620L Head: 213.63
- Grapple Skidder - Tigercat model 632E: 240.65
Project 2 - Operational Assessment: Site Preparation

- **Chopper Roller (CR)**, a dozer-based machine towing a multi-tonne drum roller with blades to break up slash material,
- **Excavator used to windrow the material** (move material into lanes away from the planting locations),
- **Excavator to move roadside material** (either to collect and burn or spreading roadside piles to allow for future planting [lane clear])

**Range of Left Slash:**
- CTL: 20-70 GMT/HA Dispersed
- WT: 10-30 GMT/HA at Roadside

(Left) Chopper Roller, (Centre) Excavator conducting CTL windrow, (right) Roadside pile after excavator manipulation prior to burning.
How much site prep. savings if switch from CTL to WT & Biomass Harvested?

<table>
<thead>
<tr>
<th>Slash Level</th>
<th>Economic Incentive ($/ha)</th>
<th>WT: Low - No Burn</th>
<th>CTL: Medium/Low</th>
<th>WT: Low - Burn</th>
<th>CTL: High</th>
<th>WT: Medium</th>
<th>CTL: High</th>
<th>WT: High - No Burn</th>
<th>CTL: High</th>
<th>WT: High - Burn</th>
<th>CTL: High</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Full Treatment</td>
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<td>No Pile</td>
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<tr>
<td>WT: High - No Burn</td>
<td>230</td>
<td>500</td>
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<td>CTL: High</td>
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<td>WT: High - Burn</td>
<td>400</td>
<td>500</td>
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<td>CTL: High</td>
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<tr>
<td>WT: Medium</td>
<td>384</td>
<td>600</td>
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<td>CTL: High</td>
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<tr>
<td>WT: Low</td>
<td>-116</td>
<td>100</td>
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</tbody>
</table>

Secondary: Operational cost savings of WT (vs. CTL): ~ $5/m³

May save $100-600/ha (0.2-1.3 $/m³) | Whole Tree Biomass Harvest (~200-400/ha)
Project 1 & 2 - Conclusions

• Viable amounts of recoverable Biomass
• Whole Tree Harvesting sites are most favorable for extraction
• There is an economic incentive to reduce on-site biomass
  • Biomass must be handled with prior to next generation planting
• Potentially Lost Value due to inefficient Harvesting Operations
• Net Revenue = Revenue - Costs (Costs are only piece of information)
  • Other Incentives may be greater than savings due to site-preparations
  • Market Considerations, Contractual agreements, logistical considerations, etc.
  • Soil Nutrient Load should be considered

Whole Tree Harvesting (Higher Volumes & More Easily Accessible!)
Need for a Supply Chain Analysis
**Step #1: Moving Raw Material**

- **Pros**:
  - Excavator: cheap, low impact
  - Skidder: on site, flexible
  - Front End Loader: cheap, robust
  - Forwarder - Slash: on site, flexible
  - Forwarder - Logs: on site, flexible, High quality

- **Cons**:
  - Excavator: short distance, dirty?
  - Skidder: only large pcs
  - Front End Loader: heavy, disturb, only large pcs
  - Forwarder - Slash: expensive, need to modify?
  - Forwarder - Logs: expensive, Low Quantity

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**Step #2: Processing (Chip/Grind)**

**Considerations**
- Optimal Pile Placement?
- Onsite Equipment?
- Contamination?
- Piece Size?
- Utilization?
- Pile Configuration?

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**Step #3: Transport**

**Considerations**
- Raw vs. Processed?
- Accessibility?

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**Costing Assumptions Developed for Each Alternative (40+)**
## Project 3 - Supply Chain Options

### Pathway Summary

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Location of chipping</th>
<th>Example</th>
<th>Comments / Variations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>At source</td>
<td>In-field chipper (e.g. Bruks unit on forwarder)</td>
<td>Empty into waiting truck or pre-positioned bins</td>
</tr>
<tr>
<td>2</td>
<td>Continuous along roadside</td>
<td>Self-contained chipper truck with chip bin +/- chip trailer (or Truck Mounted Chipper)</td>
<td>Needs excavator or similar to move residues from source (~ 20 m away) to roadside</td>
</tr>
<tr>
<td>3</td>
<td>Discontinuous along roadside</td>
<td>Truck, Trailer or Track-mounted chipper moves from roadside pile to roadside pile</td>
<td>Excavator (Skidder or Fwdr?) moves residues to roadside. Chip into waiting truck or pre-positioned bins</td>
</tr>
<tr>
<td>4</td>
<td>Centralised chipping at compartment level</td>
<td>Larger static chipper set up at each compartment</td>
<td>Modified Fwdr moves residues to central chipper (Alternatively modified dump/bin trucks shuttle material). Chip into waiting truck or bins</td>
</tr>
<tr>
<td>5</td>
<td>Chip at facility</td>
<td>Raw residues delivered in 'bin wood' trucks</td>
<td>May be suitable for very short haul distances</td>
</tr>
</tbody>
</table>
Key Assumptions:
- Volumes
- Piece Size
- Pile Placements
- Chipping Productivity
- Utilization Rate
- Distance from Market
- Equipment Costing
- Mobilisation
- Moisture Content

Many Assumptions – Need for Refinement & Testing

Lower Bound = $/GMt
Upper Bound = $/BDMT

Conceptual Evaluation

Early Preference: More Mobile & Less Capital Intensive
1. **In-Field Processing**
   - In-Field Biomass Harvesting (BRUKS Style Chipper) + No Pre-Field Manipulation

2. **Roadside Processing with Arranged Piles**
   - Truck-Mounted BRUKS Style Chipper (Bin/Hot)
   - Roadside Track-Mounted Grinder or Chipper

3. **Central Processing at Compartments**
   - Trailer or Track-Mounted Grinder or Chipper

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**Key Concept:** Sensitivity for Productivity Assumptions
For a Chosen Pathway:
- Competing Markets
- Sourcing Radius
- Trucking Availability

Modelling - Next Steps:
- MIP Model Development
- Time Series Analysis
- Market Constraints
- Costing Refinements
- Site Prep. Allocation

Development of Optimisation model built on refined assumption and regional constraints
Research – Next Steps

Waste To Biofutures (W2B) Grant – Ongoing!

Next Step: Strategic Field Trials, Refine Model Assumptions

GOAL: Corporate Investment in Equipment & Begin Delivery

- Enhanced Value Recovery – Minimize Existing Biomass Stocks
- Modified Harvest Trials – Integrated Support (Excavator/Processor)
- Residue Processing Trials – Communication Options & Productivity (In-Field, Centralized)
- Transportation and Facility Acceptance (Bins, Sequencing)