Facilitating the Adoption of Biomass Co-firing for Power Generation

By Gerard McEvilly, Srian Abeysuriya, Stuart Dix

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Foreword

Australia is actively seeking ways to reduce its electricity sector greenhouse gas emissions. One of the most cost-effective ways to do this is to substitute a renewable fuel—biomass—for a proportion of the coal used to generate electricity. This approach, biomass co-firing, is widely adopted around the world and has been successfully piloted in Australia but as yet has not been widely adopted here.

This report is focused on addressing barriers to the adoption of co-firing. Crucial insights are gained from a diverse array of previous RIRDC-funded R&D. This includes farm forestry, road and rail freight logistics, identification of native species as bioenergy crops, alley farming systems, biofuels policy, catchment studies and biofuel mapping. Links to key International Energy Agency (IEA) Tasks, such as Short Rotation Crops for Bioenergy Systems, have also been supported by RIRDC.

This report adds value to this wealth of information by placing it in the real world context of power generators, landholders, policymakers and others in the supply chain. Using South-East (SE) Queensland as a case study, and applying their knowledge of the power sector and related abatement policy development in Australia, the researchers bring a unique perspective. A range of barriers to co-firing have been identified, falling within the following framework:

- co-firing economics
- environmental concerns
- biomass market
- perceptions and attitudes.

As in any supply chain, the issues are interrelated. The report shows, for example, how government policy changes could affect co-firing economics, which in turn would drive the market. Landholder approaches to regrowth, community perceptions about tree plantations and environmental groups’ concerns about land use are also linked. Biomass co-firing can deliver important environmental and regional development benefits. This report provides a template for similar, region-specific studies.

This report is an addition to RIRDC’s diverse range of over 2000 research publications and it forms part of our Bioenergy, Bioproducts & Energy R&D program, which aims to meet Australia's research and development needs for the development of sustainable and profitable bioenergy and bioproducts industries. This report is focused on a key program strategy which aims to identify appropriate combinations of biomass feedstocks, renewable energy products and conversion processes that maximise major elements of the potential triple bottom line benefits to the Australian economy.

This project was funded from RIRDC Core Funds which are provided by the Australian Government, together with the Queensland Office of Clean Energy, part of the Department of Employment, Economic Development and Innovation (DEEDI) and three Queensland electricity generators—CS Energy, NRG Gladstone Operating Services and Tarong Energy.

Most of RIRDC’s publications are available for viewing, free downloading or purchasing online at www.rirdc.gov.au. Purchases can also be made by phoning 1300 634 313.

Craig Burns
Managing Director
Rural Industries Research and Development Corporation
About the Authors

Gerard McEvilly

Gerard is an experienced agribusiness program manager, with an extensive knowledge of rural industry in Australia (particularly horticulture). He applies supply chain thinking to problem solving and applies technical and marketing perspectives to reveal fresh insights. These are also informed through outstanding networks in all aspects of rural R&D built over 20 years. Gerard is experienced in building understanding and collaboration between the diverse perspectives found in the rural and R&D sectors.

Gerard managed strategic planning and R&D programs with Horticulture Australia Limited (HAL) for over a decade. He led the sustainable development portfolio, including the ‘Horticulture for Tomorrow’ Environmental Assurance program. With E3, Gerard has worked across the agricultural and forestry sector to develop commercial responses to climate change policy, carbon markets and emissions regulations. He has also been an invited conference speaker and facilitator as well as contributing to industry journals.

Srian Abeyesuriya

Srian has led a wide range of projects in the climate change domain for major Australian companies, including assessing greenhouse policy options and their impacts on the energy and energy intensive manufacturing sector, commercialising new technologies, developing strategy responses and supporting their implementation.

His pre-E3 experience includes 14 years in the New Zealand and Australian electricity industries where he held senior corporate positions in strategic development, market management and energy retailing and consulted to leading energy sector companies on strategy development and execution, business process analysis and change management.

In the late 1990s he was jointly responsible for providing thought leadership to, and catalysing the establishment of, the Australian Green Electricity Market (GEM), the world's first industry-governed green e-marketplace for renewable energy to support the needs of participants in the competitive green electricity market.

Stuart Dix

Stuart has over 15 years experience in the sustainability and climate change fields with a broad background in environmental management and environmental technologies. This background is complemented by a specialist focus on technologies to meet greenhouse gas emissions reduction imperatives, carbon accounting and market based measures for environmental pollutant reduction.

In this context, he has worked with a number of Australia's leading companies on assessing climate change policy impacts and greenhouse abatement initiatives. His experience spans both the technical and strategic domains. Stuart’s work on technology assessments, financial appraisals, greenhouse gas estimation frameworks and tradable instrument (carbon/renewables/environmental offset) strategies is used by organisations for compliance, policy development and business development purposes.

Stuart has a specific focus on industry with his specialist experience in power generation, metal product manufacturing, transport, mining and cement.
Acknowledgments

The authors would like to gratefully acknowledge the funding support that enabled this report to be prepared. The project was funded by RIRDC, the Queensland Office of Clean Energy, part of the Department of Employment, Economic Development and Innovation (DEEDI) and three Queensland electricity generators – CS Energy, NRG Gladstone Operating Services and Tarong Energy.

We also acknowledge the time and advice provided by the many people we consulted in gathering this information. Particular thanks are due to those individuals from New South Wales (NSW) and Queensland who participated in the generators workshop in October 2010, and to those who attended the validation workshop in February 2011, including a range of people from other sectors. We are indeed grateful for the valuable input provided.

The Queensland Department of Employment, Economic Development and Innovation (DEEDI) provided significant additional support through the provision of meeting and workshop facilities. For this logistical support as well as invaluable coordination with government expertise, we thank Peter Roberts of the Office of Clean Energy and Michael Burke of Plant Industries and Industry Development.

Our thanks to Dr Steve Schuck of Bioenergy Australia and to Dr Andrew Warden of the CSIRO Energy Transformed Flagship who generously agreed to review this report, and to Narelle Roolker from E3 for her research and technical support, including the creation of several graphics.
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACRE</td>
<td>Australian Centre for Renewable Energy</td>
</tr>
<tr>
<td>AFS</td>
<td>Australian Forestry Standard</td>
</tr>
<tr>
<td>C&amp;D</td>
<td>Construction and demolition</td>
</tr>
<tr>
<td>CCA</td>
<td>Copper chrome arsenate</td>
</tr>
<tr>
<td>CCSD</td>
<td>Cooperative Research Centre for Coal in Sustainable Development</td>
</tr>
<tr>
<td>CEC</td>
<td>Clean Energy Council</td>
</tr>
<tr>
<td>CHP</td>
<td>Combined heat and power</td>
</tr>
<tr>
<td>CQFA</td>
<td>Central Queensland Forestry Association</td>
</tr>
<tr>
<td>CRCFFI</td>
<td>Future Farm Industries Cooperative Research Centre</td>
</tr>
<tr>
<td>CSG</td>
<td>Coal seam gas</td>
</tr>
<tr>
<td>DEEDI</td>
<td>Queensland (Department of Employment, Economic Development and Innovation</td>
</tr>
<tr>
<td>DERM</td>
<td>Queensland Department of Environment and Resource Management</td>
</tr>
<tr>
<td>ESFM</td>
<td>Ecologically sustainable forest management</td>
</tr>
<tr>
<td>FPQ</td>
<td>Forestry Plantations Queensland website</td>
</tr>
<tr>
<td>FSC</td>
<td>Forest Stewardship Council</td>
</tr>
<tr>
<td>FWPA</td>
<td>Forest and Wood Products Australia</td>
</tr>
<tr>
<td>GHG</td>
<td>Greenhouse gas</td>
</tr>
<tr>
<td>HW</td>
<td>Hardwood</td>
</tr>
<tr>
<td>IEA</td>
<td>International Energy Agency</td>
</tr>
<tr>
<td>LCA</td>
<td>Life cycle assessment</td>
</tr>
<tr>
<td>LGC</td>
<td>Large-scale Generator Certificate</td>
</tr>
<tr>
<td>LRET</td>
<td>Large-scale Renewable Energy Target</td>
</tr>
<tr>
<td>LWA</td>
<td>Land and Water Australia</td>
</tr>
<tr>
<td>MIS</td>
<td>Managed investment scheme</td>
</tr>
<tr>
<td>MRET</td>
<td>Mandatory Renewable Energy Target</td>
</tr>
<tr>
<td>n.d.</td>
<td>Not dated (webpage)</td>
</tr>
<tr>
<td>NRM</td>
<td>Natural resource management</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------</td>
</tr>
<tr>
<td>ORER</td>
<td>Office of the Renewable Energy Regulator</td>
</tr>
<tr>
<td>OTC</td>
<td>Over the counter</td>
</tr>
<tr>
<td>PEF</td>
<td>Process engineered fuel</td>
</tr>
<tr>
<td>PF</td>
<td>Pulverised fuel</td>
</tr>
<tr>
<td>PFSQ</td>
<td>Private Forestry Service Queensland</td>
</tr>
<tr>
<td>PNF</td>
<td>Private native forest</td>
</tr>
<tr>
<td>REC</td>
<td>Renewable Energy Certificate</td>
</tr>
<tr>
<td>RDF</td>
<td>Refuse-derived fuel</td>
</tr>
<tr>
<td>RET</td>
<td>Enhanced Renewable Energy Target</td>
</tr>
<tr>
<td>RPS</td>
<td>Renewable portfolio standard</td>
</tr>
<tr>
<td>SEQFA</td>
<td>South East Queensland Forests Agreement</td>
</tr>
<tr>
<td>SRC</td>
<td>Short rotation crops</td>
</tr>
<tr>
<td>SRES</td>
<td>Small-scale Renewable Energy Scheme</td>
</tr>
<tr>
<td>SW</td>
<td>Softwood</td>
</tr>
<tr>
<td>tCO$_2$-e</td>
<td>Tonnes of carbon dioxide (CO$_2$) equivalent (used to compare the relative impacts of GHGs other than CO$_2$, which have different global warming capacities)</td>
</tr>
<tr>
<td>WoNS</td>
<td>Weeds of national significance</td>
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</tbody>
</table>
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Executive Summary

What the report is about

This report is about biomass co-firing, which is a method to reduce greenhouse gas (GHG) emissions by substituting a renewable fuel—biomass—for a proportion of the coal used to generate electricity in coal-fired power stations.

Importantly, the focus is on factors affecting the adoption of co-firing rather than on the technology itself. Biomass co-firing has been proven and commercially adopted around the world, facilitated by a range of supportive policies. At low levels of co-firing, minimal capital expenditure is required, making this one of the most cost-effective ways to reduce GHG emissions. This technology has been successfully piloted by generators, but as yet has not been widely adopted in Australia.

The research reported here was initiated to investigate the reasons for this failure to adopt co-firing, in order to identify the most significant barriers to adoption and to offer potential solutions. It applies a commercial perspective along the whole supply chain, as well as reviewing technical, environmental and policy aspects of co-firing, both in Australia and overseas. This approach is applied to South-East (SE) Queensland as a case study area and could be applied as an analytical framework for other regions.

The report provides a clear framework for analysing co-firing options that is designed to remain valid into the future, whether or not carbon pricing comes into play. The conclusions about prospects for the immediate adoption of co-firing in Queensland are based on current (March 2011) economic and other policy settings.

Who is the report targeted at?

Most of Australia’s electricity generators use coal, a plentiful and well-understood resource with well-established and reliable supply chains. In comparison, the supply chains for biomass are highly complex and undeveloped. This report is targeted at the wide range of parties who participate in these chains or influence them.

At the demand end, this comprises the generators themselves, as well as government agencies who regulate them and set GHG emissions policy. It also includes existing or potential alternative markets for biomass. While this report is about co-firing, none of the other potential biomass-based technologies, such as biofuels or biochar, can progress without effective biomass supply chains.

Along the chain, transport and logistics suppliers, aggregators, government regulators and market mechanisms such as information exchanges are required for effective operation.

At the supply end, unlike coal, there are a wide range of potential sources of supply and an enormous number of suppliers, many of whom may be unaware of the opportunities and challenges of this potential market.

Therefore, the supply chain must include facilitators such as local, regional and state agriculture, forestry and land management organisations as well as all levels of government involved in regional development. Other key facilitators include research managers, industry associations and investors involved in the development of biomass-based markets and technologies, including Bioenergy Australia, the Clean Energy Council and RIRDC.

Finally, biomass co-firing has the potential to deliver both direct and indirect environmental benefits. It is essential that both government and non-government organisations dedicated to environmental protection are engaged in the development of the biomass supply chain, to ensure that any potential environmental risks are scientifically assessed and managed.
Background

Co-firing of low levels (up to 3 per cent by energy value) of biomass in coal-fired power stations provides an entry level opportunity to reduce GHG emissions from the electricity generation sector, given:

- the ability to create Large-scale Generation Certificates (LGCs)\(^1\) under the Commonwealth Large-scale Renewable Energy Target Scheme
- the future capacity to avoid GHG emissions liabilities under proposed future Emissions Trading or Carbon Taxation schemes
- low incremental technology costs.

Co-firing at this level in Queensland would achieve GHG emissions reductions in the order of 1.4 million tonnes CO\(_2\)-e per annum.\(^2\) Currently, there is no material co-firing of biomass in Queensland coal-fired power stations, despite a number of trials proving the technical feasibility.

Preliminary enquiries indicated interest in co-firing from the generation, biomass supply and government sectors, as well as significant past research into aspects of this technology. These enquiries also highlighted a number of issues related to the failure to adopt co-firing in Queensland. Two generators in NSW have undertaken commercial-scale co-firing in the past, but have now ceased for a number of reasons.

Aims/objectives

- to understand the Queensland coal-fired electricity generation sector’s perceptions and experience to date of biomass co-firing
- to identify technical, commercial and logistical barriers that are limiting the uptake of biomass co-firing by coal-fired electricity generators, and conditions that would need to be satisfied for adoption to occur
- to identify possible solutions to these barriers.

Methods used

In order to achieve these objectives, the project was undertaken in the following stages:

1. Review of literature related to biomass production, economics and marketing and co-firing
2. Detailed discussions with generators in SE Queensland (and NSW) to identify their needs
3. Consultation with a broad range of current and potential biomass suppliers and supply chain participants, in and around SE Queensland, to identify barriers to meeting these needs
4. Identification of potential solutions in order to facilitate adoption of co-firing.

Results/key findings

There has been significant global progress during the last decade in the utilisation of biomass in coal-fired power stations. Co-firing is routinely practised on a commercial scale in many countries—

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\(^1\) Previously called Renewable Energy Certificates (RECs).

\(^2\) Total emissions from Queensland (2008) were 160.3 million tCO\(_2\)-e per annum (including emissions from land use, land use change and forestry (Australian Government 2010a)).
especially in Europe—supported by a combination of renewable energy, carbon and biomass policies as well as increased coal prices. Currently, there are at least 18 pulverised-coal power stations in Belgium, Denmark, Finland, Italy, Netherlands, the United Kingdom (UK) and the United States (USA) where co-firing is being carried out commercially.\(^3\)

Key themes from our discussions with generators (noting that there are differences in views between individual generators) include:

- The quantity of biomass required is significant, even for low levels of co-firing. For example, co-firing 3 per cent of biomass (by energy content) in a 1000 MW coal-fired power station would require around 192 000 t of biomass annually.

- Generators see their core business as power generation, not biomass production or processing. For this reason, and to minimise transaction costs from procurement, generators would prefer to outsource the aggregation and delivery of biomass.

- Coal-fired power station operational processes are finely tuned and are designed to handle very large volumes of coal efficiently and safely. The introduction of biomass fuel presents a range of challenges, including: accommodating multiple biomass types; co-milling biomass and coal; frequent truck movements within a tightly controlled site; and risks associated with spontaneous combustion and elevated dust levels (particularly at higher levels of co-firing). There was consensus that these issues were not insurmountable at low levels of co-firing, although resolutions would require increased capital expenditure depending on the approach adopted for biomass handling and combustion.

- The business case for biomass co-firing relies on a simple proposition—that the benefits (avoided cost of coal + LGC revenue) must exceed the additional capital and operating costs after adjusting for the time value of money. Generators find that co-firing economics have been marginal due to low REC (now LGC) prices and high delivered biomass costs. Low prices have been exacerbated by a market discount on RECs/LGCs from wood waste sources and reluctance of electricity retailers to purchase RECs/LGCs from these sources. Generators find that under current policy settings, delivered fuel costs would need to be less than $3-$4/GJ ($36–$48/t). The introduction of a price on carbon and/or higher LGC prices would raise this upper limit.

Overall, generators see the need to balance the benefits of co-firing against risks to their core business.

From both the literature and from detailed discussions with generators, biomass suppliers and supply chain participants, a range of barriers were identified. These are summarised in Table 1 below, while potential solutions are summarised below under recommendations.

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\(^{3}\) E3 update of IEA co-firing database (IEA 2009).
Table 1: Key barriers to biomass co-firing

<table>
<thead>
<tr>
<th>Category</th>
<th>Barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO-FIRING ECONOMICS</td>
<td>• The economics of biomass co-firing are marginal under current policy settings. Consequently, the maximum price that generators can afford to pay restricts potential biomass sources to very low cost materials</td>
</tr>
<tr>
<td>ENVIRONMENTAL CONCERNS</td>
<td>• Resistance to combustion of woody material for energy production</td>
</tr>
<tr>
<td>BIOMASS MARKET</td>
<td>• Known availability of low cost biomass falls short of volumes required for continuous low levels of co-firing</td>
</tr>
<tr>
<td></td>
<td>• Lack of integrated biomass supply capability</td>
</tr>
<tr>
<td></td>
<td>• Lack of information on biomass resource availability</td>
</tr>
<tr>
<td></td>
<td>• Lack of organised market for biomass</td>
</tr>
<tr>
<td>PERCEPTIONS AND ATTITUDES</td>
<td>• Perception that biomass co-firing is an established technology that does not require policy support for commercialisation</td>
</tr>
<tr>
<td></td>
<td>• Lack of interest in agroforestry within farming sector</td>
</tr>
<tr>
<td></td>
<td>• Community perception of plantations</td>
</tr>
</tbody>
</table>

A key challenge in addressing these barriers is that there are many alternative sources of biomass, some existing and some potential. These range widely in their ability to meet the technical, economic and market factors associated with co-firing. However, none were excluded from consideration because the potential of these sources will change over time, partly in response to the expected changes in the economics of co-firing.

A significant body of information is available on both existing and potential new sources of biomass in Australia and overseas (Stucley et al. 2004). The following analysis builds on this work by focusing on the practical realities of biomass supply for a specific purpose (co-firing) in a specific region (SE Queensland).

In order to deal with this complexity, the results have been summarised in Table 2 below, which provides a generalised picture across SE Queensland.
### Table 2: Comparison of biomass sources considered

<table>
<thead>
<tr>
<th>Source</th>
<th>Section</th>
<th>Preferred by generators</th>
<th>Available in 0-12 months</th>
<th>Available in 1-5 yrs</th>
<th>Available in 5+ yrs</th>
<th>Available within ETD</th>
<th>Cost</th>
<th>RET eligibility</th>
<th>Regulatory matters</th>
<th>Competing uses</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agricultural production residues</strong></td>
<td>3.1</td>
<td>Negative</td>
<td>Neutral/unKnown</td>
<td>Positive</td>
<td>Not applicable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Crop residues</strong></td>
<td>3.1.1</td>
<td>Needs pre-chopping</td>
<td>No organised supply chain</td>
<td>Positive</td>
<td></td>
<td>Nutrient value and baling cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Woody weeds</strong></td>
<td>3.1.2</td>
<td>If pre-chipped</td>
<td>No organised supply chain</td>
<td>Positive</td>
<td></td>
<td>Distance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Regrowth residues</strong></td>
<td>3.1.3</td>
<td>If pre-chipped</td>
<td>No organised supply chain</td>
<td>Positive</td>
<td></td>
<td>Needs to be confirmed Old Native Veg Act</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Agricultural energy crops (herbaceous)</strong></td>
<td>3.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Regional biofuels production</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Agroforestry for energy</strong></td>
<td>3.3</td>
<td>If pre-chipped</td>
<td>No organised supply chain</td>
<td>Positive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Agricultural processing residues</strong></td>
<td>3.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bagasse</strong></td>
<td>3.4.1</td>
<td>Difficult to mix evenly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Other agricultural processing residues</strong></td>
<td>3.4.2</td>
<td>If no handling issues</td>
<td>Low volumes</td>
<td>Low volumes</td>
<td>Low volumes</td>
<td></td>
<td></td>
<td></td>
<td>Needs to be confirmed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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4 Economic transport distance

5 Worthy of further investigation under current economics.
<table>
<thead>
<tr>
<th>Section</th>
<th>Source</th>
<th>Preferred by generators</th>
<th>Available in 0–12 months</th>
<th>Available in 1–5 yrs</th>
<th>Available within ETD 4</th>
<th>Cost</th>
<th>RET eligibility</th>
<th>Regulatory matters</th>
<th>Competing uses</th>
<th>Overall 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5</td>
<td>Forestry plantation residue SW</td>
<td>If pre-chipped</td>
<td>Low volumes</td>
<td>Low volumes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Soil health in softwood</td>
</tr>
<tr>
<td>3.5</td>
<td>Forestry plantation residue HW</td>
<td>If pre-chipped</td>
<td>Possibly from clearing only</td>
<td>Only small volumes likely</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.6</td>
<td>Native forest residue (from rehabilitation)</td>
<td>If pre-chipped</td>
<td>Large volumes possible</td>
<td>Large volumes possible</td>
<td>In some areas</td>
<td>Trials costs hold promise</td>
<td>Needs to be confirmed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.7</td>
<td>Sawmill residue</td>
<td>If large pieces pre-chipped</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.8</td>
<td>Coal seam gas-related biomass</td>
<td></td>
<td>Yet to commit</td>
<td>Yet to commit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CSG may require better returns from other markets</td>
<td></td>
</tr>
<tr>
<td>3.9</td>
<td>Development residues</td>
<td>If pre-chipped</td>
<td>No firm info beyond about 18 months</td>
<td>In some areas</td>
<td>Needs to be confirmed</td>
<td>Must be Approved Developments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.10</td>
<td>Urban waste</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.10.1</td>
<td>Green waste</td>
<td>Woody screenings could be ok if pre-chipped</td>
<td></td>
<td></td>
<td>Distance (disposal fees could change this)</td>
<td></td>
<td>Compost, landfill for methane, potential cogen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.10.2</td>
<td>C&amp;D waste</td>
<td>Must be free of contaminants if pre-chipped</td>
<td></td>
<td></td>
<td>Distance (disposal fees could change this)</td>
<td></td>
<td>Licensing conditions</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It is important to note that the relative merits of a particular biomass source will vary with each particular generator according to its location, engineering setup and site specific circumstances.

This simplified framework provides a valuable tool for any biomass supply chain participant. It also acts as a starting point in assessing resource availability for a biomass co-firing project. This approach recognises that the relative suitability of each potential source is likely to change in future as various factors continue to develop.

For example, we note that some of these potential sources require confirmation of their eligibility under the RET, as well as the removal of potential barriers to adoption by landholders and concerns by environmental groups. In addition, our analysis is based on current economic conditions. A number of
these conditions have the potential to shift, thus increasing the potential for co-firing to use higher-cost sources. These factors include a carbon price, higher prices for LGCs, waste management fee structures and other government policy adjustments and incentives.

Given the state of play in early 2011, our conclusions regarding the sources of biomass considered for co-firing to commence in the near future in SE Queensland are included in Table 3 below. The full analysis and key issues leading to these conclusions make up Section 3 of this report.

Table 3: Summary of conclusions related to biomass sources considered for co-firing in SE Queensland

<table>
<thead>
<tr>
<th>Biomass Source</th>
<th>Conclusions related to co-firing in Queensland</th>
</tr>
</thead>
</table>
| 3.1 Agricultural production residues   | *Crop residues* - At present, the use of crop residues for co-firing is not economically viable, given their nutrient value and agronomic benefits as well as the costs of baling, transport and storage. Nevertheless, the volumes are certainly available were the economics to shift in the future.  
*Woody weeds* - Woody weeds are not currently viable as a major source of biomass for co-firing.  
*Regrowth residues* - Overall, regrowth residues from agricultural operations are at best a medium to long-term possibility for generating a large and consistent supply of biomass under current economics. |
| 3.2 Agricultural energy crops (herbaceous) | Herbaceous energy crops may have future potential once their agronomy and productivity under marginal conditions have been assessed, along with their weed status and overall environmental impact. |
| 3.3 Agroforestry for energy             | At present, neither the available knowledge nor the economics support the use of land in SE Queensland for energy plantations using the WA model. |
| 3.4 Agricultural processing residues    | Only bagasse is available in the quantities required, but it already has a beneficial renewable energy use. This, coupled with the distance of the resource from coal-fired power stations, as well as potential co-milling issues, precludes its consideration for direct biomass co-firing. |
| 3.5 Plantation residue                  | Appears unlikely to be a viable source for co-firing under current economic conditions.                      |
| 3.6 Native forest residue               | This source has major potential in terms of volume and likely availability within an economic transport distance. However, significant barriers exist in terms of the perceived environmental issues. |
| 3.7 Sawmill residue                     | Sawmill residues are produced in large volumes overall, but a range of issues, including established value-adding uses, render their use for co-firing uncompetitive at present. |
| 3.8 Coal seam gas-related biomass       | Significant potential volumes in the medium to longer term but co-firing economics would need to improve if companies are to consider this avenue. |
| 3.9 Development residues                | This source appears to have significant potential in the short-term to enable co-firing to become established for one or two generators in the northern sector of the study area. However, pricing and eligibility under the RET are not clear at this stage. It also relies on the availability of an aggregator to manage the requirement for a consistent supply into the generator, as well as on quality, price and RET eligibility factors. |
| 3.10 Urban waste                        | *Green waste* - is available in significant quantities, but not close to generators, who do not consider it to be a preferred source for co-firing in its current form.  
*Construction & demolition (C&D) waste* - processed engineered fuel is worthy of further investigation. Various issues, including its affinity to co-milling and plastics content, may need to be addressed. In addition, the economics of this option should be further investigated. |
Implications for relevant stakeholders

An important overall implication is the need for an approach that recognises and integrates the different perspectives of the wide and varied group of participants in, and influencers of, the supply chain for biomass co-firing. A key implication for the generation sector is that one or more generators need to express genuine commercial interest in biomass co-firing. A key implication for the government sector is the need for support to facilitate the translation of this interest into effective projects. These are all addressed in the recommendations below.

Recommendations

As described above, the participants in, and influencers of, the supply chain for biomass co-firing are many and varied. An abbreviated version of the recommendations is included below.

CO-FIRING ECONOMICS

BARRIER - The economics of biomass co-firing are marginal under current policy settings. Consequently, the maximum price that generators can afford to pay restricts potential biomass sources to very low cost materials

Abbreviated Recommendations

- Explore the introduction of state-based renewable energy policy measures that fully or partially bridge the current economic viability gap for biomass co-firing.
- Investigate the feasibility of a biomass resource support program, drawing on international precedents and reflecting the biomass targets in the Queensland Renewable Energy Plan.

ENVIRONMENTAL CONCERNS

BARRIER - Resistance to combustion of woody material for energy production

Abbreviated Recommendations

- Convene a roundtable of key parties in an independently facilitated process to (a) identify key concerns, (b) have oversight of a program of research to support informed deliberation and (c) reach accommodations to agree a common path forward
- In conjunction with the roundtable, commission a comprehensive, science-based analysis of the pros and cons of managing forestry regrowth in private native forests in Queensland and use of sustainably harvested material for power generation, including biomass co-firing
- In conjunction with the roundtable, review the current categorisation of wood waste material within the RET regulations to ensure that the categories are relevant to, and support existing and future bioelectricity feedstocks. Use this as input to the review of the RET legislation in 2012
- In conjunction with the roundtable, develop and implement a comprehensive communications program that clarifies the economic, environmental and social impacts of energy production from sustainably harvested biomass.
### BIOMASS MARKET

**BARRIER - Known availability of low cost biomass falls short of volumes required for continuous low levels of co-firing**

<table>
<thead>
<tr>
<th>Abbreviated Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Generators should consider the availability of biomass from land clearing under Development Approvals as a key short-term biomass source for co-firing, subject to eligibility of this material under RET regulations</td>
</tr>
<tr>
<td>- Undertake research to assess the potential of regrowth management as an ongoing source of biomass in the medium to long term</td>
</tr>
<tr>
<td>- Direct waste levy funds for research into the potential of process engineered fuel (PEF) from C&amp;D waste for co-firing and bioelectricity</td>
</tr>
<tr>
<td>- Adopt the approach in Table 7 of this report as a template for assessment of biomass sources.</td>
</tr>
</tbody>
</table>

**BARRIER - Lack of integrated biomass supply capability**

<table>
<thead>
<tr>
<th>Abbreviated Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>- That one or more generators should express genuine commercial interest in biomass co-firing, with the project/s to serve as focal points for industry support and development</td>
</tr>
<tr>
<td>- The Queensland Government should consider early stage support for such beachhead projects on a case by case basis, including the provision of knowledge and information on biomass sources in the region of the power station and facilitating any approvals associated with utilisation of those biomass resources.</td>
</tr>
</tbody>
</table>

**BARRIER - Lack of information on biomass resource availability**

<table>
<thead>
<tr>
<th>Abbreviated Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Develop Terms of Reference for, and commission the preparation of inventories of biomass resources around coal-fired power stations that are actively considering biomass co-firing.</td>
</tr>
</tbody>
</table>

**BARRIER - Lack of organised market for biomass**

<table>
<thead>
<tr>
<th>Abbreviated Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Establish and maintain an online biomass information portal that provides a single point of reference for biomass suppliers and users/buyers.</td>
</tr>
<tr>
<td>- Consider the establishment of a basic information exchange—initially in the form of a bulletin board where buyers and sellers can exchange information on supply and demand opportunities.</td>
</tr>
</tbody>
</table>
**PERCEPTIONS AND ATTITUDES**

**BARRIER - Perception that biomass co-firing is a mature technology that does not require policy support for commercialisation**

**Abbreviated Recommendations**

- Biomass co-firing proponents should spell out the case for bridging support. This should be framed in the context of a live project and should highlight both the status of co-firing within the innovation chain as well as the regional development benefits arising from proposed developments.
- The Queensland Government should recognise the potential of biomass co-firing in delivering its renewable energy and greenhouse gas emissions reduction objectives and make explicit reference to this approach in its renewable energy plan and overall policy framework.
- The bioelectricity industry should clearly articulate the positioning of bioelectricity (including biomass co-firing) within the innovation chain to support the case for national policy support on the same basis as for other renewable energy technologies such as solar and wind energy.

**BARRIER - Lack of interest in agroforestry within farming sector**

**Abbreviated Recommendations**

- Research should be directed at agroforestry (strip and block plantings) for short-rotation cropping in Queensland. Knowledge is lacking on suitable varieties, productivity, environmental impacts, economics and commercialisation models. Close industry and community involvement is essential.

**BARRIER - Community perception of plantations**

**Abbreviated Recommendations**

- Consideration of biomass options should be included in any future revision of the Queensland Timber Plantation Strategy 2020. This should take into account the full spectrum of timber/biomass options from timber plantations to energy plantations and agroforestry.
- Investigate social research such as that undertaken in other states to understand community perceptions in SE Queensland regarding plantations for either timber or energy.
- Based on sound information, DEEDI should implement community education action plans as proposed in the Queensland Timber Plantation Strategy 2020.
Introduction

As a method to reduce greenhouse gas emissions from electricity generation, co-firing of biomass in coal-fired power stations has several advantages:

- It involves a minimal level of capital expenditure, compared with other forms of renewable energy, because it makes use of existing infrastructure and proven technology
- It is capable of mitigating substantial volumes of CO₂, even at low levels of co-firing
- It can be implemented immediately, unlike some other proposed methods of CO₂ mitigation
- It can make beneficial use of waste streams that are currently directed to landfill, as well as potentially stimulating new biomass supply industries
- It offers continuous electricity supply and reliability—any interruption in biomass supply can be simply substituted by coal.

Biomass co-firing has been successfully piloted at a number of power stations in Queensland and NSW, with the lessons captured in the Australian Coal-Biomass Co-firing Handbook (CCSD 2007). Co-firing is also an established practice elsewhere in the world. However, there is currently no material co-firing of biomass in Queensland coal-fired power stations. The reasons for this low adoption rate need to be well understood and addressed because co-firing is an important transition stage towards the development of the bioenergy industry. This project was initiated to address this, by identifying the key barriers to adoption of biomass co-firing and exploring options to overcome those barriers.

Biomass and biofuels are related, but are distinct elements of bioenergy—a collective term for a range of renewable energy options that use biological materials as the source of energy. Biomass is the collective term for the diverse range of biological materials that can act as feedstocks. These range from traditional products, such as firewood, to emerging products such as algae. The term biofuel generally refers to substitutes for liquid fuels such as petrol and diesel.

First-generation biofuels are derived from free sugars, starches or fatty acids in feedstocks such as grains, oilseeds and sugar. Second-generation biofuels are approaching commercialisation, using alternative processing technologies and feedstocks such as woody wastes or crop residues. Significant research is also underway to extract biofuel from mass-produced algae. Another form of biofuel is the gas emitted from anaerobic digestion of biomass (biogas) or generated from the gasification of biomass.

Biomass co-firing technologies are relatively simple compared to these biofuel options. Co-firing involves capturing the energy content of biomass by burning it in a pulverised fuel (PF) boiler furnace, along with coal, in order to power steam turbines to create electricity. However, PF boilers are quite sophisticated, finely tuned devices and this introduces some technical constraints that are discussed in the first section of this report. As such, co-firing is quite distinct from cogeneration, which describes electricity and heat generation from burning biomass and/or other fuels in industrial processes, such as sugar milling.

Importantly, the project partners from the energy generation sector identified constraints to securing affordable and ongoing supplies of suitable biomass as a key issue. The CSIRO Energy Transformed Flagship project—Sustainable Biomass Production for Biofuels and Bioenergy in Australia—has been exploring this issue on a national basis. This project was designed to complement the CSIRO studies by focusing on the specifics of biomass co-firing for electricity generators in SE Queensland. This region was selected based on the scale, scope and funding partners for this project.
However, as a case study, there are valuable lessons for other regions in understanding the barriers to, and options for, increasing the use of biomass in power generation. In addition, much of the supply chain analysis related to biomass procurement is equally applicable to other potential future uses of biomass currently under investigation.

Objectives

The objectives of this project were:

- to understand the Queensland coal-fired electricity generation sector’s perceptions and experience to date of biomass co-firing

- to identify technical, commercial and logistical barriers that are limiting the uptake of biomass co-firing by coal-fired electricity generators and conditions that would need to be satisfied for adoption to occur

- to identify possible solutions to these barriers.
Methodology

The project was undertaken in the following stages:

1. Review of literature related to biomass production, economics, marketing and co-firing.
2. Detailed discussions with generators in SE Queensland and NSW to identify their needs.
3. Consultation with a broad range of current and potential biomass suppliers and supply chain participants in and around SE Queensland to identify barriers to meeting these needs.
4. Identification of potential solutions in order to facilitate adoption of co-firing.

The literature review extended across the entire supply chain related to biomass co-firing and included overseas countries where co-firing is underway and biomass markets are well established. It also covered government policy developments related to renewable energy and emissions abatement in Australia and in some overseas jurisdictions. This review informed the following consultations and recommendations. Key references are provided and findings are incorporated into the report. Provision of a stand-alone literature review summary was outside of the project scope.

The project team engaged in structured discussions with major coal-fired generators in SE Queensland (NRG Gladstone Operating Services, Stanwell Corporation, Tarong Energy Corporation, CS Energy and Intergen). The team also met with Delta Electricity and Macquarie Generation in NSW, both of whom have significant experience in co-firing. Discussions covered the feasibility of biomass co-firing at low (up to 3 per cent levels) and identified a range of technical, commercial and logistical barriers. Following analysis of the confidential records of these discussions, key themes were identified: biomass sources and logistics; biomass handling and combustion; economics and risk management; and policy and regulation.

These themes formed the basis of a Generators Workshop, held in Brisbane on 27 October 2010. This served to confirm generator requirements for low level biomass co-firing, in order to inform discussions with potential suppliers. Discussion focused on: generator experiences to date with biomass co-firing; barriers and challenges to biomass co-firing; and generator prerequisites for uptake of co-firing.

The project team engaged in structured discussions with a wide range of suppliers and related parties associated with sources of biomass in Queensland. This identified (a) the nature and scope of barriers that are preventing the meeting of generator needs and (b) possible avenues to address these issues.

This group included forestry/plantation companies and organisations, sawmillers, agriculture companies, broadacre farming contractors and consultants, local government, waste management companies, transport companies, farming organisations, landcare organisations, coal seam gas companies, government policy advisors and researchers and industry development staff related to agriculture, forestry and regional development. This phase also included consideration of future competing uses for biomass.

From stages 1–3, a series of issues emerged. The project team refined these into key barriers to the adoption of co-firing and developed options to address these barriers. A full day workshop with stakeholders was held in Brisbane on 11 February 2011. This provided an opportunity to critically review the options from a broad range of perspectives. This informed the final stage of refining the solutions and developing recommendations.
1. Biomass Co-firing

1.1 Technology and market overview

The majority of black coal–fired power stations in Australia use pulverised fuel systems, where coal is crushed into a fine powder in specially designed mills and blown into a boiler furnace.

Co-firing generically refers to the simultaneous combustion of different fuels in a combustion system, There are several different approaches to co-firing biomass with coal in pulverised fuel systems.\(^6\) Depending on the approach adopted, the biomass utilised could be in solid (for example, woody material), gaseous (for example, biogas) or liquid (for example, biofuel) form.

Co-firing biomass and coal in existing pulverised coal-fired power stations is a relatively low cost option to reduce GHG emissions by partially substituting coal with biomass fuels. High combustion efficiency can be achieved with only minor or no modification to existing systems (CCSD 2007).

Co-firing systems are readily integrated within existing power stations as biomass can be integrated with the fuel supply to existing combustion systems. With specialised modifications, co-firing can represent up to 20 per cent of the energy input requirements (NREL 2004).

There has been significant global progress during the last decade in the utilisation of biomass in coal-fired power stations. Co-firing is being routinely practiced on a commercial scale in many countries—especially in Europe. In 2004, there were more than 150 coal-fired power stations worldwide that were co-firing on a trial basis or commercially using a range of fuels and technology approaches (Van Loo & Koppejan 2010). Currently, there are at least 18 pulverised coal power stations in Belgium, Denmark, Finland, Italy, Netherlands, the United Kingdom (UK) and the United States (USA) where co-firing is carried out commercially.\(^7\)

The majority of Australian co-firing trials have been based on solid biomass fuels.\(^8\) For low levels of biomass co-firing, co-milling solid biomass and coal and subsequently injecting the coal–biomass mixture into the boiler furnace is the simplest and least expensive investment option, illustrated in Figure 1.

*Given its simplicity, its demonstrated technical feasibility and its capacity to act as a stepping stone to more complex options, this approach will be the focus of this report.*

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\(^6\) Comprising (a) direct firing of biomass with coal, (b) indirect firing of biomass and (c) firing biomass in a separate boiler furnace, but using the steam in the existing generation plant (CCSD 2007).

\(^7\) E3 update of IEA co-firing database (IEA 2009).

\(^8\) CS Energy co-fires landfill gas at its Swanbank B Power Station (CCSD 2007).
The benefits of co-firing with biomass include:

- reduction in coal consumption resulting in a reduction in greenhouse gas emission liability
- a potential income stream in the form of Large-scale Generation Certificates (previously known as Renewable Energy Certificates) under the Federal Government’s Renewable Energy Target Scheme (explained in more detail later)
- reduction in SO$_2$ due to an overall reduction in fuel sulphur and absorption by the basic oxides in wood ash
- reduction of nitrogen oxide (NO$_x$) formation (up to 30 per cent) through a reduction in fuel-bound nitrogen
- utilisation of biomass with little or no loss in thermal efficiency
- utilisation of existing plant infrastructure.

Large-scale pulverised coal–fired power stations have become highly efficient in the receival, storage and handling, retrieval, milling and combustion of coal. As many types of biomass have significantly different properties to coal, the introduction of even low levels of biomass will have some impact on the overall operating efficiency of a coal-fired power station. Differences in moisture content, energy content and energy density are particularly important in this respect.

Moisture content is a measure of the amount of water in the biomass.$^9$ Biomass exhibits a wide range of moisture content (on a wet basis$^{10}$), ranging from 5–10 per cent for straw to around 40–60 per cent for bagasse and freshly harvested wood. In comparison, the moisture content of coal is around 15 per cent (CCSD 2007). The higher moisture content of biomass acts to reduce its energy content and lower combustion efficiency. Additionally, higher moisture levels increase the cost of transporting the

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$^9$ Comprising ‘free moisture’ (held on the surface of the biomass and readily lost through evaporation) and ‘residual moisture’ (held more strongly within the biomass and can be driven off by drying at higher temperatures).

$^{10}$ Where the moisture content is expressed as a percentage of the sum of the weights of the water, ash and dry-and-ash-free matter.
biomass on a per unit of energy content basis (i.e. a higher moisture content means more non-productive water needs to be transported for delivery of each unit of energy). The moisture content of biomass also affects the storage durability of the biomass, its susceptibility to fungi and degradation, plant design and the potential for spontaneous combustion (Stucley et al. 2004). References to biomass weights in this document are on an ‘as received’ basis (i.e. not subject to drying process).

The heating value of a fuel is a measure of its energy content—the amount of energy released when the fuel is combusted. Table 4 illustrates heating values for a range of biomass types at different levels of moisture content (as received, air dried and dry basis).

Table 4: Heating values for selected biomass

<table>
<thead>
<tr>
<th>Biomass</th>
<th>HHV (MJ/kg)</th>
<th>LHV# (MJ/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ar</td>
<td>ad</td>
</tr>
<tr>
<td>Blue gum, whole tree chips</td>
<td>8.25</td>
<td>17.63</td>
</tr>
<tr>
<td>Eucalypt sawdust</td>
<td>13.39</td>
<td>17.66</td>
</tr>
<tr>
<td>Camphor laurel</td>
<td>15.42</td>
<td>17.93</td>
</tr>
<tr>
<td>Urban green waste</td>
<td>16.78</td>
<td>17.48</td>
</tr>
<tr>
<td>Sugarcane trash</td>
<td>2.12</td>
<td>9.86</td>
</tr>
<tr>
<td>Sugarcane bagasse</td>
<td>5.14</td>
<td>12.47</td>
</tr>
<tr>
<td>Rice husks</td>
<td>12.61</td>
<td>12.82</td>
</tr>
<tr>
<td>Macadamia nut shells</td>
<td>18.96</td>
<td>19.23</td>
</tr>
<tr>
<td>Wattle twigs and leaves</td>
<td>17.27</td>
<td>17.76</td>
</tr>
<tr>
<td>Rose gum stem wood</td>
<td>16.56</td>
<td>16.78</td>
</tr>
</tbody>
</table>

ar = as received  HHV = higher heating value
ad = air dried    LHV = lower heating value
db = dry basis    # Calculated from HHV, hydrogen content and moisture

In contrast, the heating values of Queensland black coals range from 20–28 MJ/kg (Spero 2001). Due to these differences in heating values, a proportionately higher weight of biomass is required to replace the energy content of black coal. For example, the energy content of one tonne of coal is equivalent to approximately (on an ‘as received’ basis) 1.2 tonnes of wattle twigs/leaves/tree prunings, 1.5 tonnes of eucalypt sawdust and 3.9 tonnes of bagasse. For convenience, all calculations in this report are based on a biomass energy content of 12 GJ/t.

11 The Gross Calorific Value (or Higher Heating Value) is calculated when the water in the combustion products is a liquid, and the Net Calorific Value (or Lower Heating Value) is calculated when the water in the combustion products is in a gaseous state (CCSD 2007).

12 Source: CCSD 2007, after CSIRO.

13 Sometimes referred to as ‘wet’ or ‘green’ when describing woody material.

14 Assuming the lower end of the coal heating value range.
The bulk density of biomass (weight per unit volume) is low compared to coal. This, together with its lower energy content, results in an energy density (energy per unit volume) that is considerably lower than coal (Figure 2). The energy density of most biomass feedstocks, even after densification, is between 10–40 per cent of the bulk density of most fossil fuels (U.S DOE 2010). This means that the volume of biomass used for co-firing is significantly more than that of the coal it is replacing.

The introduction of the Federal Mandatory Renewable Energy Target (MRET) in 2001 catalysed interest in biomass co-firing in Australia. Under the MRET, and its successor-scheme conventionally referred to as the enhanced Renewable Energy Target (RET)\(^\text{15}\), accredited renewable energy generators are able to create tradeable renewable energy certificates, or RECs, from electricity produced from eligible renewable energy sources (now referred to as Large-scale Generation Certificates, or LGCs, in relation to larger renewable energy developments). Revenue from the sale of these certificates is designed to improve the business case for investing in renewable energy developments. The scheme and associated regulations are administered by the Office of the Renewable Energy Regulator (ORER).

As a result, over the past 10 years there have been numerous domestic pilot tests, engineering trials and engineering and resource assessments carried out in different coal-fired power stations. Generator experiences with biomass co-firing in NSW and Queensland are explored in more detail in the following section.

\footnotesize{\textbf{In NSW, Delta Electricity and Macquarie Generation co-fired low levels of biomass materials commercially for a number of years. However, these operations have now ceased due to poor economics coupled with fuel availability issues.}}

\footnotesize{Delta Electricity has stated its aspiration to establish agroforestry based sources to co-fire up to 20 per cent biomass at Wallerawang Power Station (Horner 2010). While co-firing of biomass has been investigated and trialled by some generators in Queensland, there have been no moves to commercialise operations.}

\footnotesize{\textsuperscript{15} On 1 January 2011, the enhanced Renewable Energy Target (RET) was split into two parts, the Large-scale Renewable Energy Target (LRET) and the Small-scale Renewable Energy Scheme (SRES).}
As explored later in this document, the economics of co-firing depends on several factors—the most important of these being the avoided cost of coal, the revenue from the sale of LGCs, the value of GHG emissions abatement, the capital investment required and the delivered cost of biomass.

A range of renewable energy policy initiatives have contributed to the uptake of biomass co-firing internationally. At least 83 countries (41 developed/transition countries and 42 developing countries) have some type of policy to promote renewable power generation. The ten most common policy types are feed-in tariffs, renewable portfolio standards, capital subsidies or grants, investment tax credits, sales tax exemptions, green certificate trading, direct energy production payments or tax credits, net metering, direct public investment or financing and public competitive bidding (REN 21 2010). Details of renewable energy policy measures in specific regions and countries can be accessed from the IEA Global Renewable Energy Policies and Measures Database (IEA 2010). While not all these policies are applicable to biomass co-firing in any particular jurisdiction, the adoption of co-firing has been facilitated by their use in different countries.

Renewable energy policy support has been supplemented by the introduction of a price on carbon, such as the European Union Emissions Trading Scheme, and programs to facilitate biomass supply—for example the United States Biomass Crop Assistance Program) discussed later in Section 4.1. Appendix 1 provides a selection of renewable energy, carbon and biomass policies that support biomass co-firing in the United Kingdom.

Finally, increases in international thermal coal prices have also contributed to improving the economic viability of biomass co-firing (Airlie 2010).

The European Union provides a good example of how such measures can actively facilitate the use of biomass for heat and power generation, including biomass co-firing. The EU Biomass Action Plan of December 2005 identified 32 key activities for boosting the bioenergy market, including the establishment of national biomass action plans (European Commission 2011; 2005). In 2007, EU member states committed to source 20 per cent of their energy needs from renewables (EurActiv 2011). Collectively, these measures have led to the development of a sophisticated market for wood pellets, currently trading at €129/t ($182/t)16 (discussed in Section 4.3) and the establishment of a platform for growth in the use of biomass for energy. European Commission scenarios suggest that annual biomass heat and power consumption is anticipated to double during the ten years to 2020, with growth equal to the combined growth of all other renewable energy sources (Hogan et al. 2010).

### 1.2 Location of Queensland coal-fired generators

Figure 3 illustrates the geographic location of the major Queensland coal-fired power stations17, aggregate generation capacity at each generation site and the estimated biomass requirement for co-firing 3 per cent of biomass (by energy content).

These figures should be treated as indicative only and will vary with individual power station operating characteristics (for example, plant capacity factor). Importantly, they do not reflect (a) station-specific technical constraints (discussed further in the following section) or (b) the commercial positions of the generators concerned in relation to biomass co-firing.

Subject to these qualifications, they indicate an aggregate annual biomass requirement of around 1.3 million tonnes of biomass for 3 per cent co-firing (by energy content), leading to total annual GHG emissions abatement of around 1.4 million tCO2-e.18

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16 April 2011 contract for delivery CIF Rotterdam (APX-ENDEX 2011a).

17 This excludes the 180 MW Collinsville Power Station in North Queensland owned by Transfield Services Infrastructure Fund. The focus of the study was restricted to the largest coal-fired power stations due to time and budget considerations. Nevertheless, many of the findings would be applicable to the Collinsville Station.
Figure 3: Location of major Queensland coal-fired generators and estimated biomass required for 3% co-firing

Stanwell (1434 MW) 260kt
Gladstone (1680 MW) 165kt
Callide B (700 MW) 119kt
Callide C (900 MW) 160kt
Tarong North (445 MW) 80kt
Tarong (1415 MW) 257kt
Swanbank (480 MW) Will be decommissioned in 2012
Kogan Creek (750 MW) 133kt
Milmeran (850 MW) 146kt

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18 Based on the national emissions factor for coal of 88.43 kg/kWh. Due to differing coal blends at the various Queensland power generators the actual abatement may vary from this figure.

19 Source: E3 analysis; plant capacity factors sourced from MMA 2006, and AEMO 2010. Auxiliary power = 7.5%; Heat rate = 9,700 MJ/MWh; Coal calorific value = 24 GJ/t; Biomass calorific value = 12 GJ/t (see Table 4 and discussion in Section 1.1 of report).
2. Electricity Generator Perspectives

This section describes the feedback received from a number of generators on their experience with biomass co-firing to date, perceived barriers to co-firing and their preferences if co-firing was to be progressed at their power stations. It also includes insights from the authors’ experience with co-firing and findings from the literature review.

The project team engaged in discussions with staff from electricity generators in NSW (Delta Electricity, Macquarie Generation) and Queensland (CS Energy, InterGen, NRG Gladstone Operating Services, Tarong Energy, Stanwell Corporation).

As would be expected, the feedback on issues varied from generator to generator. What follows therefore is our assessment of overall themes arising from our discussions, noting that there are differences in views between individual generators. Due to commercial sensitivities, responses of individual generators have not been identified.

The findings are grouped into the following four categories:

- biomass sources and logistics
- biomass handling and combustion
- economics and risk management
- policy and regulation.

2.1 Biomass sources and logistics

A wide range of biomass sources have been collectively trialled by generators. These include municipal green waste, sawmill residues, manufacturing wood waste, forestry residues (silvicultural and harvesting waste) and construction & demolition (C&D) waste. Other sources considered include bagasse, pelleted straw, pelleted residue from energy crops (such as mallee plantings), dedicated energy plantations, woody weeds and torrefied wood waste.

Key issues for generators

- The quantity of biomass required is significant, even for low levels of co-firing. For example, co-firing 3 per cent of biomass (by energy content) in a 1000 MW coal-fired power station would require around 192 000 t of biomass annually.\(^{20}\) This poses significant issues both from a supply and a transport perspective. Coal-fired power stations can typically contract with one or two suppliers to meet all of their fuel requirements (millions of tonnes of coal). There is no single source of biomass that could deliver a generator’s entire requirement at a price that is economically viable for sustained periods

- Biomass sources are dispersed and supply is variable in relation to quantity and timing. The sources are not always near power stations. There are also competing uses for biomass material today (for example, the use of crop residues for soil enhancement) and in the future (for example, second-generation biofuels, biochar, distributed power generation as well as European demand for wood pellets)

\(^{20}\) The quantity of biomass equivalent to the heating value of coal substituted by biomass, assuming total coal = 3.2 million tonnes per annum; coal calorific value = 24 GJ/t; biomass calorific value = 12 GJ/t.
• Coal-fired power stations are typically located directly next to the mine or supplies are delivered via rail. Economically moving close to 200 000 tonnes of biomass from disparate sources requires logistics solutions that are not standard practice for coal-fired power stations. There are also no commercially implemented aggregation and transport models to deliver the quantities required at an acceptable price (economic viability is discussed later in the document). Without such a model, generators will need to be actively involved in aggregating the required quantities of biomass. They are unwilling to assume this role.

• Coal-fired power stations are experienced at dealing with large quantities of relatively homogenous coal types. Due to the quantity of biomass required, power stations would need to use a range of biomass sources, which presents additional logistical challenges to power station operators.

• The quality of biomass material has been inconsistent. In particular, the experience with green waste has been mixed. In some cases this was satisfactory, even at high moisture content (up to 70 per cent), while in other cases there have been concerns about contamination with dirt and metals. Construction and demolition (C&D) waste quality was also an issue with the presence of large pieces of wood, plastics and treated timber products. The need to exclude copper chrome arsenate (CCA) treated timber was universally acknowledged. In some cases, material that was available a few years ago, such as sawmill residues from state-owned native forests, can no longer be used due to Queensland Government restrictions (see Section 3.7, also Sections 3.1.3 and 3.6).

• A study by one generator concluded that the cost of establishing dedicated energy plantations makes it economically unviable as a biomass source for co-firing under current policy and market settings. The study was based on a fully outsourced model with establishment from the ground up (i.e. including land acquisition and other costs).

**Generator preferences**

In light of these issues, most generators have a preference for adopting a low cost (and therefore perceived low risk) approach to co-firing. This means minimising upfront capital costs, which implies avoiding onsite preparation (for example, chipping or pelletising) or separate feeds for milling and injection. In relation to operating costs, generators recognise that tighter specifications for biomass would increase fuel costs, but would also minimise risk to operations, including emissions, fly ash, corrosion and others.

Generators see their core business as power generation, not biomass production or processing. For this reason, and to minimise transaction costs from procurement, generators would prefer to outsource the aggregation and delivery of biomass. The preferred arrangement is a long-term supply contract for nominated quantities of biomass meeting an agreed specification (which would depend on individual generator requirements) and price path. The difficulty in accommodating the impact of future transport cost increases as a result of an escalation in oil prices was recognised.

There was qualified support for a collaborative effort between several generators to facilitate aggregation of biomass. However, this would need to consider competition issues, including compliance with the Trade Practices Act.
2.2 Biomass handling and combustion

Biomass handling and combustion can be characterised by three key areas: stockpiling, reclamation and conveying; bunkering and milling; and combustion (Figure 4).

Figure 4: Biomass handling and combustion overview

Coal is stored outside in large stockpiles and managed for ease of reclamation and suppression of fire, spontaneous combustion and dust. The quantity of coal stored on site varies but is typically sufficient to allow the station to continue operating for a period of time (i.e. weeks) in the event that coal supplies are disrupted. If biomass co-firing was to be introduced at a station, new storage and reclamation facilities would be required. These requirements are specific to each station’s chosen biomass source and engineering needs.

The simplest approach would require self unloading trucks (i.e. walking floor or tipping) depositing biomass into a dedicated area where blending and stockpiling can occur. This, however, is only appropriate for small quantities. Larger quantities would require dedicated unloading facilities in combination with dump conveyors and stackers for creation of stockpiles. The physical characteristics of the biomass will require different stockpile sizes (i.e. different angle of repose) compared to coal meaning that smaller plant (i.e. dozers) may be required.

Because biomass has a lower energy density than coal, it will occupy a larger land area per GJ. For example, the bulk volume of sawdust is about 3.0 m³/t while an average value for bituminous coal is about 1.3 m³/t. Comparing the average heating values of biomass and coal, biomass occupies 0.21 m³/GJ while coal occupies 0.04 m³/GJ.22

To date, co-firing trials by Queensland power generators have involved biomass being received via truck, and the biomass fuel has generally been stored outdoors.

Pelletised biomass may break down if it gets wet, meaning dedicated silo storage facilities may be required.

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21 Removal of biomass from the stockpile.

22 E3 analysis
Reclamation of smaller quantities can be managed by front-end loaders in combination with dedicated hoppers releasing on top of the existing coal conveyors. This approach, however, places greater reliance on the existing coal conveyor magnets for metal separation. Furthermore, the different flowability characteristics of biomass means that hoppers designed for coal may be unsuitable for use with biomass. For larger quantities, active reclaim is required which, if spare capacity is not available in existing coal plants, would come at an additional cost. Conveyors on dedicated reclamation systems can have magnetic separators/detectors integrated to reduce the reliance on primary magnets.

Co-firing trials in Queensland have been limited to pre-mixing coal and biomass with front-end loaders or reclamation via front-end loader and depositing of biomass on top of existing coal conveyors. With both these methods, biomass and coal are sent in combined form to bunkering, which is required for consistent supply of coal to mills.

More extensive activities in NSW have been undertaken at Delta Electricity’s Wallerawang Power Station in NSW where it installed a dedicated biomass handling plant that integrates a biomass receiving, screening, storage and a conveyor blending facility (Figure 5).

**Figure 5: Handling system at Delta Electricity’s Wallerawang Power Station in NSW**

With the addition of biomass to the coal feed, coal and biomass are ‘co-milled’ in existing coal milling machines and introduced into the boiler furnace through the same injection ports as the coal (i.e. the biomass and coal are blended prior to injection into the boiler furnace). Fuel particles must be reduced in size (comminution) to certain limits before they can be injected into the burners.

Comminution of material is dependent on many factors, including particle properties such as hardness, density, moisture and mineral matter as well as machine variables such as grinding pressure, roller gap and type of roller (CCSD 2007). The different physical characteristics of biomass compared to coal introduce a range of problems when co-milling in existing milling systems. Woody material is fibrous, whereas existing milling equipment has been designed for coal which is brittle and has lower moisture content. Despite elevated interest, the field of coal/biomass comminution remains a relatively unexplored area of research (CCSD 2007).

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23 Source: Delta Electricity
Co-milling has been carried out on three different types of mills—namely ball mills, vertical spindle (roller) mills and hammer mills. As described below, the co-milling results vary by mill type, with some mills better suited to co-milling with biomass than others.

At low co-firing levels, the combustion of blended and milled biomass and coal is largely the same as 100 per cent coal combustion. Once the proportion of biomass becomes higher (perhaps higher than 10 per cent), there may need to be some combustion modelling and burner modifications.

There have been some engineering assessments (but not technical trials) of other co-firing techniques—for example, the use of a standalone biomass boiler (for heating feedwater) as well as the generation of syngas from biomass for gas-fuelled co-firing. These alternative techniques are typically utilised for higher proportions of biomass feed. As biomass supply for even low levels of co-firing has historically been an issue, these alternative techniques have not progressed beyond engineering assessments.

Finally, we note the comprehensive Australian Coal-Biomass Co-firing Handbook (2007) produced by the Cooperative Research Centre for Coal in Sustainable Development (CCSD). This publication provides an excellent technical reference source for biomass co-firing and contains a detailed case study of co-firing at Delta Electricity’s Wallerawang Power Station. \(^{24}\)

**Key issues for generators**

- **Receival, stockpiling, reclamation and conveying** have generally not been a significant issue. While optimal solutions at each facility differ, all companies interviewed felt that the required solutions are unlikely to pose significant economic or technical challenges. There have been fuel quality and storage issues as well as dust problems with some biomass sources (for example green waste). Biomass does not have the same properties as coal and therefore must be handled accordingly (for example, biomass does not ‘flow’ in the same way that coal does). Spontaneous combustion and the potential for dust related explosions \(^{25}\) were also identified as risks by some generators. Water contamination of biomass following a fire was also raised as a potential issue.

- **Coal-fired power station operational processes** are finely tuned and are designed to handle very large volumes of coal efficiently and safely. The introduction of biomass fuel and frequent truck movements within the confines of such a tightly controlled area has the potential to disrupt plant operations. Generators are also conscious of the number of truck movements that might be required and the permitting issues associated with these movements. One generator observed that the upper limit may be 10–20 truck deliveries per day, which would be equivalent to a range of 100 000–200 000 tonnes annually. The need to minimise risks from dust and spontaneous combustion was also recognised. While these issues are of concern, there was general consensus that they are manageable.

- **Co-milling biomass** has been difficult in some mills, even at low levels of co-firing. The different properties of biomass alluded to earlier have led to clogging and build up of wood residues in mills, loss of efficiency (increased maintenance costs) and in the worst case, damage to mills. Co-milling in ball mills has been particularly difficult. There have been fewer problems with vertical spindle roller mills and hammer mills where blending of 2–5 per cent has been achieved without too much difficulty. Subject to fuel quality 1–2 per cent co-milling in such mills should not pose any problem, with scope to achieve 3–5 per cent depending on mill type. It may be possible to achieve up to 10 per cent co-milling with wood pellets without significant changes, and potentially higher levels with other biomass pre-processing (i.e.

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\(^{24}\) The publication is currently out of print.

\(^{25}\) More likely at higher levels of biomass co-firing.
torrefaction). Where plants cannot accommodate co-milling for low levels of biomass co-
firing, dedicated milling will need to be pursued, but this would require higher capital 
investment. Maintaining a consistent blend ratio has been a challenge for some generators

- There were no significant fly ash problems. A number of Australian and overseas studies have 
suggested that ash from co-firing up to 10 per cent of biomass by weight does not vary 
significant from ash produced by coal only combustion (CCSD 2007). The use of fly ash from 
power stations as a concrete additive to replace a portion of cement provides a market for this 
material. However, discussions with generators suggest that there is some uncertainty on the 
saleability of fly ash from co-firing if its carbon level increases due to incomplete combustion 
of biomass. At low levels of co-firing (less than 3 per cent) it is believed that the cement 
industry would not have any issues with fly-ash

- There was general consensus that there would not be any issues with generation plant 
technology guarantees when co-firing low levels of biomass (1–2 per cent) at a relatively new 
power station. On newer plants which run at high temperatures and are ‘tuned’ to specific coal 
types, there may be reduced flexibility to accept a wide variety of biomass types

- Depending on the type of biomass combusted, there may be an increased likelihood of dioxin 
creation. This is dependent on the chlorine content of the biomass fuel source and the 
temperature of combustion. The chlorine content of some biomass sources such as straw can 
be managed through washing. Each station would need to consider the likelihood of changes 
to stack emissions (i.e. dioxins and furan emission levels) on a case by case basis (Van Loo & 
Koppejan 2010).

**Generator preferences**

Based on our discussions with generators, and the findings above, we concluded that there are no 
insurmountable technical barriers to direct co-firing of up to 5 per cent of biomass by weight 
(equivalent to roughly 2.5 per cent by energy content), subject to mill compatibility. Potential risk 
issues, such as spontaneous combustion and dust hazards—to the extent that they arise when co-firing 
at low levels—can be addressed through plant design approaches.

The majority of generator preferences in regard to biomass handling and combustion are for minimal 
preparation of biomass. Ideally, the biomass would be supplied as homogeneous material, for example, 
wood pellets, but it was acknowledged that this would not be viable under the current economic 
scenario. Generators would like to receive clean, screened (i.e. free from contaminants), uniform 
biomass that can be utilised as received.

In relation to biomass handling, the preference for some companies is to keep it simple—storage in the 
open (possibly covered with a tarpaulin) and manual blending before transferring onto the conveyor. 
The preference for others is to invest in higher levels of automation for fuel handling, which would of 
course require increased capital expenditure.

Finally, while the overriding preference of generators is for delivery of biomass by rail, delivery by 
truck was seen as the most pragmatic option given the location of power stations in relation to the rail 
network.
2.3 Economics and risk management

From a generator perspective, the economics of biomass co-firing depends on several key factors—the avoided cost of coal, revenue from sale of renewable energy certificates, the cost of biomass, increased operating and maintenance (O&M) costs and the capital cost associated with co-firing.

**Renewable Energy Certificates (RECs) and Large-scale Generation Certificates (LGCs)**

On 1 January 2011, the RET was split into two parts, the Large-scale Renewable Energy Target (LRET) and the Small-scale Renewable Energy Scheme (SRES). Under the LRET, generators co-firing eligible biomass will be able to create Large-scale Generation Certificates (LGCs), which replaced Renewable Energy Certificates (RECs) on 1 January 2011. At the time of writing, LGCs were trading at around $36/MWh (Nextgen 2011)

LGC prices are set by the balance of demand and supply. Demand is determined by the legislated large-scale renewable energy targets. Supply is determined by the cumulative quantity of certificates created by renewable energy generators. In recent years, prices have fluctuated from a high of nearly $55/MWh (on anticipation of the expansion of the MRET into the RET) to a low of less than $30/MWh in 2010 due to a proliferation of RECs from small technology sources (solar PV and solar hot water heaters, amongst others).

*For the purpose of this report we will refer to RECs in relation to activity prior to 1 January 2011, and to LGCs after this point.*

The business case for biomass co-firing relies on a simple proposition—that the benefits (avoided cost of coal + LGC revenue) must exceed the additional capital and operating costs (biomass and increased O&M) after adjusting for the time value of money.

In mathematical terms:

\[
\text{PRESENT VALUE OF } [\text{AVOIDED COAL COST} + \text{LGC REVENUE} - \text{BIOMASS OPEX}] > \text{CAPEX}
\]

Where:

- **LGC REVENUE** = income from the sale of LGCs
- **BIOMASS OPEX** = the cost of biomass and increased operating and maintenance (O&M) costs
- **CAPEX** = capital cost associated with co-firing

**Key issues for generators**

- Despite low levels of capital investment in biomass co-firing to date, generators find that co-firing economics have been marginal due to low REC (now LGC) prices and high delivered biomass costs. Low prices have been exacerbated by a market discount on RECs/LGCs from wood waste sources and reluctance of electricity retailers to purchase RECs/LGCs from these sources (discussed in more detail in Section 4.2)

  As noted previously, commercial co-firing has ceased in NSW, and no commercial biomass co-firing has occurred in Queensland\(^{26}\)

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\(^{26}\) CS Energy has co-fired landfill gas with coal at its Swanbank B Power Station.
The introduction of a carbon price creates an additional source of value due to the avoidance of carbon costs associated with the coal substituted by biomass. On 24 February 2011, the Federal Government announced plans to introduce a price on carbon as early as 1 July 2012 subject to negotiating agreement with a majority in both houses of Parliament and passing the necessary legislation in 2011. The Federal Government’s preference is for the carbon price mechanism to commence with a fixed price (which would function as a tax) transitioning to a cap-and-trade emissions trading scheme at some point in the future. The Federal Opposition, which opposes such a mechanism, favours a ‘direct action’ mechanism, where prospective emissions reduction measures would be selected through a competitive tendering process. Given the diverse views on carbon pricing, there continues to be significant uncertainty on when, in what form and at what level a carbon price will be introduced into the Australian economy.

The scale of low level co-firing projects was recognised as an issue by one generator, who noted that anything less than 30 MW (equivalent to roughly 3 per cent by energy content at a 1000 MW power station) would not be viable for the company due to transaction costs.

Generators preferences

Generators find that under current policy settings, delivered fuel costs would need to be less than $3–$4/GJ ($36–$48/t). The upper limit of this range is consistent with our modelling, which is discussed in more detail in Section 4.1.

Despite the ongoing regulatory uncertainty, most generators interviewed are willing to take a long-term view on future LGC and carbon prices as a basis for locking in a fuel sourcing arrangement. It was recognised that the duration of such supply arrangements would depend on the level of capital investment associated with co-firing, and could be between 5–10 years.

There were a diversity of views in relation to the level of investment for co-firing. They ranged from a preference for minimal capital investment coupled with opportunistic co-firing at one end, to larger scale operations (200 000 t/pa), higher levels of capital investment and long-term fuel sourcing arrangements that provide security of supply.

Overall, generators see the need to balance the benefits of co-firing against risks to their core business. It was noted that the cost of a single outage at a coal-fired power station is likely to exceed the annual value from co-firing.

2.4 Policy and regulation

Policy and regulatory aspects, at federal and state levels, were explored with generators. These included:

- the federal Renewable Energy (Electricity) Act 2000 (the Act), which provides the basis for revenues from the sale of LGCs associated with the renewables component of co-firing
- changes to State Environmental Protection Authority (EPA) licences permitting combustion of materials at power stations
- state environmental legislation, regulations and policies that impact on the supply of biomass for co-firing – for example, the Queensland Vegetation Management Act 1999 and the South East Queensland Forests Agreement
- federal and state funding for renewable energy project developments
- local planning issues related to co-firing.
In regard to the RET, accreditation of power station biomass co-firing operations is specific to the type of biomass used. Regulations under the Act (Renewable Energy (Electricity) Regulations 2001) (RET regulations), detail the criteria for eligible biomass sources (refer to Appendix 2 for selected extracts).

To support the interpretation of these regulations, the Office of the Renewable Energy Regulator (ORER) has released guidelines for calculating eligible renewable generation when co-firing renewable fuels with coal (ORER 2000). The ORER has also developed assessment sheets to assist generators to interpret the wood waste provisions in the RET regulations and for building appropriate record sets to demonstrate the eligibility of wood waste. The ORER notes that the use of these assessment sheets is not mandatory, but claims for large-scale generation certificates (LGCs) that are supported by these records are more likely to be approved (ORER 2010).

**Key issues for generators**

- There was universal disappointment at the low level of REC prices and their impact on the economics of co-firing (discussed previously). Regulatory uncertainty in relation to renewable energy and climate change policy is a major concern to generators given the sensitivity of co-firing economics to REC and carbon prices.

- At a state level, the complexity of vegetation laws (particularly regarding native regrowth) needs to be overcome when establishing whether this material could be used for co-firing. The state government restrictions on use of sawmill residue from state-owned native forests was acknowledged.

- The lack of investor/financier interest in biomass (compared to gas and wind generation), and the perception that biomass co-firing is an ‘established’ technology, and so does not qualify for grant support, were also seen as presenting challenges to the adoption of biomass co-firing. One generator expressed concern that no biomass proposals were funded under the Renewable Energy Demonstration Program (REDP). This aspect is discussed in more detail in Section 4.4.

- The negative perceptions around combusting forest residues for power generation among many environmental groups, and their unwillingness to engage in constructive dialogue, are a major cause for concern. These perceptions have had adverse impacts on RECs from wood waste sources (with some certificates being labelled as ‘dead koala’ RECs). Generators point out that other jurisdictions have not had these problems and refer to the rapid uptake of biomass for both power and heat in Europe as an example.

**Generator preferences**

Generators would like to see policy certainty in relation to both carbon and renewable energy policy to support long-term investments. However, the political challenges in achieving this were recognised.

Generators also recognise the need for reporting associated with wood waste material. Compliance with ORER requirements was not seen as a major issue. Generators point out that they have well developed processes for managing regulatory compliance, which is an issue they take very seriously. In regard to the integrity of biomass used, the overriding preference of generators is for biomass suppliers to assume responsibility for biomass authentication to support compliance reporting to ORER.

Generators accept the need for EPA approval of biomass sources used for co-firing, but do not consider this to be an obstacle.

Resolution of the current negative perceptions around the combustion of forest residues for power generation was seen as an important requirement.
3. Biomass Sources and Supplier Perspectives

Introduction

A significant body of information is available on both existing and potential new sources of biomass in Australia and overseas (Stucley et al. 2004). The following analysis builds on this work by focusing on the practical realities of biomass supply for a specific purpose (co-firing) in a specific region (SE Queensland). To this end, over 150 individuals were consulted, including: direct suppliers of biomass; representatives and practitioners from the farming, forestry and land management sectors; logistics and transport operators; market intermediaries; government policy advisors; and researchers.

The consultation extended to other current or potential uses of biomass, including the compost and landscaping sectors as well as industries that may develop in the future to process biomass into pellets, torrefied wood/biochar or biofuels.

The cost of transporting biomass is a major constraint that is discussed later in this section. As with previous studies, there was a focus on sources within around 100 km of each generator—illustrated in Figure 6. However, as a starting point, this study sought wide coverage of biomass sources and no potential source of biomass was ruled out entirely. It should be noted that the study was not scoped to comprehensively identify individual biomass sources or locations, although some have been identified as case studies. Biomass mapping is discussed in the Barriers section.

As discussed previously, the ability to generate LGCs is a key requirement for biomass co-firing. Where relevant, we have therefore highlighted any issues associated with eligibility under the RET legislation and regulations. The eligibility of residues from native forestry silviculture or processing is also subject to state regulations and is of particular concern to environmental groups. These issues are explored in Section 4.2.

In this report, some of the sources on the ORER list have not been considered as they are not applicable to co-firing. Other more specific resources are discussed where this has a particular relevance to SE Queensland.

27 The biomass resources deemed eligible under the Renewable Energy (Electricity) Act 2000 are:

- Forest and forestry residues
- Wood and wood wastes
- Agricultural crop residues
- Agricultural process residues
- Energy crops
- Black liquor
- Wet waste from animal husbandry and food processing
- Municipal solid wastes.

28 The eligibility criteria for potential biomass sources applicable to biomass co-firing are detailed in Appendix 2.
Figure 6: Generator location map showing 100 km radius around each power station and estimated biomass required for 3% co-firing

Stanwell (1434 MW) 260kt
Gladstone (1680 MW) 165kt
Callide B (700 MW) 119kt
Callide C (900 MW) 160kt
Tarong North (445 MW) 80kt
Tarong (1415 MW) 257kt
Swanbank (480 MW)
Will be decommissioned in 2012
Kogan Creek (750 MW) 133kt
Milmerran (850 MW) 146kt

Source: E3 analysis: Plant capacity factors sourced from MMA 2006, and AEMO 2010. Auxiliary power = 7.5%; Heat rate = 9,700 MJ/MWh; Coal calorific value = 24 GJ/t; Biomass calorific value = 12 GJ/t (see Table 4 and discussion in Section 1.1 of report).
This chapter contains findings in relation to the following categories of biomass (Table 5).

**Table 5: Biomass sources investigated**

<table>
<thead>
<tr>
<th>Category</th>
<th>Subcategories</th>
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<tbody>
<tr>
<td>3.1 Agricultural production residues</td>
<td>3.1.1 Crop residues</td>
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<tr>
<td></td>
<td>3.1.2 Woody weeds</td>
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<td></td>
<td>3.1.3 Regrowth residues</td>
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<td>3.2 Agricultural energy crops (herbaceous)</td>
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<td>3.3 Agroforestry for energy</td>
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<tr>
<td>3.4 Agricultural processing residues</td>
<td>3.4.1 Bagasse</td>
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<td></td>
<td>3.4.2 Other agricultural processing residues</td>
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<td>3.5 Forestry plantation residue</td>
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<td>3.6 Native forest residue</td>
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<tr>
<td>3.7 Sawmill residue</td>
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<td>3.8 Coal seam gas-related biomass</td>
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<td>3.9 Development residues</td>
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<tr>
<td>3.10 Urban waste</td>
<td>3.10.1 Green waste</td>
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The chapter concludes with a discussion in harvesting, processing and logistics, including transport:

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3.1 Agricultural production residues

The agriculture sector in SE Queensland comprises a wide range of enterprise types. In terms of the potential to generate biomass, farming activities may be broadly characterised as cropping or grazing. The types of secondary biomass generated as a result of growing crops and animal fodder are:

- crop residues, such as straw
- woody weeds
- regrowth residues.

3.1.1 Crop residues

Most crops grown in SE Queensland, including wheat, barley, sorghum, cotton and others, produce a significant amount of stem and leaf growth in addition to the primary harvested product. Using a grain crop as an example, the harvesting process cuts the upper portion of this growth, along with the head of grain or other product and separates the grain from the other material, which is spread behind the harvester as straw or trash. The lower, uncut, portion of the stems and leaves remains in the ground as stubble.

In the past, tilling was generally used to prepare the soil for the next crop and the volume of residues could hamper this operation. Therefore, burning the straw, trash and/or stubble in situ was common practice and may still be carried out, especially where herbicide-resistant weeds are present. However, the widespread adoption of minimum-till practices, equipment and techniques that can manage straw and stubble generally makes it unnecessary to remove residues. The consensus among the growers and agronomists consulted is that crop residues play an essential role in stabilising the soil surface and assisting water infiltration to benefit the following crop. Straw also contains low levels of plant nutrients and recently reported work (Herr 2010) indicates that it would cost $40 to replace the nutrients removed per tonne of straw.

In some instances, straw is baled and stored for use as supplementary feed for stock. This depends on the season and the availability of higher quality fodder. Other markets also exist, such as for animal bedding and straw-bale house construction. This indicates that at least some farmers will forgo the agronomic benefits of retaining crop residues if the value of these alternative uses is high enough.

One option would be to retain residues in most years, but to occasionally remove and sell them. It is reported (S Dix 2010, pers. comm.) that at least one enterprise explored this option in recent years, based on regional collection points and pelleting plants. Evidently there was strong interest from farmers, but the proposal was unable to be commercialised.

**Key issues related to co-firing in Queensland:**

1. Economic/environmental cost of nutrient removal in residues
2. Cost of baling and aggregation
3. Soil protection value of residues.

**Conclusion related to co-firing in Queensland**

At present, the use of crop residues for co-firing is not economically viable, given their nutrient value and agronomic benefits as well as the costs of baling, transport and storage. Nevertheless, the volumes are certainly available were the economics to shift in the future.
3.1.2 Woody weeds

Large areas of Queensland are infested with a range of weeds of national significance (WoNS). These reduce productive capacity as well as having significant ecological impacts. Some species, such as prickly acacia (*Acacia nilotica*) produce large volumes of woody biomass. A process to remove these and dispose of them through co-firing would appear to be attractive. However, according to DERM, the main areas of heavy infestation lie in the western half of the state. The transport costs alone would render this option unviable for the purposes of this study.

DERM advise that, although there are infestations of noxious weeds in SE Queensland, the species involved do not generally produce biomass in the significant volumes required to make co-firing viable. One possible exception is the tree species Camphor laurel (*Cinnamomum camphora*), which is widely distributed along the east coast (Figure 7).

**Figure 7: Camphor laurel control in suburban creekside location – poisoned and left in situ**

Camphor Laurel

This was seen as an important feedstock to supplement bagasse in the cogeneration facilities established at Condong and Broadwater in northern NSW. However, despite there being very heavy infestations of camphor laurel in the region, there have been problems in harvesting it. Much of the infestation is on steep hillsides or along watercourses where removal is difficult and must be planned and managed carefully to avoid erosion problems. The sites tend to be on farming land, with limited access in wet weather. These factors, and the cost of collection, have severely limited the supply of camphor laurel for power generation.

Key issues related to co-firing in Queensland:

1. Distance from large-scale sources
2. Collection and aggregation costs for localised sources
3. Environmental issues around removal from sensitive sites.

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30 Source: E3
Conclusion related to co-firing in Queensland

Woody weeds are not currently viable as a major source of biomass for co-firing.

3.1.3 Regrowth residues

This potential source derives from pasture management practices for cattle grazing in SE Queensland.\(^{31}\)

Many of the areas that were cleared in the past for grazing have the capacity to rapidly re-establish native vegetation. This must be controlled to ensure that the established pasture remains productive and is not crowded out. Generally, regrowth is controlled chemically or by physical means, resulting in an accumulation of the dead residues as on-farm biomass. There also appears to be a perception that some landholders believe that failure to control regrowth will result in land being ‘locked up’ under the auspices of the *Vegetation Management Act (Qld) 1999*, although this is not necessarily the case (Queensland Government 2009a).

There appear to be two main opportunities for biomass co-firing from regrowth residues. Firstly, the possible salvaging and processing of on-farm residues from regrowth clearing. This resource is unquantified and widely dispersed. Therefore, the collection and aggregation costs are likely to exceed the co-firing value in the immediate future.

Secondly, the possibility of developing a version of agroforestry, such as the alley farming described in the report section Agroforestry for Energy. Any such system could be based on maintaining and managing native vegetation regrowth, with ongoing shelter and biodiversity benefits and occasional harvesting for biomass. However, consultation to date with both the grazing and cropping sectors have indicated little, if any, interest in this.

Nevertheless, some Landcare and regional NRM groups are already focused on alternative ways to manage vegetation. Also, some individual growers are developing production systems that they feel are more fully integrated with the natural vegetation (T.McCosker 2011, pers. comm.). Nevertheless, this has not had a reported impact to date on land management at a large scale.

Key issues related to co-firing in Queensland:

1. Major cultural change required to alter the established practice of regrowth removal
2. Lack of research data on costs and benefits of retaining/managing regrowth
3. Lack of information on potential volumes and collection/aggregation costs within economic distance of generators.

Conclusion related to co-firing in Queensland

Overall, regrowth residues from agricultural operations is at best a medium to long-term possibility for generating a large and consistent supply of biomass under current economics.

\(^{31}\) The term ‘regrowth’ is also used when native vegetation regenerates on land cleared for timber or cropping. The management of regrowth in private native forest is discussed in the section on Native Forest Residue.
3.2 Agricultural energy crops (herbaceous)

Plants capture energy from the sun through photosynthesis and, in doing so, store carbon as photosynthates, such as sugar and other derived compounds including cellulose and lignin. These carbon-containing compounds are allocated to the growth of leaves, stems, roots and other storage organs such as seeds. Most crops such as grains, cotton or sugar have been developed for their ability to maximise the allocation of photosynthates to the primary product that humans want to harvest for food or fibre.

In contrast, herbaceous energy crops are selected for their ability to maximise the allocation of photosynthates to leaf or stem material.

Farmers are already highly experienced in producing high-biomass crops for animal fodder, such as grass, sorghum, oats and lucerne. Such crops are generally grown in higher rainfall areas, carefully managed to ensure they provide the correct nutrient content for healthy growth of stock and valued accordingly. In theory, if the economics supported it, these crops could be used instead as biomass for co-firing. However, there could be community concerns about diversion of products from the food chain into energy generation.

Researchers have investigated a wide range of other herbaceous plant species for biomass production. These are generally not suitable for consumption by humans or stock, but are believed to be highly productive in more marginal or ‘low rent’ areas. Examples include giant reed (*Arundo donax*) (Williams & Biswas 2010), giant *Miscanthus* (*Miscanthus x giganteus*) and switchgrass (*Panicum virgatum*).

Production of these species for biomass in Australia would depend on such plants being assessed and cleared for weed potential. In addition, combustion characteristics should be assessed, since some herbaceous crops are claimed to have high ash and silica contents (Bakker & Elbersen 2005).

From a SE Queensland perspective, marginal areas suited to these crops (rather than higher-value crops), lie further west, beyond an economic transport distance. It has been suggested that crops such as these, grown in remote areas, may lend themselves to regional processing into high-value, energy-dense products, using second-generation biofuels technology (Warden & Haritos 2008; Stucley 2010).

The International Energy Agency (IEA) Bioenergy initiative has a range of task groups, of which Task 30 was devoted to ‘Short Rotation Crops’ meaning ‘woody crops such as willows, poplars, *Robinia* and *Eucalyptus* with coppicing abilities as well as lignocellulosic crops such as reed canary grass,
Miscanthus and switch grass’ (IEA Bioenergy Task 30 n.d.). IEA Bioenergy Task 43 (2010–2012) now ‘covers all aspects of feedstock, its markets and environmental as well as [socio-economic] impacts’ (IEA Bioenergy Task 43 n.d.). In the United Kingdom, all forms of energy crops are considered together under the United Kingdom Energy Crops Scheme, which offers information as well as establishment grants.\textsuperscript{32} The program is primarily based on Miscanthus and short rotation coppicing and support is subject to various criteria, including an environmental appraisal (Natural England n.d.).

For the purposes of the current report, short rotation woody crops such as coppicing Eucalyptus (mallee) have been considered under Agroforestry below.

**Key issues related to co-firing in Queensland:**

1. Lack of research into herbaceous energy crop species in Australia
2. Weed potential
3. Marginal production areas are a long distance from generators.

**Conclusion related to co-firing in Queensland**

Herbaceous energy crops may have future potential once their agronomy and productivity under marginal conditions has been assessed, along with their weed status and overall environmental impact.

### 3.3 Agroforestry for energy

There is a rich body of applied research from the past RIRDC/FWPA/LWA Joint Venture Agroforestry Program (JVAP) (Powell 2009). This is primarily focused on timber production as part of farming systems and is referred to again in report section Forestry Plantation Residue. However, much of the JVAP work is highly applicable to tree crops for energy, as well as other environmental benefits (Gurr et al. 2009).

This section is based primarily on the strong interest in strip planting with woody plants in agricultural paddocks. This approach has been trialled in Western Australia, aimed at supplying a dedicated power generation plant. Other trials with similar mallee species have been established more recently in NSW, with the aim of high (20 per cent) co-firing by Delta Electricity. While the rationale for strip planting is clear, this does not preclude the option of block planting part of an agricultural enterprise with mallee or some other suitable feedstock.

\textsuperscript{32} Refer also to information in Section 4 of this report.
The mallee plantings in WA (Figure 8) have been widely reported and supported by a significant research effort from the CRC for Future Farm Industries (CRCFFI) (Future Farm Industries CRC 2008; 2010). The primary driver for these was the need to use deep-rooted perennials to reduce the water table and thereby manage the impact of dryland salinity caused by excessive tree clearing. With 7.5 per cent of the land used for mallee plantings, the area (or alley) between the strips, is used for normal cropping or grazing. Harvesting the mallee at regular intervals stimulates vigorous regrowth (and water uptake).

Initially, the harvested stems were to be used to generate energy after eucalyptus oil extraction. The plan for a centralised and dedicated biomass-powered generator has not as yet been implemented, meaning that there is currently no market for the biomass.

Research by the CRCFFI has included variety trials and economic analysis as well as input to the development of a dedicated mallee harvester by Biosystems Engineering of Toowoomba. This

33 Source: DEC and CRC for Future Farm Industries
34 Source: DEC and CRC for Future Farm Industries
35 Source: CRC for Future Farm Industries
harvester is operational, but currently needs large-scale testing (such as on a previous MIS plantation). At present, the projected landed cost of chipped biomass using this system is $100/tonne (Future Farm Industries CRC 2010). However, further testing is required before development of a larger scale version which is expected to significantly lower the harvesting costs. Ideally, the planting configuration and the machine configuration would be co-developed to ensure optimum machine utilisation. In addition, plantings would need to be planned and coordinated to minimise downtime between different sections of row and to maximise truck utilisation. This is more likely to be achieved by partnering with a limited number of large landholders, rather than attempting to coordinate production and harvest across multiple small producers.

### Agroforestry and Plantations for Timber and Energy

There is a broad spectrum of ways that trees are integrated into land management. This report discusses these under various categories, to clarify particular issues. However, in many respects, these should be considered together as there is much crossover between them.

Natural vegetation is discussed under both Agricultural Production Residues (regrowth) and under Native Forestry Residue (which is primarily about managing regrowth in Private Native Forests). In reality, most ‘natural’ vegetation in SE Queensland has been subject to human intervention to a greater or lesser extent.

Agroforestry has largely focused on timber production as part of farming systems. This can occur through managing natural vegetation or by planting particular species, at both small and large scales. Recently, agroforestry has been developed to produce biomass for energy.

Plantations, as the name implies, involve the planting of particular species on a larger scale, typically for timber or pulpwood production. However, plantations could also act as a source of biomass for energy, either from thinnings or from a total harvest.

In summary, a tree can be seen by different people to fulfil many different roles, depending on their perspective. Many, but not all, of these roles are complementary. They include shelter for crops and livestock, an obstacle to efficient machinery use, habitat for wildlife, soil improver, fire hazard, competitor to other crops (including surrounding trees), provider of fine timber or source of energy.

An integrated approach to considering these different roles of trees in the landscape might help address some of the understandable concerns and conflicts that arise about trees in the landscape and their ecological, economic and aesthetic values.

While the principles of alley farming using mallee species have been well established by the work in WA, there are some significant barriers to the adoption of this system in Queensland agriculture. The key driver for the system in WA was salinity management, whereas this is reportedly a less extensive concern in the study area of SE Queensland. In addition, farmers in Queensland have a history of needing to control vigorous native regrowth and are less disposed to plant trees. There is also a lack of extensive field testing on appropriate species for Queensland, although past RIRDC projects do provide a strong foundation for such research to be developed (Henry & Rice 2009; Hobbs et al. 2009; Hobbs, Bennell & Bartle 2009a; Hobbs, Bennell & Bartle 2009b; Hobbs 2009; Sudmeyer & Daniels

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36 Refer to Section 3.11.1 on Harvesting.

37 refer notes on regrowth in Section 3.1.3.
One option, considered above, could be to manage native regrowth as vegetation strips, rather than undertaking planting of particular species.

**Key issues related to co-firing in Queensland:**

1. Wealth of experience and knowledge from WA work, but limited research on suitability, costs and benefits in Queensland, where conditions are entirely different (Donaghy et al. 2009)

2. Need for aggregated plantings to ensure machine utilisation and efficient logistics may need to consider block planting rather than strips.

**Conclusion related to co-firing in Queensland**

At present, neither the available knowledge nor the economics support the use of land in SE Queensland for energy plantations using the WA model.

### 3.4 Agricultural processing residues

#### 3.4.1 Bagasse

According to the Queensland Renewable Energy Plan (Queensland Government 2009e), bagasse (the fibrous residue from sugarcane processing), is currently the key source of biomass for energy and for renewable energy overall:

> Biomass [co-generation] (primarily from bagasse) is the major renewable energy source in Queensland and provides 415 megawatts of the state’s renewable energy capacity. (Queensland Renewable Energy Plan, Queensland Government 2009e)

and

> Twenty-four sugar mills located from the south of Brisbane to the north of Cairns generate electricity from bagasse, and this accounts for more than half of Queensland’s renewable energy generation. (Queensland Renewable Energy Plan, Queensland Government 2009e)

There is a clear pathway to generation of electricity at the existing mills, using well-established logistics systems and infrastructure. This builds on past capacity to handle and combust bagasse to generate steam for cane processing.

Some sugar mills, such as Rocky Point in SE Queensland and the Condong and Broadwater mills in north-east (NE) NSW, have developed cogeneration capacity. In some cases, this has been in partnership with an energy generator. This enables the mills to generate power year-round by supplementing bagasse with other biomass feedstocks. Some of these feedstocks may equally be potential sources for co-firing (although the boiler furnaces are different) and there has been consultation with this sector about their issues with accessing biomass resources. However, there is little overlap between the economic transport distance for the mills and for the coal-fired power generators.

The switch to energy generation by sugar mills is continuing to be developed, in terms of capital investment to extract higher efficiencies (ibid p13, Mackay Sugar Cooperative; Queensland Government 2009f), as well as research on methods to maximise the production of second-generation biofuels from bagasse (O’Shea 2010).

Technologies such as second-generation biofuel production will require a ready source of lignocelluloses as feedstock. While many sources of biomass could be suitable, bagasse already has logistics systems in place to handle large volumes and does not compete with food production.
3.4.2 Other agricultural processing residues

Other potential residues include those produced by cotton and grain mills. While worthy of consideration as sources, the volumes involved, low densities and transport distances serve to render these a low priority for further investigation.

Issues

1. Existing bioenergy uses and potential future uses will fully utilise the available bagasse resources

2. No other high-volume sources of processing residues have been identified within an economic transport distance.

Conclusion related to co-firing in Queensland

Only bagasse is available in the quantities required, but this already has a beneficial renewable energy use. This, coupled with the distance of the resource from coal-fired power stations as well as potential co-milling issues, precludes its consideration for direct biomass co-firing.

3.5 Plantation residue

Plantations are distinct from native forests in that they involve the coordinated planting of selected species rather than the management of natural regrowth. Plantations often comprise native species, although these may be improved varieties. Plantation species may be either softwood or hardwood. In Queensland, the vast bulk of plantations are of softwood species because hardwood needs have, in the past, been met by harvesting native forest timber.

Much of the non-plantation native forest estate owned and managed by state governments is being phased out of timber production.\(^{38}\) As a result, state and federal governments are encouraging increased investment in timber plantations, particularly hardwoods. At the federal level, the Plantations 2020 strategy (1997) (Plantations2020 2001) has a notional target of trebling the area of commercial tree crops by 2020.

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\(^{38}\) Refer to later discussions on Environmental Concerns.
The Queensland Timber Plantation Strategy 2020 (Queensland Government 2010b) does not specify planting targets, but focuses on enabling development in line with market demands. However, in accordance with the SE Queensland Forestry Agreement (SEQFA) (Queensland Government 1999), 5000 ha of hardwood plantations were to be developed by the government. This undertaking was expanded to 20 000 ha in 2004. Plantation estates in Queensland have, until recently, primarily been developed and managed by the government through Forestry Plantations Queensland (FPQ Ltd). FPQ has recently been privatised.

### Plantations and Agroforestry

Note that, as previously highlighted, there is a linkage with the earlier discussion on agroforestry for energy. Farmers may well allocate land to a plantation for the primary purpose of timber production (with or without partnering with an organisation such as FPQ). This may generate a by-product of residues with potential value as biomass for co-firing. However, the same issues about logistics costs would apply.

Farm forestry, in its many forms, is the subject of a major ongoing joint research program (Powell 2009; URS Forestry 2008a; URS Forestry 2008b; Polglase et al. 2008).

The advice from FPQ is that very little residue is generated from softwood plantations. This is due in part to the efficiencies generated by genetic improvement programs. Modern varieties produce more uniform stands with fewer faults. Therefore, a high proportion of thinnings are of merchantable quality, particularly given the high demand for wood fibre. In addition, it is standard practice to retain as much leafy material as possible on site due to its nutrient value and soil stabilisation properties.

Genetic improvement of hardwood species is less advanced, so significant woody residues are produced from hardwood plantations. However, the hardwood plantings are highly dispersed, with a minimum area of 50 ha set by FPQ to initiate planting arrangements with landholders. This increases collection and aggregation costs.

Other hardwood plantations have been established by a number of companies under Managed Investment Scheme (MIS) arrangements. These have tended to be large-scale block plantings. The Global Financial Crisis triggered the financial failure of a number of these forestry programs, leading to a number of consequences:

- in some cases, plantings are to be removed due to crop failure and/or a requirement to liquidate the land asset
- investors have become wary of forestry as an asset class
- community concerns raised about the impact of MIS forestry schemes on land values and food production have been reinforced. This has strengthened an anti-forestry sentiment in some rural areas (Williams 2009; CRC Forestry n.d.).

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39 Refer to further details under Section 4.4.
Key issues related to co-firing in Queensland:

1. Little or no excess residues from the majority of the plantation estate (i.e. softwood)

2. Collection/aggregation costs from hardwood plantations still under investigation and have potential to be high where plantings are not consolidated (Ghaffariyan 2010; Ghaffariyan & Andorovski 2011)

3. Current community concerns about block plantings for forestry.

Conclusion related to co-firing in Queensland

Plantation residues appear unlikely to be a viable source for co-firing under current economics.

3.6 Native forest residue

This resource should be assessed in two categories:

1. Publicly owned native forests on Crown land
2. Private native forest (Parsons & Pritchard 2009).

In Queensland, as in other states, government has responded to pressure from environmental interest groups to stop logging activities in State forests. Where such activity is carried out, it is subject to extensive codes of practice for managing State forests to support overall forest management goals (Queensland Government 2010d).

Native Forestry Code

In State forests, the cardinal principle of management is the permanent reservation of areas for the purpose of providing timber and associated products in perpetuity, and protecting a watershed therein, having due regard to:

- conservation of the soil and the environment
- benefits of permitted grazing
- the possibility of applying the area to recreational purposes.

State forests are managed for multiple uses under the principles of ecologically sustainable forest management (ESFM) (Queensland Government 2010d).

The SE Queensland Forests Agreement (SEQFA) was established in 1999 in order to phase out timber production from government-owned native hardwood forests over a twenty-five year period. During this time, the aim is to transition the hardwood industry to using timber from plantations (discussed above) and private native forests, instead of from Crown native forests.

The SEQFA states ‘There will be no harvesting of non-sawlog material and residues other than for products currently produced’. This precludes the use of residues from state-owned native forests for co-firing. However, residues may be available from private native forests due to the rehabilitation process that is required to restore a balanced ecosystem.

The selective harvesting practices carried out under the Code are designed to ensure a healthy, balanced mix of tree ages in Crown forests. This is in contrast to the situation after a clear-felling operation when natural regeneration typically produces a flush of regrowth of uniform age and size.
The latter situation is common in large areas of private native forests that were subjected to wide-scale land clearing in the past.

According to Private Forestry Service Queensland (PFSQ) and SE Queensland Catchments (P Daly, 2011 pers. comm.), there are about 1 million ha of privately-owned native forests in this unmanaged, single-age state, in the southern part of the study area (Figure 9). This figure includes areas classified as remnant vegetation, which vegetation management regulations require to be conserved but which may be managed under compliance to the code of practice for private landholders (Queensland Government 2009d). These ‘regrowth forests’ require significant investment in order to rehabilitate them into productive, multi-use areas capable of supplying future timber needs along with environmental services such as wildlife habitats.

According to PFSQ (S Ryan, 2011 pers. comm.), a carefully managed program of rehabilitation is required to return such areas to an age-balanced cover that is close to the pre-clearance situation. This may involve an initial thinning from (say) 1500 stems/ha to (say) 100 stems/ha, after selecting healthy stems and ensuring the appropriate species mix. Thinning can be achieved by chemical treatment, leaving the dead wood in situ, or by physical removal.

Figure 9: Dense regrowth of native vegetation on previously cleared land results in restricted growth of trees, understory and groundcover due to competition effects.41

This exercise stimulates a further flush of regrowth, requiring further selective thinning after several months and ongoing management. Ideally, this process would be managed under a long-term management plan that complies with the Australian Forestry Standard, or similar. Guidelines and supporting case studies are available for undertaking this process (Ryan & Taylor 2006). However, the costs involved are prohibitive for many landholders, especially for sites where no saleable timber is present. In addition, it is claimed that, as with regrowth management on grazing land above, many landholders are unaware that such rehabilitation processes are approved under Queensland’s Native

40 PFSQ is one of three Queensland-based Private Forestry Development Committees, established to promote private forestry under the National Plantations 2020 initiative http://www.plantations2020.com.au/ PFSQ is a not-for-profit organisation, now self-funded from operational and advisory service provision.

41 Source: Sean Ryan, Private Forestry Services Queensland
Vegetation Management Act, subject to the codes applicable to each vegetation classification (Queensland Government 2009g).

This issue was recognised in the following clause of the SEQFA:

2.20 The Queensland Government will facilitate and provide incentives for ecologically sustainable management of forests and timber resources on private land. (SEQ Queensland Forests Agreement 1999)

To date, no such incentives have been provided. However, there was initial government support for the Private Forestry Development Committees established in Queensland (two of these groups are now operating as independent not-for-profits—Private Forestry Service Queensland and the Central Queensland Forestry Association). There was also significant government support for the AgForward program, delivered through the AgForce farmers association and designed to assist understanding of the Vegetation Management Act (Qld) 1999. Overall, based on informal advice, there appears to be no immediate likelihood of active government support for private native forest rehabilitation given the strong objections from some environmental lobby groups. This is discussed further in the section on Environmental Barriers.

From a biomass perspective, this rehabilitation process has the potential to supply significant quantities of residues from the initial thinning process, estimated at 20–30 tonnes (as received) per hectare. PFSQ have cited trials that indicated a total cost of $49/t (as received, unchipped) for harvesting, loading and haulage to a distance of 100 km. In the trial, this was almost covered by the price received for the material from Australian Hardboards, a processor which has since closed down.

**Key issues related to co-firing in Queensland**

These recognise that the thinning process is said to be compliant with the Queensland Vegetation Management Act and its associated codes, and is also certified under the Australian Forestry Standard (AFS).

1. The need to ensure that the thinnings will be eligible under the RET regulations
2. The need to demonstrate to environmental groups the science-based rationale (Borough, Parsons & Frakes 2007; Peacock 2008; Clinnick, McCormack & Connell 2008; Thompson & Connell 2009; Jay 2009) for rehabilitation to a healthy balanced forest ecosystem. This includes consideration of the acceptability of AFS, compared with other codes such as that produced by the Forest Stewardship Council (FSC)
3. The need to pinpoint the locations of potential sources of thinnings within an economic transport distance of the generators
4. The need for a process of aggregation to ensure an effective chain of supply
5. The need to further engage with owners of Private Native Forests to facilitate the adoption of improved management systems (Kater 2007; Roth & Molony 2008; Fisken 2009).

**Conclusion related to co-firing in Queensland**

This source has major potential in terms of volumes and likely availability within an economic transport distance. However, significant barriers exist in terms of the perceived environmental issues.
3.7 Sawmill residue

Processing logs into uniform sections such as planks produces significant waste, ranging around 50 per cent of the initial log volume. One of the aims of the sawmill industry is to minimise this waste and, if possible, to market it as ‘low value sawmill by-products’. In researching this source we consulted with a large number of individual sawmills. However, the project scope did not extend to a comprehensive audit of availability or trends.

Queensland processes 2.2 million m$^3$/annum of log input or approx 1.6 million tonnes of dry wood (Timber Queensland n.d.) (updated through Timber Queensland 2011, pers. comm.). The bulk of this is from softwood plantations. Of the remainder, 300 000 m$^3$ is from native forest, with 110 000 m$^3$ from private native forest and 190 000 m$^3$ from public native forest (Burgess  n.d.).

Of this, approximately 0.7 million tonnes becomes sawn timber (plus some board products), 0.3 million tonnes residue used for board products, and 0.6 million tonnes becomes by-products (Timber Queensland 2011, pers. comm.). These by-products consist of sawdust, shavings, shorts, trims and other offcuts. A significant volume of these by-products are already used for bioenergy, by combustion on site to produce heat for drying timber. Power generation is another option considered by some mills, particularly those cypress pine processors located further west, where distance excludes other markets.

Finer residues (softwood or hardwood) such as sawdust, chips and shavings are suitable for composting for a variety of uses in landscaping such as mulches and soil improvement. Other alternative raw materials for use in compost or mulches include urban green waste and hardwood chip from forestry operations and/or land clearing for development. Other potential markets for softwood sawdust include processing into high-quality pellets for sale as animal bedding (hardwood sawdust is generally avoided, due to possible toxins). At least one enterprise has announced plans in this market.

In the case of softwood residues, much of this has a ready, and expanding, market for processing into particleboard, alongside timber that is harvested and chipped specifically for this purpose (Timber Queensland 2004). Alternative uses for hardwood residues include their incorporation in composite materials (Dura Composites n.d.) or at low levels into particleboard (Gamage 2006). Until recently, there was a market for hardwood residues at the Australian Hardboards masonite factory in Ipswich, which closed in December 2010. However, we understand that the bulk of the raw material used was unprocessed hardwood forestry and land clearing residues (Australian Hardboards 2010, pers. comm).

Most of the sawmills approached stated that their residues were already contracted (primarily for landscape or particleboard use). However, one larger mill stated it had a significant excess of softwood residues that could be available for co-firing. We are also aware of smaller mills and other processors who are likely to have small volumes available. In addition, portable mills are also used in the industry and would generate some localised residues.

Given environmental regulations, and as with forestry residue, it is important to distinguish between sawmill residue from native forestry sources and plantation sources. In parallel with the discussion regarding Forestry Residues above, governments have legislated to ensure that any material derived from native forest timber is only used for energy generation under very close guidelines.

In Queensland, the South East Queensland Forestry Agreement has been interpreted as excluding the use of sawmill waste from state-owned native forests for power generation. In practice, although it will not be eligible for any applicable government support, it may, in fact, be acceptable under state laws (DERM 2010, pers. comm.). Certainly, such material would appear to meet ORER eligibility criteria (refer Appendix 2). Native forest residues will be generated by sawmills until 2025, although increasingly, hardwood residues will be from plantations. Certifying the source of any hardwood residues used in co-firing is an important factor, and an added cost, given the dispersed nature of the industry and its small scale.
**Key issues related to co-firing in Queensland**

1. Total volume is significant (600 000 tonnes) but widely dispersed, with little or no major supply close to power stations. There are well-established value-adding uses already, including for the landscape sector and (for softwood residues) for conversion to particleboard, with demand increasing. The latter adds significant economic/employment value

2. The large bulk of sawmill residues are softwood, reflecting the fact that approximately 75 per cent of timber processed is softwood. Environmental restrictions apply over the use of native forest-derived hardwood sawmill residues

3. One sawmill, out of those contacted, had relatively large volumes (>50 000 t) of excess residues available but it is located 200 km from the nearest power station

4. Pricing is believed to be in a range around $10/m³ ($40/t dry) (Various sawmills 2011, pers. comm.) excluding transport. The low bulk densities of sawdust and shavings make them expensive to transport

5. The physical characteristics of sawmill residue are attractive for several generators, but larger format residues may require pre-processing, thus adding cost.

**Conclusion related to co-firing in Queensland**

Sawmill residues are produced in large volumes overall, but the issues above render their use for co-firing uncompetitive at present.

**3.8 Coal seam gas-related biomass**

A major change in land use is underway in Queensland with the ongoing expansion of the coal seam gas (CSG) industry. The Queensland government, as well as the major CSG proponents, have detailed information available about the development of this industry (Queensland Government 2010e; Santos n.d.; Origin n.d.; QGC n.d.). Two of the key proponents of CSG were interviewed regarding their plans for the water and land associated with CSG extraction. The CSG extraction process produces large volumes of water, which tends to be high in salts and highly alkaline. The Queensland government has developed a policy to ‘ensure that salt produced through coal seam gas (CSG) activities does not contaminate the environment and to encourage the beneficial use of treated CSG water.’ (Queensland Government 2010f). 42 This highlights the need to phase out disposal through evaporation pans. A number of desalination plants are underway or in place to treat this water.

The CSG companies also own significant landholdings (although extraction will also occur on privately owned or leased land). This land is understood at present to be managed according to conventional agricultural practices for the region. However, there may be potential to manage some landholdings for approved environmental offsets to counter any deleterious effects from CSG processes.

It has also been suggested that a potential beneficial use of this water and land could be the production of biomass for energy generation. Any such crop would ideally have high water uptake rates from an early stage of development—generally, this would suit herbaceous energy crops better than agroforestry. In addition, the companies consulted are conscious of community concerns over the development of large-scale timber plantations. There is also a desire to explore higher value crops, given the high cost of water treatment and the potential to support regional development. For example,

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42 ‘A beneficial use approval changes the status of the material from a waste to a resource that can be used for a beneficial purpose’. The Guideline includes aquaculture and human consumption of aquatic foods; coal washing; dust suppression; industrial use; irrigation; livestock watering.
one company has run trials, of up to 300 ha in extent, with Millettia (also known as Pongamia)—a tree species with oil-bearing seeds suitable for diesel production.

According to Queensland Government information (Queensland Government 2010e), each major company is developing its own gas pipeline to the coast for LNG exports. Depending on requirements for land use and pipeline access in these corridors, there could be potential for some form of biomass cropping.

Finally, there is believed to be significant land clearing required for at least four approved development sites on Curtis Island, near Gladstone, where the piped gas will be liquefied and loaded onto ships for export. While it is understood that much of this material will be chipped and retained on site for landscaping use, some of it may also provide a short-term source of biomass suitable for co-firing (refer to Section 3.9 below on Development Residues).

**Key issues related to co-firing in Queensland**

1. Land and water availability indicates the potential to provide a biomass source, but economic returns may be unfavourable in the short term
2. Proximity to power stations ranges from good to poor
3. CSG is in the early stages of development, with rapid growth likely in the next decade—current focus is on developing the industry, rather than alternative land-use options.

**Conclusion related to co-firing in Queensland**

Significant potential in the medium to longer term, in terms of volumes, but co-firing economics would need to improve if companies are to consider this avenue.

**3.9 Development residues**

Significant areas of land are cleared in Queensland each year for the purposes of urban and industrial development. While much of this is small in scale—where the biomass removed will be directed to the urban green waste scheme—there are also large-scale projects producing major volumes. The following are some of the estimated volumes from developments. We have been unable to confirm these quoted volumes.

- dam development—Murrumba 70,000 tonnes and Connors River 100,000 tonnes
- CSG export facilities around Gladstone—160 000 tonnes
- unspecified development (Gold Coast hinterland)—60 000–70 000 tonnes
- clearing of previous MIS forestry plantation north of Rockhampton—240 000 m³ total.

Such sources have the potential to partially meet generator needs in terms of the volumes required to enable low-level co-firing. It has been suggested that the Development Application process is both extended and public, making it feasible to forecast when these sources may be on stream (given that they are ‘one-off’ sources that are available at irregular intervals, rather than being available continuously). However, there is clearly a need for an intermediary with the ability to aggregate the various sources as they become available and manage the supply as required by the generators, as well as to provide the certification/documentation required to support the creation of LGCs from this material.
Key issues related to co-firing in Queensland

1. Total volumes appear to be significant and in some regions, e.g. Gladstone-Rockhampton, and, subject to cost, could supply the initial period of co-firing, while ongoing sources become established.

2. Pricing of this source is unclear—possibly built into overall contract for land clearing and preparation and based on existing alternative disposal costs such as burning. Informal advice suggests around $60/t delivered within 100 km, but this should not be relied upon.

3. RET eligibility—the regulations (Appendix 2) do not specifically address biomass from land clearing. There appear to be three different possible routes, but there is uncertainty regarding the eligibility of this material (ORER 2011 pers. comm.). One route is Section 6 (biomass-based components of municipal solid waste). Alternative routes could be Section 8 (wood waste) or Section 9 (energy crops). However, there are a number of issues that would need to be resolved and these would be particular to each individual application by the relevant generator.

4. Product quality—as with green waste, land clearing residue would need to be chipped and guaranteed clean of soil, rocks, metal and other contaminants.

5. Availability—the supplier would need to schedule supply to meet the generator’s capacity—this could entail storage and double-handling by the supplier if the land clearing schedule demands it.

Conclusion related to co-firing in Queensland

This source appears to have significant potential in the short-term, to enable co-firing to become established for one or two generators in the northern sector of the study area, at least. However, pricing and eligibility under the RET are not clear at this stage. It also relies on the availability of an aggregator to manage the requirement for a consistent supply into the generator, as well as on quality, price and RET eligibility factors.

3.10 Urban waste

For the current study, this is considered as two main streams with apparent potential for co-firing—green waste and construction & demolition (C&D) waste. Municipal solid waste (MSW) also contains other organic materials but these are definitely unsuitable for co-firing (for example, 35 per cent of the MSW stream is reported to be food waste (Australian Government 2009a as reported in Hyder 2009)).

Both these sources are only produced in excess volumes at urban centres, which creates a distance penalty for their use in co-firing, given the locations of the power stations. Feedback has highlighted potential opportunity ‘grey areas’ that are currently limited by environmental regulations in some states—a case in point is the combustion of wood pallets, on the basis of their surface coatings (see case study). Similar issues have been reported from NSW regarding combustion constraints on C&D waste even after hand-sorting to remove any treated timber.

43 For example, under Section 6, there would need to be proof that the material was suitable for acceptance at a landfill site. Under Section 8, it must satisfy 8(2) (a) and (b) (i) or (ii) and (c) (i) or (ii).

44 Municipal solid waste (MSW) is defined in Hyder 2009 as ‘Municipal: Solid waste generated from domestic (household) premises; also usually includes council activities such as street sweeping, litter and street tree lopping; waste dropped off at recycling centres and transfer stations; and construction waste from owner/occupier renovations’.
Case Study: Sydney Pallet Waste

The introduction of dumping fees significantly changed the economics of co-firing with these materials. It is reported that 120,000 tonnes of pallet waste is dumped annually in Sydney landfills, at a cost of $120/t in dumping fees (David Moller, pers. comm.). This material is thought to be an ideal feedstock for the cogeneration plant at the Broadwater Sugar Mill. Despite the distance (800 km), avoiding the dumping fee would make it economical to transport the material for power generation. Currently, this option has been unable to be tested, due to delays in gaining necessary approvals from the NSW Environmental Protection Authority. There are potential concerns related to the identification of the paint used on some pallets. While perhaps an extreme example, this illustrates how waste policy decisions can affect the economics of biomass to energy.

A key factor affecting both these streams in Queensland is the adoption of the Queensland Waste Management Strategy, which will introduce a waste disposal levy of $35/t on landfill (excluding municipal solid waste), from 1 December 2011, with higher fees applicable to more hazardous materials.

According to DERM (Warren Muller 2010, pers. comm.), about 50–60 per cent of landfill is generally believed to be organics (Figure 10), but there is a lack of solid data on the volumes, or on the proportion that could be suitable for co-firing (Queensland Government 2007; Hyder 2009). Importantly, a significant proportion of the waste levy revenue will be devoted to grants to improve waste management.

Figure 10: Wood waste at a local council clean-up

3.10.1 Green waste

Green waste was used for co-firing successfully for some time in the past at Swanbank power station, which is situated close to Ipswich and also to one of the landfill sites for Brisbane. However, green waste is, by its nature, extremely variable and bears a high risk of contamination with dirt, rocks and metal. As noted previously, for this reason, generators have indicated that it is not a preferred material for co-firing.

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45 Source: E3
In addition, other than Swanbank, which is due to be decommissioned, none of the generators are within an economic transport distance of Brisbane as the major source of green waste. Enquiries to some local government authorities nearer to the generators have indicated that the green waste generated in regional areas finds a ready market with local residents for landscaping/soil improvement purposes.

3.10.2 Construction and demolition (C&D) waste

According to a recent report, 1.5 million tonnes/annum of C&D waste is disposed of in Queensland. This is equivalent to 70 per cent of the total C&D waste generated, with the remainder being recycled (Hyder 2009, page 4) (note that this uses 2006 data).

From a co-firing perspective, C&D waste has similar issues to green waste, in terms of transport distance. A major concern for generators is the risk of contamination with CCA-treated timber, that could result in excessive emissions if combusted. However, the disposal fees increase the incentive to sort C&D waste carefully and find alternative avenues for disposal. One company has been identified with a processing system to undertake this, which merits further investigation, although it is understood that the material has not yet been assessed by generators.

Figure 11: Processed engineered fuel

**Case Study: Reclamation of C&D waste**

SITA ResourceCo Alternative Fuels Pty Ltd (a joint venture company of SITA Australia and recycling group ResourceCo Pty Ltd) commissioned its C&D processing plant in November 2006 in Adelaide. It now transforms 160 000 t of C&D waste into 80 000 t of process engineered fuel (PEF) per annum (Figure 11). This processed material is co-fired with natural gas in a cement manufacturing plant under agreement with Adelaide Brighton Limited.

The existence of waste disposal fees, as well as a ready market for the PEF product, helped to underpin the viability of this project.

ResourceCo plans to establish additional PEF manufacturing facilities throughout Australia. (Source: ResourceCo n.d.).

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46 Source: ResourceCo
Key issues related to co-firing in Queensland

1. Volumes are significant in Brisbane, but transport distance is an issue under current economics
2. Contamination is a key concern
3. Factors such as the introduction of disposal fees are acting as an incentive to improve recovery of C&D waste, through innovations such as the ResourceCo process.

Conclusions related to co-firing in Queensland

Green waste is available in significant quantities, but not close to generators, who do not consider it to be a preferred source for co-firing in its current form.

Processed engineered fuel is worthy of further investigation. Various issues, including its affinity to co-milling and plastics content, may need to be addressed. In addition, the economics of this option would need to be investigated further.

3.11 Harvesting, processing and logistics

As described in the previous chapter, the advantage of co-firing a small proportion of biomass with coal in existing pulverised fuel power stations is the ability to leverage existing infrastructure, with minimal additional capital cost. The ability to co-mill biomass along with the coal, using some existing mills, is particularly attractive. However, this does pose certain constraints on the type of biomass that can be used. In addition, generators would prefer the biomass supplied to be as uniform as possible, to enable their plant to operate at maximum efficiency without requiring continual retuning. Processing offers some options to address these issues. While many of these are cost-prohibitive at present, this could change under future economic scenarios.

3.11.1 Harvesting

The many options for harvesting of various configurations of biomass are covered in great detail by Stucley et al. 2004 (currently under revision).

Some key issues arising from our consultations include:

- There is a key need for appropriate harvesting technology suited to the agroforestry option of mallee strip plantings. This is a key factor identified in the economic analysis by the CRC for Future Farm Industries (CRCFFI 2010). There has been significant recent progress towards a mallee harvesting system by Biosystems Engineering (Figure 12). This working harvester requires further wide-scale testing and the possible development of a larger-scale model to gain further economies of scale. However, as stated elsewhere, the mallee strip agroforestry option may not be suitable for Queensland.

- It has been suggested that the harvesting of regrowth on grazing land merits further investigation. This should include consideration of potential harvesting options, since the resource is believed to be widely dispersed across a large area of farmland.
3.11.2 Processing

**Chipping**

Several of the biomass sources described above are chipped as part of their normal collection/handling/disposal methods. This includes urban green waste and mallee strip plantings. Material that is difficult to handle and of low density, such as brushy residues from forestry or land clearing can be rendered uniform and easily transportable by chipping. Chipping would be required for sources such as private native forestry thinnings or C&D waste.

**Pelleting**

This is a well-established process for creating a uniform, relatively dense material from a potentially wide range of sources. Wood pellets would be a preferred biomass co-firing source for generators. In recent years a large global market for pellets has developed, driven to a large extent by the European renewable energy targets. The prices available in Europe make the production and shipment of pellets profitable, even from locations as distant as British Columbia (where there is a very large resource of standing waste timber from insect-affected forests). However, pelleting is an energy-intensive and costly process, especially for bulky feedstocks which have to be ground first before they can be converted into pellets. This is illustrated in Table 6:

<table>
<thead>
<tr>
<th>Table 6: Pelleting costs</th>
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<tr>
<td><strong>Source</strong></td>
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<tr>
<td>2007 Australian study (AVONGRO 2007)</td>
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<tr>
<td>2010 Pellet Handbook (EU) (Van Loo &amp; Koppejan 2010)</td>
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</table>

As mentioned elsewhere, Plantation Energy Australia was established for the production and export of wood pellets to Europe (initially from WA).

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47 Source: Richard Sulman, Biosystems Engineering
Torrefaction & Pyrolysis

Torrefaction is a ‘blanching’ process under low or zero oxygen conditions, which drives off water as well as some volatiles from the biomass as energy-bearing gases (Bergman & Kiel 2005). These can provide an immediate energy source to drive the torrefaction process, or to serve other purposes. Torrefaction can be carried out on an industrial scale as an extension to normal drying/curing processes to produce torrefied timber for construction. Such timber has certain valuable properties, such as lighter weight and water repellency.

Torrefaction can also be applied to biomass wastes to create a localised gas supply, but also to reduce water content (to reduce transport costs and combustion efficiency) and to increase brittleness (potentially becoming easier to grind into dust for co-firing). Torrefied timber may also be more amenable to densification by pelleting.

Torrefaction of biomass, coupled with pelletisation permits higher levels of co-firing (in the order of 20 per cent) in pulverised systems (EPRI 2010 pp. 6–82). The lower moisture content and higher energy density compared to wood pellets improves combustion characteristics and transport efficiency. First-of-a-kind pilot plants are expected to be operational in Europe in the near future (EPRI 2009 pp. 6–83).

At higher temperatures, this process is known as pyrolysis, which has long been practiced in making charcoal. Applying pyrolysis to biomass produces biochar (Lehmann & Joseph 2009), which has potential value for soil improvement and/or industrial processing, as well as for co-firing.

Few torrefaction or pyrolysis facilities exist in Australia at present and the economics are not well understood. Both processes have significant potential to broaden the available sources for co-firing. However, their suitability would need to be tested, particularly regarding dust issues (Ibid p215; Winkler 2010). Delta Electricity is hosting a two year pyrolysis/torrefaction demonstration project at its Vales Point Power Station on the NSW Central Coast (Delta Electricity 2010).

3.11.3 Transport

Transport implications have arisen through much of the previous discussion and this is clearly a major factor from both the cost and the emissions perspectives. Because the economics of co-firing demands the use of low-cost sources of biomass, which are bulky in nature, the cost of transportation is highly significant. It was beyond the project scope to negotiate specific haulage rates for specific sources to specific generators, or to assess specific back-loading opportunities. However, consultation with the transport and logistics sectors as well as the review of biomass literature provided some key learnings.

In the short term, rail is not an option for transport of biomass to the Queensland power stations, because:

- Coal transport for export already makes full use of bulk rail freight capacity.
- The dispersed nature of the biomass resource does not favour rail logistics.
- The generators are not generally well served by the mainstream rail network, being situated in close proximity to coal reserves.

An alternative to rail for biomass sources from more remote areas could be the use of newer truck configurations such as the BAB Quad, which comprises two sets of B-double trailers, or four trailers in total. According to the National Transport Commission, ‘This “modular” concept offers significant efficiencies as it can be used as a road train in rural Australia and then split into two B-double sets for operation in outer metropolitan areas’.

Other truck configuration factors include the use of ‘walking floor’ trailers. These are widely used for materials such as bark and woodchip, which tend to settle into a solid mass that can be difficult to eject.
from a tipping trailer. The moving floor is divided into sets of narrow slats. These move alternately in sets in order to gradually eject the load.

An alternate arrangement is to install tipping platforms at the receival point. These are able to tip to greater angles than a normal tipping trailer and enable the use of non-tipping trailers. After the truck and trailer is secured to the platform, the platform is elevated, thereby tipping the entire rig until the load is dislodged. This would increase the capital expenditure for the generator, but could reduce transport costs.

The bulk road freight operators consulted have indicated that delivery capacity is not an issue, particularly in a situation of ongoing, regular deliveries, such as would be required for biomass supply for co-firing. Factors that may need to be considered include the significant increase in truck movements in the vicinity of the generation facilities, as well as potential localised limitations on access by multiple-axle configurations such as B-doubles. However, these are not seen as major barriers by the transport companies consulted.

Setting aside capital and maintenance costs, transport operating costs are a combination of: loading costs (including waiting time), travel (a function of road speed), unloading costs (including waiting time) and return trip. Within these basic variables sit another larger set, including those affecting fuel consumption, as outlined below. This means that costing of the transport of biomass by truck is dependent on many factors and difficult to capture in a formulaic sense. Nevertheless, some attempts have been made to do this. For example, the CRC for Future Farm Industries developed a model, including a formula, to allow for changes in transport costs according to road speed (Hobbs 2009). This suggests a cost curve ranging from 14 cents/t/km return at high road speeds to 35 cents/t/km return at low speeds.

It should be noted that these are modelled costs only and extreme caution should be used regarding these as per the comments below.

The Coal-Biomass Cofiring handbook (CCSD 2007) (Section 7.4.2) provides some examples of transport costs, mainly based on informal communications and summarised in a graphic, which indicates a cost curve ranging from 16 cents/t/km (for a 50 km journey) to 12 cents/t/km for journeys of 175 km or more.

A 2007 study (Access Economics 2007) compared road and rail costs for rural commodities. The report provides some averaged figures for the gross mass (36.4 tonnes) and fuel consumption (51.7 litres/100 km) of articulated vehicles, based on ABS Survey of Motor Vehicle Use data. The survey authors made no suggestion that these averaged figures from ABS could or should be extrapolated to produce average fuel consumption per tonne.

A study by the CRC for Forestry has investigated forestry transport costs (Griffin & Brown 2010). This study involved fourteen B-double trucks, with an average load of 45.7 tonnes and fuel consumption of 67.3 litres/100 km, resulting in a ‘fuel intensity’ (cost) of 1.5 cents/t/km. While this is similar to the example calculation in the box below, it should not be extrapolated to any particular transport situation.

It should be emphasised that any attempt to compare averaged figures such as these to actual fuel consumption for a given transport task in the ‘real world’ is highly risky. Road freight fuel consumption is not a simple derivative of payload and distance. Many other factors are involved, including: gradient, number of stops, road surface, weather conditions and driver (Figure 13). There are also significant differences in fuel efficiency between modern truck engines and older ones that are

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Note that ABS data uses the Gross Combination Mass, which is ‘Tare weight (i.e. unladen weight) of the motor vehicle and attached trailers, plus their maximum carrying capacity’.
still in use. In addition, fuel tax credits apply on trucks that comply with certain environmental standards and this also affects the net costs (ATO 2011).

Finally, in terms of fuel costs and their impact on the economics of biomass transport, alternative fuels such as liquefied natural gas (LNG) or compressed natural gas (CNG) may provide lower-cost options in the future (Truck Industry Council 2011).

In consulting with transport operators and logistics experts (Tom Rafferty 2011, pers. comm.), it appears that the wide range of variables applying to road haulage precludes the use of formulaic projections when considering a diverse and widely distributed product such as biomass. Given the need to maximise returns on capital and labour employed, each transport business is likely to make a different set of judgements about the pricing of particular consignments, depending on the constraints and capacities applying to the business at a particular time.

An extreme example of this is the availability of excess bulk transport capacity in the sugar industry out of season. This fleet is available to biomass cogeneration operators at operating cost only for six months of the year, reducing the cost of sourcing other forms of biomass. A study currently underway (Schmidt, pers comm.) is aiming to compare the supply chains for the WA mallee biomass program and the Queensland sugar industry, in order to apply learnings from the latter’s long experience in biomass logistics.

### Sensitivity to Fuel Prices

It would be useful to know how sensitive the economics of transporting biomass would be to potential increases in the price of fuel. However, both the overall cost and the proportion of this cost that is attributable to fuel are extremely variable. Therefore, as an academic exercise only, we have applied the average consumption rates published by ABS across all heavy road freight, as follows.

An average gross mass (36.4 tonnes) and fuel consumption (51.7 litres/100 km) of articulated vehicles, would translate to 0.014 litres/t/km, or approximately 2 cents/t/km at a fuel price of $1.50/litre (on gross tonnage, not payload tonnage). On a haulage rate of, say, 12 cents/t/km, this would make fuel costs 16 per cent of transport costs, while at 32 cents/t/km, fuel would be 6 per cent.

It is not suggested that these are realistic figures, but they are included to indicate the need to further investigate the sensitivity of the delivered biomass cost to increases in global oil prices. The difference in sensitivity to fuel costs between long-haul and local haulage has been reported (Rafferty 2009).

Note that calculators do exist to determine the exposure to fuel prices of particular transport quotes. The levy or surcharge referred to here is applied by some transport operators when there is a sharp increase in fuel price that is beyond their ability to absorb (Freightmetrics n.d.).
This inherent transport cost variability also underlines the potentially onerous nature of the task for generators entering multiple negotiations regarding multiple sources of biomass. An aggregator would be better placed to balance the cost risks across a broad process of securing biomass sources and managing transport and logistics.

In terms of the emissions costs of transporting biomass in order to reduce emissions at a power station, specific studies would be required, taking all factors into account (the life cycle emissions impacts of biomass co-firing is considered further in the Barriers section of this report).

**Key issues related to co-firing in Queensland**

1. Economical methods of harvesting regrowth on grazing land and transporting this to generators are required for this resource to be viable

2. Chipping may be essential in order to render some sources suitable for co-firing and some of the cost may be offset by efficiencies in handling and transport costs

3. Any processing options, such as chipping, pelleting, torrefaction or pyrolysis, need to be undertaken prior to delivery to the generator

4. Current economics rule out pelleting, while infrastructure is not yet in place for torrefaction or pyrolysis and costs are unknown

5. Transport costs are affected by many variables and these are accentuated by the diversity and distribution of biomass sources. Costs appear to range from 10–30 cents or more per tonne per km

6. The emissions impacts of transporting biomass should be considered as part of a wider life cycle assessment (LCA) of biomass co-firing (also refer to LCA discussion in Section 4.2).

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49 Source: Richard Sulman, Biosystems Engineering
Conclusion related to co-firing in Queensland

Harvesting and chipping costs need to be accounted for in the delivered price for some materials in order to rule them in as biomass options for co-firing. More advanced processing such as pelleting, torrefaction and pyrolysis are ruled out at present, largely on economic grounds. Transport costs are highly variable, given the diverse nature of the source, and would be best managed by a biomass aggregator.

3.12 Summary of implications for biomass co-firing

Table 7 summarises the merits of each type of biomass considered, in a relative sense only. It is designed to serve as a tool, providing a fairly coarse filter to summarise the relative merits of each source. It should be noted that these are subjective indications only, not absolute judgements.

As has been stated elsewhere in the report, the potential of these sources will change over time, partly in response to the expected changes in the economics of co-firing. In addition, the table provides a generalised picture across SE Queensland. The relative merits of a particular biomass source will vary with each particular generator according to its location, engineering setup and site specific circumstances.
<table>
<thead>
<tr>
<th>Source</th>
<th>Preferred by generators</th>
<th>Available in 0–12 months</th>
<th>Available in 1–5 yrs</th>
<th>Available in 5+ yrs</th>
<th>Available within ETD 50</th>
<th>Cost</th>
<th>RET eligibility</th>
<th>Regulatory matters</th>
<th>Competing uses</th>
<th>Overall</th>
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<td><strong>Crop residues</strong></td>
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<td>3.1.1</td>
<td>Needs pre-chopping</td>
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<td>3.1.3</td>
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<td><strong>Agricultural energy crops (herbaceous)</strong></td>
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<td><strong>Agroforestry for energy</strong></td>
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<tr>
<td><strong>Agricultural processing residues</strong></td>
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<tr>
<td><strong>Bagasse</strong></td>
<td>Difficult to mix evenly</td>
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<td>3.4.1</td>
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<tr>
<td><strong>Other agricultural processing residues</strong></td>
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<tr>
<td>3.4.2</td>
<td>If no handling issues</td>
<td>Low volumes</td>
<td>Low volumes</td>
<td>Low volumes</td>
<td></td>
<td></td>
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</tbody>
</table>

Key: Negative | Neutral/unknown | Positive | Not applicable

50 Economic Transport Distance

51 Worthy of further investigation under current economics.
<table>
<thead>
<tr>
<th>Section</th>
<th>Source</th>
<th>Preferred by generators</th>
<th>Available in 0–12 months</th>
<th>Available in 1–5 yrs</th>
<th>Available in 5+ yrs</th>
<th>Available within ETD 50 yrs</th>
<th>Cost</th>
<th>RET eligibility</th>
<th>Regulatory matters</th>
<th>Competing uses</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5</td>
<td>Forestry plantation residue SW</td>
<td>If pre-chipped</td>
<td>Low volumes</td>
<td>Low volumes</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3.5</td>
<td>Forestry plantation residue HW</td>
<td>If pre-chipped</td>
<td>Possibly from clearing only</td>
<td>Only small volumes likely</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3.6</td>
<td>Native forest residue (from rehabilitation)</td>
<td>If pre-chipped</td>
<td>Large volumes possible</td>
<td>Large volumes possible</td>
<td>In some areas</td>
<td>Trials costs hold promise</td>
<td>Needs to be confirmed</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3.7</td>
<td>Sawmill residue</td>
<td>If large pieces pre-chipped</td>
<td></td>
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<tr>
<td>3.7</td>
<td>Coal seam gas-related biomass</td>
<td></td>
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<td></td>
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<tr>
<td>3.8</td>
<td>Development residues</td>
<td>If pre-chipped</td>
<td>No firm info beyond about 18 months</td>
<td>In some areas</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3.9</td>
<td>Urban waste</td>
<td></td>
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</tr>
<tr>
<td>3.10</td>
<td>Green waste</td>
<td>Woody screenings could be ok if pre-chipped</td>
<td></td>
<td></td>
<td></td>
<td>Distance (disposal fees could change this)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.10.1</td>
<td>C&amp;D waste</td>
<td>Must be free of contaminants</td>
<td></td>
<td></td>
<td></td>
<td>Distance (disposal fees could change this)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>3.10.2</td>
<td></td>
<td>If pre-chipped</td>
<td></td>
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</tbody>
</table>

Key: Negative Neutral/unknown Positive Not applicable
4. Barriers and Possible Pathways to Resolution

The preceding findings from our discussions with both generators and biomass suppliers were analysed to identify and assess the key barriers that are preventing the uptake of biomass co-firing in Queensland. These are summarised in Table 8 and discussed in more detail in this section. Possible pathways to resolution are also canvassed.

Table 8: Key barriers to biomass co-firing

<table>
<thead>
<tr>
<th>Category</th>
<th>Barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-firing economics</td>
<td>• The economics of biomass co-firing are marginal under current policy settings. Consequently, the maximum price that generators can afford to pay restricts potential biomass sources to very low cost materials</td>
</tr>
<tr>
<td>Environmental concerns</td>
<td>• Resistance to combustion of woody material for energy production</td>
</tr>
<tr>
<td>Biomass market</td>
<td>• Known availability of low cost biomass falls short of volumes required for continuous low levels of co-firing</td>
</tr>
<tr>
<td></td>
<td>• Lack of integrated biomass supply capability</td>
</tr>
<tr>
<td></td>
<td>• Lack of information on biomass resource availability</td>
</tr>
<tr>
<td></td>
<td>• Lack of organised market for biomass</td>
</tr>
<tr>
<td>Perceptions and attitudes</td>
<td>• Perception that biomass co-firing is an established technology that does not require policy support for commercialisation</td>
</tr>
<tr>
<td></td>
<td>• Lack of interest in agroforestry within farming sector</td>
</tr>
<tr>
<td></td>
<td>• Community perception of plantations</td>
</tr>
</tbody>
</table>

4.1 Co-firing economics

The economics of biomass co-firing are marginal under current policy settings. Consequently, the maximum price that generators can afford to pay restricts potential biomass sources to very low cost materials.

Context

While every generator faces a different set of commercial circumstances, it is possible to make some generalised observations on the economics of biomass co-firing.

As discussed in Section 2.3, biomass co-firing economics depends on the interplay of several key factors—the avoided cost of coal, revenue from sale of LGCs, the cost of biomass, increased operating costs.
and maintenance (O&M) costs and the capital cost associated with co-firing. In summary, the benefits (avoided cost of coal + LGC revenue) must exceed the additional capital and operating costs (biomass and increased O&M), after adjusting for the time value of money.

Appendix 3 includes an indicative economic analysis of biomass co-firing from a generator’s perspective. This suggests that under current policy settings and commodity prices, the maximum price generators could afford to pay for delivered biomass (i.e. inclusive of transport), which we will refer to as the biomass affordability threshold, is in the order of $4/GJ. This is approximately $48/t assuming energy content of 12 GJ/t. An LGC price of $50/MWh would raise the biomass affordability threshold to $5.60/GJ (around $67/t).

The introduction of a carbon price will increase the biomass affordability threshold by avoiding the carbon cost on each tonne of coal displaced by biomass. For example, a carbon price of $20/tCO₂-e coupled with LGC prices of $50/MWh would raise the affordability threshold to $7.50/GJ ($90/t).

The absence of LGC revenues leads to a steep decrease in the affordability threshold, illustrating the importance of securing LGC revenues. As illustrated in Table 9, the threshold falls to $2.20/GJ (or around $26/t) in the absence of REC revenues, and a carbon price of $20/tCO₂-e.

The sensitivity of the affordability threshold to carbon and LGC price assumptions is illustrated below.53

<table>
<thead>
<tr>
<th>Carbon price ($/tCO₂-e)</th>
<th>LGC price ($/MWh)</th>
<th>zero</th>
<th>35.00</th>
<th>50.00</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4.00 (48.00)</td>
<td>5.60 (67.20)</td>
<td></td>
</tr>
<tr>
<td>zero</td>
<td></td>
<td>1.30 (15.60)</td>
<td>4.90 (58.80)</td>
<td>6.50 (78.00)</td>
</tr>
<tr>
<td>10.00</td>
<td></td>
<td>1.30 (15.60)</td>
<td>4.90 (58.80)</td>
<td>6.50 (78.00)</td>
</tr>
<tr>
<td>20.00</td>
<td></td>
<td>2.20 (26.40)</td>
<td>5.80 (69.60)</td>
<td>7.50 (90.00)</td>
</tr>
<tr>
<td>30.00</td>
<td></td>
<td>3.10 (37.20)</td>
<td>6.70 (80.40)</td>
<td>8.30 (99.60)</td>
</tr>
</tbody>
</table>

The affordability threshold is less sensitive to the avoided cost of coal. For example, a doubling of the avoided cost of coal would increase the affordability threshold by around $1/GJ ($12/t).

Based on the findings in relation to biomass availability, likely delivered costs, (including the cost of biomass, cost of collection/processing and cost of delivery) are, for many sources, well in excess of the required threshold.

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52 For convenience, all references in this report assume an energy content of 12 GJ/t—see discussion in Section 1.1.

53 These figures are based on a real discount rate of 20 per cent. We note that some generators may choose to use a higher or lower rate reflecting their assessment of co-firing risks, which would lead to a corresponding decrease or increase in these affordability thresholds respectively.
Possible pathways to resolution

This barrier can only be addressed through two avenues:

- an increase in the biomass affordability threshold
- a lowering of the cost of delivered biomass.

Given that (a) many Queensland generators own the coal mines supplying the power stations, (b) coals used for power generation in Queensland are generally of a lower grade than the thermal coal that is exported (Queensland Government 2009b) and (c) capital and operating and maintenance cost levels for low levels of co-firing are unlikely to change significantly, any change in the biomass affordability threshold will be determined by renewable energy and carbon policy settings.

While carbon policy is likely to be addressed at a national level, we note that many states have elected to introduce specific policies to support renewable energy development. Given the support provided by feed-in tariffs for bioenergy internationally (Global Feed-in Tariffs 2010), this may be an avenue that the state government may wish to consider. However, we recognise the difficulties in providing feed-in tariffs for some technologies but not others, and suggest that any feed-in tariff approach for biomass co-firing should be part of a wider program to support renewable energy technology deployment. In this regard we note a recent publication on feed-in tariff design produced by the United States National Renewable Energy Laboratory which provides a comprehensive resource guide for policymakers seeking to introduce a feed-in tariff regime (NREL 2009a).

Pathways to lowering the cost of delivered biomass include efficiency gains through improved logistics (for example, sourcing biomass more closely to generation sites), economies of scale and policy measures that incentivise the establishment of biomass resources. In regard to the latter, there are a number of approaches internationally that could be considered. Two examples are highlighted below, but the efficacy of these measures in increasing the uptake of biomass co-firing has not been verified as part of this work.

<table>
<thead>
<tr>
<th>The US Biomass Crop Assistance Program (BCAP)</th>
<th>Energy Crops Scheme (England)</th>
</tr>
</thead>
</table>
| The BCAP, administered by the United States Department of Agriculture’s (USDA) Farm Service Agency (FSA), provides (conditional) support to parties seeking to establish, produce, and deliver biomass feedstocks through two mechanisms:  
- Establishment and annual payments to certain producers to produce eligible biomass crops. If selected, producers will be eligible for reimbursements of up to 75 per cent of the cost of establishing a bioenergy perennial crop. Producers also can receive up to 5 years of annual payments for grassy crops (annual or perennial), and up to 15 years of annual payments for woody crops (annual or perennial).  
- Matching payments for the collection, harvest, storage and transportation of eligible material to qualified biomass conversion facilities (including power generation) by eligible parties. Assistance | The Energy Crops Scheme, which is part of the Rural Development Program for England 2007—2013, provides establishment grants for land owners in England to plant Miscanthus or short rotation coppice (SRC). The scheme is designed to cover setup costs including ground preparation, fencing, purchase of planting stock, planting and weed control. Payment will cover 50 per cent of actual costs (suppliers/materials/contractors costs) and/or 50 per cent of on-farm costs (use of own labour and machinery). Crops must be used for heat, combined heat and power or power generation, and own use is permitted.  
Applicants must demonstrate an energy end-use for the crops (including through a contract with a power station). Natural England will consider each application on an individual basis to ensure that the end use is within a reasonable distance of the crops, including method of transport and other carbon impacts. |
will be available for 2 years, through a matching payment of up to US$45 per ton of the delivery cost. Assistance is reduced on sale of the crop by varying percentages depending on how the resource is utilised (25 per cent if biomass sold for heat, power).

(Source: USDA 2010)

Successful applicants are required to enter into a 5 year agreement with Natural England.

(Source: Natural England 2009)

Step changes in waste policy which leads to increased fees for waste disposal could also improve the economics of waste-stream sources. The introduction of the new waste management regime in Queensland from 1 July 2011 would provide a valuable boost in this respect.

The above analysis is based around the cost of delivered biomass, which will clearly be affected by transport fuel price increases. The extent of this will depend on (a) the transport distance, (b) the contribution of transport fuel costs to total transport costs and (c) any corresponding impact on coal transport cost (for power station receiving coal by rail). A significant increase in transport fuel costs (for example as a result of a significant rise in oil prices) could lead to a situation where delivered biomass costs increase significantly, but the biomass affordability threshold does not, rendering biomass co-firing unviable from a generator standpoint. While this risk could be temporarily managed by hedging fuel price risk (for example through forward fuel purchases), a sustained increase in oil prices could lead to a diversion of biomass resources to the production of biofuels for transport, where the market price is better correlated with transport fuel costs.

4.2 Environmental concerns

Resistance to combustion of woody material for energy production

Context

Feedback from industry proponents, both on the supply and demand side, highlights the resistance, particularly from some environmental groups, to combustion of woody material for energy production. This is underpinned by the perception that the removal of any woody material is harmful, regardless of opportunity cost.

This resistance is particularly strong in relation to the use of native vegetation, especially native forest residues, for electricity generation. The RET regulations include native forest residues as an eligible renewable energy source, subject to strict conditions (refer Appendix 2). However, some environmental groups oppose this. Australia appears to be unique among OECD nations in this respect, as this does not appear to be an issue in other countries where bioenergy is implemented and accepted on a much broader scale (CEC 2008a).

The concerns of such groups relate to the perceived environmental impacts associated with the use of this material—principally the reduction in carbon carrying capacity and loss of healthy biodiverse forest ecosystems, as well as the propensity of increased biomass demand to increase logging rates or shorten rotation times (Wilderness Society 2009). Opposition has included coining emotive references to the use of such material for power generation—for example ‘forest furnaces’, and demonstrations against electricity generators utilising native forest residues (Wilderness Society 2003).

54 If there is no counterbalancing movement of LGC and carbon prices.
Electricity retailers account for the majority of LGC purchases. In the face of these concerns, they are reluctant to purchase RECs (now LGCs) associated with native forest residues, with many retailers adopting policy positions against transacting in any material that falls under the ‘wood waste’ category of the RET regulations (Manning 2010). As described in the relevant extracts from the regulations in Appendix 2, the wood waste category includes all woody biomass (excluding energy crops), and covers:

- biomass produced from non-native environmental weed species (and harvested for the control or eradication of the species, from a harvesting operation that is approved under relevant Commonwealth, state or territory planning and approval processes)
- manufactured wood products or by-products from a manufacturing process
- waste products from the construction of buildings or furniture, including timber off-cuts and timber from demolished buildings and sawmill residue.

While we understand that some retailers are willing to accommodate LGCs from non-native forest residue sources where there is source tracking in place (for example, where there is a dedicated Power Purchase Agreement with auditing provisions), this market stance presents a major barrier to the commercialisation of biomass to electricity projects utilising material that falls within the wood waste definition.

Our modelling suggests that in the absence of LGC revenues from biomass co-firing, a carbon price of around $40/t would be required to make co-firing projects viable—a price level that appears unlikely in the near term. Consequently, revenue from the sale of LGCs is a key requirement for biomass co-firing.

We note that there are non-retailer markets for LGCs (for example, direct purchases by major electricity users to support their compliance against the RET) which may provide some market opportunity for these LGCs, albeit most likely at a discount to the prevailing market price.

Our consultation indicates that electricity generators and forestry industry players acknowledge that there are legitimate concerns that need to be addressed. However, there is broad consensus that ideology, and in some cases extreme viewpoints, prevents the development of pragmatic and balanced solutions that accommodate the needs of all stakeholders.

Native Forestry Residue Volumes

This section notes that the barriers to the use of native forestry residues extend well beyond the stringent rules applied at state level and through the RET regulations. The use of even fully compliant forestry material is likely to meet opposition from some quarters.

In terms of native forest sawmill residues, the contentious issue relates only to residues from private forests, (since State forest products are excluded). Private forests produce about 110 000 m³, or 80 000 t/annum of unprocessed timber. This would generate 24 000–40 000 tonnes of sawmill residues.* While significant, this volume is spread across multiple, dispersed sites. This makes it a less favoured resource, given that careful audit trails will also be required to ensure that sawmill wastes from State forests are not used.

In terms of silvicultural thinnings, the loss of access created by these barriers to use are more significant. There is an estimated 1 million ha of private native forest in SE Queensland requiring rehabilitation and this can generate up to 30 t/ha of biomass.**

* based on Timber Queensland gross estimates
** according to PFSQ
Forestry proponents point out the existence of forest certification systems that are designed to promote good forestry practices to achieve balanced environmental, economic and social outcomes—in particular, the Forest Stewardship Council (FSC) and the Australian Forestry Standard (AFS).

**Forest Certification Systems and Native Forests**

Both the Australian Forestry Standard (AFS) and the Forest Stewardship Council (FSC) include natural/native forests management in their certification processes.

Under these schemes, there are two approaches to forest certification—forest management and chain of custody (CoC).

The CoC standards are designed to track wood from its source through to its final destination, providing users with certainty that the end use material is from certified forests.

The FSC is an international organisation founded in 1993 by environmentalists, social interest groups, indigenous peoples’ organisations, retailers and forest management companies to develop standards by which responsible forest practice can be measured. Over 106 million hectares in more than 81 countries have been certified according to FSC Forest Management standards (FSC 2010).

The AFS was developed during 1999–2003 by a committee comprising: Commonwealth, state and territory governments; National Association of Forest Industries; Plantation Timber Association of Australia; Australian Forest Growers; and the Australian Council of Trade Unions. The Scheme has mutual international recognition by the Programme for the Endorsement of Forest Certification Scheme (PEFC) (AFCS 2010). The AFS has certified more than 10 million hectares—around 90 per cent of the 11.3 million hectares of plantations and native forests from which timber is harvested—under the Australian Standard for Sustainable Forest Management. Notwithstanding this, some environmental groups are opposed to the certification of any timber harvesting operations in forests deemed to be of high conservation value (Barclay 2010).

More broadly, the sustainability of utilising biomass resources for energy has been subject to much scrutiny in recent years—both internationally and in Australia. The issue is complex and depends on a range of factors (such as the type of biomass used, production methods, geography, local environmental and social conditions) (Hogan et al. 2010).
In this regard, the life cycle emissions impacts of different biomass to energy processes are particularly relevant. Australian research on the life cycle emissions impacts of biomass co-firing is sparse. However, a 2001 study in the United States concluded that co-firing significantly reduced the environmental footprint of the average coal-fired power plant. It found that at rates of 5 per cent and 15 per cent by heat input, co-firing reduces greenhouse gas emissions on a CO₂ equivalent basis by 5.4 and 18.2 per cent, respectively. Additionally, total system energy consumption is lowered by 3.5 per cent and 12.4 per cent for the 5 per cent and 15 per cent co-firing cases, respectively (Mann & Spath 2001). EU research suggests that the most common types of biomass for heat and power applications reduce emissions by 55 to 98 per cent compared to today’s fossil fuel mix in European power generation, even in situations where the biomass is transported internationally (European Commission 2010).

Possible pathways to resolution

Given its implications for monetising RECs from wood waste sources, we believe addressing this barrier is a prerequisite to any meaningful level of adoption of biomass co-firing. Overcoming this barrier is likely to require a multi-faceted approach, preferably grounded in a real commercial co-firing proposition.

Clarifying environmental facts vs fiction in the biomass for energy debate

This requires credible science-based analysis of the environmental impacts of harvesting biomass for power generation. In particular, it needs to focus on sustainably harvested biomass from private native forests and management of regrowth on grazing land, and should encompass a life cycle assessment of GHG emissions and impacts on forest/vegetation health including biodiversity as well as other conservation values. The analysis should take into consideration environmental group positions (and associated research studies they are based on), and should also include sources of risks, and how they might be best managed.
Reconciling the opposing views of biomass industry proponents on the one hand, and environmental groups on the other hand

Many stakeholders perceive that this would be extremely difficult to achieve given the entrenched positions of some environmental groups and their refusal to engage on this issue, while others believe a collaborative facilitated process would be invaluable.

While any process needs to be informed by credible science based analysis (as above), stakeholders must be open to constructive dialogue and be willing to reconsider their positions where there is a demonstrated scientific basis for doing so. At a simplistic level, the biomass sector must accept that any woody material needs to be harvested in accordance with environmental practices and oversight mechanisms that provide the required level of integrity and assurance; in turn, environmental groups need to recognise that human intervention is required for restoration of forest regrowth into environmentally balanced eco-systems, and that use of this material for bioenergy production is environmentally beneficial.

The concerns of electricity generators and retailers and how they might be addressed as part of any resolution should also be considered. The role of an enhanced certification/labelling framework for sustainably harvested biomass, which strikes an appropriate balance between cost and rigour, may need to be explored in this regard. Schemes such as the National GreenPower Accreditation Program and the Gold Standard for carbon credits, amongst others, provide useful examples to draw on.

GreenPower

In 1997, in response to consumer interest in voluntary support for renewable energy, the NSW Sustainable Energy Development Authority (SEDA) established the GreenPower Accreditation Program. It was developed in consultation with the energy industry, and non-government organisations including the Australian Consumers Association, Greenpeace, the Australian Conservation Foundation and the World Wide Fund for Nature.

The program has since expanded nationally through collaboration by participating agencies in ACT, NSW, SA, QLD, VIC and WA (with non-financial member organisations in Tasmania, Northern Territory and the Commonwealth), collectively known as the National GreenPower Steering Group.

The program is designed to provide consumer confidence in the environmental integrity of renewable energy products. Under the program, GreenPower providers must ensure that customer purchases of accredited GreenPower products are matched by the production of an equivalent quantity of renewable energy from approved GreenPower generators. The program features technical audit, reporting and compliance arrangements, and allows eligible GreenPower providers to use a special label to differentiate their GreenPower products.

(Source: NGAP 2011)
Resolution will also require a review of the current categorisation of wood waste within the RET regulations and identification of changes that would be required to (a) better align the category definitions with emerging products, and (b) enable electricity retailers and other purchasers to make finer judgements on the LGCs they purchase.
Finally, we believe that the state government has an important role to play in facilitating a balanced outcome.

Securing community understanding of the issues and acknowledgement of the merits of utilising woody materials for power generation

The social licence to utilise woody materials for power generation is a critical enabler for any future industry development in this area, and community acknowledgement of the merits of doing so is a key part of achieving this. The development and implementation of a coordinated communications program that is grounded in good science, has broad-based stakeholder support, articulates the fit with state/national priorities, is endorsed by respected advocates and features a credible set of messages is a potential route towards this goal. In our view, such a program should be launched once the preceding two elements have been progressed.

4.3 Biomass market

**Known availability of low cost biomass falls short of volumes required for continuous low levels of co-firing**

Availability is a combination of volume, quality and distance. As indicated previously, the biomass volumes required are very significant, e.g. 192 000 tonnes for a 1 000 MW power station at 3 per cent co-firing. The other key elements of this barrier are ‘known’, ‘low cost’ and ‘continuous’.

The analysis of Biomass sources and Supplier perspectives in Section 3 of this report identifies many potential sources of biomass for co-firing. For many of these, information is lacking on the exact locations or volumes available. This issue is covered in more detail under barrier Lack of information on biomass resource availability.

Known sources consist of:

- those already consistently available and being used for some purpose, e.g. crop residues, bagasse, sawmill residue, green waste
- those already inconsistently available, but with no current market, e.g. development residues
- those known to exist, but with barriers to conversion to biomass e.g. private native forest rehabilitation residue, woody weeds, regrowth residue.

The economic modelling identifies that the maximum price that generators can afford to pay restricts potential biomass sources to very low cost materials. This translates into a requirement to identify low cost sources that are by-products/waste materials with no existing alternative use, at least until such time as the economics of co-firing improves.

Low cost sources are currently limited to those within an economic transport distance, including:

- existing sources with no existing market, e.g. development residues
- potential sources with no existing market, e.g. regrowth residues, private native forest rehabilitation residue.

As previously stated, large volumes of biomass are required to meet the demand from a generator, even at low levels of co-firing. Once a generator makes the decision to invest in co-firing, a continuous supply of biomass is required over many years in order to recoup that investment.
Continuous sources consist of:

- existing sources with all their product accounted for
- existing sources with surplus available e.g. one timber mill with good volumes and a number of small sawmill sources at present, although generally not in close proximity to generators
- potential sources with no apparent existing markets, e.g. private native forest rehabilitation residue, CSG-related biomass, C&D waste, regrowth residue

Therefore, overall, there is no currently available source of biomass in the volume required that ‘ticks all the boxes’ with regard to being known, low cost and continuous.

**Possible pathways to resolution**

Based on the feedback from suppliers, a case can be made for enough biomass being immediately available to justify at least one co-firing project at the lower end of low level co-firing, say 1–2 per cent by energy content. This would need to use a combination of short-term sources, such as development residues and potential longer-term sources that currently have no existing markets.

- In the immediate term (0–12 months), there are limited, but important opportunities. These primarily revolve around approved land clearing under Development Applications, as well as some sawmill residues. However, these are unlikely to be sufficient to support the wide-spread uptake of co-firing
- In the medium term (1–5 years), opportunities include thinnings from private native forest rehabilitation, management of regrowth of native vegetation on grazing land and processed C&D waste
- In the longer term (5 years plus), opportunities include agroforestry (both strip and block plantings), as well as pelleting, torrefaction or pyrolysis, if economics permit.

We note that some of these potential sources require confirmation of their eligibility under the RET, as well as the removal of potential barriers to adoption by landholders and concerns by environmental groups.

In addition, our analysis is based on current economic conditions. A number of these conditions have the potential to shift, thus increasing the potential for co-firing to use higher-cost sources. These factors include a carbon price, higher prices for LGCs, waste management fee structures and other government policy adjustments and incentives.

As the economics of co-firing change over the longer term, this may open up new opportunities. For example, higher prices could make it viable to densify some materials through pelleting and this in turn can alter the transport economics. Alternatively, higher value uses of biomass such as the production of biofuels could emerge over time, potentially making co-firing less competitive.

**Lack of integrated biomass supply capability**

The biomass supply chain incorporates commercial issues such as supply and demand forecasting, (covered in the next section) as well as logistics issues and their associated contractual options. These cover harvesting and aggregation of biomass from multiple and potentially disparate sources, processing of that biomass to agreed quality standards, storage, transport and delivery to power stations as required by generators. An efficient biomass supply chain is a key requirement for the uptake of biomass co-firing.
As noted in Section 2.1, electricity generators have a preference for outsourcing the supply of biomass, and dealing with a single operator in relation to supply.

Our discussions with supply side stakeholders suggest that there are currently no individual suppliers who are able to commit to long-term delivered supply arrangements of biomass resources in the quantities to support low levels of co-firing and at the price required over a multi-year timeframe. Notwithstanding this, there is at least one player who states their ability to aggregate multiple biomass sources and offer guaranteed delivery and price (with the latter dependent on the type of biomass).

The lack of a well organised supply chain is perceived as a major barrier by generators, who feel they must effectively step into the business of building the supply chain if they are to secure continuous supply in the volumes required and/or devote full-time resources to procuring biomass. This is evidenced by Delta Electricity’s proactive involvement in establishing the supply chain required to support its co-firing aspirations (Horner 2010) as well as the need for a full-time fuel procurement manager at the Conond Biomass Cogeneration Project in Northern NSW and the Rocky Point Cogeneration Facility in SE Queensland (David Moller 2010, pers. comm.). However, we also find that some biomass service providers are of the view that a competitively priced supply contract could provide the foundation for developing the necessary supply chain.

The absence of innovative commercial models for new biomass sources may also be a contributing factor. This applies in particular to short-rotation woody bioenergy resources (for example mallee), where the conventional commercial model is one where the landowner invests upfront capital in exchange for a long-term supply contract. In the absence of an ‘aggregator’ this requires the generator to engage and contract with a potentially large number of landowners. Our assessment is that this model will be difficult to implement given generator preference for delivered supply. It is also not clear whether new commercial operators would be willing to engage on this basis. We note that there are other models that we understand have been explored in NSW, in particular approaches where there is a legal separation of trees from the land. This involves third-party ownership and management of trees, with landowners effectively acting as the hosting party, and being remunerated accordingly. Similar arrangements exist for timber plantings (Forestry Plantations Queensland 2009).

While we acknowledge the perspectives of both generators and biomass service providers, it would appear that the current economically viable price that can be paid for biomass does not provide an incentive for the establishment of commercial operations specialising in end-to-end biomass supply, as has been the case in other related commodities in Australia (for example wheat and bagasse) and biomass for co-firing overseas.

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Enviva (United States) (adapted from website profile)

Enviva sustainably sources energy-rich wood residues and transforms them into renewable fuels like Wood Chips, Mini Chips, Micro Chips, and Wood Pellets for industrial and utility-scale energy applications.

Enviva has been aggregating and delivering hundreds of thousands of tons of biomass fuel to customers around the world since 2004. Currently, Enviva operations source approximately 350,000 tons of woody biomass annually for customers in the United States, Europe, and the Caribbean.

(Source: Enviva 2010)
In an ironic twist, we also note that an Australian company has in fact established the capacity to deliver wood pellets to Europe. Plantation Energy Australia has positioned itself as a densified biomass fuel pellet manufacturing company utilising non-commercial timber and harvest residues from sustainably managed timber plantations as feedstock (Plantation Energy Australia n.d.).

According to its website, PEA has constructed the first of its planned pellet manufacturing facilities close to Albany in Western Australia and will establish storage and export infrastructure within the harbour infrastructure at Albany. It expects to export more than 250 000 tonnes of pellets annually from this facility in full and partial shipments. The company is developing further manufacturing capacity in the Green Triangle region of Victoria and South Australia with planned production to be exported via the Port of Portland in Victoria.

Importantly, PEA’s example illustrates how a supply chain can be established given the right economic drivers.

Possible pathways to resolution

There is broad consensus amongst supply side stakeholders that generator interest in co-firing is a prerequisite to any biomass supply chain development to support the co-firing activity.

We believe what is required is a beachhead project (or projects) to catalyse supply chain development, and that this should take the form of genuine commercial interest from one or more generators to enable prospective biomass service providers to pursue supply arrangements. This may be best achieved by these generators calling for expressions of interest in delivered supply, and engaging in commercial negotiations with a small number of potential aggregators to agree on the commercial framework including quality standards, delivery arrangements, volume and price and key contract issues. There may be merit in generators ‘pooling their interest’, to avoid duplication of effort by aggregators, potentially through some form of biomass buying group. However, this will need to address how to share limited biomass quantities amongst participating generators, as well as other commercial issues. Such arrangements may be overly ambitious at this early stage of industry development, but provide scope for future efficiencies.

In the absence of an inventory of biomass sources, we note that there will be ‘search costs’ associated with detailed exploratory work required by aggregators to identify and audit potential biomass sources, and that it may not be feasible for aggregators to fund this work without any guarantee of a subsequent contract from generators. There may therefore need to be some funds committed by generators for this upfront activity to be paid in the event that they do not proceed with a supply contract. There may also be a role for government to contribute in kind—for example, sharing information on biomass sources,
and potentially drawing on any synergies with biomass resource mapping work underway (DEEDI 2011, pers. comm.).

The beachhead created by these ‘foundation’ supply arrangements, which are most likely to focus on immediate supply opportunities, could then be expanded to include biomass sources with longer term potential, in particular residues from private native forests, regrowth, agroforestry and bioenergy plantations.

**Lack of information on biomass resource availability**

Aggregating biomass for a co-firing project requires identifying, quantifying and assessing the commercial suitability of biomass resources within an economically viable distance from the power station. Currently this is an extremely onerous task as it requires a project proponent (or an aggregator), to carry out their own desktop and field research, which can often be a time consuming and potentially expensive exercise. Our own experience with this particular study (focused on Queensland) is that:

- Most available mapping is at a macro level, ranging from mapping the zones covered by regional Natural Resource Management bodies (Queensland Government n.d(f)), to mapping soils and rainfall across particular regions (CQFA n.d), or major native vegetation groups (ANRA 1997). There is also a map of Queensland bioregions (Queensland Government n.d(c))

- The Department of Environment and Resource Management (DERM) ‘develops, administers and maintains Queensland’s spatial reference framework and positioning infrastructure’ (Queensland Government 2010c). A range of DERM maps are available to order online, based on providing coordinates, lot numbers, or placenames (Queensland Government n.d(g)). These cover a range of land use classifications, including Remnant Vegetation Regional Ecosystems (Queensland Government n.d(d)), Assessable Vegetation and Environmentally Sensitive Areas (Queensland Government n.d(a)). The mapping is an ongoing process (Queensland Government 2010a). A range of other map layers, ranging from wind speed and minerals to soil and land resources, are also available (Queensland Government n.d(b)). These are important in identifying restrictions on use, but do not identify actual current or potential future land use

- DERM also has a process underway to identify and map land areas of strategic importance for cropping (Queensland Government n.d(c))

- Information on the location and quantities of specific resource types at a regional level is virtually nonexistent. Again, mapping tends to be at a macro scale, such as for timber plantations (Australian Government 2007, 2009c), or woody weeds (Queensland Government 2009). These have little value for identifying specific sources and volumes. Even basic information, such as the location of sawmills and their capacity, is difficult to access

- There is no centralised data repository for such information. We note that there have been at least two past national initiatives to assess biomass resources. The Bureau of Rural Sciences carried out a resource assessment in 2002, which was updated in 2007 (Bugg 2007). However, the related resource maps are no longer in the public domain

- Information currently available is fragmented and not designed to support the needs of the bioenergy project proponents. There is currently no process to collate such information

- Some recent analysis is also available through the ABARE/Geoscience Australia energy resource assessment (Australian Government 2010b) report, but again this is at the macro level
Another resource is the inventory of Private Native Forests (Meynink 2003), but this was state-wide and involved sampling and validating, in order to derive a macro picture of the resource.

In 2008, the Clean Energy Council carried out a biomass resource appraisal to support the development of its Bioenergy Roadmap (CEC 2008b). This featured a bottom up approach based on a technical and economic evaluation of available biomass resources (rather than a quantification of the bioenergy potential of the total biomass available in Australia).

In Queensland, CSIRO has done some work on estimating bioenergy resources (CSIRO 2009) and we understand more up to date research will be published shortly.

However, our assessment is that while these studies are enormously useful in supporting the strategic development of the bioenergy industry as a whole, they are unable to support the needs of individual project proponents. In Victoria, a biomass resource assessment is underway to provide a detailed mapping of the available biomass to better inform investors of the scale and scope for resource recovery initiatives (Guss 2010).

Persons collating information on biomass sources need to consider whether and how it accommodates (a) current use/commercial availability, (b) future projections of supply and associated uncertainties and (c) product and market shifts that could change supply. There are however international precedents that could be drawn on in developing an approach tailored to Australian circumstances (refer box).

**United Kingdom - Study into the potentially available woodfuel resources**

The study was designed to estimate the present potential available resource from a range of biomass sources (including traditional forests products and residues, co-products from sawmills, woody and green waste and short-rotation coppice) and forecast future availability of those resources. It also delivered an online facility that provides users with customised reports on resource availability on both a geographic and temporal scale.

(Source: Woodfuel n.d)

**United States – National Renewable Energy Laboratory (NREL) web based biomass resource assessment tool**

This online tool allows users to view biomass resources, infrastructure and other information, as well as query specific data. It grew out of the U.S EPA’s desire to combine past biomass resource assessments and data into a user-friendly, interactive, and web-accessible format rather than just in written reports or static maps. Users can select a location on the map, quantify the biomass resources available within a user-defined radius and then estimate the total thermal energy or power that could be generated by recovering a specific portion of that biomass.

(Source: NREL 2010, Biomass Power and Thermal Magazine 2009)
Possible pathways to resolution

From a biomass co-firing perspective, there is a need for an inventory of biomass sources, preferably within a radius of 150–200 km around a power station, but potentially including a wider area given wider bioenergy applications.

While detailed consideration would need to be given to the scope of such an initiative, we believe it would need to identify the following (within a mapping application):

- current land-use (for example grazing, annual and perennial cropping, forestry plantations, industrial/commercial, residential, conservation and others)
- vegetation type (referencing DERM categories as defined under native vegetation legislation)
- significant infrastructure such as transport hubs and processing facilities
- current and potential future biomass quantities, including secondary sources of biomass that are related to land-use such as forest/plantation residues and sawmill residues
- short-term biomass opportunities such as development approved land clearing.

This work should also bring together work done by related groups—for example DERM’s native vegetation maps and forest and plantation industry information, amongst others. As noted above, there are a number of precedents and existing initiatives, both in Australia and internationally, that could provide useful input to this process.

The value of this information is that it can be shared amongst a wide range of stakeholders; consequently, we believe it would be appropriate for such an initiative to be funded by government as part of its regional development and bioenergy strategy. Indeed, this has been the case with the initiatives described above in the United Kingdom and the United States. However, in time, and as the market develops, this could well become a commercial offering. In this regard, we note that the Queensland Renewable Energy Plan has a focus on mapping wind, solar and geothermal resources, but not biomass resources (Queensland Government 2009c).

Lack of organised market for biomass

Markets usually emerge when there is underlying demand, combined with willing buyers and sellers. The European market for biomass is a clear example of this. The policy drivers and associated commercial interest in biomass resources for heat and power applications have led to the creation of a sophisticated market in wood pellets. This includes:

- Information on markets. For example, the PELLETS@LAS project which aims to develop and promote transparency on the European fuel pellet market to facilitate pellet trade and to remove or overcome market barriers (PELLETS@LAS n.d)
- Mechanisms for discovering price (for example FOEX’s wood pellet price indices) (FOEX 2011)
- Trade facilitation mechanisms (there are moves to introduce tradable (standardised) bio-energy futures and OTC Clearing Service for bio-energy forwards (APX-ENDEX 2011))
- Integrated information portals that provide comprehensive information resources (for example the United Kingdom Biomass Energy Centre which aims to be a one stop shop able to provide information, advice and guidance to United Kingdom individuals and organizations, signposting to other specialised sources of advice as necessary, on a wide range of biomass fuels and conversion technologies (Biomass Energy Centre n.d.)
• The emergence of standardised biomass contracts (several of Europe’s largest buyers of industrial wood pellets met in September 2010 and agreed to move forward with plans to introduce a standard contract for spot, or short-term delivery deals out to a year ahead) (Argus Media 2010).

In comparison, in Australia, there is no mechanism for price discovery; no easy way for buyers and sellers to interact; an absence of market intermediaries (for example, brokers); absence of standardised woody biomass products (with the possible exception of sawmill residue); and fragmented information resources. However, we recognise that this lack of market organisation is largely a reflection of the biomass supply-demand dynamic, principally, the inability of buyers and sellers to achieve price levels that support industry profitability.

Possible pathways to resolution

While market infrastructure will inevitably follow once there are willing buyers and sellers, the lack of an organised market increases search cost for buyers and sellers. In the worst case, market opportunities are not realised. For example, there is no easy way for a power generator and/or a biomass aggregator to quickly assess biomass supply options; similarly, there is no ready ‘market’ for one-off biomass supply opportunities (for example, the biomass arising from development approved land clearing or harvesting of previous plantations).

Our assessment is that, in the first instance, the provision of good market information has the capacity to play a valuable facilitation role. This could be achieved via the establishment of a biomass information portal that provides a single point of reference for biomass suppliers and users/buyers. The United Kingdom Biomass Energy Centre provides a good starting point in this regard.

Additionally, some form of limited information exchange may facilitate initial trade—for example, a simple online facility where buyers and sellers can exchange information on supply and demand opportunities. This could be limited in the first instance to information on:

• type of biomass (where possible other information such as moisture, and energy content)

• quantity

• geographic location

• accessibility

• timing of availability

• environmental clearances.

An industry association may be in the best position to deliver these outcomes, with funding support from the government.
4.4 Perceptions and attitudes

*Perception that biomass co-firing is a mature technology that does not require policy support for commercialisation*

**Context**

Any discussion on commercialisation of renewable energy technologies is usually framed within the context of where the particular technology fits within the technology innovation chain, commonly accepted as a continuum spanning early research, demonstration and commercialisation (Figure 14). Technologies towards the left end of the chain are usually referred to as ‘emerging’ technologies, and those at the extreme right end of the chain are usually referred to as ‘mature’ technologies.

![Figure 14: The innovation chain](image)

The mid-point of the chain is often referred to as the ‘valley of death’ as this is the point that many technologies fail to make the transition to successful commercialisation, due to being beyond the point of needing public R&D funding, but before the point that private sector capital is forthcoming.

The positioning of a technology on the innovation chain has a strong influence on the nature of policy support it is seen to require, and potentially receives. For example, renewable energy technologies at the early stage of the innovation chain are usually acknowledged to need ‘technology push’ type measures (such as R&D support), while those towards the commercial end of the chain are generally acknowledged to need ‘market pull’ type policy measures such as the RET and feed-in tariffs. Those that are regarded as ‘mature’ are often perceived to be ‘fully commercial’, and therefore not dependent on customised policy support.

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55 Source: ABCG 2009, after Grubb 2004
Our discussions with biomass co-firing proponents reveal a shared concern that co-firing is perceived as a mature or established technology, with the corollary being that it does not require ongoing financial support. Industry proponents observe that funding is often directed at more ‘high profile’ renewable energy technologies—for example solar energy, and that the regional development potential of biomass for electricity generation is not fully recognised. The Clean Energy Council has identified that state and federal innovation and renewable energy funding must treat bioenergy equally to all other forms of renewable energy, and that there is a need to ensure that an equitable part of all government funding for renewables is allocated to bioenergy to allow the industry to grow to its potential (CEC 2008a).

These perceptions may be due to the fact that biomass co-firing is well established overseas, especially in Europe, and has also been technically proven in Australia. However, this fails to recognise that biomass co-firing is in fact still an ‘under-developed’ technology in Australia, unlike in Europe, where it has been commercially adopted as a result of policy support.

In addition, biomass co-firing is fundamentally different to other renewable energy technologies in that it is characterised by relatively low upfront capital investment (ignoring for the moment any capital investment associated with establishing energy plantations), but with high operational costs, principally associated with the procurement of biomass resources. In comparison, other renewable energy technologies—for example, solar and wind—are characterised by relative high upfront costs, but zero ongoing resource costs.

Finally, it should be recognised that, even where co-firing overall has been commercialised, such as in Europe, there are aspects that are still very much in the ‘emerging’ phase, such as torrefaction, where technology support may still be appropriate to support commercial adoption.

For this reason, in the case of biomass co-firing (and indeed other biomass to energy technologies), when assessing the position of the technology on the innovation value chain, it is important to consider the status of both the biomass resource supply chain and the conversion technology as an integrated ‘bundle’. When viewed from this perspective, it is clear that in Australia, the technology is underdeveloped and is in reality at the demonstration/pre commercialisation phase.

**Possible pathways to resolution**

Overcoming this barrier would require, as a first step, ensuring that policymakers understand and appreciate the current status of the technology and the need for policy support to both bridge the cost gap and develop industry capacity. The regional development benefits associated with biomass co-firing—in particular the creation of new employment opportunities associated with harvesting, processing and transporting biomass, and flow on benefits to regional economies, must be clearly articulated.

It is noteworthy that the 2009 Queensland Renewable Energy Plan, the primary objective of which is to increase the deployment of renewable energy infrastructure in Queensland, has an explicit target to increase electricity generation from biomass from 415 MW (mainly bagasse) to 645 MW by 2020.56 It

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56 To place this in perspective, in 2008, renewable energy accounted for approximately 6 per cent or almost 750 megawatts of Queensland’s total installed generating capacity of more than 12 500 megawatts (including solar hot water systems) (Queensland Government 2009c).
notes that achieving this (and other goals) means providing the right incentives, financial and otherwise, to encourage industry to move beyond ‘business as usual’ and look for new opportunities to deploy renewable energy. DEEDI note that the state government has provided grant support in excess of $10 million to several second and third-generation biofuel projects based on strong proposals by proponents, as well as $9 million to Mackay Sugar Limited for their $120 million bagasse cogeneration facility (DEEDI 2011, pers. comm.).

At a national level, the recently established Australian Centre for Renewable Energy (ACRE) has been tasked with providing advice to the (federal) minister in relation to strategies to fund and promote the development, commercialisation and use of renewable energy technologies. In its December 2010 consultation ACRE sought feedback in regard to bioenergy—in particular should ACRE prioritise the assessment of sustainable and economic pathways, R&D and pilot projects for second-generation biofuels projects (including algae), and direct or co-fired biopower and bioheat projects where there are compelling regional benefits (ACRE 2010). This provides an avenue for the state government to work with the Commonwealth to secure capacity building support for biomass co-firing.

Discussions with Queensland government and industry stakeholders suggest that there is a role for both parties in moving forward. Industry stakeholders believe that the state government needs to proactively engage and work with industry in addressing market failures. Government stakeholders in turn believe that industry needs to come up with project proposals that it can ground its facilitation and support efforts around.

**Lack of interest in agroforestry within farming sector**

**Context**

As described in Section 3, there appears to be much less interest in agroforestry in SE Queensland than in some other parts of the country. Several people consulted have pointed to the fact that much of the area was only cleared for agriculture relatively recently (1960s onwards). The nature of native vegetation is such that it responds to clearing with vigorous regrowth, which requires continual control in order to keep the land productive for livestock production and cropping. Therefore, it is suggested, a culture of tree planting has not tended to emerge in the region.

This is compounded by the relative absence of salinity as a driver for revegetation in Queensland, as is the case in Western Australia, where alley farming between rows of trees was pioneered. In addition, SE Queensland is believed to be at about the northern limit for vigorous growth in the mallee species used in WA (Hobbs et al. 2009). There is little evidence for any substantial trials having been undertaken in Queensland to demonstrate whether or not agroforestry for energy is a viable economic option for landholders. However, recently published work (Donaghy et al. 2009) indicates that it is worthy of further investigation.

**Possible pathways to resolution**

There is every possibility that the economics of co-firing could improve to the point at which agroforestry for biomass production becomes a viable option. However, the lack of a tree planting culture makes it likely that economic and other benefits would need to be clearly demonstrated before many landholders would consider agroforestry for energy. Given the relative lack of data on this in Queensland, there is a strong case for government support for research and industry capacity building.

**Community perception of plantations**

**Context**

Biomass for energy could be generated from either (a) thinnings or harvest waste from timber plantations, or (b) from plantations of species designed for short-term rotations for biomass production, such as mallee. (This ‘block’ plantation scenario is different from the concepts of planting on marginal land or in strips for biodiversity, salinity, windbreak or other reasons).
The theoretical potential for short-rotation bioenergy woody plantations is significant. CSIRO observe that short-rotation plantations for dedicated bioenergy production are not currently grown in Queensland, but could be in the future. It is estimated that currently there are around 20 million ha of cleared non-cropland in Queensland that could become bioenergy plantations. Taking into consideration planting rates, logistical requirements, competition with other land uses, potential impact on water and biodiversity and the distance to existing markets, the attainable area of bioenergy plantations harvestable by 2050 is estimated to be in the range of 1.5–3.0 million ha. (CSIRO 2010).

However, even if economic conditions are favourable, we believe achieving this potential will require overcoming community opposition to plantations. Social research carried out in south-west Western Australia in 2008 on community views of different types of plantations, in particular eucalypt plantations, reveals information on community acceptance of plantations. The study revealed that (a) plantations are generally viewed differently from traditional rural land uses such as cropping and grazing, and differently from new ‘green’ land uses such as wind farms and native vegetation, (b) while the majority of participants considered plantations acceptable at some level, with around 20 per cent finding plantations very acceptable, there is also evidence of some opposition, with 5–12 per cent of participants considering plantations very unacceptable and (c) plantations are acceptable when they are planted in areas with good water availability, on poorer or saline soils, on land previously used for plantations, on only part of a property rather than the whole property on land owned by an individual landholder and where products can be processed locally. The study notes that the findings suggest that plantations are more acceptable to residents of Western Australia than to residents in some other parts of Australia (Williams 2009).

Social research in the Towong Shire Local Government Area in north-east Victoria identified a key concern of the farming community being the impact of plantations on local communities—loss of farms and employment—causing families to move away. The loss of only a few families in a small farming valley was regarded as sufficient to have a significant effect on the social capital of the community. There were also widespread concerns regarding managed investment schemes (MIS)—particularly the perception that the tax arrangements for MIS create market distortions for land and water resources at the expense of farmers (Stewart et al. 2007).

It appears that there are multiple factors that contribute to community opposition to plantations. These include the boom and bust associated with managed investment scheme (MIS) plantations, concerns over inflation of land prices resulting from investment activity, the perceived environmental impacts associated with monoculture plantations and unease at turning over agricultural land to produce non-food crops.

Research also reveals the socioeconomic benefits of plantations. A 2009 study concluded that plantation industry expansion is associated with changes to employment availability, rural population, community groups and land prices, and how these changes impact on people living in rural and regional communities where plantations are expanding will differ depending on individual circumstances. In relation to employment, the study estimated the employment generated by plantations (based on 2006 industry employment levels) to be equivalent to 0.45 jobs per 100 ha of hardwood plantation and 1.44 jobs per 100 ha of softwood plantation (Schirmer 2009).

The importance of timber plantations in Queensland is recognised in the 2020 Timber Plantations Strategy, which notes that in Queensland, commercial timber plantations on private land are a relatively new and immature form of primary production compared to traditional industries such as horticulture, cropping and grazing. The strategy flags that the Queensland Government will work with timber plantation companies and other stakeholders to help improve community understanding and acceptance of the timber plantation sector in key regions, in particular:

**Action 5.1**

We will initiate and support research projects to provide robust information about the timber plantation sector and its social, economic and environmental benefits.
Action 5.2

We will work with industry to build collaborative relationships with key stakeholders such as local governments, the Local Government Association of Queensland, other land users and industries to identify actions to improve the understanding of the timber plantation sector in key regional communities.

Action 5.3

We will regularly communicate the economic, social and environmental benefits of sustainable, well-managed timber plantations. (Queensland Government 2010b)

Finally, the sale of land to MIS proponents suggests that landowners will generally seek to maximise their financial returns from land use activities. Consequently it is possible that this barrier could be overcome given the correct economic circumstances, i.e. where there is demonstrated profitability and a compelling business case to switch land use to timber or energy plantations.

Possible pathways to resolution

A strong economic case for bioenergy woody plantations could well address this barrier. However, it is clear that biomass co-firing is unlikely to provide a compelling economic case in the short to medium term. Consequently, other initiatives will be needed.

We believe a key requirement is to ensure that any change in land use to bioenergy woody plantations is firmly aligned with community interest. This will require ongoing engagement with local landowners in the first instance, and subsequently engagement with wider communities and demonstration of value to those local communities from the regional development associated with bioenergy.

The community engagement initiatives outlined in the Queensland 2020 Timber Plantations Strategy provide a useful framework, but these will need to be adapted to the needs of the woody bioenergy plantation sector. In particular, a science based assessment of the economic, environmental and community impacts of bioenergy woody plantations and the establishment of demonstration sites illustrating best practices could create a basis for such engagement. Additionally, if such plantations are to play a meaningful role in the future, it will be necessary to address concerns regarding food security.

The current strategy to build collaborative relationships with key stakeholders and communicate the economic, social and environmental benefits of sustainable, well-managed plantations should explicitly include bioenergy woody plantation activity.
5. Conclusions and Recommendations

Biomass co-firing is a relatively low cost option for reducing GHG emissions in coal-fired power stations. The technology has been widely trialled, demonstrated and commercially adopted overseas, where supportive renewable energy, carbon and biomass policies have facilitated its commercial adoption.

Several Australian coal-fired generators have invested time and effort in biomass co-firing, including engineering trials, commercial co-firing and collaboration with the Cooperative Research Centre for Coal in Sustainable Development (CCSD) to publish a comprehensive Australian technical reference source on the subject.

Where there are a number of technical issues associated with co-firing low levels of biomass, none are believed to be insurmountable. However, the economic viability of co-firing presents a significant challenge, as does the continuous availability of competitively priced biomass resources. Commercial co-firing operations in NSW have ceased due to poor economics coupled with fuel availability issues, and while co-firing of biomass has been investigated and trialled by some generators in Queensland, there has been no move to commercial operations.

Our research has identified generator preconditions for adoption of biomass co-firing. Chief amongst these is the ability to have third parties aggregate and deliver competitively priced biomass in the volumes, quality and timeframe required. Discussions with biomass suppliers indicate that there are a number of existing and potential biomass sources that could be integrated to support initial low level co-firing within at least one power station.

We estimate that adoption of 3 per cent co-firing (by energy content) by the major Queensland coal-fired generators would require around 1.3 million tonnes of biomass annually and reduce greenhouse gas emissions by around 1.4 million tCO$_2$-e each year. However, the widespread uptake of biomass co-firing is unlikely to occur until a number of market and institutional barriers are addressed. We list these below, and propose number of recommendations that, addressed together, would pave the way for biomass co-firing in coal-fired power stations.

CO-FIRING ECONOMICS

BARRIER

The economics of biomass co-firing are marginal under current policy settings. Consequently, the maximum price that generators can afford to pay restricts potential biomass sources to very low cost materials

RECOMMENDATIONS

- Explore the introduction of state-based renewable energy policy measures that fully or partially bridge the current economic viability gap for biomass co-firing. These measures should provide time-bound transition support, indexed to market circumstances (such as biomass costs, LGC and carbon prices), and supplement support under the Federal Renewable Energy Target

- Investigate the feasibility of a biomass resource support program, drawing on international precedents such as the United States Biomass Crop Assistance Program and England’s Energy Crops Scheme, which provides incentives for the establishment and ongoing production of biomass resources utilised for bioenergy including biomass co-firing. This should reflect the
biomass targets in the Queensland Renewable Energy Plan, and take into consideration the sustainability issues associated with growing biomass for energy production.

ENVIRONMENTAL CONCERNS

BARRIER

*Resistance to combustion of woody material for energy production*

RECOMMENDATIONS

- Convene a roundtable of key stakeholders including representatives from the electricity/clean energy sector, environmental NGOs, regional communities, regional private forestry committees, farming sector, government (environmental and regional development) and environmental science community in an independently facilitated process to (a) identify key concerns, (b) have oversight of a program of research to support informed deliberation and (c) reach accommodations to agree a common path forward.

- In conjunction with the stakeholder roundtable, commission a science based analysis of the pros and cons of managing forestry regrowth in private native forests in Queensland and use of sustainably harvested material for power generation, including biomass co-firing. The analysis should consider life cycle carbon, energy and water impacts, fire risks and conservation values amongst any other issues agreed at the time of commissioning this work.

- In conjunction with the stakeholder roundtable, review the current categorisation of wood waste material within the RET regulations to ensure that the categories are relevant to, and support existing and future bioelectricity feedstocks. Outputs from this review could be incorporated in stakeholder submissions to the review of the RET legislation in 2012.

- In conjunction with the stakeholder roundtable, develop and implement a communications program that clarifies the economic, environmental and social impacts of energy production from sustainably harvested biomass, drawing on both the research and accommodations reached within the roundtable. The program should be directed at policymakers, environmental groups, the electricity sector and community groups interacting with bioelectricity project developments.

BIOMASS MARKET

BARRIER

*Known availability of low cost biomass falls short of volumes required for continuous low levels of co-firing*

RECOMMENDATIONS

- Generators should consider the availability of biomass from land clearing under Development Approvals and confirm the eligibility of this material under RET regulations. If eligible, this could act as a key short-term biomass source for co-firing, enabling the ongoing development of medium to longer term sources of biomass.

- Agricultural research and regional development resources in government should be directed at research to assess the potential of regrowth management as an ongoing source of biomass in the medium to long-term. This should be in collaboration with the grazing sector primarily, as well as logistics and transport service providers. Research trials should extend to feasibility studies on the harvesting of existing stockpiles of previously removed regrowth.
• Government through the Department of Environment and Resource Management (DERM) should consider directing waste levy funds for research into the potential of process engineered fuel (PEF) from C&D waste for co-firing and bioelectricity. This could provide a mechanism for reduced landfill as well as a beneficial use for the material

• Stakeholders should adopt the approach in Table 7 as a template for assessment of biomass sources. This may assist with case-by-case analysis by individual generators as well as forming the basis for detailed identification of regional biomass sources.

BARRIER

_Lack of integrated biomass supply capability_

**RECOMMENDATIONS**

• That one or more generators should express genuine commercial interest in biomass co-firing, with the project/s to serve as focal points for industry support and development. Biomass supply chain development could be facilitated by these generators calling for expressions of interest in delivered supply and engaging in commercial negotiations with a small number of potential aggregators to agree on the commercial framework for biomass supply

• The Queensland Government should consider early stage support for such beachhead projects on a case by case basis, including the provision of knowledge and information on biomass sources in the region of the power station and facilitating any approvals associated with utilisation of those biomass resources.

BARRIER

_Lack of information on biomass resource availability_

**RECOMMENDATIONS**

• Develop Terms of Reference for, and commission the preparation of inventories of biomass resources around coal-fired power stations that are actively considering biomass co-firing, at least within a 150–200 km radius of the power stations, but potentially further, given the wider interest in biomass resources for bioenergy applications. The resource inventory should integrate existing information and draw on precedents in other jurisdictions, both in Australia and overseas. Consideration should be given to inclusion of the following elements:

  o current land-use (for example grazing, annual and perennial cropping, forestry plantations, industrial/commercial, residential, conservation and others)

  o vegetation type (referencing DERM categories as defined under native vegetation legislation)

  o significant infrastructure such as transport hubs and processing facilities

  o current and potential future biomass quantities, including secondary sources of biomass that are related to land use such as forest/plantation residues and sawmill residues

  o short-term biomass opportunities such as development approved land clearing.


BARRIER

Lack of organised market for biomass

RECOMMENDATIONS

• Establish and maintain an online biomass information portal that provides a single point of reference for biomass suppliers and users/buyers. The portal should provide a road map to existing information on biomass sources, research reports, applicable Federal and Queensland policies and regulations, facts and figures, biomass to energy case studies, commercial developments, funding avenues, relevant industry and government contacts, as well as key future developments (for example, proposed future initiatives). The United Kingdom Biomass Energy Centre provides a good starting point in this regard

• Consider the establishment of a basic information exchange—initially in the form of an online facility—where buyers and sellers can exchange information on supply and demand opportunities. This could be limited in the first instance to information on:
  • type of biomass (where possible other information such as moisture, and energy content)
  • quantity
  • geographic location
  • accessibility
  • timing of availability
  • environmental clearances.

PERCEPTIONS AND ATTITUDES

BARRIER

Perception that biomass co-firing is a mature technology that does not require policy support for commercialisation

RECOMMENDATIONS

• Biomass co-firing proponents should spell out the case for bridging support. This should be framed in the context of a live project and should highlight both the status of co-firing within the innovation chain as well as the regional development benefits arising from proposed developments

• The Queensland Government should recognise the potential of biomass co-firing in delivering its renewable energy and greenhouse gas emissions reduction objectives and make explicit reference to this approach in its renewable energy plan and overall policy framework

• The bioelectricity industry should clearly articulate the positioning of bioelectricity (including biomass co-firing) within the innovation chain to support the case for national policy support on the same basis as for other renewable energy technologies such as solar and wind energy.
BARRIER

Lack of interest in agroforestry within farming sector

RECOMMENDATIONS

- Agricultural research and regional development resources in government should be directed at research on agroforestry (strip and block plantings) for short-rotation cropping in Queensland. Knowledge is lacking on suitable varieties, productivity, environmental impacts, economics and commercialisation models. However, this should build on recent work in Queensland as well as the significant prior work by the CRC for Future Farm Industries. Any such program should include liaison with major landowners, including the CSG industry. It should also integrate with initiatives taken to address community concerns, noted in the recommendation regarding plantations.

BARRIER

Community perception of plantations

RECOMMENDATIONS

- Consideration of biomass options should be included in any future revision of the Queensland Plantations 2020 Strategy. This should take into account the full spectrum of timber/biomass options from timber plantations to energy plantations and agroforestry. It should include pilot projects that demonstrate the scientific and economic viability of combined timber and biomass production, as well as any environmental benefits and/or concerns. Any such projects should be developed in close consultation with major landholders and community groups, as well as involving collaboration with the entire supply chain for timber and biomass

- Investigate social research such as that undertaken in other states. If necessary, DEEDI should commission similar work to understand community perceptions in SE Queensland regarding plantations for either timber or energy

- Based on sound information, DEEDI should implement community education action plans as proposed in the Queensland Timber Plantation Strategy 2020. These should integrate activity related to the full spectrum of timber plantations, energy plantations and agroforestry and deliver effective and measurable communication outcomes.
Appendices

APPENDIX 1: Selected policy measures to support biomass co-firing in the United Kingdom (UK)

The European Union has adopted a target to source 20 per cent of its energy needs from renewables, including biomass, hydro, wind and solar power, by 2020. As part of this, the UK is targeting 15 per cent of energy from renewables by 2020—equivalent to a seven-fold increase in UK renewable energy consumption from 2008 levels. Under its lead scenario, it is aiming to source more than 30 per cent of its electricity generation from renewables, compared to around 5.5 per cent in 2009 (UK Government 2009). This will be achieved through the development and implementation of a comprehensive set of renewable energy policies.

Under this policy framework, the overall value of electricity from utility scale renewable energy sources in the UK (estimated at around £93/MWh for 2010/11) is made up of four elements:

- The price for non renewable (brown) electricity, comprising around 44 per cent of the overall value of renewable energy
- Revenue from Renewable Obligation Certificates (ROCs) under the UK Renewables Obligations (the UK equivalent of the RET in Australia), comprising around 40 per cent of overall value
- The recycled buyout fund (RBF) premium providing an additional variable income dependent on the total production of renewable energy against the government targets under the Renewables Obligation, comprising around 11 per cent of overall value
- Levy Exemption Certificates (LECs) providing an additional index-linked supplement (Climate Change Levy), comprising around 5 per cent of overall value.

The UK Renewables obligation features targets for different renewable energy technologies (banding). The banding for new capacity in co-firing will receive 0.5 ROCs/MWh compared with 1.0 ROCs/MWh for co-firing of biomass for combined heat and power (CHP), 1.5 ROCs/MWh for co-firing of energy crops with CHP and 2.0 ROCs/MWh for dedicated energy crops and dedicated biomass with CHP.

In response to recent growth in creation of ROCs from biomass co-firing, the Renewables Obligation has imposed a cap on co-firing and a right to review the banding provisions in the event of overproduction:

- Article 13(3): No more than 12.5% of a supplier’s renewables obligation may be satisfied by ROCs from generating stations utilising partly fossil fuel and partly biomass (co-firing)
- Article 33 (3)(f): Allows for a review if the banding provisions for co-firing are leading to over production of co-firing ROCs against the target limit of 12.5%.

In December 2010, the UK Government announced a consultation process related to replacing the Renewables Obligation in 2017 with a feed-in-tariff scheme. It will publish a White Paper 2011 in this regard (FIM Services 2010).

Additionally, the UK is subject to the European Union Emissions Trading Scheme (EU ETS), where coal-fired generators co-firing biomass receive a greenhouse gas emissions benefit proportionate to the price of carbon (European Union Allowances), currently trading at around €15/t CO2 (Point Carbon 2011).

These electricity sector measures are supplemented by specific policies to incentivise the establishment of energy crops, including the Energy Crops Scheme detailed in this report.
APPENDIX 2: Extracts from Renewable Energy (Electricity) Regulations 2001

native forest means a local indigenous plant community:

(a) the dominant species of which are trees; and

(b) containing throughout its growth the complement of native species and habitats normally associated with that forest type or having the potential to develop those characteristics; and

(c) including a forest with those characteristics that has been regenerated with human assistance following disturbance; and

(d) excluding a plantation of native species or previously logged native forest that has been regenerated with non-endemic native species.

8 Meaning of wood waste

(1) For section 17 of the Act, wood waste means:

(a) biomass:

   (i) produced from non-native environmental weed species; and

   (ii) harvested for the control or eradication of the species, from a harvesting operation that is approved under relevant Commonwealth, State or Territory planning and approval processes; and

(b) a manufactured wood product or a by-product from a manufacturing process; and

(c) waste products from the construction of buildings or furniture, including timber off-cuts and timber from demolished buildings; and

(d) sawmill residue; and

(e) biomass from a native forest that meets all of the requirements in subregulation (2).

Examples for paragraph (b)

Packing case, pallet, recycled timber, engineered wood product (including one manufactured by binding wood strands, wood particles, wood fibres or wood veneers with adhesives to form a composite).

(2) Biomass from a native forest must be:

(a) harvested primarily for a purpose other than biomass for energy production; and

(b) either:

   (i) a by-product or waste product of a harvesting operation, approved under relevant Commonwealth, State or Territory planning and approval processes, for which a high-value process is the primary purpose of the harvesting; or
(ii) a by-product (including thinnings and coppicing) of a harvesting operation that is carried out in accordance with ecologically sustainable forest management principles; and

c) either:

(i) if it is from an area where a regional forest agreement is in force — produced in accordance with any ecologically sustainable forest management principles required by the agreement; or

(ii) if it is from an area where no regional forest agreement is in force — produced from harvesting that is carried out in accordance with ecologically sustainable forest management principles that the Minister is satisfied are consistent with those required by a regional forest agreement.

(3) For subparagraph (2) (b) (i), the primary purpose of a harvesting operation is taken to be a high-value process only if the total financial value of the products of the high value process is higher than the financial value of other products of the harvesting operation.

(4) In this regulation:

**ecologically sustainable forest management principles** means the following principles that meet the requirements of ecologically sustainable development for forests:

(a) maintenance of the ecological processes within forests, including the formation of soil, energy flows, and the carbon, nutrient and water cycles;

(b) maintenance of the biological diversity of forests;

(c) optimisation of the benefits to the community from all uses of forests within ecological constraints.

**high-value process** means the production of sawlogs, veneer, poles, piles, girders, wood for carpentry or craft uses, or oil products.

9  **Energy crops (Act s 17)**

(1) For section 17 of the Act, biomass from a plantation is not an energy crop unless all of the following apply to it:

(a) it must be a product of a harvesting operation (including thinnings and coppicing) approved under relevant Commonwealth, State or Territory planning and approval processes;

(b) it must be biomass from a plantation that is managed in accordance with:

(i) a code of practice approved for a State under regulation 4B of the Export Control (Unprocessed Wood) Regulations; or

(ii) if a code of practice has not been approved for a State as required under subparagraph (i), Australian Standard AS 4708—2007 — The Australian Forestry Standard;

(c) it must be taken from land that was not cleared of native vegetation after 31 December 1989 to establish the plantation.

(2) For section 17 of the Act, biomass from a native forest is not an energy crop.
APPENDIX 3: Biomass co-firing economic model

The model described below is based on a discounted cash flow analysis of income (revenue and avoided costs) and expenditure associated with biomass co-firing from a power generator’s perspective (Tables 10&11, Figure 15).

It is designed to test the maximum price that a generator would be willing to pay for delivered biomass under the chosen set of inputs (‘Delivered biomass cost Year 1’ in Table 10 below).

Table 10: Co-firing economic model inputs

<table>
<thead>
<tr>
<th>% co-firing (by energy)</th>
<th>3.0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal thermal efficiency</td>
<td>37%</td>
</tr>
<tr>
<td>Biomass efficiency loss factor (ELF)</td>
<td>97%</td>
</tr>
<tr>
<td>Total coal (million tonnes)</td>
<td>3.20</td>
</tr>
<tr>
<td>Coal Calorific Value (CV) (GJ/t)</td>
<td>24.00</td>
</tr>
<tr>
<td>Biomass Calorific Value (CV) (GJ/t)</td>
<td>12.00</td>
</tr>
<tr>
<td>GHG intensity of coal-fired generation (tCO₂-e/MWh)</td>
<td>0.90</td>
</tr>
<tr>
<td>Capital cost ($/kWe)</td>
<td>100</td>
</tr>
<tr>
<td>Operating cost (fixed) ('000)</td>
<td>150</td>
</tr>
<tr>
<td>Operating cost (variable) ($/GJ biomass)</td>
<td>0.020</td>
</tr>
<tr>
<td>Carbon price Year 1 ($/t)</td>
<td>0</td>
</tr>
<tr>
<td>Carbon price real increase</td>
<td>0.0%</td>
</tr>
<tr>
<td>LGC price Year 1 ($/MWh)</td>
<td>35.00</td>
</tr>
<tr>
<td>LGC price real increase (over 15 years)</td>
<td>0.0%</td>
</tr>
<tr>
<td>Delivered biomass cost Year 1 ($/GJ)</td>
<td>4.00</td>
</tr>
<tr>
<td>Delivered biomass cost real increase</td>
<td>0.0%</td>
</tr>
<tr>
<td>Coal cost Year 1 ($/GJ)</td>
<td>0.90</td>
</tr>
<tr>
<td>Coal cost real increase</td>
<td>0.0%</td>
</tr>
<tr>
<td>Pre tax Weighted Average Cost of Capital (real) (WACC)</td>
<td>20.0%</td>
</tr>
</tbody>
</table>

58 % of thermal energy substituted with biomass energy equivalent
59 Reflecting the loss of plant efficiency when co-firing biomass.
60 Low estimate (IEA)…Co-firing biomass residues with coal in traditional coal-fired boilers for electricity production generally represents the most cost-effective and efficient renewable energy and climate change technology, with investment costs commonly ranging from 100–600 US$/kWe depending on the fuel and technical option chosen (KEMA 2009).
61 VOM = $0.02/GJ, equivalent to a 20% increase in typical VOM ($1.20/MWh)—i.e. $0.24/MWh (assuming 33% thermal efficiency for biomass).
**Key Relationships** (refer abbreviations above)

\[
\text{TOTAL BIOMASS}^{62} = \frac{\text{TOTAL COAL} \times \% \text{ CO-FIRING} \times \text{COAL CV} \times 1,000}{(\text{BIOMASS CV} \times \text{ELF})}
\]

\[
\text{LGC REVENUE}^{63} = \text{TOTAL BIOMASS} \times \text{BIOMASS CV} \times \text{COAL THERMAL EFFICIENCY} \times 0.2778 \times \text{LGC PRICE}
\]

\[
\text{AVOIDED COST OF COAL}^{64} = \text{TOTAL COAL} \times \% \text{ CO-FIRING} \times \text{COAL CV} \times \text{COST OF COAL}
\]

\[
\text{AVOIDED COST OF CARBON}^{65} = \text{TOTAL COAL} \times \% \text{ CO-FIRING} \times \text{COAL NCV} \times \text{COAL THERMAL EFFICIENCY} \times 0.2778 \times \text{GHG INTENSITY OF GENERATION} \times \text{CARBON PRICE} \times 1,000
\]

Table 11: Co-firing economic model outputs

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total biomass('000 t')^{66}</td>
<td>198</td>
</tr>
<tr>
<td>Equivalent co-firing by weight</td>
<td>6.2%</td>
</tr>
<tr>
<td>Total annual operating cost ($'000)</td>
<td>198</td>
</tr>
</tbody>
</table>

---

62 '000 t
63 $ '000
64 $ '000
65 $ '000
66 Adjusted for biomass efficiency loss
Figure 15: Biomass co-firing discounted cash flow analysis (for selected inputs)

<table>
<thead>
<tr>
<th>(2010 $ '000)</th>
<th>t = 0</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
<th>Year 6</th>
<th>Year 7</th>
<th>Year 8</th>
<th>Year 9</th>
<th>Year 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon price ($/t)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>LGC price ($/MWh)</td>
<td>35.00</td>
<td>35.00</td>
<td>35.00</td>
<td>35.00</td>
<td>35.00</td>
<td>35.00</td>
<td>35.00</td>
<td>35.00</td>
<td>35.00</td>
<td>35.00</td>
<td>35.00</td>
</tr>
<tr>
<td>Biomass price ($/GJ)</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Coal price ($/GJ)</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
</tr>
</tbody>
</table>

**Cash inflows and outflows**

| LGC revenue                            | 8,545 | 8,545  | 8,545  | 8,545  | 8,545  | 8,545  | 8,545  | 8,545  | 8,545  | 8,545  | 8,545   |
| Avoided coal cost                      | 2,074  | 2,074  | 2,074  | 2,074  | 2,074  | 2,074  | 2,074  | 2,074  | 2,074  | 2,074  | 2,074   |
| Avoided carbon cost                    | -      | -      | -      | -      | -      | -      | -      | -      | -      | -      | -       |
| Capital cost                            | -      | -      | -      | -      | -      | -      | -      | -      | -      | -      | 3,000   |
| Biomass cost                            | -      | 9,501  | 9,501  | 9,501  | 9,501  | 9,501  | 9,501  | 9,501  | 9,501  | 9,501  | 9,501   |
| Fixed O&M                              | -      | 150    | 150    | 150    | 150    | 150    | 150    | 150    | 150    | 150    | 150     |
| Variable O&M                           | -      | 48     | 48     | 48     | 48     | 48     | 48     | 48     | 48     | 48     | 48      |
| Net cashflow                            | -      | 3,000  | 920    | 920    | 920    | 920    | 920    | 920    | 920    | 920    | 920     |

**NPV @ WACC**

857
Glossary

Agroforestry  Tree production as part of farming systems, for timber, energy and/or environmental or production benefits

Angle of repose  The maximum angle of slope at which granulated material will remain in place without sliding

Bagasse  The fibrous residue remaining after sugar cane is processed

Biochar  Carbon-rich product obtained when biomass... is heated in a closed container with little or no available air (Lehmann & Joseph 2009)

Bioelectricity  Electricity derived from the energy in biomass

Bioenergy  The collective term for a range of renewable energy options that use biological materials as the source of energy

Biofuel  Substitutes (derived from biomass) for fossil fuels such as petrol and diesel (see also Second-generation biofuels)

Biogas  The gas emitted from anaerobic digestion of biomass

Biomass  The collective term for a wide variety of biological materials

Coal seam gas (CSG)  Methane adsorbed into the solid matrix of the coal which is released and collected as water is pumped out of the coal seam

Co-firing  Capturing the energy content of biomass by burning it in a pulverised fuel (PF) boiler furnace, along with coal, in order to create steam that drives turbines to create electricity

Cogeneration  The simultaneous production of electricity and useful heat in an electricity generating system

Co-milling  The blending of coal and biomass in a coal milling machine

Comminution  Process in which solid materials are reduced in size by crushing, grinding and other techniques

Electricity retailer  Entities that are licensed to sell electricity to end use customers

Expanded Renewable Energy Target (RET)  An enhancement to the Commonwealth Mandatory Renewable Energy Target

Feed-in tariff  Premium rate paid for electricity produced or injected into the electricity grid from defined renewable electricity generation sources

Flowability  Capability of a liquid or granulated solid material to move by flow

Fly ash  Fine particle residue generated during combustion

Forestry residues  Thinnings and prunings generated from silviculture practices and trimmings generated during timber harvesting
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green waste</td>
<td>The biodegradable portion of the waste stream arising from various sources including waste from domestic and commercial premises and municipal operations. Generally limited to plant-based waste such as such as grass cuttings and hedge trimmings and excluding food and putrescible waste.</td>
</tr>
<tr>
<td>Herbaceous</td>
<td>Leafy, soft-stemmed. Not woody</td>
</tr>
<tr>
<td>Large-scale Generation Certificate (LGC)</td>
<td>Certificate produced by eligible renewable energy generators under the Large-scale Renewable Energy Target (LRET)</td>
</tr>
<tr>
<td>Large-scale Renewable Energy Target (LRET)</td>
<td>One of two elements resulting from the breakup of the Expanded Renewable Energy Target, which came into effect on 1 January 2011. The other elements is the Small-scale Renewable Energy Scheme (SRES)</td>
</tr>
<tr>
<td>Life cycle emissions</td>
<td>Method to assess emissions at all stages of a product or process from ‘cradle-to-grave’ (i.e. from raw material extraction through processing, manufacturing, distribution, end use and disposal/recycling)</td>
</tr>
<tr>
<td>Mallee</td>
<td>Generic description of a range of mainly <em>Eucalyptus</em> species that form woody shrubs or small trees able to coppice (produce multiple stems) readily after top-growth removal or damage e.g. by fire</td>
</tr>
<tr>
<td>Mandatory Renewable Energy Target (MRET)</td>
<td>Commonwealth scheme to increase the share of renewable electricity under the Renewable Energy (Electricity) Act 2000</td>
</tr>
<tr>
<td>Pelletising</td>
<td>Process for creating a uniform, relatively dense material through compression</td>
</tr>
<tr>
<td>Over the counter (OTC)</td>
<td>Transaction involving a financial instrument that is not handled over an organised exchange</td>
</tr>
<tr>
<td>Photosynthesis</td>
<td>Process undertaken by green plants that uses light energy to convert CO₂ and water into carbohydrates</td>
</tr>
<tr>
<td>Pyrolysis</td>
<td>Thermochemical decomposition of organic material at high temperatures in the absence of oxygen</td>
</tr>
<tr>
<td>Regrowth</td>
<td>Re-establishment of vegetation cover after land clearing. In the Queensland context, generally refers to suckering and coppicing growth emanating from stumps or root systems. May also include seed-based regrowth.</td>
</tr>
<tr>
<td>Renewable Energy Certificate (REC)</td>
<td>Certificates created by eligible generators under the Mandatory Renewable Energy Target (MRET) and Expanded Renewable Energy Target (RET), prior to its break up on 1 January 2011. From this date, certificates from Large-scale Renewable Energy Projects are known as Large-scale Generation Certificates (LGCs)</td>
</tr>
<tr>
<td>Renewable Portfolio Standard (RPS)</td>
<td>Policy measure that places an obligation on certain parties (usually electricity retailers) to source a defined percentage of their electricity from defined renewable energy generation sources</td>
</tr>
<tr>
<td>Second-generation biofuels</td>
<td>Biofuels produced using alternative feedstocks and processing technologies, rather than free sugars, starches or fatty acids as used in first-generation biofuels. Includes lignocellulosic ethanol, catalytic</td>
</tr>
</tbody>
</table>
conversion and synthetic fuels via thermal. These widen the choice of potential biofuel feedstocks to woody biomass, crop residues, grasses and other potential non-edible crops such as switchgrass, *Arundo donax* and *Miscanthus*

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-rotation crops (SRC)</td>
<td>Woody crops with coppicing abilities that enable rapid regrowth, enabling the top growth to be harvested on a regular basis for biomass. See also mallee</td>
</tr>
<tr>
<td>Small-scale Renewable Energy Scheme (SRES)</td>
<td>One of two elements resulting from the breakup of the Expanded Renewable Energy Target and came into effect on 1 January 2011. The other element is the Large-scale Renewable Energy Target (LRET)</td>
</tr>
<tr>
<td>Spontaneous combustion</td>
<td>Combustion which occurs in the absence of an external ignition source</td>
</tr>
<tr>
<td>Syngas</td>
<td>Gas fuel containing carbon monoxide and hydrogen. Can be produced from biomass through torrefaction or pyrolysis</td>
</tr>
<tr>
<td>Torrefaction</td>
<td>Thermochemical treatment of biomass similar to pyrolysis but at lower temperatures producing a high quality fuel for combustion and gasification</td>
</tr>
<tr>
<td>Walking floor</td>
<td>Conveyance system for moving material. The moving floor is divided into sets of narrow slats. These move alternately in sets in order to gradually eject the load</td>
</tr>
</tbody>
</table>
References

ABCg 2009, Stepping up – accelerating the deployment of low emission technology in Australia, Australian Business & Climate Group.


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URS Forestry 2008a, Farm forestry area and resources in Australia, Publication no. 08-104, Rural Industries Research and Development Corporation, Canberra, viewed 2 November 2010, <https://rirdc.infoservices.com.au/items/08-104>.


This report is about biomass co-firing, which is a method to reduce greenhouse gas (GHG) emissions by substituting a renewable fuel—biomass—for a proportion of the coal used to generate electricity in coal-fired power stations.

Importantly, the focus is on factors affecting the adoption of co-firing rather than on the technology itself. Biomass co-firing has been proven and commercially adopted around the world, facilitated by a range of supportive policies. At low levels of co-firing, minimal capital expenditure is required, making this one of the most cost-effective ways to reduce GHG emissions.

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