



Oil mallee industry development plan for Western Australia



This industry development plan has been prepared by URS Australia Pty Ltd on 12 November 2008.

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Foreword from the Minister for Forestry

The humble oil mallee has a lot to offer. This hardy group of native trees is well adapted to our nation's agricultural landscapes, and when integrated onto the farm, can provide many on- and off-farm benefits. There is great potential to provide sustainable solutions to pressing environmental issues such as salinity and climate change. Within our agricultural landscape, oil mallees provide landscape stability, particularly in and after prolonged dry seasons when the effects of wind erosion may be more severe.

Verve's Narrogin Integrated Wood Processing (IWP) demonstration facility has shown that mallees can produce biomass for renewable energy, eucalypt oil and activated carbon. Research has also shown potential for mallees to produce a range of other products, such as wood panels, transport fuels, pharmaceuticals and industrial solvents. With development of these markets, it has great potential to provide an additional source of income for our farmers and provide more jobs and economic resilience for our regional communities.

A major strength of the mallee industry is the passion and vision of all those involved. This has often resulted in collaboration and cooperation not often experienced in other industries, resulting in some truly remarkable achievements, including, for example:

- the Narrogin IWP
- production of eucalyptus oil by Kalannie Distillers
- a robust and state of the art regional nursery network
- the Oil Mallee Company's management of a carbon sequestration project (for General Environmental Technos)
- unique collaboration between government and the farming community in developing a large scale integrated tree farming system for the medium and lower rainfall areas of WA
- the creation of the Oil Mallee Association, promoting the benefits of oil mallees on farms, driving industry development and representing growers across the wheatbelt
- the first use of WA's new Tree Plantation and Carbon Rights Acts, and more recently
- offsets for State Government vehicle fleet emissions.

The industry is at an important juncture in its development, and this industry development plan points the way forward to allow the sector to flourish and realise its great potential. This plan will help inform decisions by Government and industry to guide the next growth phase, and maximise the benefits to the community of WA. This plan may well serve as a model for other parts of the country and I look forward to working with the industry as it moves towards realising its considerable potential.

A handwritten signature in black ink, appearing to be 'Terry Redman'. The signature is stylized and fluid, with a long horizontal stroke at the end.

Terry Redman MLA
Minister for Agriculture and Food; Forestry

Foreword from the President of the Oil Mallee Association of WA

The need for an oil mallee industry development plan (IDP) grew out of a widely expressed need to get a snapshot at this point in time of the industry as a whole. The Oil Mallee Association of Western Australia (OMA) also believed the plan would serve to reinforce the existence of an 'industry' based around the species of eucalypts grouped together as oil mallees. This change in perception to that of an industry, as opposed to promotion of a tree, is important in order to investigate the many commercial options which appear to be available in the near future.

The opportunity to join with the FPC in undertaking this project was most welcome and helps consolidate the role of the OMA as the key independent industry body supporting the growers and industry participants. It also marks a change for the Oil Mallee growers from the focus on establishing trees on farms for NRM benefits to industrial agroforestry – while retaining all the benefits of an integrated approach.

The IDP highlights the positive influences which will drive the industry over the next decade and clearly prominent is the impact of carbon policy and regulation. Not only does carbon continue to push investment towards sequestration programs, but it also drives the viability of bioenergy projects along with renewable energy programs.

Necessarily the IDP identifies the challenges facing the orderly development of the industry as well as some approaches that are being pursued or could be investigated to overcome the problems facing the integration of agriculture and industry.

The motivation of many mallee advocates over the years has been the potential for considerable regional development and the consequential social benefits to rural communities. The belief that processing of mallee for the many products and bi-products will increase employment and perhaps reverse the declining population in some areas remains a strong belief throughout the membership of the OMA. Perhaps as a consequence, the report places an emphasis on the utilisation of mallee biomass and value adding through the supply chain from paddock to processing to power plant and beyond. All the issues, from harvest technology to appropriate planning guidelines are dealt with in the IDP, and I congratulate the Committee and the Experts Group for their work.

The promotion of localised value adding is common to many agricultural enterprises and, like them, there will be problems in bringing this ambition to reality. The IDP makes the idea seem possible.

The OMA has received funding from the Commonwealth to promote our version of sustainable agriculture and its link with forestry. It includes a program to develop an implementation strategy for the IDP through consultation with growers and industry partners. We hope that all interested people will take part in the discussions and help us forge a successful roadmap for the industry which will see us closer to realising the dreams of the very earliest of the champions of the oil mallee and all the many advocates along the way.

A handwritten signature in black ink, consisting of a series of loops and a long horizontal stroke extending to the right.

Mike Kerkmans

President of the Oil Mallee Association of WA Inc

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Preface

The Oil Mallee Association of Western Australia Inc (OMA) and the Forest Products Commission (FPC) have engaged URS Forestry to prepare an industry development plan (IDP) for the WA mallee industry. New policies and regulation that favour low carbon fuels, the development of renewable energy sources and sustainable land management practices are expected to lead to an expansion of the industry in the WA Wheatbelt. The scale of the expansion could be equivalent to the area of Tasmanian blue gum that has been planted in higher rainfall areas of WA and there is a need to ensure that frameworks for industry development are consistent with the potential scale of development.

The plan has been prepared in conjunction with the IDP Management Group and other key industry stakeholders with the aim of summarising the current state of the industry, identifying opportunities, issues and impediments, and recommending key actions to ensure the sustainable growth and commercial development of the industry.

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Executive summary

Part 1: Strategies for the WA oil mallee industry

There are emerging commercial markets for wood and non-wood products that can be produced from mallees, and tree crops have already been established in WA based on the prospect of these markets being developed further.

There is now an international focus on global warming and climate change that provides further opportunities to develop financially viable industries through the instigation of new policies and regulation favouring low carbon fuels and sustainable land management practices. An economy that is increasingly carbon constrained will give preference to less carbon intensive, and eventually carbon neutral sources of energy and commodities. At the same time oil prices are increasing, which provides clear economic opportunities for alternative fuels.

The mallee system is ideally structured to meet these needs. It focuses on the planting of belts of trees across the landscape, fully integrated with cropping and livestock production. This design enables the continuation of contemporary farming between the mallee belts. Mallees therefore create a unique opportunity for the development of sustainable products, including wood products and bioenergy, as a dedicated carbon sink, or even providing all products from the same area of land.

The natural resource management benefits of mallees are recognised by landowners that have previously established the trees, but these non-monetary benefits alone cannot be relied on as the basis for tree crop development. For the industry to develop, the trees will need to provide at least an equivalent financial return to existing farm enterprises.

Strategies for industry development and associated actions must seek to overcome three key impediments to the development of new industries based on mallees.

- The technologies and markets associated with the processing of mallees into industrial products on a large scale are not yet developed to the stage where any single product, or combination of products, provides a clear basis for economically viable development.
- If clear opportunities were currently available, current mallee plantings are not at a sufficient scale for a processing industry to be developed.
- The current demand for mallees as part of a dedicated carbon sink that is not intended for harvest is far greater than that for industrial production. Under current 'Greenhouse Friendly' requirements, this could result in suitable land being 'locked up' on a non-harvest regime for more than 70 years, although arrangements under the proposed national Carbon Pollution Reduction Scheme (CPRS) seem likely to be different. In any case, an opportunity for better long-term land use through the production of wood-based energy and industrial products may be foregone if large areas are planted as carbon sinks on a non-harvest regime.

The first two impediments result in a 'chicken and egg' scenario where the commitment from processors towards developing an industry is tempered by the lack of resource in the short term, and potential growers are looking for clear evidence of future profitability before they develop tree crops.

These impediments can be overcome by capitalising on the opportunities that can be provided by carbon trading and the further development of policies that encourage sources of renewable energy. Such policy developments have the potential to provide a 'circuit breaker'

and a way forward for the industry. However, at the time of writing, policy settings under the CPRS have not been finalised, and potential issues linger, associated with dedicated 'no-harvest' carbon sinks and failure to encourage the optimal establishment of mallees for biomass production. These issues must be addressed through strategic actions.

The strategies and actions should also seek to recognise that the manner in which future industries develop will be dependent on the scale of planting that can be achieved and the infrastructure that is available in specific regions. The technology and markets associated with some industries, such as the production of eucalyptus oil or wood pellets, are well suited to small scale operations (< 100,000 tonnes per annum). Other emerging industries, such as the generation of bioelectricity or the production of ethanol, have significant economies of scale. Some industrial plants may require the establishment of resources that are capable of producing in excess of 300,000 tonnes per annum (pa) within a financially viable transport distance.

With this background there are two key strategies that emerge for the WA mallee industry.

Key strategies

- 1) Develop diverse regional industries based on mallees that match the biophysical characteristics of a region and available infrastructure with the type and scale of operation that is most economically viable.
- 2) Assist the development of these new industries by leveraging off the current interest in tree crops as carbon offsets. This should be done by encouraging flexible policy frameworks that allow the objectives of minimising greenhouse gas emissions to be achieved by harvesting trees for the production of bioenergy and wood products **and** by creating a carbon sink from the same crop, thereby enhancing the potential socio-economic value of carbon sinks.

Actions required to implement the strategies

Policy frameworks that are important to achieving these goals are currently being developed or reviewed. The mallee industry has a unique opportunity to secure a viable future by influencing these developments and supporting the new frameworks with ongoing research and development that provides a positive investment climate.

Federal Government policy initiatives

Based on the Commonwealth's green paper, it seems that it will be possible for permits from eligible treefarms to be traded under the future Australian Carbon Pollution Reduction Scheme (CPRS), where the forest owner elects to 'opt-in'. There is also support for the inclusion of carbon stored in harvested wood products as offset credits. The use of woody biomass as a substitute for fossil fuels in energy production is recognised as a carbon neutral source of energy that reduces the potential liability of energy producers. However, it is unclear whether the production of woody biomass for uses where it displaces fossil fuels, or the use of biochar as a soil additive, will generate an offset credit for the grower in the same way that some stakeholders are proposing for wood products.

It can be demonstrated that the greenhouse benefits of a harvesting regime that leads to the substitution of fossil fuels or the retention of carbon in wood products can be greater and more permanent than the development of tree crops as dedicated carbon sinks. The regional socio-economic benefits of production regimes are also far superior to those accruing from

dedicated sinks. The development of the CPRS should encourage parties wishing to establish offsets via tree crops to also participate in a future industry based on biomass harvesting.

Under such a framework the resource owner would retain carbon credits at the time of harvest that are equivalent to the net greenhouse benefit from the carbon stored in wood products or by replacing fuels that generate more CO₂-e during the production of energy or commodities.

Without direct recognition of wood products or fossil fuel displacement as a carbon offset credit, large emitters of carbon dioxide (such as oil and gas producers) that establish mallees for the purpose of generating carbon offset credits will need to forego some of their accumulated credits at the time of harvest (some carbon remains stored below-ground). They might then need to buy another offset on the market to meet their obligations under any future emissions cap. This exposes the organisation to a price risk associated with future carbon trading that they were seeking to avoid through the early action of planting mallees.

A further issue that needs to be addressed in the CPRS relates to the width of tree belts. The most recent (and as yet unpublished) research indicates that mallee productivity (per hectare planted) can be greater by planting two row belts than wider configurations such as four row belts or block plantings¹. However, for tree-based projects to be eligible as an approved abatement under the current Greenhouse Friendly Scheme, the planting must have a minimum width of ten metres (typically greater than most two row belts planted to date). This creates a disincentive to establish trees in the most financially viable configuration.

Action 1

Industry participants should provide input to the future Carbon Pollution Reduction Scheme that includes:

- 1) recognising sequestration via harvested wood products or fossil fuel displacement as an offset credit against emissions; recognition of wood products should include charcoal returned to the soil
- 2) defining tree-based sinks in such a way as to include two row belts of mallees.

State and local government policy initiatives

In Western Australia the *Planning and Development Act 2005 – Department of Planning and Infrastructure* gives rise to State Planning Policies which have the force of a regulation, including State Planning Policy 2.5: Agricultural and Rural Land Use Planning. The policy does not currently refer to tree crops as a land use, but is currently being reviewed with a view to including a reference to tree crops. The revised policy may list tree crops as a permitted, discretionary or not permitted use for specific zones.

The implementation of State Planning Policy 2.5 could be guided by *Planning Bulletin 56: Farm Forestry Policy* (PB 56). The guidelines in PB 56 relate to the level of planning approval required for plantation development applications, and the need to prepare plantation management, harvesting and transport plans. PB 56 is also currently being reviewed. However, it is only a guideline that can be used by local government planning officials and amendments to the policy alone are unlikely to give growers the comfort they need to ensure that plantations can be established at a suitable scale to develop an industry. A State Planning Policy that provides the necessary 'as-of-right' assurance is required.

1 Figure 2-4 provides an illustrated example

The *Wildlife Conservation Act 1950* controls the sale of both wild and cultivated native plants in WA. Under this legislation a licence issued by the Department of Environment and Conservation (DEC) is required for the sale of products from WA native species planted on private property, but no licence is required to harvest the trees. It is unclear why a licence should be required for sale of products from trees planted with the intent of harvest and sale. Industry development might be better facilitated if rights to sell harvested products were incorporated at the planting approval stage, rather than falling under another, separate statute or process.

Action 2

Input should be provided to the current review of state and local planning policies by stakeholders that promotes the following:

- 1) agreement on the criteria used to define a tree crop, including scale (suggested greater than 40 ha on any land holding) and definition of land holding (eg land title versus land holding of one owner)
- 2) development of a State Planning Policy specifically supporting farm forestry
- 3) in consideration of the emerging nature of the industry and lead times between planting and harvest, notification of a transport plan should not be required until 12 months prior to the commencement of harvesting
- 4) guidelines for management plans, fire protection and chemical use that are consistent with other codes of practice, including *Guidelines for Plantation Fire Protection* and the *Code of Practice for Timber Plantations*
- 5) recognition and support for tree crop development that is integrated with contemporary agriculture as a legitimate land use in the General Agricultural Zone
- 6) a process for authorisation of sale of products from harvest of mallee crops from private property that provides approval at the time of crop establishment in order to favour the use of native species and to reduce risk for large scale investment.

Research and development

Mallee cropping on the scale envisaged for industrial biomass feedstock supply is an entirely new concept and will require intensive, long-term research and development to develop the species, the agronomic practices and the production systems necessary for a sustainable industry. On the biomass supply side there are four high priority areas that need to be better understood before investors in mallee tree crops can make well informed decisions.

- Empirical data on growth rates and biomass yields. Several researchers have identified that reliable empirical data is needed to improve current models and their predictive ability. These data are expensive to obtain, often not collected adequately and there is consequently a large variation in reported productivities. This exposes the industry to reputational risks if investors commit funds on the basis of higher growth rates than are ultimately achieved. Alternatively, growth of the industry may be constrained because the estimated yields from harvesting are too conservative.

- The impact of mallee belts on adjacent cropping or pasture systems. Under some conditions there is an impact of mallee belts on adjacent crops. Where competition occurs, it imposes a financial cost that needs to be considered when evaluating land use alternatives. This cost will be related to the period of the rotation over which this competition occurs, the width of the area where competition occurs and the extent of the decline in crop or pasture productivity. None of these factors are clearly understood at the present time.
- Changes in below ground biomass under cropping regimes. The amount of below ground biomass associated with mallees becomes important when estimating the value of this biomass as an offset credit under carbon trading systems.
- Efficient harvest, handling and transport equipment and systems. A fully commercial oil mallee industry requires establishment of a cost-effective harvesting and transport system. The harvesting and logistics system must take into account all components of the mallee supply chain from harvest to delivery to customer.

Action 3

Research programs should continue to be supported that focus on:

- 1) delivery of valid short term data on above and below ground yield estimates and competition zone effects. This should be a co-operative whole industry project that will pool existing data for consolidation and provide whole industry access.
- 2) expansion of the whole harvest cycle research initiated by DEC and the Department of Agriculture and Food WA to provide long term data on above and below ground yield and competition zone effects.
- 3) efficient harvest, handling and transport equipment, including optimal planting strategies to minimise the delivered cost of biomass.

Implementation of the IDP strategy and actions

The Oil Mallee Association of WA (OMA) was established in 1995 as an industry association to promote mallee industry development. It is an incorporated body and its constitution directs it to represent the common interests of the industry. It has become the peak industry body for the oil mallee industry, representing growers and industry participants.

Through *Western Australia's Strategy for Plantations and Farm Forestry*, the State Government has allocated the Forest Products Commission (FPC) the lead role in supporting the forest products industry in relation to agroforestry. In this role the FPC will collaborate with the DEC, the Department of Agriculture and Food WA (DAFWA) and other Government stakeholders on the implementation of the strategies and actions associated with this industry development plan. Another key stakeholder is the Future Farm Industries Co-operative Research Centre (FFI CRC). It is important that these stakeholders work together and form an *implementation taskforce* that is adequately resourced to ensure priority actions are implemented and a successful industry developed.

It is important that a strong industry body continues beyond the implementation of this IDP to further the ongoing development of the industry.

Part 2: Summary of background information

Mallee plantings in the WA Wheatbelt region began in the early 1990s to address agricultural salinity management on the necessary scale. The early industry leaders determined that to encourage the adoption of mallees as part of a landcare practice it would be necessary to develop a commercial return from the trees, and that these commercial returns would need to be comparable with the long term average returns from agriculture.

The first broad scale plantings were coordinated by the Western Australian Department of Conservation and Land Management (CALM) and by 1995 there was sufficient interest in mallees for a body of growers to form the OMA. The OMA is the peak industry body for the oil mallee industry, and is currently delivering a range of projects in partnership with funding programs. It plays a key role in developing the industry and coordinating oil mallee resource development, through an established regional manager network and sub-regional OMA associations. The OMA initiated the formation of the Oil Mallee Company (OMC) to form an independent commercial arm for the oil mallee industry in WA.

State Government involvement in commercial tree cropping has been through the FPC, which has been appointed by the State Government as the lead agency to support the forest products industry on behalf of Government. DEC (formerly CALM) plays a key research and developmental role within the industry, along with the FFI CRC. DAFWA maintains involvement with research and collaboration.

Other key stakeholders involved in the development of the resource include private investment groups, NRM groups and the PFDCs. The NRM groups and the PFDCs work closely together and in partnership with regional land owners and organisations to develop strategies and to implement the National Action Plan for Salinity and Water Quality (NAP) and National Heritage Trust programs (NHT). New opportunities are emerging for all stakeholders to collaborate to further the WA oil mallee industry through implementing outcomes of the Commonwealth Government's 'Caring for our Country' program.

The mallee resource

Since the early 1990s almost 13,000 ha of mallees have been established in WA. Eight different species and subspecies have been utilised, seven of which occur naturally in Western Australia. Significant effort has been invested in developing silvicultural systems to optimise yields and a large body of research data exists that has added to the understanding of how mallees grow. A tree breeding program has been established and seed from first generation seed orchards is available to growers.

An important factor influencing the expected harvest yields from mallees is the use of available water by the trees. From the early days of establishment, the way in which mallees can respond to water availability led to an understanding that productivity will be enhanced by planting in narrow belts, as mallee belt plantings have a significant capacity for both utilising water stored in the soil that surrounds the root zone and for capturing lateral flows. The most common configuration has been four row belts with an effective belt width of ten metres, which is the informal standard established by the Australian Greenhouse Office to ensure compliance with the Kyoto standards for eligible reforestation and carbon credit creation². Recent (and as yet unpublished) research has indicated that productivity will be enhanced by belts with

2 Canopy cover must be capable of reaching 10 metres across and covering 20% of the registered land. The trees must be observable using standard remote measurement technologies e.g. Landsat

only two rows of trees, but the extent to which such a configuration meets Kyoto standards still needs to be tested.

It is estimated that 50% of the total area of all cleared land in the WA Wheatbelt has suitable soils for mallee plantings. Table ES-1 provides an estimate of productivity, and potential planting areas that could be achieved. In this example two row belts are assumed, and the area planted is based on estimates of the proportion of suitable area that could be established to maintain these yields. Greater areas could be planted either as belts or blocks, but adjustments to productivity of the tree crop would need to be made that are commensurate with the proportion of the paddock area planted³. Estimates such as the ones in Table ES-1 are important when determining the area that would need to be planted to service an industrial process of a particular scale. It should be noted that there are a wide range of productivity estimates from various sources and more definitive yields from species, soil types and rainfall zones are the subject of ongoing research.

Table ES-1: Estimated areas and growth rate potential of plantings by rainfall zone

Rainfall zone	Total available area¹	Total suitable area²	Average growth rate aboveground from two row belt³	Potential tree crop area assuming 10% of suitable area planted
(mm pa)	(M ha)	(M ha)	(gmt/ha pa)	(ha)
300-400	10.9	5.5	8.6	545,000
401-500	3.8	1.9	12.1	190,000
501-600	1.9	1.0	15.5	95,000
Total	16.6	8.3		830,000

Sources: 1. Bartle *et al* (2007a)

2. Cooper *et al* (2005); Bartle *et al* (2007).

3. J. Bartle pers comm (2008). Growth increments to age 7 to 11 only. Estimates converted from bdmt to gmt assuming 42% moisture content of green biomass

Development of uses, products and markets

The environmental benefits of planting mallees in the WA Wheatbelt were an early driver for adoption by farmers. While the multiple environmental benefits of planting mallees were seen as being very beneficial, on their own they were not enough to catalyse large-scale plantings and a major industry. Commercial drivers for mallee plantings have therefore been sought.

A range of potential processing options and markets exists for mallees. The commercial viability of these options is dependent on a number of factors, including:

- costs of production from planting to processing
- demand for products
- prices that can be achieved in markets
- achieving necessary resource requirements (scale) for market development.

3 Figure 2-4 provides an illustrated example

Historically, there has been a significant focus on processing mallees to produce multiple products. Integrated wood processing (IWP) was considered as a production option for its potential to efficiently direct specific biomass fractions to higher value products while directing residues to lower value uses such as bioenergy and eucalyptus oil, and achieve a commercially viable industry. Following several years of feasibility analysis and technology development, Western Power (now Verve Energy) completed construction of a trial IWP plant in 2006 to undertake operational scale testing. During the trial phase the plant produced activated carbon from the wood fraction of the mallees and eucalyptus oil from the leaves, while all residues, including spent leaf and waste heat, were used for bioelectricity (the production of electricity). The trial indicated that production of activated carbon, eucalyptus oil and energy from mallee biomass is feasible.

Verve Energy is investigating the potential to attract investment in the construction and operation of a larger plant and to replicate the plant in other areas of the WA Wheatbelt and other parts of Australia. The prospects for integrated processing are well developed and appear promising. The potential scale of the mallee resource is such that a range of additional markets should be considered as either stand alone industries or as part of an integrated production process. Table ES-2 provides a summary of these products and markets.

Table ES-2: Summary of market opportunities

Product	Opportunities and constraints
<p>Bioelectricity is the production of renewable electricity from solid biomass through direct combustion of wood, co-firing with other fuel sources, or via production of gaseous and liquid fuels.</p>	<ul style="list-style-type: none"> • Strong market opportunities exist in Australia for bioelectricity production. Small scale co-firing is being implemented around Australia and there are currently several proposals to develop dedicated bioenergy plants. • Opportunities for renewable electricity in Australia are expected to grow as a result of government policies, particularly the Commonwealth Government's Mandatory Renewable Energy Target (MRET) scheme. The increased renewable energy target of 20% by 2020 is likely to be a catalyst for significant investment in renewable energy infrastructure. • The placement and size of bioenergy plants can be linked closely to the electricity grid in an area with excess network transmission capacity, and must have sufficient long term feedstock supplies within viable transport distances. • Distributed energy supply can also be provided to isolated projects.
<p>Carbon is carbon dioxide removed from the atmosphere, stored in biomass and recognised as a carbon sink which offsets greenhouse gas emissions and thereby helps to mitigate global climate change.</p>	<ul style="list-style-type: none"> • The Australian Government established the Department of Climate Change and Water (DCC) on 3 December 2007. Shortly thereafter, the Australian Government officially ratified the Kyoto Protocol, and in doing so committed to limiting its national greenhouse gas emissions to 8% above 1990 levels during the first Kyoto period of 2008 to 2012. The Government also committed to implement the CPRS by 2010.

<p>Wood pellets are produced by grinding wood material into small particles, then compressing the material to bind the wood together. Energy is produced upon combustion.</p>	<ul style="list-style-type: none"> • Principal markets for wood pellets are in Europe, Canada, Japan and the United States. There is increasing interest from Australian investors to export wood pellets. Tests have shown that pellets manufactured from mallee will meet the standards required for the export market. • Export represents the clearest opportunity for Australian wood pellets in the short term, notwithstanding the significant transport distances and increasing domestic production in Europe. • Prices for renewable electricity in Australia may increase and potentially support a domestic market. • Domestic heating could also provide a market for pellets as a replacement for firewood, as the pellets have proven energy efficiency and environmental advantages.
<p>Activated carbon is a form of charcoal that is valued for its ability to purify liquids and gases. It can be produced from wood through carbonisation and activation processes.</p>	<ul style="list-style-type: none"> • Opportunities exist to replace imports of activated carbon into Australia. Particularly for use in the gold industry and water filtration systems, where it is used in the recovery process. • Feasibility will depend on production costs, but the quality of the product that can be produced from mallees has proven to be suitable.
<p>Composite wood products such as Medium Density Fibreboard (MDF), particleboard and Engineered Strand Lumber (ESL) are used extensively in a range of applications in the construction, manufacturing and furniture sectors.</p>	<ul style="list-style-type: none"> • Australia is a significant exporter of MDF and consumption of composite wood products is likely to continue to increase in Australia. Tests have shown that mallee is a suitable input for the production of MDF. • Global markets for engineered wood products such as ESL are expanding and there are strong opportunities to supply the ESL market based on growing international demand for this relatively new product.
<p>Eucalyptus oil is produced from the leaves of trees and used as an ingredient in a range of products.</p>	<ul style="list-style-type: none"> • Most of Australia's eucalyptus oil consumption is based on imports from China and there appears to be an attractive opportunity for domestically produced oil to replace imports. • There are strong precedents to the use of naturally occurring terpenes (such as those found in Eucalyptus oil) as industrial solvents and cleaners, albeit at significantly lower prices than current uses of Eucalyptus oil. • Eucalyptus oil is currently a niche product and large scale sales have the potential to significantly lower prices and reduce the viability of the industry.

<p>Charcoal presents two opportunities: industrial carbon, which is used in the steel industry as a substitute for coking coal or in the non-ferrous industry as a specialty reductant, and biochar which is used as a soil additive.</p>	<ul style="list-style-type: none"> • It will be very difficult for industrial carbon produced from biomass to compete with the current coking coal industry, where supply is well established and low prices for coal are highly competitive. However, specialised activities requiring wood charcoal for reduction could provide a market for certain fractions of mallee. • Development of the biochar product is being undertaken, including trials to demonstrate the benefits of biochar as a soil enhancer and partial replacement for fertiliser. Other financial incentives, including official recognition of biochar as a tradeable carbon sink, will increase the potential of the market.
<p>Lignocellulosic ethanol is a liquid biofuel produced from wood by breaking down biomass to isolate the component sugars, which are then processed to produce ethanol. Its most likely immediate application is in the blended fuel product – E10.</p>	<ul style="list-style-type: none"> • Lignocellulosic ethanol offers several advantages over traditional ethanol production from agricultural feedstocks, (such as sugar cane and grain) in that it utilises a potentially cheaper feedstock and has a better energy balance as a result of lower greenhouse gas emissions during production. Lignocellulosic ethanol is also less likely to compete with human and agricultural food markets. • The lignocellulosic process is yet to be commercialised but is currently undergoing intensive research and development overseas. Several commercial prototypes of the technology are planned over the next 3-5 years.
<p>Biomass to liquid fuels are produced when biomass undergoes a gasification process and the gases are synthesised into a range of liquid fuels such as methanol and synthetic diesel.</p>	<ul style="list-style-type: none"> • Biomass to Liquid fuels present an opportunity to supply Australia’s diesel market. Growing demand and increasing prices for diesel will increase the viability of synthetic fuels. • Individual technologies are well understood, but integrated production requires further development and is a current constraint to the industry.
<p>Bio-oil is produced through a process of pyrolysis, where woody biomass is heated in the absence of air. It is a combustible product and has potential as a substitute for fossil fuels in a range of applications. Technology has recently been commercialised overseas.</p>	<ul style="list-style-type: none"> • Markets for bio-oil are limited by the fact that it cannot currently be used as a fuel in existing forms of transportation. However, it can be used as a boiler fuel or in gas turbines for power generation. • Research and development is being undertaken to allow blending with hydrocarbon fuels; which is hoped to broaden the overall market for the product.

Table ES-3 provides an indication of the status of current technologies and the scale required for different processing options based on current or emerging technologies.

Some processing options, such as wood pellets for export, have the potential to supply large markets and the processing technologies used are flexible enough to adapt to a changing resource base. However, the nature of export markets is such that growers are exposed to changes in exchange rate, international market conditions and the costs of shipping freight, that are outside the control of the domestic industry. Changes in these factors can occur rapidly and impact on the financial viability of the resource within a short period of time.

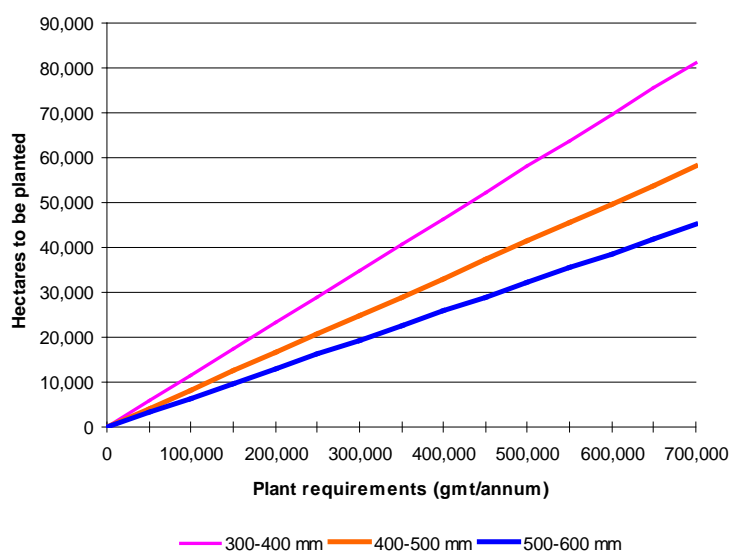
Industries that require significant investment in fixed infrastructure, such as a bioelectricity plant, can not afford the same flexibility in terms of the resource base. However, the plant is usually only established on the back of long term supply agreements with domestic energy users. These agreements also provide security to mallee growers, who can establish a resource in the knowledge that there is likely to be a buyer at the time of harvest.

Table ES-3: Status of technology and scale required for different processing options

Processing option	Status of technology	Scale requirements	Comments
Bioelectricity	Available	5 MW: 60,000 gmt pa 25 MW: 280,000 gmt pa	<ul style="list-style-type: none"> Unit costs decrease with scale Large plants are dependent on proximity to SWIS or direct supply to industrial operations
Wood pellets	Available	> 100,000 gmt pa	<ul style="list-style-type: none"> Markets unlikely to be impacted by scale
Engineered wood products	Available	> 300,000 gmt pa	<ul style="list-style-type: none"> Estimate is for a plant that only utilises mallee Mallee can also be supplied as an input with other wood fibres
<ul style="list-style-type: none"> Biochar 	Available	Any scale	
<ul style="list-style-type: none"> Ethanol Biomass to liquid Bio-oil 	Developing Developing Available	> 500,000 gmt pa > 500,000 gmt pa > 100,000 gmt pa	<ul style="list-style-type: none"> Estimates based on developing technologies
<ul style="list-style-type: none"> Eucalyptus oil Activated carbon 	Available	< 100,000 gmt pa	<ul style="list-style-type: none"> Most prospective as a co-product of other industrial processes Markets will be impacted by large scale operations

Figure ES-1 shows the net area that needs to be planted (ie only that area that contains trees) to service plants of a particular size. The data is presented by rainfall zone and is based on the productivity estimates in Table ES-1.

Figure ES-1: Net planted area required for different processing plants by rainfall zone



Development of harvest and transport systems

A fully commercial oil mallee industry requires establishment of a cost-effective harvesting and transport system. Most harvesting of mallees to date has been for limited purposes focussing on whole tree harvesting for the demonstration IWP plant using chainsaws and manual feeding into a chipper, and some leaf harvesting for eucalyptus oil producers. Kalannie Distillers has developed a harvester for smaller size, high leaf fraction mallees specifically for distillation. Further development of mallee harvesting systems is required to supply commercial scale industries.

The harvesting and logistics system must take into account all components of the mallee supply chain from harvest to delivery to customer.

- **Harvesting and chipping or bundling:** Traditional harvesting systems used in the forest industry are limited in their application for the harvest of mallees. In the late 1990's a prototype mallee harvester with an on-board chipper was developed by the OMC and CALM (now DEC). This prototype harvester showed that the concept was feasible and is likely to lead to the lowest cost harvesting system, but further development to a commercial stage has not yet occurred. Plans by Verve Energy to build a full-scale IWP plant have revived efforts to develop a harvester and the Future Farm Industries CRC (FFICRC) has taken on responsibility for harvester development. The Intellectual Property acquired by OMC and DEC has been deposited into the FFICRC for the term of the Centre and efforts are currently being made to attract additional investor finance.
- **Haul-out from paddock to roadside:** Haul-out is an important part of the supply chain and has been shown to be one of the major components in the delivered cost to the customer. The cost is directly related to the average distance that the biomass must be hauled from the harvester to the roadside, and to the plantation design and density.
- **Transport to customer:** The WA Wheatbelt has an established system of roads and rail which could be utilised by the mallee biomass industry. The Australian sugar cane industry is similar to the proposed mallee industry in that it moves large tonnages of low bulk-density biomass moderate distances to central processing plants, and sugar cane transport systems could be adapted to meet the needs of the oil mallee industry. Mallees can be harvested for most of the year thereby reducing the time when capital equipment is not utilised and possibly justifying purpose-built equipment.

In June 2008 the WA Government announced \$1.5 million of funding for the development of a prototype mallee harvester that will help create a viable farm-to-factory supply chain for the mallee industry. The research is to be focussed on developing technology that gets trees from the farm paddock and delivered to a processing plant efficiently. A 'chipper harvester' approach is being investigated that incorporates techniques and concepts used in forestry and agricultural systems to cut trees at ground level and chip them in one continuous operation.

Economic modelling

A model has been developed by URS using principles of benefit-cost analysis to provide discounted cash flow comparisons between agriculture, biomass production and carbon sequestration land use options. The model allows comparison between locations and areas with different growth potential, and between biomass production options at different scales.

Case study examples have been developed to provide a comparison between rainfall zones and areas adjacent to a port, rail or major electrical transmission line. The characteristics of the four examples are described in Table ES-4.

Table ES-4: Characteristics of case study examples

Region	Characteristics				Potential industries					
	Rainfall (mm)	On SWIS	Near a port	Near other biomass residue sources	Pellet export	Small bio-energy plant (5MW)	Medium bio-energy plant (25MW)	Engineered wood products	Eucalyptus oil product	Activated carbon products
Region 1	500-600	Yes	Yes	Yes	✓✓✓	✓✓✓	✓✓✓	✓✓	Co-product	Co-product
Region 2	400-500	No	Yes	Yes	✓✓✓	✓✓✓	✓	✓✓	Co-product	Co-product
Region 3	300-400	Yes	No	No	✓	✓✓✓	✓✓	✓	Co-product	Co-product
Region 4	300-400	No	No	No	✓	✓✓✓	✓	✓	Co-product	Co-product

✓✓✓ Very good potential ✓✓ Good potential ✓ Some potential

Note: The analysis assumed transport distances and costs associated with fuelling a 25MW plant in Region 1, and a 5MW plant in Regions 2, 3, 4. A 25 MW was chosen as an example only, larger plants are also a possibility in the WA wheat belt.

Table ES-5 shows the value of returns from biomass over a range of factory gate prices for mallee biomass and the value of carbon sequestered (\$/t CO₂-e). The estimates of returns are presented as annualised values which are based on the net present value of returns from biomass plantings harvested regularly over a thirty year period. These returns should be compared against returns from agriculture or other land uses that might be achieved in each rainfall zone, noting any equivalent changes in agricultural production values from carbon policy.

In the analysis, the value of CO₂-e impacts directly on the value that the resource has as a carbon offset. In the case of wood fibre being supplied to a domestic energy producer, the value of CO₂-e will also have an impact on the factory gate value, as will the value of RECs and the value of any capacity credits⁴. The potential interaction between markets for CO₂-e, RECs and capacity credits is complex. ACIL Tasman (2008) estimates that returns from renewable energy generation on the SWIS could more than double between 2007 and 2010/11 based on a combination of potential outcomes. However, the extent to which the energy producer passes this value on to the grower will depend on supply and demand

4 A capacity credit is a measure of an electric power generator's expected or actual contribution to meeting system reliability goals.

factors at any point in time. As a general guide it can be assumed that as the value of CO₂-e increases, so will the factory gate price that can be paid by an energy producer for the mallee biomass.

As an example of how the values in Table ES-5 could be interpreted, consider a region with 550 mm of annual rainfall that is near the SWIS and considered suitable for the development of a 25 MW bioelectricity plant (e.g. Region 1). It could then be assumed that the market price of CO₂-e is \$40/t CO₂-e and future policy settings are such that the combined value of CO₂-e, RECs and capacity credits enable an energy producer to pay \$45/gmt of biomass delivered to the plant. If 10% of land is established to mallees, the annualised net returns from mallee tree crops planted as four row belts are expected to be \$126/ha. If these returns are greater than the value that could be achieved from contemporary agriculture the land owner could consider the establishment of mallees as a competitive land use option.

Table ES-5: Annualised returns from biomass harvesting (\$/ha pa)⁵

		Factory gate value (\$/gmt)				
		\$35	\$40	\$45	\$50	\$55
Region 1						
	\$0	-\$3	\$21	\$44	\$67	\$90
	\$20	\$39	\$62	\$85	\$108	\$131
Carbon value (\$/t CO ₂ -e)	\$40	\$80	\$103	\$126	\$150	\$173
	\$60	\$121	\$145	\$168	\$191	\$214
	\$80	\$163	\$186	\$209	\$232	\$255
Region 2						
	\$0	-\$8	\$10	\$28	\$46	\$64
	\$20	\$24	\$42	\$60	\$78	\$96
Carbon value (\$/t CO ₂ -e)	\$40	\$56	\$74	\$92	\$110	\$128
	\$60	\$88	\$106	\$124	\$142	\$160
	\$80	\$120	\$138	\$156	\$174	\$192
Region 3						
	\$0	-\$41	-\$28	-\$15	-\$2	\$11
	\$20	-\$18	-\$5	\$8	\$21	\$34
Carbon value (\$/t CO ₂ -e)	\$40	\$5	\$18	\$31	\$44	\$57
	\$60	\$28	\$41	\$54	\$67	\$80
	\$80	\$51	\$64	\$77	\$90	\$103
Region 4						
	\$0	-\$36	-\$23	-\$10	\$3	\$16
	\$20	-\$13	\$0	\$13	\$26	\$39
Carbon value (\$/t CO ₂ -e)	\$40	\$10	\$23	\$36	\$49	\$61
	\$60	\$33	\$46	\$59	\$72	\$84
	\$80	\$56	\$69	\$82	\$95	\$107

5 It must be noted that the analysis includes a number of assumptions that are discussed within this document. Outcomes are sensitive to the assumptions used. In making comparisons between agricultural returns and the returns from tree crops under various values of CO₂-e, it needs to also be noted that there are likely to be changes in agricultural production values that result from carbon trading if agriculture becomes a covered sector under the CPRS. These impacts are likely to be in the form of liabilities incurred by agricultural production and will make any advantages of tree crops more favourable.

1. Introduction

The Oil Mallee Association of Western Australia Inc (OMA) and the Forest Products Commission (FPC), have engaged URS Forestry to prepare an Industry Development Plan (IDP) for the WA mallee industry. The plan has been prepared in conjunction with the IDP Management Group and other key industry stakeholders with the aim of summarising the current state of the industry, identifying opportunities, issues and impediments, and recommending key actions to ensure the sustainable growth and commercial development of the industry. The Oil Mallee Company of Australia (OMC) has been appointed to represent the OMA in the management of this project. Enecon Pty Ltd was engaged by URS Forestry to assist with sections of the plan that deal with harvesting and processing technology.

There are commercial markets for wood and non-wood products that can be produced from mallees and tree crops have been established based on the prospect of these markets being developed further. The global and national focus on greenhouse issues such as global warming and climate change will influence the pace at which these markets mature. Sustainable and secure fuel and energy supplies will need to be developed and there are very promising opportunities for meeting this demand from energy crops. Mallees can contribute to energy supply solutions. However, there is also some concern that these energy crops will compete for land for the production of food.

The mallee system is ideally structured to meet these needs. It focuses on the planting of belts of trees across the landscape, fully integrated with cropping and livestock production. This design enables the continuation of contemporary farming between the mallee belts. Mallees therefore create a unique opportunity for the development of sustainable products, including wood products and bioenergy, as a carbon sink, or even providing both products from the same planting. The mallee supply chain is shown diagrammatically in Appendix A.

The first sections of the IDP provide some important contextual background to the industry. Section 2 focuses on the mallee resource as an integrated tree crop and Section 3 outlines the potential to produce commercial products from the mallee resource, including both wood and non-wood products. Industry viability is dependent on the development of efficient harvesting and transport systems and the development of technology to meet these needs is discussed in Section 4.

Section 5 of the IDP presents the outcomes of economic models that show a comparison between the financial returns from tree cropping and traditional agriculture. Tree cropping is considered in terms of its potential to produce commercial products in combination with its value as a carbon sink. The analysis forms the background for a discussion of opportunities for future industry development that is presented in Section 6 and the formation of recommendations in Section 7.

Regional scope

The strategies developed in this report focus on four natural resource management (NRM) regions in WA. These are the Northern Agricultural region, Avon region, South West region, and South Coast region. The geographic location of regions is shown in Figure 1-1. Each of the regions has a NRM group that is responsible for developing long-term regional strategies and investment plans in consultation with their regional stakeholders.

2. Resource development

The following section discusses the development of the mallee resource in WA. An historical overview is presented as well as the current status of the resource. Contemporary knowledge of optimal silvicultural systems and yields is discussed.

2.1 Historical overview

Mallee plantings in the WA Wheatbelt region began in the early 1990s, based on the concept of developing a commercially viable tree crop to tackle agricultural salinity management on the necessary scale (Bartle and Shea 2002). Woody crops like mallee with their industrial products potential were also seen as an option to diversify farm business and regional economies in the face of the long term decline in the terms of trade for agricultural products (Bartle 2006).

Research undertaken at Murdoch University in the 1980s identified potential uses of constituents in eucalyptus oil for industrial products (Barton and Tjandra 1988, 1989; Barton and Knight 1997). Further investigations into the prospects of mallee species were undertaken from 1992-1993 and identified four mallee species as having potential for salinity mitigation and eucalyptus oil production in the Wheatbelt region (Eastham 1993).

The WA Department of Conservation and Land Management (CALM)⁶ coordinated the first broad scale investment and establishment of oil mallee plantings in the period 1994-96 during which a total of six million mallee trees were planted (Bartle 2006). By 1995 there was a substantial interest in furthering industry development and a body of growers formed the OMA (Bartle and Shea, 2002, OMC 2007). In 1997 the OMC was established by the OMA to form a commercial arm for the oil mallee industry in WA (OMC 2007). Both the OMA and OMC are currently in operation today, furthering the expansion and diversification of the industry.

In New South Wales and Victoria a eucalyptus oil industry based on blue mallee (*Eucalyptus polybractea*) in native woodlands has existed for nearly 100 years (Slee *et al* 2006). These traditional industries have also commenced their own planting to secure and expand the resource. The development of the NSW Greenhouse Gas Abatement Scheme (NGAS) and the commitment of the current Commonwealth Government to a Carbon Pollution Reduction Scheme (CPRS) by 2010 has provided further impetus for the mallee industry in NSW and this is likely to follow in other states.

2.1.1 Drivers of mallee tree farm development

Historically, the factors driving development of the mallee industry have included:

- potential for diversification of farm business and local processing to stimulate regional economic development, providing greater resilience to rural communities
- potential for mallee to be complementary to, and integrated into, traditional agricultural systems
- natural resource management
- carbon sequestration.

The drivers all need to be considered in terms of the taxation treatment of forestry, which is outlined in Box 2-1.

⁶ Now the Department of Environment and Conservation (DEC)

Box 2-1: Forest taxation

Commercial forestry: For forest owners that establish a plantation with the intention of harvesting timber from thinning and clearfelling operations, costs are immediately deductible under Section 8-1 of the Income Tax Assessment Act 1997 (ITAA) and returns are treated as general income when they are derived. As plantation growers are recognised as primary producers under the ITAA, they may also be eligible to utilise the 5-year income averaging provisions or Farm Management Deposit Schemes to reduce the incidence of tax when income is derived from the forestry operations.

Managed Investment Schemes (MIS): For investments in forestry Managed Investment Schemes (MIS), the major portion, if not all, of the funds invested in the projects are immediately deductible against other forms of income. New taxation arrangements for investments in MIS came into affect during July 2007. The new arrangements require 70 per cent of investor funds to be directed to direct forestry costs, such as land rental, plantation establishment, tending and harvesting. The new arrangements also allow for secondary trades in investments after a holding period of four years.

Carbon sinks: The costs of establishing trees as carbon sink forests are not currently deductible. However, a Bill has recently been presented to parliament that amends Division 40 of the Income Tax Assessment Act 1997 (ITAA 1997) to provide a deduction for capital expenditure for the establishment of trees in carbon sink forests. It is proposed that establishment expenditure will be immediately deductible for trees established in carbon sink forests in the 2007-08 to 2011-12 income years (inclusive). After this initial period, establishment expenditure will be deductible over 14 years at a rate of 7 per cent per annum. The primary and principal purpose of establishing the trees must be for carbon sequestration and can not include the purposes of felling the trees or for using them in commercial horticulture. The deduction is not available for expenditure on establishing trees in a carbon sink forest by a managed investment scheme or a forestry managed investment scheme.

Potential for regional processing industries

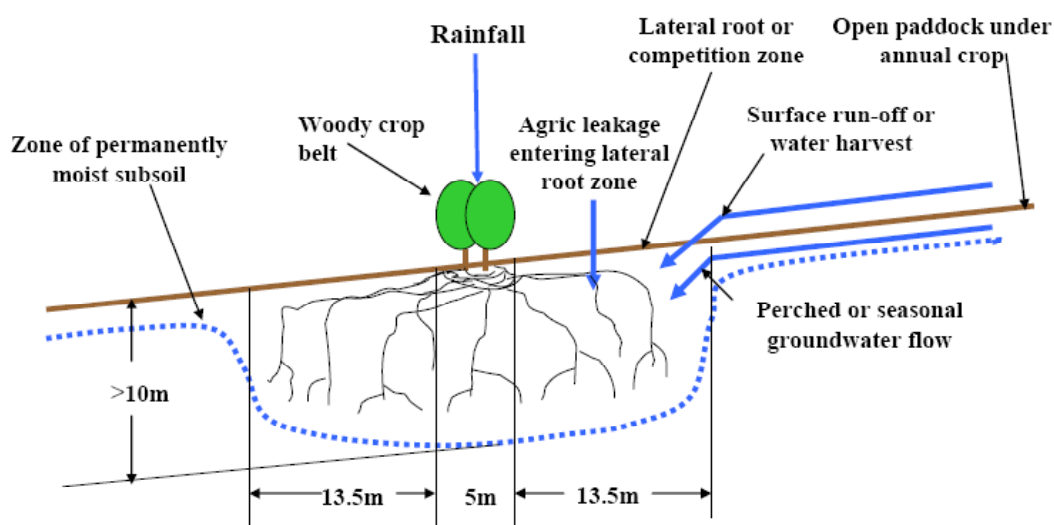
Processing industries are discussed in more detail in Section 3 of this report. The promise of industry development has provided impetus for mallee establishment. There have been two particular initiatives that indicate the response of growers to commercial signals.

- A commercial feasibility investigation undertaken by Enecon Pty Ltd (2001) led to the establishment of a 20%-scale (1 MW) demonstration plant at Narrogin for the production of mallee oil, activated carbon and electricity. The demonstration plant operated for a period in 2006. It generated a large volume of operational and product data and Verve Energy continues planning to build the first full scale (5 W) IWP plant. The emergence of this prospect initially stimulated mallee planting but slow and uncertain subsequent development of a plant dampened the confidence of potential growers. The prospect of new renewable energy targets being established by State and Commonwealth Governments (see Section 3.3.3) is now leading to renewed interest from potential growers and investors.
- A bioelectricity project was proposed by Metasource Pty Ltd (a wholly owned subsidiary of Woodside Petroleum) during the period 2000-2002. The project was to be established in the Esperance region and Metasource planted one million mallee seedlings during 2001. However, Metasource's tender for the electricity supply contract failed when the State Government decided instead to extend the gas pipeline from Kalgoorlie. These plantings now constitute the bulk of the oil mallee resource in the Esperance region.

Improved agricultural productivity

Mallees are readily combined with large scale annual cropping (Bartle et al 2007). However, to make a real contribution to improving agricultural productivity mallees have to be complementary to, not just compatible with, annual plant agriculture. Although water is the most limiting resource in agriculture, annual plant systems allow a proportion of rainfall to run-off or infiltrate below root zones and to be lost from production, leading to rising water tables and dryland salinity. A real complementary role for mallee is achieved when some of this water is captured. Carefully designed narrow belts of deep rooted perennials like mallee are used for this purpose. Robinson et al (2006) and Sudmeyer and Goodreid (2007) have shown that mallee belts develop a broad (up to 20 m either side) and deep (beyond 10m) zone of dewatered soil that can theoretically be used as a sink for lateral flows and leakage from the adjacent annual plant agriculture (Figure 2-1).

Figure 2-1: Water capture by mallees



Source: Huxtable and Bartle (2007)

In the evaluation of mallee performance the interactions between mallee belts and adjacent annuals must be taken into account. The strong lateral root systems of mallee in belts impose competition on adjacent crop or pasture as observed by Sudmeyer et al (2002) for pine. Cooper et al (2005) developed a method to assess the positive and negative impacts of mallee roots on the competition zone, i.e. the positive effect of intercepting leakage below the annual plant root depth and the negative effect of suppression of crop yield. Current research aims to provide further data on each of these effects. The negative impact of competition will vary with mallee species, soil type, rainfall and other factors such as the harvest regime. In combination, these factors determine the width and intensity of competition imposed on the adjacent crop or pasture. It may be possible to manage such competition in the short term by root ripping along the perimeter of the mallees but this will reduce mallee yield. These effects will need to be quantified and included in economic analysis as proposed by Cooper et al (2005).

Mallee belts can also provide a shelter belt effect, where the barrier to wind can reduce wind erosion, and improve crop and stock performance. Farmers report that this effect is useful in some situations such as on the highly erodible wodgil sands of the central and northern Wheatbelt. Analysis of shelter benefits shows that significant wind events are intermittent and the benefit on average may be small (Sudmeyer et al 2002). However, benefits such as those provided in the Northern Wheatbelt are likely to become increasingly important as climate variability increases.

Natural resource management

Revegetation of the landscape with deep-rooted plants has been one of the primary mechanisms identified to control the effects of salinity. Salinity is caused by the broad scale replacement of perennial native vegetation with short term annual agricultural crops, resulting in an increase in recharge and a rise in groundwater tables. Vast areas of WA's agricultural land have been damaged by salinity.

The WA Government has strongly promoted revegetation including the development of potentially commercial species like mallees. The value of revegetation in alleviating salinity has long been contentious (George et al 1999, Bartle 1999). Recently Bennett and George (2008) reviewed the impact of conventional forestry species on groundwater behaviour in areas with rainfall greater than 500 mm per annum. It was found that plantings had a modest impact on groundwater levels in the upslope recharge area and little impact on down slope groundwater level or discharge area, regardless of the area planted. The authors concluded that less than 50% revegetation is unlikely to result in significant, measurable on-farm salinity benefits.

The results are consistent with observations from the 1980s that less than 30% of agricultural development in forested water catchments could activate salt discharge on a scale that is able to compromise the water quality of whole river systems (Schofield et al 1988). Hence the criteria for assessment of benefit (groundwater depth and area of discharge) used by Bennett and George (2008) are too narrow. In particular, it is clear that recharge planting can reduce volume of recharge and run-off water, thereby making discharge areas more amenable to, and potentially reduce the costs of, other forms of intervention to achieve both on-farm and off-farm benefits.

Mallee plantings can also contribute significantly to regional biodiversity objectives, because the species used are predominantly natives and they improve habitat connectivity if they are appropriately located in the landscape. A recent survey of biodiversity in mallee plantings in the WA Wheatbelt found that a wide variety of birds, mammals, reptiles, amphibians and invertebrates use the plantings for food and as habitat (Smith 2006).

Carbon sequestration

Carbon markets have emerged as a new source of investment in mallee plantings. Through the process of photosynthesis, plants remove carbon dioxide (CO₂) from the atmosphere and store it in the plant tissue. In this way, trees are said to act as carbon 'sinks' and can play a role in the mitigation of global climate change. Mallees are well suited for inclusion in carbon sequestration projects because they exhibit the following characteristics:

- relatively fast growth/carbon sequestration rates on areas that are marginal for other commercial tree plantings and used extensively for agriculture (Shea 2003)
- long lifespan, individuals in natural mallee populations have survived and been utilised for production for over 100 years (Wickens 1998)
- large root system capable of continuing to store carbon underground, even if aboveground biomass is harvested
- ability to regenerate after fire and harvesting by re-shooting of foliage (coppice) from the trunk and lignotuber (Bartle et al 2007).

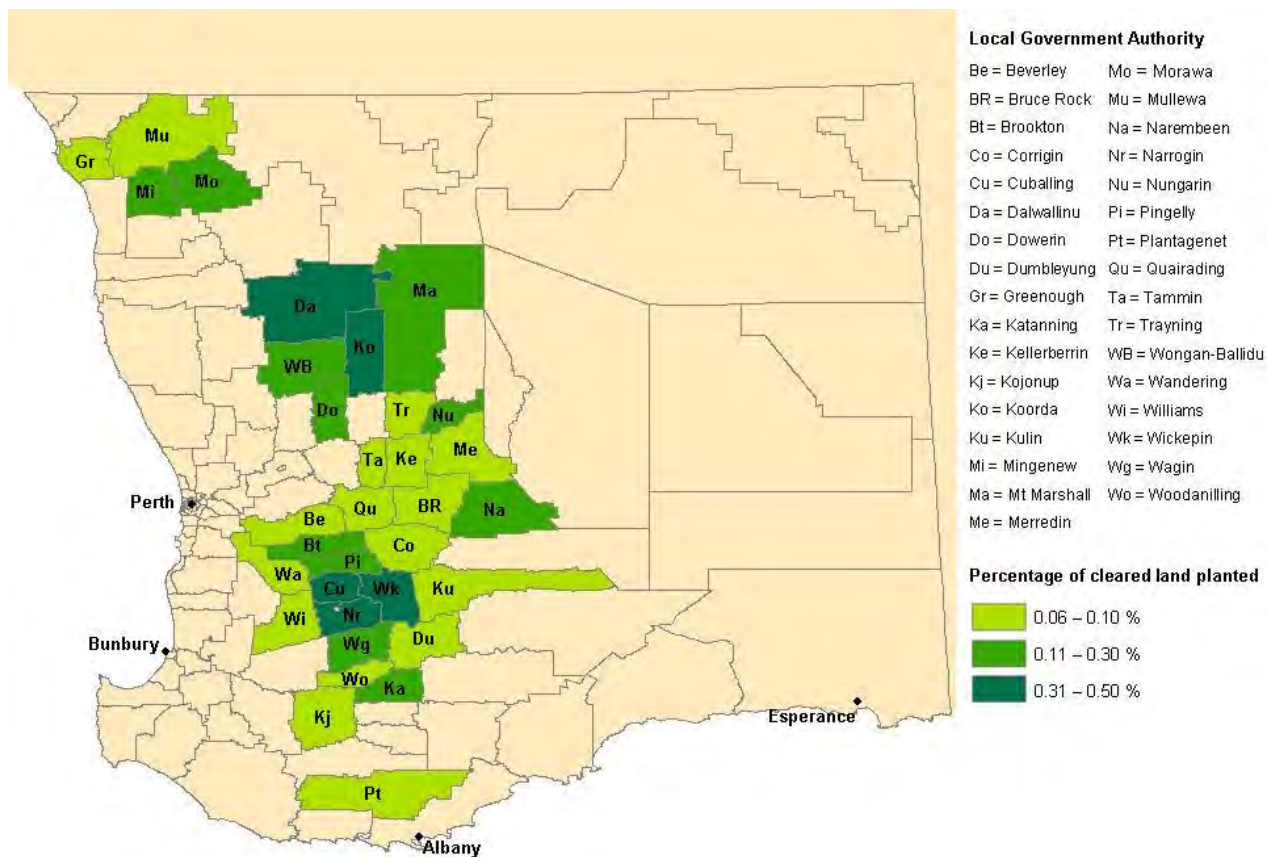
Significant investment into mallee plantings for carbon sequestration in WA began in 2003, when the OMC established 1,000 ha of plantings across 24 farms for voluntary offsets purchased by a Japanese power producer, General Environmental Technos Co Ltd (previously

Kansai). The OMC has since established a joint venture with CO2 Australia Limited to further industry investment in mallee plantings for carbon offsets. Issues and policy associated with carbon trading are discussed in Section 3.7.

2.2 The current resource

Since the early 1990s, there has been substantial expansion in the area of plantings in WA. Figure 2-2 shows the concentration of mallee plantings by local government region and the area planted by region is shown in Appendix B.

Figure 2-2: Concentration of oil mallee plantings, 2007



Source: OMA. Map prepared by URS

Table 2-1 shows that almost 13,000 ha has been established and approximately 25 million mallee trees planted. Eight different species and subspecies have been utilised and these are summarised in Table 2-2. The different species are suited to particular soil types (Bartle 2006). All species occur naturally in WA except for *Eucalyptus polybractea* which originates from New South Wales.

Table 2-1: Number and area of mallee plantings in WA, 1988-2008

Year planted	No. trees planted	Hectares (using 2,000 stems per ha)
1988	20,000	10
1992	29,980	15
1993	22,175	11
1994	784,691	392
1995	1,992,628	996
1996	2,292,748	1,146
1997	909,083	455
1998	1,438,022	719
1999	2,552,778	1,276
2000	4,084,486	2,042
2001	2,217,364	1,109
2002	995,954	498
2003	2,550,119	1,275
2004	980,700	490
2005	775,080	388
2006	1,870,771	935
2007	2,036,530	1,018
TOTAL	25,553,109	12,777

Source: OMA

Table 2-2: Mallee species used for plantings in WA

Species	Proportion of total trees established (%)
<i>Eucalyptus loxophleba</i> subsp. <i>lissophloia</i>	39%
<i>Eucalyptus kochii</i> subsp. <i>plenissima</i>	23%
<i>Eucalyptus kochii</i> subsp. <i>borealis</i> *	18%
<i>Eucalyptus loxophleba</i> subsp. <i>gratae</i>	8%
<i>Eucalyptus polybractea</i>	8%
<i>Eucalyptus kochii</i> subsp. <i>kochii</i>	2%
<i>Eucalyptus myriadena</i>	1%
<i>Eucalyptus angustissima</i> subsp. <i>angustissima</i>	1%
Total	100%

* Formerly *Eucalyptus horistes*

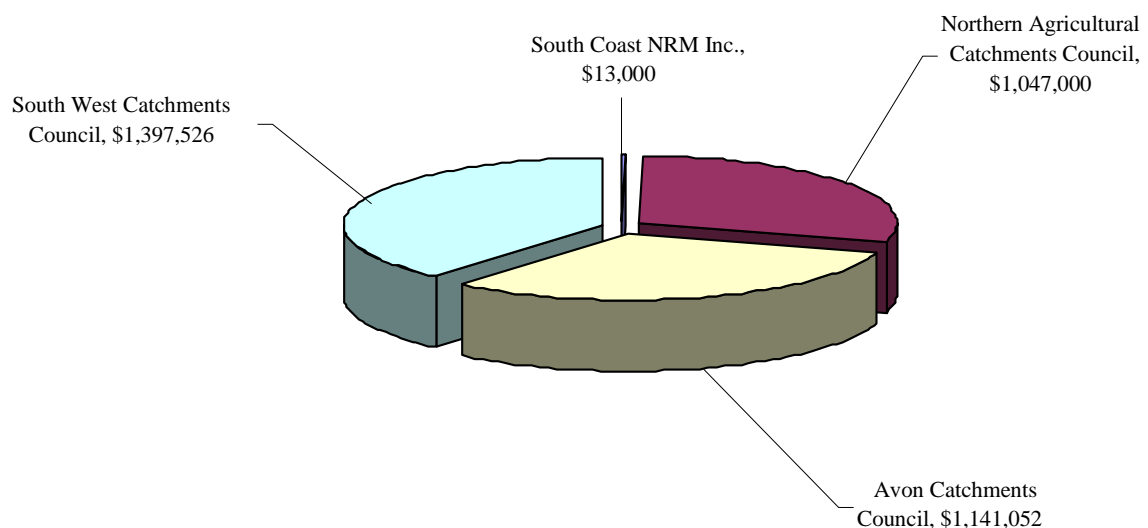
Source: OMA

2.3 Stakeholders in WA

The primary stakeholders involved with development of the mallee resource in WA are briefly discussed below.

- **The Oil Mallee Association (OMA)** is the peak industry body for the oil mallee industry, representing growers and industry participants and has been coordinating oil mallee industry development activities in WA for the past 13 years. The OMA is currently delivering a range of projects in partnership with NRM funding programs including resource building, extension, education and developing quality management systems. The OMA has recently held the inaugural National Oil Mallee Conference in WA (March 2008) and is currently developing a national approach for the industry. The OMA represents the majority of growers and currently has a grower base of over 1,200 oil mallee growers in WA and functions to promote and disseminate relevant information amongst its members, and other stakeholders. The OMA maintains strategic links with industry stakeholders.
- **The Oil Mallee Company (OMC)** has undertaken a key role in facilitating the growth and development of the oil mallee industry since 1997.
- **Natural resource management (NRM)** groups work in partnership with government, regional organisations, industry, landowners, researchers, environmental and community groups. The community-based groups are responsible for delivering the NAP and NHT programs throughout WA and have been engaged in developing long-term regional strategies and investment plans in consultation with their regional stakeholders. There are four NRM groups in WA that have an interest in the various benefits of mallee plantings. Figure 2-3 shows that the Commonwealth and State Governments have made a significant financial contribution towards the industry through these groups since 2005.

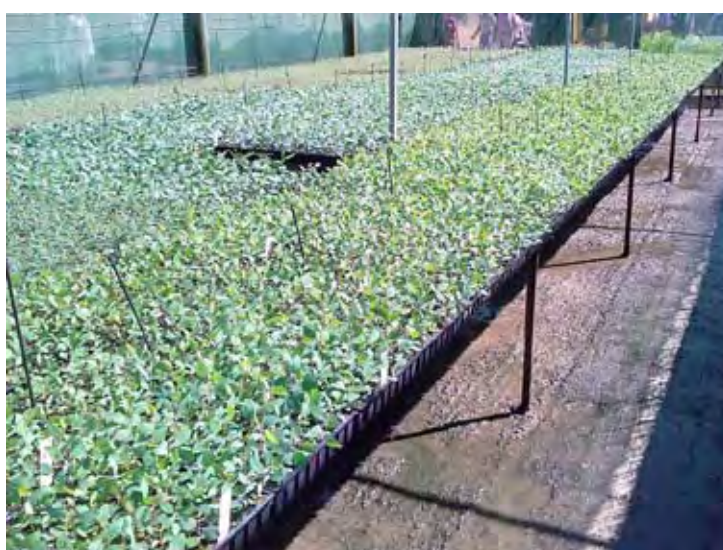
Figure 2-3: Public investment into the WA mallee industry through NRM groups, July 2005 to June 2008



Source: OMA

- **Private Forestry Development Committees (PFDCs)** help to facilitate the development of industries based on tree crops and mallees have the greatest potential for wide-scale integration and adoption in the agricultural region. The PFDCs work closely with NRM groups to help ensure that tree crops meet their NRM needs while building up the resources to supply new industries. As such PFDCs have an important role in linking tree crop opportunities and the community.
- **The State Government** has also played a key role in the establishment of the industry. For many years the WA State Government has supported tree farm development, primarily under the auspices of the Department of Environment and Conservation (DEC) and the FPC (both previously CALM); and the Department of Agriculture and Food WA (DAFWA). The majority of plantings since 1994 have been co-funded by State and Commonwealth Government grants and the farming community (OMC, 2007).
- **The State Government** also plays a key role in research and development related to oil mallee plantings and the production industry. This research is supported by research bodies such as the Future Farm Industries Cooperative Research Centre (FFI CRC) (formerly the CRC for Plant-based Management of Dryland Salinity (CRC PBMS)); and the Joint Venture Agroforestry Program (JVAP).
- **Private investment groups** have had an increasing role in the establishment of mallees and this contribution is expected to increase, particular as opportunities to earn income from carbon trading or processing industries are realised. The single greatest private investment thus far has been the project initiated by General Environmental Technos Co Ltd. Further investment is expected during 2008 by CO2 Australia, which is currently the largest single shareholder of the OMC and functions to attract and establish investors in mallee plantings for carbon sequestration. Other investment groups are also emerging to capitalise on the opportunities presented by carbon sequestration.
- Since the industry commenced, nine locally owned **nurseries** have been set up throughout the Wheatbelt, supplying seedlings (Plate 2-1) to local farmers.

Plate 2-1: Seedlings at Kalannie Tree Supplies



2.4 Planting design and water use

A *Code of Practice for Tree Plantations in Western Australia* (FIFWA, AFG and FPC 2006) has been developed that provides goals and guidelines for managers so that operations are conducted in accordance with principles of good forest management, while also recognising that the primary aim of tree farms is to be economically competitive and sustainable. A *Mallee Cropping Code of Practice* (OMA 2003) is also available that has similar objectives, but is specific to mallee crops.

Increasing knowledge about the way in which mallees use water has led to an understanding that productivity will be enhanced by planting in narrow belts. Belts increase the interface with adjacent agriculture where the competition effect of the lateral root zone provides a net benefit through increasing total water use. Also the layout of belts can be designed to capture intermittent lateral flows of surface or shallow sub-surface water after peak rainfall events. Block plantings will not enable the same benefits to be concentrated in the area planted and will have significantly reduced productivity per unit area planted.

Plate 2-2: Examples of mallee belts



Belt plantings were originally established with stockings as high as 2,600 stems per hectare (spha), but rates of establishment as low as 1,600 spha may maintain the same productivity per unit area planted, while reducing the costs of establishment and harvesting. The most common belt configuration has been four row belts with a width of 2 metres between rows. The effective belt width to the drip line of the trees under this configuration is 10 metres⁷. The distance between mallee belts allows integration with agricultural practices and typical farm plans have the belts 40-100 m apart, depending upon farm machinery requirements.

Water availability can be influenced by planting design and research is being conducted to investigate optimal planting regimes for mallee plantings (Eastham et al 1993, Milthorpe et al 1998, Okimori et al 2003, Siberstein 2002, Smith 2006, Cooper et al 2005). Current analysis by DEC (Bartle, pers comm) shows that the effectiveness of mallee in water use means that economic factors will push down planting density and row number. It appears likely that a two row or even a one row belt may be the economic optimum from the biomass yield perspective, but other considerations like operational efficiency, cost, aesthetics or shelter benefit may work against this. Mallee water use effectiveness will also push design of belt layout into configurations that will facilitate better interception of lateral water flows.

7 This width meets Australia's current definition of Kyoto compliant forests under Article 3.3 of the Kyoto Protocol

2.5 Harvest yields

The rate of growth of mallee plantings is affected by a number of variables. Apart from species and provenance, all of the factors are linked to water availability. These variables include climate (rainfall, temperature and evaporation); soil (depth, type and structure); and the quality of site preparation and management – particularly weed and pest control.

Huxtable and Bartle (2007) describe two types of yield models:

- process models which simulate physical and biological processes to predict yield at a specified location
- empirical models where sufficient data on site attributes and actual growth performance are correlated.

Until recently, most estimates of mallee productivity have been made using a process model developed by Cooper et al (2005). The model was developed based on water availability and water use efficiency research (see Wildy et al 2003, 2004) to provide an estimate of the potential scale of biomass production by region, rainfall zone or transport horizons.

A major project was initiated in 2005 that was funded by the JVAP, Avon Catchment Council, DEC, DAFWA, OMA and the former Co-operative Research Centre for Plant-based Management of Dryland Salinity (CRC PBMS) to establish a long-term study on season and frequency of harvest across a representative range of soils and climates. To date the first of a series of harvest data collections has been completed (Huxtable and Bartle 2007) and this data constitutes important empirical information on productivity.

Comparisons of empirical data and the process model developed by Cooper et al (2005) indicate that the model is overestimating production for all of the sites that have been studied by more than 50%. Huxtable and Bartle (2007) report that actual yields of above ground biomass range from 5-10 bdmt⁸/ha/annum based on measurements at ages 7 to 11 years. Using these growth increments to adjust outcomes from Cooper et al (2005), Huxtable and Bartle (2007) suggest that productivity will lie in the range 5-15 bdmt/ha/annum over the rainfall range 350-550 mm pa. It should be noted that these yields have been standardised such that they are based on two row belts (ie where four row belts have been established only the two outer rows have been included in the productivity estimates). If a given area is to be established using four row belts the overall productivity is expected to be around 25% lower and block plantings may only achieve 30-50% of the productivity of two row belts over the area planted. This is shown diagrammatically in Figure 2-4.

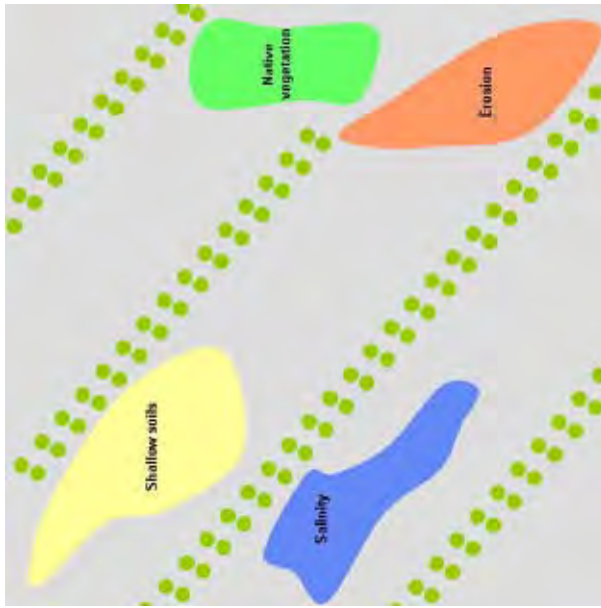
The total area of cleared land in each rainfall zone has been reported by Bartle et al (2007). Cooper et al (2005) describe a process for identifying the area of suitable soils by deducting the following areas from the total available area of cleared land:

- buildings, yards, farm tracks, pockets of remnant vegetation — the total area reduction from these land uses is estimated to be 10%
- soils affected by salinity, waterlogging or with a shallow hardpan or bedrock
- shallow duplex soils.

8 Bone dry metric tonnes

The results of this analysis are presented in Bartle et al (2007), which reports the area of suitable soils to typically be 50% of the total cleared area in the WA Wheatbelt. The productivity of the area planted to trees will then be determined by the planting configuration (e.g. two row, four row, blocks) and the percentage of the suitable soils planted. Productivity from subsequent coppice crops will be strongly influenced by the season and frequency of harvest (Huxtable and Bartle 2007). Few mallee crops have been harvested and coppiced as yet and so a project to test the impact of season and frequency of harvest on coppice yield, and to define the competition zone effects on adjacent crop, was commenced in 2005. It is anticipated that the series of experiments in this project will become the major source of data to improve yield prediction and guide economic analysis.

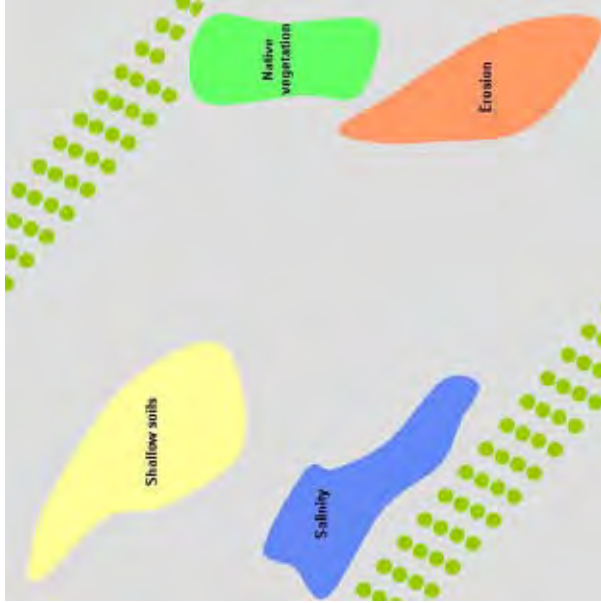
Figure 2-4: Examples of mallee planting configurations and yields



Two row belts

Assuming 7 bdm/ha/annum of growth, yield at age 5 is expected to be:

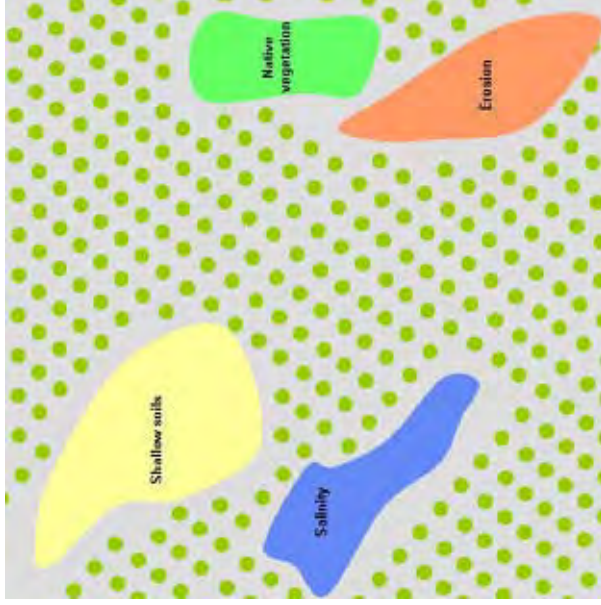
- 35 bdm/ha net hectare planted
- 1.75 bdm/ha gross (paddock) hectare, assuming 50% of soils suitable and 10% of suitable soils planted.



Four row belts

Assuming 5.25 bdm/ha/annum of growth (75% of two row productivity), yield at age 5 is expected to be:

- 26.25 bdm/ha net hectare planted
- 1.3 bdm/ha gross (paddock) hectare, assuming 50% of soils suitable and 10% of suitable soils planted.



Block planting

Assuming 2.8 bdm/ha/annum of growth (40% of two row productivity), yield at age 5 is expected to be:

- 14 bdm/ha net hectare planted
- 7 bdm/ha gross (paddock) hectare, assuming 50% of soils suitable and all suitable soils planted.

Table 2-3 provides an indication of productivity, land availability and potential areas of plantings that could be attained in the WA Wheatbelt. In this example two row belts are assumed. The area that can actually be planted to trees (within the suitable 50% of soils) to achieve the target productivity based on two row belts is then in the range of 5 to 15% across the rainfall range from ~300 to 600 mm/year. This provides the belts with enough potential extra water through lateral flows to achieve the target productivity (Bartle, pers. comm.). Greater areas could be planted either as belts or blocks, but adjustments to productivity would need to be made that are commensurate with the area planted. Estimates such as the ones in Table 2-3 are important when determining the area that would need to be planted to service an industrial process of a particular scale.

Table 2-3: Estimated areas and growth rate potential of plantings by rainfall zone

Rainfall zone	Total available area¹	Total suitable area²	Average growth rate aboveground from two row belt³	Potential tree crop area assuming 10% of suitable area planted
(mm pa)	(M ha)	(M ha)	(gmt/ha pa)	(ha)
300-400	10.9	5.5	8.6	545,000
401-500	3.8	1.9	12.1	190,000
501-600	1.9	1.0	15.5	95,000
Total	16.6	8.3		830,000

Sources: 1. Bartle *et al* (2007a)

2. Cooper *et al* (2005); Bartle *et al* (2007).

3. J. Bartle pers comm (2008). Growth increments to age 7 to 11 only. Estimates converted from bdmt to gmt assuming 42% moisture content of green biomass

2.6 Research and development

Mallee cropping on the scale envisaged for industrial biomass feedstock supply was an entirely new concept when it was initiated in WA in the early 1990s. A major R&D investment was required to establish a knowledge base including species selection, agronomic practices and production systems. CALM was the major provider during the 1990s but with good support provided through Commonwealth landcare programs, other state programs, the NRM councils and the Rural Industries R&D Corporation (RIRDC). More recently the CRC PBMS made a significant contribution and its successor the FFI CRC now coordinates most mallee R&D. Good progress has been made but much remains to be done. Major areas of research include:

- **Mallee species selection and genetic improvement:** The most competitive species of mallee have now been identified and CALM has conducted intensive selection for elite trees from the full range of natural populations of the major species listed in Table 2-2. These were tested in progeny trials and the superior germplasm has been included in breeding populations. Progeny trials have now been culled to become seed orchards. A large volume of orchard seed is now available for most species. The FFI CRC has established a woody crop breeding program that will support this early work.

- **Agronomy and productivity of mallee crops:** Most of the development of establishment and management techniques was undertaken by growers and information was pooled through the OMA. Through the diversity of planting it became apparent that the major factor in yield was availability of water to the mallee crop and this was well supported by research results (see Section 2.1 and Figure 2-1). The FFI CRC has initiated a project to clarify the extent to which additional water might be made available to mallees through both passive and active water harvest techniques. This will also involve prediction of the extra yield that might be achieved by applying these techniques. Harvest itself will have a strong influence on yield. RIRDC and the Avon Catchment Council have sponsored DEC and the Department of Agriculture and Food WA (DAFWA) on a major long term project to test the impact of the season and frequency of harvest on yield⁹. This project will be an important source of empirical yield data for calibration and validation of growth models.
- Attention to possible threats from **pests and diseases** needs to be maintained. Spring beetle damage to young coppice is likely to be a high priority in this area.
- **Sheep grazing** management practices in the period of early coppice regeneration will need to be investigated to determine whether a withholding period is necessary.
- **Nutrient removal** in harvested biomass may be significant and management practices designed to maintain nutrient supply and achieve yield potential may need to be developed.
- Dr Hongwei Wu at Curtin University leads a group doing research on biomass properties in relation to **energy conversion technologies**. This is an important area, for example, the nutrient content of biomass is likely to be important in combustion where it can contribute to slagging in furnaces.
- **Integrating desirable agronomic practices** for the mallee crop into systems that complement with other farm activities and objectives will be a major challenge. For example, surface water management, farm water supply and precision agriculture all reduce the degrees of freedom in designing systems incorporating mallee. Design and assessment of such systems will require a strong Geographic Information Systems analysis capability.
- Mallee crops even in the form of narrow belts can make a contribution to **biodiversity protection** in farmland, but practices to maximise these benefits need further study.
- FFI CRC has pulled together the long standing **mallee harvester development** interests into a new coordinated project. It hopes to bring 'critical mass' to this project and thereby attract the large amount of funds required to undertake the complex design and engineering work to build an operational prototype.
- There are now sufficient data and a favourable market outlook such that it is appropriate for FFI CRC to construct a **biomass supply model**. This will incorporate current R&D results and provide a tool for feasibility assessment and research priority allocation. It will focus on project and farm level analysis.

In addition to this work, a number of commercial organisations are also undertaking their own research on commercial-in-confidence basis.

9 Previous work in this area has been completed by Wildy (2003)

3. Uses and potential products

Mallees have formed the basis of a processing industry in Australia for over 100 years as a result of their historic natural abundance and yield of high quality eucalyptus oil (Bartle and Shea 2003). It has also been recognised for a number of years that mallees may provide a source of woody biomass that can be used for generation of electricity. In the early stages of industry development in WA, commercial drivers were such that neither oil production nor electricity generation could be commercially viable industries on their own (Groves et al. 2007, Enecon 2001) and alternative means were required for gaining additional value from the resource. To make a mallee industry viable, it was considered that multiple products would be required and that these could be produced through development of innovative new production processes.

Integrated wood processing (IWP) was considered as a production option in order to develop a more competitive method of energy production and because the requirements of the Renewable Energy Credit (REC) scheme of the time required that renewable energy needed to be sourced from waste streams and not from dedicated energy crops¹⁰. By 2006 a trial plant (1 MW) at 20% of full commercial scale (5 MW) was constructed by Western Power¹¹ at Narrogin in WA to conduct operational testing and process refinement. The plant utilised resource that was located over a wide area and was harvested by the OMC. During extensive trials a number of key performance milestones were met and Verve Energy is now investigating the potential to build and operate a larger plant. The success of such a plant will be determined by the optimal use of the technical data gathered during trials at the Narrogin plant and also by the value of RECs and markets for the eucalyptus oil and activated carbon that is produced.

The potential scale of the mallee resource is such that a range of additional markets should be considered as either stand alone industries or as part of an integrated production process. These products include:

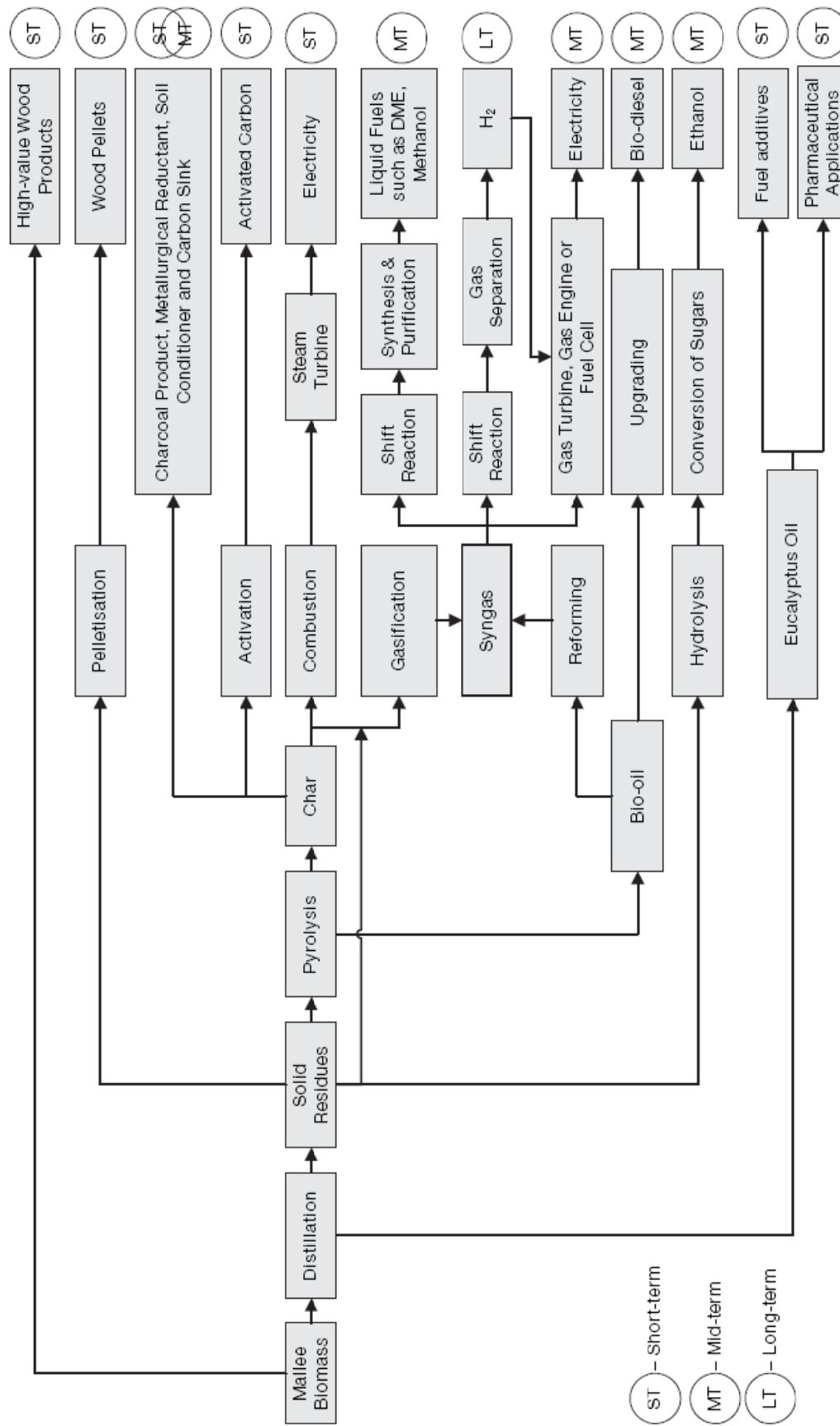
- existing products: eucalyptus oil, composite wood products (eg MDF, fibre cement), bioenergy, wood pellets for bioenergy and activated carbon
- emerging products: lignocellulosic ethanol, biomass to other liquid fuels and chemicals, bio-oil, biochar and industrial charcoal.

Figure 3-1 shows the various options for biomass utilisation and these options are discussed further in this section of the IDP. The full mallee supply chain is shown diagrammatically in Appendix A.

10 Subsequent amendments to the *Renewable Energy (Electricity) Act 2000* allow the production of RECs from dedicated energy crops

11 This part of Western Power is now Verve Energy

Figure 3-1: Technical options for mallee biomass utilisation



Source: Wu et al (2006)

3.1 Eucalyptus oil

Eucalyptus oil is an essential oil complex found in the leaves of *Eucalyptus* trees. The quantity and strength of oil varies across eucalypt species. Mallee oil has been shown to produce a relatively high yield of cineole (or 1, 8-cineole), which has chemical and physical properties that make it suitable for a range of applications.

Eucalyptus oil is used throughout the world mostly as an ingredient in general pharmacy products (eg liniments, inhalents, expectorants) and as a flavour and aroma enhancer in domestic food and cleaning products. Aside from cineole, eucalyptus oil also contains a complex mixture of constituent chemical compounds, some of which have an existing market value and others which hold market potential for various applications (provided they can be extracted at suitable quality and cost). Eucalyptus oil has recently been analysed for potentially valuable bioactive compounds that may hold potential for pharmaceutical applications (Foley & Lassek 2006; Dumsday et al 2007).

There are strong precedents to the use of naturally occurring terpenes (such as those found in eucalyptus oil) as industrial solvents and cleaners. The terpene d-limeone is currently extracted from the peel that is generated by the orange processing industry worldwide. It has been taken up by many speciality groups in a similar way to the current boutique markets for eucalyptus oil. It is also being used as an ingredient in cleaners that are produced in bulk for industrial use.

There are a large number of eucalyptus oil growers and producers around Australia many of which operate on a small scale. GR Davis Pty Ltd is the largest company engaged in mallee oil production in NSW and currently utilises plantings of *E. polybractea* established near West Wyalong in western NSW. The largest producer of eucalyptus oil in Victoria is Felton Grimwade and Bickford (FGB). FGB currently produces high grade oil from 5,000 ha of native *E. polybractea* forest near Bendigo (FFB, 2008).

In Western Australia, Kalannie Distillers was established in 2000 and the company now harvests and distills eucalyptus oil in the Central Wheatbelt. The mallees are mechanically harvested and the resultant leafy biomass is steam distilled on growers' properties using a purpose built still. The eucalyptus oil is bottled and packaged in Kalannie.

Market overview

There is very little long term data publicly available on the eucalyptus oil market. There is often a complex supply chain that makes eucalyptus oil difficult to account for in international trade data. The industry is characterised by a significant amount of processing and re-processing, as well as international imports and re-exports of the products.

Global consumption of eucalyptus oil is currently estimated to be around 7,000 tonnes pa (Pain 2006). The European Union (EU) is reported to be the largest source of demand worldwide, accounting for around 5,000 tonnes pa. The United States (US) is also a major importer of eucalyptus oil, in 2005 importing 730 tonnes (Pain 2006). The US sources the majority of imported oil from China.

China is the world's largest producer of eucalyptus oil, predominantly as a by-product of the hardwood plantation timber industry. Because the oil is a by-product and China can utilise a relatively cheap labour market, this source of production is highly competitive. Brazil is also a producer of eucalyptus oil and is reported to export around 60 tonnes pa to the United States. Like China, production is generated as a by-product to hardwoods grown for an existing

industry – the pulp and paper industry. Portugal and Spain are also producers and processors of eucalyptus oil.

Australia produces between 100-200 tonnes of oil per annum (Pain 2006). However, the majority of Australia's eucalyptus oil consumption is based on imported oil. In 2005/06 there were approximately 130 tonnes of eucalyptus oil exported from Australia (Pain 2006).

In recent years the world price of eucalyptus oil has been relatively stable at around \$A4,500 to \$5,000 per tonne (Pain 2006). There is a price premium for Australian eucalyptus oil in the US market. This is reportedly a result of the higher quality of Australian oil compared to Chinese oil and this is likely to be a result of market specific production in Australia compared to China. The small size of the eucalyptus oil market means that a large increase in supply volume may act to lower world price.

Annual world production of the terpenes that are extracted from orange peel is estimated to be approximately 70,000 tonnes per year¹², and selling price for D-limonene (the terpene produced in orange peel) is stated as between \$A1,000 to 2,000 per tonne¹³.

In addition to the mainstream eucalyptus oil market, the wide range of constituent compounds (eg pinene, terpinene, myrcene) contained in eucalyptus oil present numerous niche market opportunities for applications including flavouring, fragrance or for insecticides (Pain 2006). While markets for these compounds may only accept small volumes, if extracted at the right quality and cost they present an opportunity for diversifying supply across a range of markets.

Opportunities for mallees in WA

The eucalyptus oil market appears to be an attractive opportunity for an expanded mallee resource in WA. The reported high quality of oil produced from mallees and the existing supply channels, particularly to the US, provide a clear basis for market development. With ongoing research there may be opportunities to diversify supply into niche markets for a range of products, including for pharmaceutical and other applications.

However, the levels of eucalyptus oil that would be produced from large scale planting of mallees is many times the current world markets. New, large-scale uses for the oil will be needed. One use with significant potential is as an industrial solvent and cleaning agent.

3.2 Biofuel

Biofuel production is an emerging market for forest products. It involves the production of a liquid fuel from plant biomass for the purpose of transportation, heating or electrical power. There is currently strong interest in biofuels worldwide, largely as a solution to problems associated with fossil fuel use, including the effects on global climate and limitations in global oil supplies. However, there is also an emerging global debate on the issue of 'food vs fuel' and this debate provides opportunities for cellulosic biofuels, such as those produced from mallees (see Box 2-1). Figure 3-2 also shows the favourable energy balance resulting from the use of mallees versus other biomass feedstocks.

12 <http://www.emulso.com/store.asp?pid=11250>

13 <http://www.xethanol.com/media/stories/biomass-cover.htm>

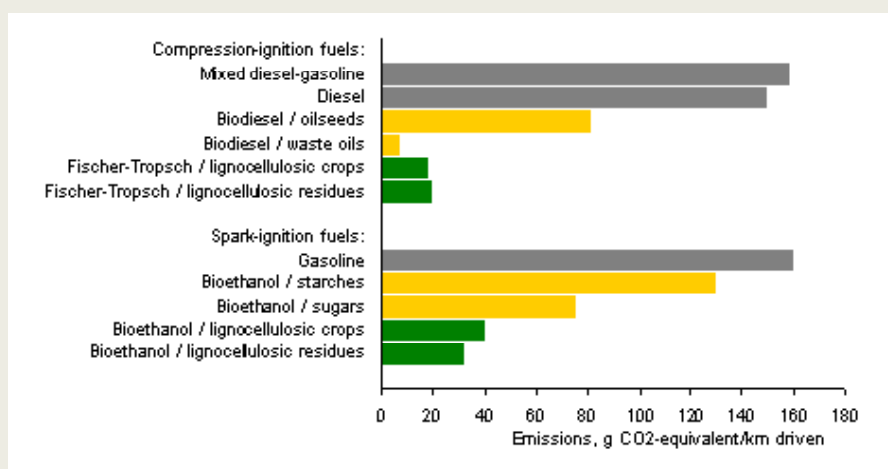
Box 3-1: Food versus fuel

There has been a recent rise in demand for feedstocks for biofuel production as nations have introduced mandates and goals for the use of renewable fuels, and associated subsidies. The rapid increase in production of liquid biofuels, principally from agricultural crops, has raised concerns about the impacts of biofuel production on food availability and rising food prices.

The Food and Agriculture Organisation of the United Nations predicted in 2007 that biofuel production under existing mandates would increase food costs by 10-15% towards 2010. Food commodity prices have risen by as much as 43% in the year that has passed since this prediction and the International Food Policy Research Institute in Washington suggests that biofuel production might account for 25-33% of the total increase food costs.

Non-food feedstocks offer several advantages over agricultural food crops and in many countries the development of second generation biofuels (like cellulosic ethanol or biomass-to-liquid technologies) forms a major component of biofuel strategies in the mid to long-term. Most studies agree that cellulosic ethanol is characterised by a much better energy balance and lower greenhouse gas emissions, in comparison to corn-based ethanol or petroleum fuels (see Figure 3-2).

The chart below shows that cellulosic ethanol would produce net emissions of about 38-42 g CO₂-e per km driven, compared to gasoline which would produce net emissions of about 170 g CO₂-e per km driven, bioethanol from corn at about 140 g, and bioethanol from sugarcane at about 80 g. Cellulosic (wood-based) bioethanol provides on average 4 times as much energy in the final product as is required to produce the liquid fuel, compared to corn (starch-based) bioethanol that provides only 1.3 times as much energy as is required to produce the fuel.

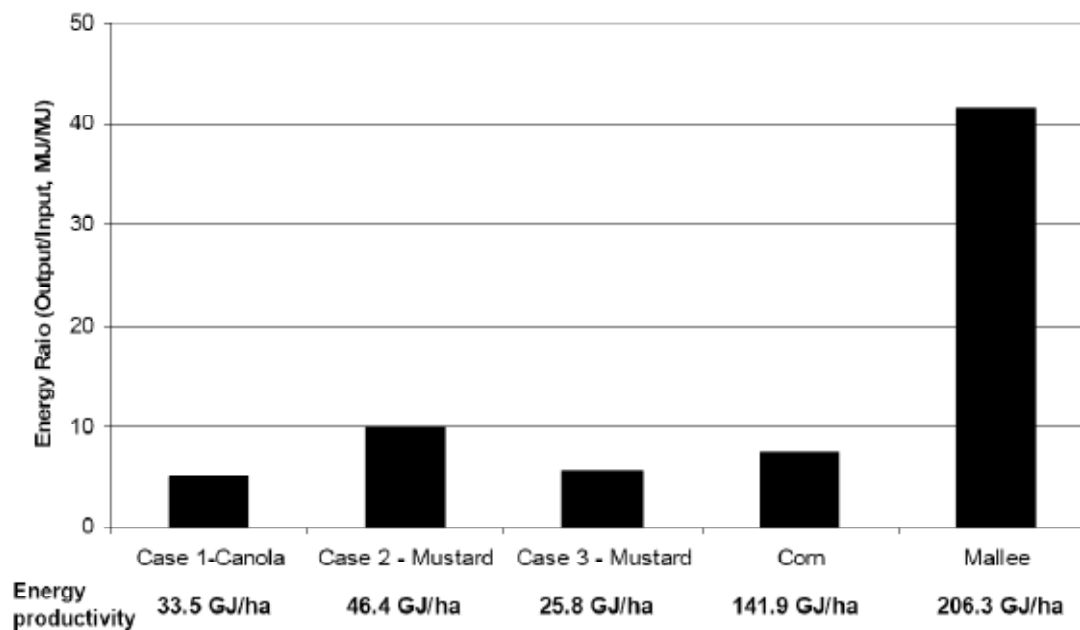


Comparing greenhouse gas emissions of biofuels and conventional fuels, using advanced (>2010) technologies for production and use (Spitzer et al 2006, VIEWLS 2005)

Many countries are already implementing strategies to reduce the impact that biofuels have on food prices, by supporting research and development to diversify the biofuel sector towards cellulosic biofuels. The benefits that cellulosic biofuels have over currently commercial biofuels represent a positive step towards sustainability in terms of both energy consumption and greenhouse gas emissions.

Source: IEA Bioenergy Task 39 Newsletter

Figure 3-2: Energy balance of biomass feed stocks



Source Wu et al 2007

The following discussion focuses on four specific biofuel products – lignocellulosic ethanol, biomass to liquid fuels, wood pellets, and bio-oil. The potential to use biomass in the production of bioelectricity is presented in Section 3.3.

3.2.1 Lignocellulosic ethanol

One of the most positive prospects for biofuel production from wood products is the production of ethanol through a second generation¹⁴ process termed ‘lignocellulosics’. Under this process, ethanol is produced by breaking down the cellulose and hemicellulose contained in biomass to isolate the component sugars. These sugars are then fermented and distilled to produce concentrated ethanol. The lignocellulosics process is yet to be commercialised anywhere in the world but is currently the topic of intense research and development. A number of multi-million dollar pilot plants have been operating in North America and Europe over the past ten years.

The US Biofuels Initiative is heavily investing in biofuels scale up and R&D over the next decade (www.energy.gov). This includes grants totalling \$US385 million towards for the development of 6 lignocellulosic ethanol production facilities at commercial scale.

Ethanol currently produced as a transport fuel is based on a first generation biofuel process using sugar cane or sugars derived from starchy plant feedstocks such as corn and various grains. Lignocellulosic ethanol presents some key advantages over the first generation process.

- Lignocellulose feedstocks are potentially a much cheaper source of feed material than sugar cane and grains
- The full life cycle analysis for ethanol from perennials is estimated to be significantly better than for ethanol production for sugarcane and starch crops (see Box 3-1 and Figure 3-2)

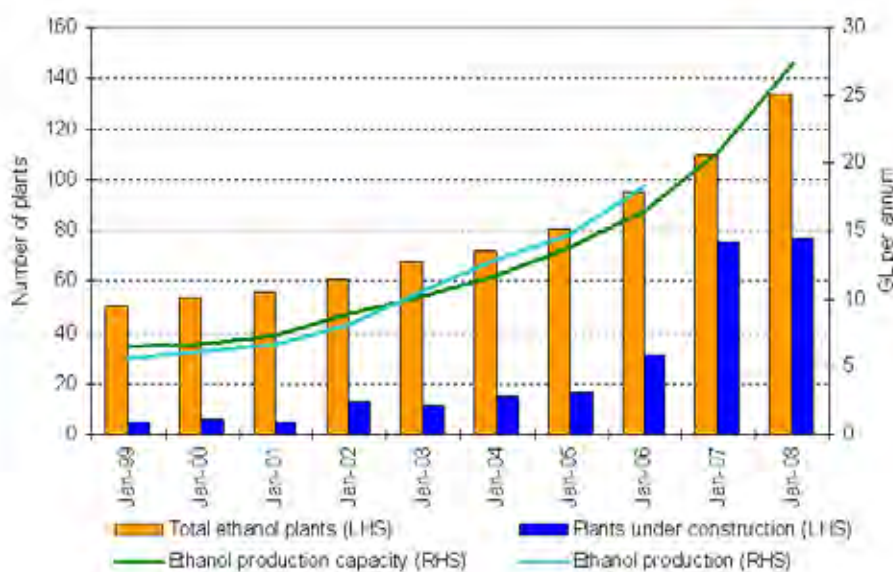
¹⁴ Second generation biofuels are generally considered as being produced from cellulose feedstocks including wood and perennial grasses. Production techniques have usually evolved from the production of first generation biofuels utilising direct sugars stored in plant biomass and also from the adaptation of technologies applied to make liquid fuels from coal and natural gas.

- The use of second generation feedstocks is less likely to compete with human and agricultural food markets. Recent rapid increases to global ethanol production (often based on government subsidies) have contributed to significantly increased world prices for basic food commodities (OECD/FAO 2007).

Market overview

Biofuel production world wide is currently based on first generation technologies and currently stands at over 37,000 megalitres (ML) pa, most of which is ethanol produced in Brazil (from sugar cane) and the US (from corn) (O’Connell et al. 2007). World production is growing fast as many developed countries invest heavily in supporting biofuel crops, and research and development into production processes. The US has seen the greatest level of growth in biofuels production which has been based on substantial government support (Figure 3-3).

Figure 3-3: Ethanol production and production capacity in the United States



Source: US Renewable Fuels Association

Prices for fuel ethanol have risen with demand over the past five years, showing proportionally larger increases over the past 12 months. The US wholesale price for ethanol at the start of April 2008 was \$US 2.65 per gallon for 100% ethanol. This compares against the equivalent price for conventional petrol over the same period of \$US 3.30 per gallon (www.DTN.com).

A 2002 study (Enecon 2002) indicated that the gap that needed to be made up in order for ethanol from biomass to be equivalent to petrol as a transport fuel was around 25 cents per litre. At the time of the study, crude oil prices were \$US 22 per barrel. With current (2008) prices at \$US 130 per barrel it is not surprising that ethanol is currently sold on the Australian retail fuel market as the product ‘E10’ – a blend of 10% ethanol and 90% unleaded petrol. Given current ethanol prices and government rebates, the E10 product provides a lower cost ‘petrol alternative’ to consumers.

Opportunities for mallees in WA

The Australian Government has introduced a policy to support investment in biofuels and has a target to increase biofuel production to 350 ML pa by 2010 (CIE 2005). The development of sustainable energy policies that support further growth could see continued support for biofuels including support for the introduction of second generation technologies.

Demand for clean transportation fuels is increasing worldwide and ethanol is emerging strongly as a new product. While there is a longer term opportunity for ethanol as a stand alone fuel for vehicles, the clearest market opportunity currently would be for mallee-fed lignocellulosic ethanol production for supplying blended E10 product. In this market, lignocellulosic ethanol would compete against alternative sources of ethanol supply.

There is currently no ethanol production capacity in WA however one or more large grain to ethanol plants have been publicly announced and may be built in the next few years. Such plants could potentially capture all of the WA market for an E10 blend and so WA based production of ethanol from mallee wood may need to look at export markets. The still developing production technology means that technology will not be commercially available for at least five years.

3.2.2 'Biomass to liquid' fuels

Biomass to liquid (BtL) fuels are also being researched internationally as a sustainable, alternative fuel for transportation. BtL fuels are produced through a two stage process where biomass is converted to hydrogen and carbon monoxide (termed 'syngas') through gasification at a high temperature. These gases can then be synthesised (using catalysts) into a range of fuel types including methanol, dimethyl ether (DME) and synthetic diesel. Unlike ethanol, synthetic diesel can be used as a stand-alone fuel.

Similar gasification and synthesis technologies already use coal or natural gas as feed stock in a number of countries. A recently completed plant in Germany by Choren will be the world's first demonstration scale production plant producing synthetic diesel from biomass (Enecon 2007). Successful operation of this plant over the next couple of years will hopefully lead to the development of full scale plants, initially in Germany and then overseas.

Market overview

The Australian diesel market is around 18 billion litres per annum. Because diesel engines are more fuel efficient than petrol engines there has been a trend of increasing usage of diesel powered vehicles in Australia. However, as demand has increased, diesel prices have increased at a faster rate than petrol prices.

Due to the size of the diesel market, synthetic diesel produced from woody biomass will need to be competitive with the current market price as the dominance of the existing supply will set the price. Sustained increases to oil prices may make BtL production a gradually more viable option.

Opportunities for mallees in WA

The market for diesel in Australia is growing and there is a clear market opportunity for producing synthetic diesel from woody biomass. Due to the strength of the international oil market, a WA based production facility will need to produce synthetic diesel that can be competitive with the market price for diesel, taking into account any carbon credits that are available for such fuels under future legislation. Production technologies for synthetic diesel are currently the barrier to competitively supplying the WA diesel market and initiatives such as the plant by Choren in Germany should be monitored.

3.2.3 Wood pellets

Wood pellets are a standardised form of wood bioenergy produced by grinding wood material into small particles, then compressing the material through a perforated matrix which acts to heat and bind the wood together. Because wood pellets only require low quality wood they can be produced from forestry and wood product processing residues. Wood pellets have higher bulk density, and therefore higher energy content per unit volume than woodchips. As such, they represent a cost effective method of transporting woody biomass over long distances.

Wood pellets produce energy through combustion where they are clean burning and generally achieve 96% efficiency (Enecon 2007). Wood pellets can be used for heating (either domestically or on a district/community level) or for industrial electricity generation, as is common in northern Europe.

Market overview

The strong, policy driven incentives created in the EU for bioenergy have increased demand for wood feedstocks, particularly wood pellets which meet a standardised volume and energy content. At present, the principal markets for wood pellets are EU countries (particularly Sweden, Denmark, Germany and Austria), Canada and the United States. Japan is emerging as a potential market. The market in Australia is small and limited to niche opportunities for domestic heating in the coldest parts of the country.

At present bioenergy accounts for around 4% of the EU's energy supply and wood pellets form a significant and increasing proportion of this supply. For example, Austria's wood pellet output grew from 15,000 tonnes in 1996 to around 520,000 tonnes in 2005 (Enecon 2007). Although imported wood pellets are accounting for an increasing portion of supply, EU production capacity has risen strongly alongside supply. Since 2005, Germany has doubled its wood pellet production capacity to around 940,000 tonnes per annum.

The production from around 60 pellet mills in the US is reported to be capable of supplying that country's domestic market with around 550,000 tonnes per annum (US Pellet Fuel Institute 2007).

In the EU a substantial proportion of supply comes from imported sources both within the EU and from external countries (eg Russia, Ukraine, South Africa) (Enecon 2007). Canada is also a major source of wood pellets for the EU market. The majority of Canadian supply is sourced from west coast of Canada, where shipping distances to the market are a significant extra supply cost (Watkins 2007), but a cheap resource has resulted from the large areas of forest killed by bark beetles.

Despite the lack of a substantial wood pellet market in Australia, there is developing interest from Australian investors to export wood biomass particularly to the EU. At the time of writing, one company, Plantation Energy, is planning to manufacture and export pellets from Albany, WA. Residue is sourced from the harvest residues of Tasmanian blue gum (*E. globulus*) plantations. The initial goal is to manufacture 145,000 tonnes per annum (www.plantationenergy.com.au).

With the increase in demand for wood pellets, prices are reported to have increased to record levels. The price of pellets for bulk/industrial consumption in the EU is reported to be around 100-135 Euros per tonne in 2007.

Opportunities for mallees in WA

The clearest opportunity for mallees to supply wood pellet markets in the short term is by exporting to the EU. The EU is already a strong source of demand and is expected to grow strongly. However there are several limiting factors to a WA supply of wood pellets including the significant transport distance to EU consumers and the demonstrated growth in domestic production capacity in EU countries. Evidence of the viability of Canadian wood pellet supply is a positive sign that supply from WA may be viable.

The price paid for wood pellets as a fuel for power generation in EU countries reflects the prices paid for renewable electricity in these countries, which can be up to three times the price paid in Australia. The viability of future domestic markets for wood pellets will depend on future prices paid for renewable energy in Australia. The Federal Government has stated that it will substantially increase Mandatory Renewable Energy Targets (see Section 3.3.3), and there may be a future scenario where markets for wood pellets develop in Australia that are competitive with export markets.

As mentioned above there is a pellet manufacturing plant being developed in Albany at the present time. Plantation Energy is understood to be interested in securing a supply of mallee biomass for transforming into pellets for export.

3.2.4 Bio-oil

Bio-oil is produced through a process of pyrolysis where woody biomass is heated in the absence of air. The process produces various combinations of charcoal and bio-oil depending on the temperature and exposure time of the pyrolysis heating process. Slow pyrolysis produces predominantly charcoal and combustible gas, whereas fast pyrolysis produces predominantly bio-oil and smaller quantities of charcoal and combustible gas. Bio-oil is a combustible product and has potential as a substitute for fossil fuels in a range of applications. Its potential for energy production is currently the subject of extensive research and development worldwide.

Fast pyrolysis technology has been developed to commercial scale and Bio-oil has been trialled successfully in boilers and gas turbines in the USA and Canada. It can be burnt in conventional burners but currently requires its own fuel storage and handling equipment. Work is underway to further simplify its use and blending with other liquid fuels.

Market overview

Markets for bio-oil are limited by the fact that it cannot currently be used as a fuel in existing forms of transportation. It does not readily mix with petrol or diesel and is not currently suitable for car engines. However there is potential for its use to generate heat and electricity (Enecon 2007).

As with other forms of bioenergy, bio-oil currently struggles to compete with cheap coal and natural gas in Australia. However its proponents maintain that bio-oil already provides a cost-effective alternative to fuel oils and LPG. Short term commercial viability is dependent on replacing these fuels in local or overseas markets. In the longer term, R&D is underway or proposed to allow blending with hydrocarbon fuels, use in medium speed diesel engines and to extract high value chemicals. Success with these developments is expected to greatly broaden the overall market for fast pyrolysis.

Opportunities for mallees in WA

More than 100 different types of biomass have been pyrolysed. As virtually any form of biomass will pyrolyse, the key requirements for biomass feed are reliability, consistency, location and price. As the industry is still in its infancy, current pyrolysis opportunities are focussed on negative value or low value feeds such as industrial or forestry residues. Such low cost feeds will help to establish a pyrolysis industry. Mallees may be considered a contender as feed material in the near future.

3.3 Bioelectricity

Bioelectricity refers to the production of renewable electricity based on biomass. A range of technologies exist for generating electricity from wood including direct combustion of wood, co-firing with other fuel sources, and via production of gaseous and liquid fuels through gasification, pyrolysis and fermentation¹⁵. The different technologies are described below.

- **Direct combustion** is the best established and most commonly used technology for converting biomass to heat. During combustion, biomass fuel is oxidised ('burnt') in excess air to produce heat. The heat is then used to raise steam, which is expanded in a turbine or steam engine to drive a generator set to produce electricity. When burning woody biomass there is a release of carbon dioxide to the atmosphere, but the equivalent carbon dioxide has also been sequestered by growing the biomass and continues to be sequestered by the next crop. The use of woody biomass to produce electricity is therefore considered to have a much lower 'carbon footprint' than the burning of fossil fuels.
- **Co-firing** or co-combustion of biomass with coal and other fossil fuels can provide a low risk, low cost option for producing renewable energy while simultaneously reducing the use of fossil fuels. Co-firing involves utilising existing power generating plants that are fired with fossil fuel (generally coal), and displacing a small proportion of the fossil fuel with renewable biomass fuels. Co-firing of biomass from sustainably managed resources has been accepted as a complying source of renewable energy by the Federal Government for producing Renewable Energy Certificates under the *Renewable Energy (Electricity) Act 2000* and its *Regulation*.

A range of biomass fuels have been trialled or are in commercial use for co-firing around the world in power plants ranging in size up to 900 MW. These biomass fuels include wood and wood residues, straw and other agricultural residues. In Australia, Macquarie Generation has co-fired biomass with coal at its Liddell Power Station in the Hunter Valley, NSW for several years. Delta Electricity has trialled co-firing of plantation and other wood waste in NSW. Verve Energy co-fires sawmill residues at its Muja power station.

- **Gasification** of biomass takes place in a restricted supply of air or oxygen at temperatures up to 1200–1300°C. The resultant fuel gas may then be burnt to generate heat; alternatively it may be processed and then used as fuel for gas-fired engines (or, in theory, gas turbines) to drive generators.

The variability of biomass fuels with respect to moisture content and particle size affects gas composition. Overall, the products are mostly gases of low to medium calorific values. Gasification also produces unwanted by-products such as char particles, tars, oils and ash, which tend to be damaging to engines and turbines and which must therefore first be removed or processed into additional fuel gas. This can mean that gasifier operation is significantly

more demanding than the operation of biomass combustion systems. Biomass gasification systems generally require close control of the feed quality, particularly with respect to moisture content, particle size and particle size distribution.

3.3.1 Plant size and cost

Bioenergy plants for electricity can be designed and built to almost any size, from several kilowatts up to tens of megawatts. The scale of construction influences project viability for a number of reasons.

- **Capital costs:** there are significant differences in the capital costs for small and large bioenergy plants. A large electricity plant of 40 MW or more may cost \$2.5 million per MW of installed capacity¹⁶. However a smaller plant of, say 1 MW capacity, may cost more than \$8 million per MW.
- **Operating costs:** smaller plants usually have higher operating costs per unit of electricity sold. Much of these higher costs come from labour requirements.
- **Efficiency:** larger plants typically offer greater overall efficiencies than smaller plants.
- **Infrastructure:** again, larger plants typically offer reduced costs for infrastructure (e.g. permits, grid connection) per unit of output. An exception to this general rule occurs when a large plant requires a network upgrade to carry or accommodate the electricity it generates. This is particularly relevant for the WA Wheatbelt, where most locations are served by a distribution network not designed for more than a few MW.
- **Feed supply:** smaller plants generally offer an advantage over larger plants with regard to feed supply. Bioenergy plants must have reliable long term supply of feed material in place before they are built, to accommodate the needs of funding bodies. Long term supply of several hundred thousand tonnes of wood feed each year for a large bioenergy plant can be far more complex and costly than securing, say 20,000 tonnes per year for a small plant.

In summary, large plants offer a number of cost advantages over small plants that suggest they will usually provide more competitive prices for electricity. However the opportunities for large plants are limited by availability of sufficient feed and grid infrastructure to accommodate the electricity that is produced.

3.3.2 Possible locations

Biomass power stations can either link into the existing transmission and distribution system, or provide a dedicated source of power to operations in a remote location. Both of these options are discussed below.

Linkage to the South West Interconnected System

The transmission and distribution of electricity in south west WA is achieved by the South West Interconnected System (SWIS). A map of the SWIS is shown in Appendix C. Electricity generated at a variety of sites such as Muja and Collie power stations is sent via this grid to consumers throughout the south west of the state.

16 Pacific Energy Limited, Investor Presentation July 2007 – ASX website

The transmission lines leaving major power stations are constructed to be able to carry hundreds of MW of energy. As the distance from the stations increases, the lines become progressively smaller as they carry electricity to districts, towns and eventually, individual houses and farms. Thus the main transmission lines to Albany and Kalgoorlie are capable of carrying far more electricity than, for example, the distribution line to Ravensthorpe. Design of the grid system is based on the requirements of power users at various locations, allowing wherever possible for some growth in power consumption.

The cost of installing transmission and distribution lines, together with switching gear, voltage regulation and other management and safety equipment, is quite significant. Changes to these systems can also be costly. The costs of line changes to accommodate new power generation must be determined on a case by case basis, and in many cases they can be quite prohibitive. So in general the size of a power plant is dictated by the size of the grid nearby. The following can be said in terms of the SWIS.

- With access to the main transmission lines, for example the line to Albany, it is feasible to construct large biomass power stations (20MW or more) without prohibitive line upgrade costs.
- With access to a smaller distribution network it is feasible to construct smaller power stations (say 1-5 MW) without prohibitive line upgrade costs.

It was noted above that the larger the biomass power plant, the lower the unit cost for power generation. Unfortunately the locations suitable for large plants in WA are limited by the transmission infrastructure. Most of the mallee planting region is served by a distribution grid that will not accept large new generators without major and costly upgrades. The target region for electricity generation favours small plants, but unfortunately these plants are less cost effective.

Dedicated supply to remote locations

Bioenergy may have a greater chance of commercial success if it can be linked to a dedicated electricity user at a remote location. Potential opportunities would include mines or mineral processing plants off the SWIS grid or which would be unable to be adequately served by the existing electricity infrastructure (although many such sites in WA are already using pipeline natural gas for power generation). At such sites bioenergy would compete not against coal or gas fired power stations but against diesel generators or significant grid connection costs.

The best opportunity to fully meet the variable load requirements of a remote site may well be a bioenergy plant for part of the load, with diesel generators providing emergency back up and peaking requirements. These diesel sets can also be used to service the site while a mallee feedstock is established. The added cost of any such diesel sets must be included in the economic analysis of the project.

3.3.3 Market for renewable electricity

In Australia there is a growing interest in renewable electricity driven by government policies to promote the development of renewable energy. The Commonwealth Government introduced the Mandatory Renewable Energy Target (MRET) scheme in 2001. This mandated that an additional 2% of Australian electricity output be from renewable sources by 2010. This was determined to be the equivalent of an additional 9,500 GWh of generation. Subsequent to the establishment of MRET, several State governments have introduced their own schemes to provide further incentives for additional generation, including the Victorian Renewable Energy Target (VRET) scheme and the NSW Renewable Energy Target (NRET) both of which set a

10% target for renewable energy production. The incoming federal Government stated in 2007 that it will increase MRET targets, incorporating the existing MRET scheme and State targets towards a total of 45,000 GWh by 2020 (the so-called '20%' renewables target).

A system of Renewable Energy Certificates (REC) has been established to allow convenient trading in renewable energy to meet MRET obligations. The price of RECs is not fixed and so availability and other market forces dictate their traded value. However, the penalty for not meeting an MRET target is \$40/MWh before tax, which has influenced the prices of REC's over the life of the MRET program and it effectively sets a price cap.

MRET legislation provides information on what is, or is not, a conforming source of renewable electricity for the generation of RECs. Beyond that, it does not provide any minimum targets or other incentives for any particular technology such as wind, solar or biomass. The Australian electricity industry has therefore sought to meet its obligations for additional renewable electricity via the lowest cost sources available. Significant examples of this are the wind farms, cogeneration plants in sugar mills and land-fill gas projects that have been implemented since MRET legislation came into force.

In the market for renewable electricity created via MRET in Australia, there have not yet been any new plants established that use wood feed alone to generate electricity that is distributed via the grid. Wood feed for power generation under MRET to date has generally been as:

- an auxiliary fuel for cogeneration at sugar mills (such as Rocky Point mill in Qld)
- co-firing at coal-fired power stations (such as Muja in WA, and Liddell and Wallerawang in NSW)
- fuel for cogeneration plants (specifically the cogeneration plant at the Visy pulp mill near Tumut in NSW).

The electricity generated has been seen as a competitive option where the base cost of generation plus the value of a REC will be lower than the base cost from a fossil fuel source plus the penalty for not meeting an MRET target. Within MRET all sources of renewable electricity must compete against fossil fuel based electricity, using the penalty for not meeting legislated targets as a mechanism to induce retailers to pay extra for electricity for accredited renewable sources. Electricity from biomass must therefore compete against electricity from wind, solar, and hydro.

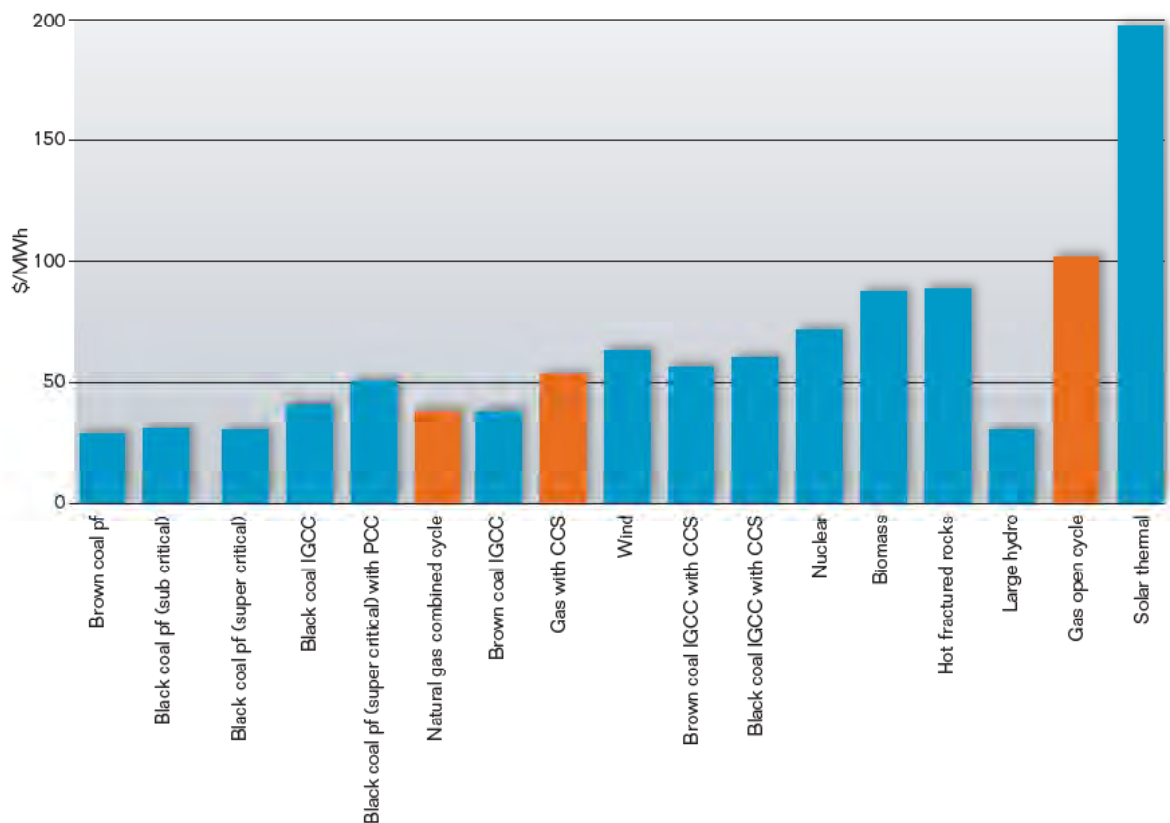
A Scheme Design Paper was released by the WA Sustainable Energy Development Office in August 2007¹⁷. Also issued in August 2007 was a modelling report: 'Impacts of a Renewable Energy Target for 2020 on Electricity Markets in WA'¹⁸. The WA Government is now evaluating details of the enlarged renewable electricity scheme proposed by the new Commonwealth Government. It is likely that all of the state-based targets initiated during the previous Commonwealth Government will be rolled into the new federal target.

Relative costs for the alternative forms of electricity generation are shown in Figure 3-4.

17 http://www.sedo.energy.wa.gov.au/pdf/scheme_design_paper.pdf

18 http://www.sedo.energy.wa.gov.au/pdf/modelling_report.pdf

Figure 3-4: Estimated electricity generation costs, 2006



Notes: pf = pulverised fuel; IGCC = integrated gasification combined cycle; PCC = post-combustion capture; CCS = carbon capture and storage.

Source: Wright (2007).

The two main opportunities for additional renewable electricity generation in WA come from wind and biomass. Wind is well understood and the technology is readily available however there are grid-management issues with substantial increases to the supply of this intermittent electricity into the WA SWIS. Bioenergy offers more predictable supply that can potentially replace other base load generation, however secure access to long term feed supplies is required before projects can be funded and built.

The current cost of energy in the wholesale electricity market in WA is reflected in the Short Term Energy Market (STEM). The average STEM price during 2007 was \$43.55/MWh (ACIL Tasman 2008). In addition to the STEM price there is also a market for capacity credits. A capacity credit is a measure of an electricity generator's expected or actual contribution to meeting system reliability goals and is paid to generators in return for offering their capacity into the market at all times. The value of capacity credits in 2007 was approximately \$14.55/MWh, giving a combined return (from sales and capacity credits) in 2007 of \$58/MWh (ACIL Tasman 2008).

ACIL Tasman (2008) has estimated the impact of markets for CO₂-e (via the CPRS), MRETS and capacity credits on the price of future renewable energy generation, including biomass. The estimates suggest that:

- wholesale electricity prices could rise to around \$58/MWh (excluding the value of capacity credits) based on future values of carbon
- provision of capacity credits could provide another \$15/MWh
- the return to renewable electricity generation from MRET could exceed \$55/MWh.

The combination of all three outcomes suggests that renewable energy generation on the SWIS could realise a central estimate of \$125/MWh from 2011/12 – more than double the current returns from non-renewable electricity generation. However, the extent to which the energy producer passes this value on to the grower will depend on supply and demand factors at any point in time.

The overall opportunity for renewable electricity in WA, and the role for bioenergy, will become clearer as the Commonwealth Government's scheme is documented and the State Government can take action with any of its own initiatives.

3.3.4 International experience

The Australian policy situation is mirrored internationally with many countries mandating targets for a transition to renewable energy production. In particular, the European Union (EU) has already established a carbon emission trading scheme aimed at reducing industrial carbon emissions and has set a renewable energy goal for member countries of 20% by 2020.

There are two relevant points which must be considered when comparing electricity from biomass in Europe against opportunities for similar power production in Australia.

- The price paid for renewable electricity from biomass in many European countries is much higher than the equivalent prices in Australia. For example, biomass electricity in parts of Germany can be sold at approximately 3 times the price offered in much of Australia. This is in part caused by higher prices for base electricity generation in Europe. It is also due to government policies and legislation that provide far greater incentives for biomass electricity than are currently available in Australia.
- Much of the biomass electricity in Europe is generated via cogeneration plants, providing electricity and heating to communities or industry. The generation of heat in parallel with electricity increases plant efficiencies and sales revenues. However, its commercial success is predicated on reliable, long term customers for the heat. The cooler European climate creates many opportunities for district heating which are not available in WA. Also the concentration of industries using heat in Europe is greater than the mallee growing area of WA. Finally the alternative fuels for heating in Europe, such as fuel oil and natural gas, are generally more expensive than natural gas in WA.

For these reasons, notwithstanding the prospective increases in the price of energy, it is not possible to simply take the success of bioenergy in Europe and translate it to WA.

3.4 Activated carbon

Activated carbon is a highly microporous form of charcoal, valued for its ability to purify liquids and gases. It works effectively as a purifier due to its adsorptive properties and extremely high surface area (as a result of its microporosity). Activated carbon is commonly used for water treatment, gold recovery and in the food and beverage industry.

Activated carbon can be produced from a range of sources including different types of biomass and from coal. Most activated carbon currently sold is made from coal, although a large volume is also made from coconut shell and to a lesser extent peat. Activated carbon can be produced from wood through carbonisation, where the wood is heated to a high temperature in an atmosphere with reduced, or no, oxygen. The resulting charcoal is then 'activated' to increase its porosity by applying steam or chemicals.

Market overview

World consumption of activated carbon in 1998 was around 700,000 tonnes pa and reported to be growing by approximately 4-6% pa (Enecon 2001). Indications from major world suppliers suggest that this type of growth is still being experienced. The US is the largest consumer of activated carbon, accounting for 175,000 tonnes pa of consumption. Western Europe and Japan are also significant consumers.

Australian consumption of activated carbon has been reported as 7,500 tonnes pa with around 5,000 tonnes pa used for gold recovery and 2,500 tonnes pa for water treatment and the food and beverage industry (Enecon 2001). Activated carbon supply in Australia comes from a mixture of domestically produced and imported product. Australia imports around two-thirds of its activated carbon requirements for use in gold production. One major Australian company, Activated Carbon Technologies based in Perth, produces activated carbon that supplies 60% of the carbon used for domestic water treatment. Most of this product is produced from coal as a by product of mineral sands processing, although some is produced from coconut shell.

The majority of activated carbon is produced in the US and China (Schaeffer 2007). Price information is not widely reported but was estimated at \$A3,000 per tonne for higher quality pellets and granules and between \$A1,200-1,700 per tonne for lower quality carbon powder (Enecon 2001). Prices are reported to have increased over the past three to four years both in China and the US (Schaeffer 2007). Chinese prices have increased by around 10-20% as a result of coal shortages, shipping costs and currency revaluation. Prices for activated carbon sold by major US based companies have also increased recently by around 15% as a result of rising energy and raw material costs. Ongoing increases in coal prices, and the preference that is likely to be given to renewable sources of energy through carbon trading schemes, may encourage the production of activated carbon based on alternative feedstocks.

Opportunities for mallees in WA

There is some market opportunity for producing this product based on a WA oil mallee resource. A significant proportion of the activated carbon supply in Australia is currently based on imports and if an oil mallee based resource can match the quality of this product while remaining cost competitive, there is the potential to replace some of this supply. This is particularly the case with the gold industry which relies heavily on a large supply of high quality, imported activated carbon. However, because the Australian market is relatively small, large scale production may have a negative effect on prices, counter-acting the currently positive market conditions. It should also be noted that there is significant international trade in activated carbon. If activated carbon from mallee can be made in commercial quantities at suitable quality, there is potential for it to be sold into the much larger markets in North America and Europe.

While the market opportunity appears positive overall, the feasibility of supplying this market will ultimately depend on the production costs and quality of this product.

3.5 Charcoal

Charcoal is produced from wood through carbonisation where the wood is heated to a high temperature. Such carbonisation may be achieved via controlled combustion (as in the IWP demonstration plant in Narrogin), gasification, and slow and fast pyrolysis.

Two emerging charcoal based markets, industrial carbon and biochar, may offer market potential for the oil mallee resource.

3.5.1 Industrial carbon

Industrial carbon is used extensively in the steel industry as a fuel for blast furnaces and as a reductant (a reducing agent) in the smelting process. It is also used in the sintering process of steel making and in the non-ferrous metallurgical industries. Coking coal (or metallurgical coal) is currently the primary source of supply for the industrial carbon market.

Increasing energy prices, potentially stricter environmental regulations and increasing environmental awareness within companies are creating an opportunity for alternative sources of carbon for the steel making process, including wood based charcoal. As an industrial fuel source, charcoal has particular advantages over coke as an alternative source of industrial carbon due to it being cleaner burning and holding higher energy content than coke. As a reductant, charcoal is more reactive than coke (CSIRO 2006). Furthermore, when charcoal production is based upon sustainable biomass production such as mallees, it is also a carbon neutral product.

The only significant producer of charcoal for industrial carbon in Australia is Simcoa, a WA based silicon producer which produces 25,000 tonnes pa of charcoal for their smelting operations near Bunbury (Langberg et al. 2006). The charcoal is produced from local native forest harvesting and processing residues. The quality of the wood used, particularly its ash content, is very important to avoid impurities in the silicon.

Market overview

Australia is the largest exporter of coking coal world wide, currently accounting for a 58% share of global exports. In 2006/07, Australia produced approximately 320.1 million tonnes of black coal, with 131.9 million tonnes exported as coking coal largely for the steel making industry (ABARE 2008). Japan is the largest consumer of Australian coking coal, importing 48.9 million tonnes in 2006/07. The Australian steel industry uses approximately 5.2 million tonnes pa of domestically produced coking coal in its production processes (ACA 2006).

World coal prices have increased substantially over the last four years (ABARE 2008). Hard coking coal prices were relatively stable in the early part of this decade, but jumped from around \$US50 per tonne in 2003/04 to around \$US120 per tonne in 2005/06. Prices eased slightly in 2006/07 but remain very high relative to prices earlier in the decade. There is very little information available on the potential price of charcoal in the industrial carbon market.

Opportunities for mallees in WA

The use of coking coal particularly for steel making is well established as a supply source, low prices of coal are highly competitive and the volume of charcoal required to supply a single mill is likely to be high. Furthermore, research and development into processing technologies in the steel making industry is high and charcoal will need to compete with other emerging industry products and processes over time. Because steel mills operate on a large scale, the amount of charcoal required to successfully supply the market will also need to be high. The CSIRO has been investigating niche applications for wood char in steel making and also in the manufacture of non-ferrous metals.

3.5.2 Biochar

Biochar (sometimes known as 'agrichar' or 'black carbon sequestration') is the term used to describe small particles of charcoal used as a soil additive. Biochar has been shown to improve the structure and fertility of soils (Lehmann 2007a). The consistency of biochar can encourage retention (reducing water and fertiliser run-off) and the high surface area and adsorbancy potential of biochar has been reported to promote beneficial bacterial and fungal growth.

Biochar can be a highly stable form of carbon sequestration, with current estimates of duration ranging from hundreds to thousands of years (Lehmann 2007b). Unlike dry wood, which has a carbon content of around 50%, biochar typically has a carbon content of around 70-80% (Winsley 2007).

Market overview

Biochar currently has no legislated standing as a tradeable carbon benefit. So at this stage the marketability of biochar is highly uncertain and current commercial use of this product is negligible. Market development will need to be based on demonstrated benefits of biochar as a soil enhancer as well as legislation that allows trading carbon sequestration benefits and recognises Kyoto Article 3.4 sinks¹⁹. Potential prices for this product are untested, however it is likely that they would need to be low for a new market to become established. If the process was based on a cheap source of feedstock and a favourable carbon price was available for production, this would make prices more attractive for potential consumers.

Opportunities for mallees in WA

Wood products produced from trees are a less durable form of carbon sequestration than biochar and are difficult to account for due to complex range of uses and life cycles. Biochar conversely appears to be a dedicated sequestration product. This could possibly make it a significantly easier product for life cycle monitoring and easier to incorporate into the CPRS, compared to traditional wood products.

The current market opportunity for biochar based on a mallee resource in WA is considered low due to the current lack of financial incentive. Further data on the productivity benefits of char, together with changes to climate change policy (particularly the introduction of a price on carbon emissions that applies to agricultural practices – Kyoto Article 3.4 sinks) may increase the potential of this market in the future.

3.6 Composite wood products

Composite wood products are made by combining wood particles or wood fibres with resin, to produce a strong, uniformly finished wood product. Composite wood products have been popular, particularly in manufacturing, as a low cost alternative to using solid timber products. Consumption of composite wood products is currently driven by a range of sectors including the construction, manufacturing and furniture sectors.

¹⁹ Article 3.4 relates to carbon sinks associated with agricultural soils, land use changes and existing forest management.

3.6.1 MDF and particleboard

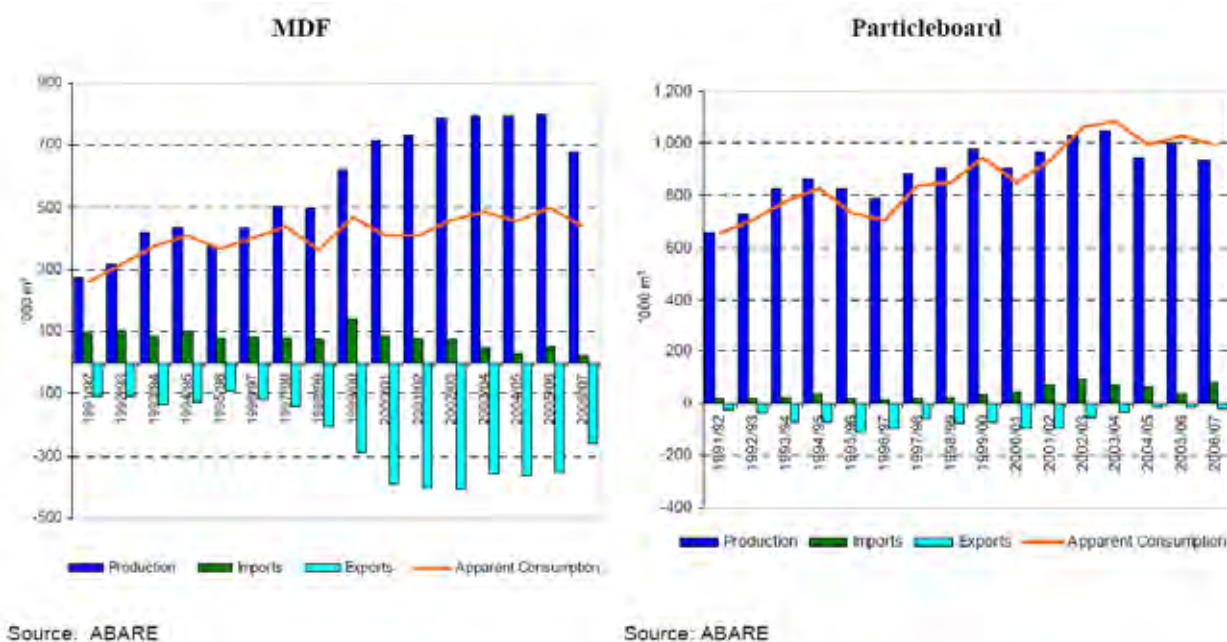
Composite wood products currently produced in Australia include medium density fibreboard (MDF), particleboard and to a lesser extent hardboard. There are two existing composite board producers in WA, the Wesfi Limited MDF mill in Perth and the Wesfi particleboard mill in Dardanup. Both mills are located in the South West of the state, where they are close to softwood resources on which production is currently based.

Market overview

Production and consumption of both MDF and particleboard have been growing in Australia. Since 1991/92, production of MDF has increased by an average of 8% pa, while apparent consumption has increased by an average of 5% pa. Over the same period, particleboard production and apparent consumption have both increased at an average rate of around 3% pa.

Since 1991/92 exports of Australian MDF have increased by an average of 9% pa. Over 40% of all MDF produced in Australia is exported.

Figure 3-5: Apparent consumption of MDF and particleboard



Increasing consumption of MDF and particleboard has been driven by substitution for solid wood products in the construction sector (including timber and plywood) and furniture and mouldings markets where the use of MDF has grown worldwide. As a result of this substitution, per capita consumption of composite wood products in Australia has been increasing steadily.

Domestic production has been internationally cost-competitive however, producers have found export markets more difficult as the \$A has strengthened against the \$US in recent years. Prices for MDF and particleboard have remained stable in real terms since 2004.

Opportunities for mallees in WA

Mallee fibre has been trialled in WA as potential fibre source for the production of MDF and shown to be suitable (J. Bartle, pers. comm.). This market may provide opportunities as the mallee resource expands, with consumption of composite wood products likely to continue to increase in Australia. While the construction of a new mill appears to be unlikely in the short term because of the reliance on export markets to achieve the necessary scale, WA already has established plants which produce composite wood products and these plants may provide a market for resources within an economic haulage distance.

3.6.2 Engineered strand lumber

Engineered strand lumber (ESL) is manufactured from lower grade wood fibre to produce wood products with strong physical and mechanical properties. ESL or Laminated Strand Lumber (LSL) is made in a similar manner to Oriented Strand Board (OSB) where timber is flaked into strands, oriented in longitudinal direction and glued/pressed into billets that are sawn into required dimensions.

Due to the nature of the product, ESL is well suited for high strength applications such as beams, I-joint flanges, flooring supports and rim boards where it can be a low cost alternative to laminated veneer lumber (LVL) and solid timber products. The primary disadvantages of ESL and ESB from a market perspective are related to market acceptance of the new technology and the appearance of the product for some applications.

Market overview

Engineered wood products are a fast expanding market world wide. Most of the global consumption and growth comes from the US market where ESL products have become well established and have strong product marketing. ESL has gained a large market share in high strength applications.

There is currently no production of ESL in Australia. The Australian company, Lignor Limited, recently developed an ESL product utilising existing Tasmanian blue gum resources and native forest residues. Unfortunately Lignor was unable to finance the mill because of changes in global debt markets and the project proposed for Albany is on hold.

If such a plant is successful in the future, ESL could create significant competition in domestic markets for higher strength products including hardwood sawn timber and Laminated Veneer Lumber (LVL). It is also likely to have considerable export potential once developed.

Opportunities for mallees in WA

There are opportunities for the development of a market for ESL, based on growing international demand for this relatively new product. No studies have been undertaken on the suitability of mallees for producing an ESL. If the Lignor plant is built and mallee fibre is shown to be a technically acceptable feed, the mallee wood will need to compete against the established blue gum fibre source and native forest residues.

3.6.3 Fibre cement

Fibre cement (or wood-cement composites) is a composite material produced by combining wood fibre and cement. It is mainly used in residential construction for a variety of applications including floor lining, cladding, fencing and decorative purposes. Fibre cement can also be used to produce injection-moulded products (such as seating) and non-pressure reinforced pipes, where it provides a lightweight and strong alternative to regular steel reinforced pipes. Overall, the benefits of fibre cement include strength and resistance to water and pest damage.

Softwood pulp is the main fibrous material currently used to produce fibre cement. Softwood pulp is favoured due to the nature of the fibre, which has long strands and a strong bonding compatibility with cement. Carter Holt Harvey (CHH) in New Zealand has developed technology to produce high quality softwood kraft pulp with long fibre strands suitable for fibre cement production. As a result, CHH dominates fibre supply to the fibre cement market (CSR, *pers. comm.*).

Market overview

There are no pulp mills in Australia producing pulp for fibre cement products and the market is currently supplied solely by imported New Zealand fibre.

The Australian market for fibre cement pulp is a relatively small market with an import volume of 25,000 tonnes pa (CSR, *pers. comm.*). As a result of the small market size and market control by CHH in New Zealand, it is unlikely that there will be future investment into this market in Australia.

Opportunities for mallees in WA

A Joint Venture Agroforestry Program (JVAP) funded research project was undertaken to assess the suitability of using mallee and Melaleuca stem residues to produce fibre cement (Semple & Evans 2004). The project aimed to demonstrate the potential of this product as a value adding opportunity to eucalyptus oil production based on expanding Wheatbelt plantings in WA. The report concluded that wood of both genera could produce a good quality product. The project did not attempt to assess the market opportunity for such a product or the feasibility of production based on Wheatbelt plantings.

3.7 Carbon

Through the process of photosynthesis, plants remove carbon dioxide (CO₂) from the atmosphere and store it in the plant tissue ('biomass'). In this way, trees are said to act as carbon 'sinks' and can play a role in the mitigation of global climate change. The process of carbon accumulation in the tree is known as 'sequestration', and the rate of sequestration is directly related to the rate of tree growth. Young, actively growing trees sequester carbon at a greater rate than older, mature trees. Foresters can quantify the amount and rate of carbon sequestration in a tree by measuring its volume, and applying a series of conversion factors. As a general rule of thumb, approximately half of the dry weight of a tree is carbon.

The ability of trees to sequester carbon provides an important role for tree farming in the reduction of greenhouse gas emissions and opportunities for tree farmers to benefit from the future trading of carbon.

3.7.1 Emissions trading schemes

International concern about the potentially dangerous effects of increased atmospheric concentrations of GHGs on the global climate system, resulted in adoption of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. The Kyoto Protocol to the Convention was adopted in 1997, which sets out legally binding targets that would result in an average five percent reduction in GHG emissions below 1990 emissions for Annex I²⁰ or 'developed' countries between 2008 and 2012. The Protocol came into force in 2004 when a threshold number of countries had ratified the agreement.

The Federal Government established the Department of Climate Change (DCC) on 3 December 2007. Shortly thereafter, the Australian Government ratified the Kyoto Protocol and in doing so committed to limiting its national greenhouse gas emissions to 8 percent above 1990 levels. The Government also proposed to implement the CPRS by 2010. Development and implementation of the CPRS is primarily the responsibility of the DCC.

Prior to the Commonwealth Government's commitment to develop a compliance-based CPRS, the Australian Greenhouse Office implemented a voluntary emission reduction scheme known as the Greenhouse Friendly scheme. The following discussion presents a summary of information relevant to mallees from the Kyoto Protocol, the CPRS and the Greenhouse Friendly scheme.

Kyoto Protocol

Article 3.3 of the Kyoto Protocol allows carbon sequestered by tree planting to be used by Annex I countries to meet their emission reduction targets. For tree planting to be eligible to obtain offsets under Article 3.3, the 'forest' must (UNFCCC, 1997):

- have been planted on land that was previously non-forest (i.e. meet the definition of 'afforestation'²¹ or 'reforestation'²²)
- have been planted after 1 January 1990
- have minimum tree crown cover of between 10 and 30 percent
- have minimum tree height of between 2 and 5 metres
- have a minimum area of between 0.05 and 1 hectares.

Under Article 3.3 tree farms are not required to be planted in addition to business-as-usual activity, as long as they were planted after 1990. Therefore commercial tree farms are potentially eligible. The Kyoto Protocol requires that once tree-based offsets are registered under Article 3.3, changes in carbon stock should be accounted for in perpetuity.

Currently, accounting methodologies under Article 3.3 assume that if a tree farm is harvested for timber production, all carbon that has been sequestered is emitted in the year of harvest. The methodologies do not recognise carbon stored in harvested wood products or the net carbon emissions saved by using woody biomass as a substitute for fossil fuels (see Box 3-1).

20 Annex I of the UNFCCC lists the developed countries and countries classified as 'economies in transition' with an emission reduction target in Annex B of the Kyoto Protocol.

21 'Afforestation' is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources.

22 'Reforestation' is the direct human induced conversion of non forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land. For the first commitment period, reforestation activities will be limited to reforestation occurring on those lands that did not contain forest on 31 December 1989.

This significantly reduces the net amount of carbon that can be claimed in commercial tree farms under Article 3.3. However, the Intergovernmental Panel on Climate Change (IPCC) is currently considering the inclusion of carbon stored in harvested wood products in a post-Kyoto scheme.

Greenhouse Friendly

Greenhouse Friendly is a voluntary GHG certification program run by the DCC. Under the program, products, services, individuals or businesses can be independently certified as 'carbon-neutral', meaning that all GHG emissions associated with the certified product or service have been eliminated or offset. The program provides independent verification of offsets from accredited forestry abatement projects, and allows these offsets to be used to assist emitters to become carbon-neutral.

Eligibility for carbon sequestration in tree plantings under the Greenhouse Friendly scheme is assessed in a similar way to Article 3.3 of the Kyoto Protocol. The primary exception is that the project must result in GHG reductions or sequestration that are additional to 'business-as-usual' practices. The inclusion of an additional requirement under the Greenhouse Friendly scheme has effectively precluded commercial forest growers from participation. This is because commercial forests have been or would be planted under routine business practices. Forest offset providers who have become accredited under the scheme are generally those who undertake biodiversity plantings; and/or plantings in marginal areas.

For tree farming projects to be eligible as approved abatement under Greenhouse Friendly, the planting must (Department of Climate Change, 2006):

- have been established since 1 January 1990, on land that was clear of forest at 31 December 1989
- have been established by direct human induced methods, such as planting, direct seeding, or the promotion of natural seed sources
- consist of trees with a potential height of at least two metres and crown cover of at least 20 percent
- exist in patches greater than 0.2 hectare in area and a minimum width of 10 metres
- the tree-based sink abatement project must be maintained for a minimum period of 70 years.

Proposed Carbon Pollution Reduction Scheme

The Australian Government has committed to implementation of a national CPRS by 2010, with the design of the system to be finalised by the end of 2008. The Government has specified that the national CPRS must reduce emissions by 60 percent by 2050 and it must have a 'cap and trade' design, whereby the total allowable emissions for all participants is 'capped', and the number of permits allocated is equivalent to this cap.

In July 2008, the Government released a green paper outlining its policy and design approach to the CPRS. The green paper proposes that forestry activities initiated post-1990 should be included in the CPRS, but on a voluntary basis. Forest owners who 'opt-in' eligible plantings to the CPRS will be offered units for the carbon sequestered on their land, but will also need to surrender permits when carbon is released, for example through harvest, fire or stand mortality. The proposal encourages investment in the sector and will potentially accelerate the rate of new plantings.

CPRS discussion papers and Australian forest industry discussion papers and submissions to the CPRS development have supported the inclusion of carbon stored in harvested wood products (eg A3P, 2008) as offset credits. The use of woody biomass as a substitute for fossil fuels in energy production is likely to be recognised as a carbon neutral source of energy that reduces the potential liability of energy producers. However, it is unclear whether the production of woody biomass for uses where it displaces fossil fuels will generate an offset for the grower in the same way that some stakeholders are proposing for wood products. This is discussed further in Section 6.1.1.

3.7.2 Carbon pricing

Pricing of carbon varies under the various trading mechanisms and is dependant on a number of factors. Domestically, prices under the New South Wales (NSW) Greenhouse Gas Abatement Scheme (GGAS) have been in decline for the last 18 months from around \$A14/t CO₂-e to currently around A\$7/t CO₂-e. This drop in price is a result of an oversupply of the trading certificates, uncertainty regarding the future of the system and the relative ease of achievement of the benchmark target. Under Australia's voluntary program, Greenhouse Friendly prices vary depending on scale and the nature of the offset. Prices for tree-based projects have been between \$A8.80/t CO₂-e and \$A16/t CO₂-e, but there have been trades of up to \$25/t CO₂-e.

The principal international trading system is the European Union Emissions Trading Scheme (EUETS). Trade value has increased steadily over recent years while volume has also been rising rapidly. Currently the forward price of December 2008 carbon is \$US41.05/t CO₂-e. The pricing within the EUETS is not necessarily applicable to the broader market as various trading restrictions apply. In particular, credits from land use, land use change and forestry are not currently included in this scheme.

International voluntary markets, including the Chicago Climate Exchange (CCX), have relatively low prices with a forward rate to 2010 for carbon at \$US 7.30/t CO₂-e. In voluntary markets the average price of tree-based trades is between \$US 4.80/t CO₂-e and US\$8.20/t CO₂-e.

Future domestic pricing is uncertain. A number of groups have modelled greenhouse gas reduction scenarios to predict the future value of carbon. McKinsey & Company (2008) estimated tree-based abatement to be valued at A\$40/t CO₂-e, while the National Greenhouse Gas Emissions Trading Taskforce found that permit prices will be between A\$26/t CO₂-e and A\$34/t CO₂-e by 2020 depending on the cap on electricity generation emissions.

3.8 Scale requirements for different processing options

The suitability of different processing options for a geographic region will be dependent on the scale that can be achieved within an economically viable distance of processing plants. Table 3-1 provides an indication of the status of current technologies and the scale required for different processing options based on current or emerging technologies.

Some processing options, such as wood pellets for export, have the potential to supply large markets and the processing technologies used are flexible enough to adapt to a changing resource base. However, the nature of export markets is such that growers are exposed to changes in exchange rate, international market conditions and the costs of shipping freight that are outside the control of the domestic industry. Changes in these factors can occur rapidly and impact on the financial viability of the resource within a short period of time.

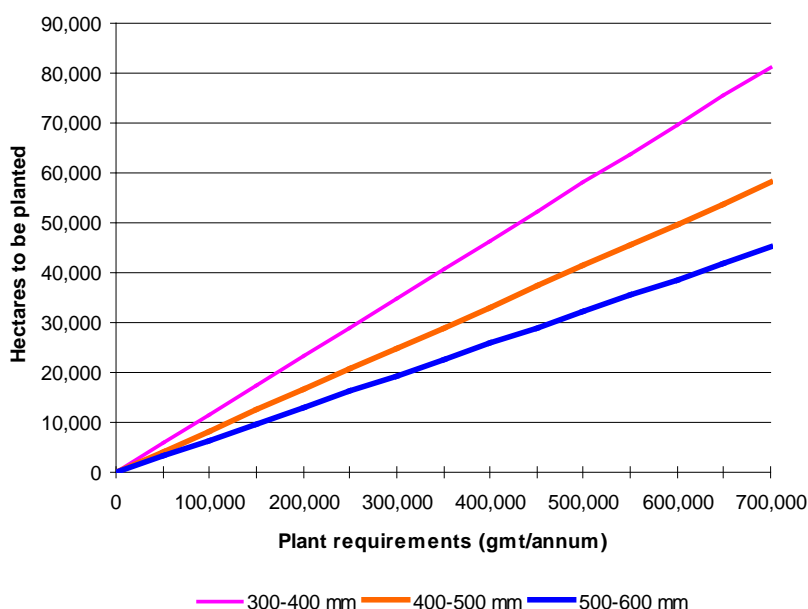
Industries that require significant investment in fixed infrastructure, such as a bioelectricity plant, do not afford the same flexibility in terms of the resource base. However, the plant is usually only established on the back of long term supply agreements with domestic energy users. These agreements also provide security to mallee growers, who can establish a resource in the knowledge that there is likely to be a buyer at the time of harvest.

Table 3-1: Status of technology and scale required for different processing options

Processing Option	Status of Technology	Scale Requirements	Comments
Bioelectricity	Available	5 MW: 60,000 gmt pa 25 MW: 280,000 gmt pa	<ul style="list-style-type: none"> Unit costs decrease with scale Large plants are dependent on proximity to SWIS or direct supply to industrial operations
Wood Pellets	Available	> 100,000 gmt pa	<ul style="list-style-type: none"> Markets unlikely to be impacted by scale
Engineered wood products	Available	> 300,000 gmt pa	<ul style="list-style-type: none"> Estimate is for a stand alone plant. Mallee can also be supplied as an input with other wood fibres
Biochar	Available	Any scale	
• Ethanol	Developing	> 500,000 gmt pa	<ul style="list-style-type: none"> Estimates based on developing technologies
• Biomass to liquid	Developing	> 500,000 gmt pa	
• Bio-oil	Available	> 100,000 gmt pa	
• Eucalyptus oil	Available	< 100,000 gmt pa	<ul style="list-style-type: none"> Most prospective as a co-product of other industrial processes Markets will be impacted by large scale operations
• Activated carbon			

Figure 3-6 shows the net area that needs to be planted (i.e. only that area that contains trees) to service plants of a particular size. The data is presented by rainfall zone and is based on the productivity estimates in Table 2-3.

Figure 3-6: Net planted area required for different processing plants by rainfall zone



4. Harvesting and transport systems

Development of a large scale oil mallee industry is currently constrained by lack of a cost-effective harvesting and transport system. Harvesting to date has been for limited purposes, focussing on whole-tree harvesting for Verve Energy's IWP demonstration plant at Narrogin and leaf harvesting for Kalannie Distillers eucalyptus oil plant, and other eucalyptus oil distillers in the eastern states. The eucalyptus oil distillers use conventional equipment, such as forage harvesters or wheat headers, on very small mallees, typically less than 2 m high, with a high proportion of leaf, and stems not exceeding 20 mm diameter. In these cases a high proportion of leaf material is targeted to assist production of eucalyptus oil (Plate 4-1).

Plate 4-1: Harvesting of mallee biomass for production of eucalyptus oil



Kalannie Distillers (WA)



West Wyalong (NSW)

The IWP plant required higher proportions of wood material, for manufacture of charcoal and activated carbon, and so required larger trees. Trees were felled by manually-operated chainsaw and then fed manually into a trailer-mounted chipper. Large trees were moved by a forklift into the chipper. To supply a full scale IWP plant, or other large scale industry, further development of mallee harvesting systems is required. Without innovations that improve the efficiency and reduce costs of harvest, the price of harvested mallee feedstock will remain an impediment to establishing a viable industry.

Development of a harvesting system must take into account the characteristics of mallee feedstock and the form of the tree, which affects the financial feasibility of harvesting wood only. Although whole tree harvesting has the benefit of allowing access to wood and eucalyptus oil, which may be advantageous to an IWP, leaf content causes handling issues in a fibre processing plant. The harvested leaves also begin to compost fairly quickly, affecting wood quality if they are not separated soon after harvest.

Technologies for separating wood and leaf material were demonstrated at the Verve IWP plant but will benefit from further commercial development. Bark is also an issue because the trees are fairly small and the proportion of bark is relatively high. Economic technologies for removing bark from mallee do not currently exist.

The harvesting system must take into account all components of the mallee supply chain from harvest to delivery to customer.

- Harvesting
- Debarking (for some products)
- Chipping, bundling, or other means of compaction
- Haul-out from paddock to roadside
- Transport to customer.

This section examines each of the elements of this part of supply chain.

4.1 Harvesting and chipping

Various options for harvesting and chipping mallees have previously been considered.

- **Grapple harvesters** are used extensively in Australian forestry operations. They are suited to medium-to-large trees with single straight stems. This system does not seem to have any application to multi-stemmed trees such as mallees where the cost of harvesting with conventional forestry equipment such as grapple harvesters appears prohibitive.
- **Feller bunchers** offer the advantage over the grapple harvester of being able to handle smaller stems more effectively. They have clamps that grasp the stem and additional stems can be added to the bunch held by the clamps. When the clamps are full, the bunch is dumped. The bunches can be chipped at the stump or at the roadside. The greatest limitation to this method is the number of mallees that can be collected into each bunch, because the cost of harvesting and the collecting of the bunches depends upon bunch size.
- **Modified forage harvesters** are used to harvest willow (in the deciduous phase) in Europe. The stems are fairly small and typically branchless and are pushed forwards as they are cut, collected underneath the harvester and chipped. The concept seems applicable to mallees, except that the mallee stems have too many branches to lie flat when the stem is cut and pushed over. Also, the close planting of mallees means the crown of the tree would fall against the next tree, further reducing the ability to lie flat.
- **Debarking** may be important for some products, such as ESL. For other products such as bioelectricity or MDF, debarking may not be as important. If debarking is required this will provide some significant challenges as the high bark/wood fibre ratio associated with small stems may result in the loss of a significant amount of saleable wood fibre during the debarking process.
- **Chipping** is an important step in the overall delivery process, as it converts the mallee into the product received and used by the customer and increases bulk density, which acts to reduce transport costs. Chipping can be conducted in-field as an integrated operation with harvesting, or at road side.

4.1.1 Prototype mallee harvester

Due to the limitations of the harvesting methods described above, early proponents of a commercial mallee industry in WA saw a need to develop a harvester that accommodates the particular characteristics of mallees and the row planting proposed across Wheatbelt farms. The OMC and CALM developed a prototype mallee harvester with on-board chipper in the late 1990s. It comprises three main processing sections:

- a saw mounted at the front, to cut the trees at a height of about 100mm. Trees up to about 150 mm diameter at cutting height can be handled
- a conveyor/accumulator. This transported the newly cut trees, still vertical, to the chipper. The conveyor holds up to four trees at any one time
- a drum chipper. Trees are fed, stem first, into the chipper.

Plate 4-2: The OMC/DEC prototype mallee harvester



This prototype harvester showed that the concept was feasible and is likely to lead to the lowest cost harvesting system, but further development to a commercial stage has not yet occurred. The most significant problem encountered with the prototype was that the biomass had to change direction as the tree reached the top of the conveyor system and had to be fed down into the chipper. Inadequate power to the chipper made this problem worse as it created a bottle neck at the chipper feed rollers.

The Rural Industries Research and Development Corporation (RIRDC) funded some further development work of the chipper component of the prototype mallee harvester in 2004 and 2006. This work sought to understand the mechanism for improved chipping, so that commercial-scale chippers could be designed with some confidence. The research delivered the required outcomes, but the detailed results are not publicly available. RIRDC's report summary states:

“The potential performance of the prototype mallee harvester, in terms of its specific energy and mass flow rate, has been greatly improved by the installation of the new chipper. The harvester is now limited by its capacity to feed mallees to the chipper, whereas previously the chipper itself was a significant choke point in the flow of material through the harvester. The reduced specific energy requirement of the new chipper and its high-mass flow rate indicate that it is realistic to envisage and develop a mobile and manoeuvrable self-propelled chipper harvester capable of processing 75 green tonnes of biomass per hour.”

In June 2008 the WA Government announced of \$1.5 million funding to the CRCFFI for the development of a prototype mallee harvester that will help create a viable farm-to-factory supply chain for the mallee industry. The research is to be focussed on developing technology that gets trees from the farm paddock and delivered to a processing plant efficiently. A ‘chipper harvester’ approach is being undertaken that incorporates techniques and concepts used in forestry and agricultural systems to cut trees at ground level and chip them in one continuous operation.

4.2 Transport systems

There are two components of the transport system for mallee biomass – haul-out from the paddock to roadside and transport from roadside to the customer.

4.2.1 In-field haul-out

In-field haul-out, sometimes called on-farm haulage or forwarding, refers to the transfer of biomass from the harvester to the road for loading on to trucks. It is an important part of the supply chain and has been shown to be one of the major components in the delivered cost to the customer²³. The cost is directly related to the average distance that the biomass must be hauled from the harvester to the roadside, and hence to distance, speed and payload. Planting density, layout and productivity will all have an impact on cost.

Anticipated hauls of 2km or more have long been compared to typical hauls of 500 metres in forestry and sugar cane. At distances of about 2 km, on-farm transport will probably cost more than harvesting and as much as road transport for about 100 km. The amount of woody biomass that will be produced within 2 km of a single landing may be quite modest, perhaps representing only one or two days' harvesting. The frequent moving from one landing to another will also have a significant impact on the efficiency of the whole supply chain. Hence a mallee planting of less than one day's harvesting (400 tonnes or more) will incur significant extra costs.

Vehicles used for in-field haul-out need to be suitable for off-road use and be able to negotiate gates. The means of emptying chipped mallee biomass into the road transport must also be suitable. For example, wheat chasers use an auger arrangement which is not likely to work well for mallee, particularly if the product contains large quantities of stick material.

4.2.2 Road transport

The WA Wheatbelt has an established system of roads which could be utilised by the mallee biomass industry. The sugar cane industry is similar to the proposed mallee industry in that it moves large tonnages of low bulk-density biomass moderate distances to central processing plants by rail and truck. Sugar cane road transport systems could be adapted meet the needs of the oil mallee industry. In WA's Ord River sugar growing region and northern NSW, cane is typically moved by purpose-built trucks, with high mesh sides intended for holding low-bulk density materials, and side-tipping arrangement to facilitate quick and easy emptying at the mill (Plate 4-3). Each tipping unit holds about 120 m³ of biomass.

Plate 4-3: Emptying road train at mill, Ord River



Side tipping road trains are considered essential to avoid the problems of end tipping. For some free-flowing products, such as wheat and woodchips, this can be accommodated by tipping through a grizzly into a pit. However, whole chipped mallee does not flow as well and must be tipped clear of the road.

The relevance of the sugar cane system to a mallee system cannot be underestimated. In fact mallee offers several advantages relative to sugar, particularly the opportunity to harvest for most of the year, thereby reducing the time when capital equipment is not utilised and justifying purpose-built equipment. The product to be transported has a better bulk density and similar flow characteristics to cane, and a road system suitable for road trains already exists throughout the WA Wheatbelt for cartage of wheat.

The effect of reduced winter deliveries on the customer may be reduced by stockpiling or by supply of alternative feed stocks for short periods. Stockpiling has its own issues. While woodchips can be stored outside for lengthy periods, the leaf content in mallee typically undergoes major changes within a few days. Composting sets in, causing quality reductions in both the leaf and the wood. It is suspected that the eucalyptus oil content reduces quite quickly after harvest, though hard data on this is not available. It is therefore desirable to process feedstock as quickly as possible, certainly within a few days.

One possible way of storing mallee feedstock is to separate out the leaves prior to storage and store the wood only.

4.3 Harvest and transport costs

4.3.1 Harvest and in-field haul-out

As discussed above, harvest and transport technologies require further development before they can be considered reliable and cost effective. Currently, harvest costs can best be estimated using the operating costs of similar equipment (similar power, tracks, hours of operation each week and capital cost). The haul-out cost depends on the distance that the haul-outs must travel. Large farms will typically have a longer average haul-out distance to the roadside, requiring more time for travel.

On-farm transport is unlikely to involve haulage to a single roadside landing per farm. Areas between about 500–1,000 hectares would probably be hauled to one landing, but areas greater than about 1000–1,500ha are likely to require multiple landings. Harvesting the mallees from 500ha of farm will take only about one ten hour shift, so moving from landing to landing will require high levels of coordination between harvesters, forwarders and road trucks. Systems analysis of alternative supply chain arrangements and modelling of costs are currently being conducted. Indications are that getting biomass chipped and loaded into road transport for less than \$25 per tonne could be possible with powerful machinery and very sophisticated logistics to accommodate the highly mobile nature of the harvesting operation (R. Giles, pers. comm.).

4.3.2 Transport

Road transport for mallee biomass has been studied extensively. Yu, Bartle and Wu (2007) modelled two scenarios in the WA Wheatbelt:

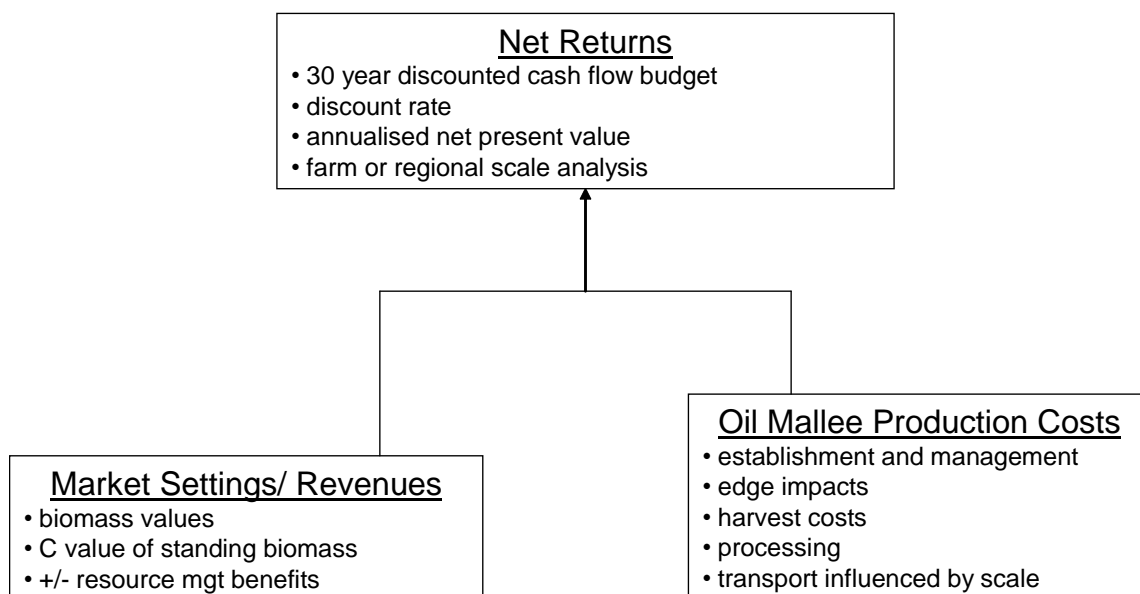
- a conventional contract transport arrangement where a contractor is paid \$0.10/tonne/km for transport from the farm roadside to the customer
- an owner-operator based system, which showed cost reductions over the contract system. The cost per tonne delivered to the customer decreased as transport distance increased (as a result of a fixed loading costs being spread over greater distance). At 50km, the cost was estimated at about \$4.20/gmt or \$0.08/gmt/km.

It is noted that this transport cost is significantly lower than the cost of transporting hardwood woodchips in WA over a similar distance. The cost of transporting woodchips over 50km is approximately \$0.17/gmt/km and this cost has been used in the economic modelling that has been undertaken in the next section.

5. Economic modelling

This section describes a spreadsheet model that was developed to allow the assessment of oil mallee production alternatives. The model was developed using principles of benefit-cost analysis to provide a discounted cash flow analysis of biomass production. The model allows comparison between locations and areas with different growth potential, and between biomass production options at different scales. A 30 year timeframe has been used and a real, pre-tax discount rate of 7% has been assumed. The basic structure of the model is shown in Figure 5-1.

Figure 5-1: Structure of the benefit-cost assessment model



5.1 Case study examples

Case study examples have been developed to provide a comparison between rainfall zones and areas adjacent to a port, rail or major electrical transmission line. The characteristics of the four examples are described in Table 5-1.

Table 5-1: Characteristics of case study examples

Region	Characteristics				Potential industries					
	Rainfall (mm)	On SWIS	Near a port	Near other biomass residue sources	Pellet export	Small bio-energy plant (5MW)	Medium bio-energy plant (25MW)	Engineered wood products	Eucalyptus oil product	Activated carbon products
Region 1	500-600	Yes	Yes	Yes	✓✓✓	✓✓✓	✓✓✓	✓✓	Co-product	Co-product
Region 2	400-500	No	Yes	Yes	✓✓✓	✓✓✓	✓	✓✓	Co-product	Co-product
Region 3	300-400	Yes	No	No	✓	✓✓✓	✓✓	✓	Co-product	Co-product
Region 4	300-400	No	No	No	✓	✓✓✓	✓	✓	Co-product	Co-product

✓✓✓ Very good potential ✓✓ Good potential ✓ Some potential

Note: The analysis assumed transport distances and costs associated with fuelling a 25MW plant in Region 1, and a 5MW plant in Regions 2, 3, 4. A 25 MW was chosen as an example only, larger plants are also a possibility in the WA wheat belt.

The typical value of agricultural production in each region can be described by net margin returns on a per hectare basis that are described in BankWest Benchmark reports from 2000 to 2007. These data were adjusted using the consumer price index to reflect 2008 operating returns and the range of returns for typical regions with the above characteristics are shown in Table 5-2.

Table 5-2: Operating returns by region

Region	Net operating returns (\$/ha pa)		
	Lower 25 percentile returns	Median returns (50 percentile)	Upper 25 percentile returns
Region 1	20	110	200
Region 2	20	100	180
Region 3	0	60	120
Region 4	-20	70	160

5.2 Model inputs and case study assumptions

Model inputs are described in the following section along with indicative parameters provided for the case study assessment.

5.2.1 Agriculture production

Competition zones

Oil mallee plantings, especially as 2 and 4 tree row plantings, exert an effect on the adjacent agricultural enterprise (see Section 6.1.3). The impacted area can be proportionally high given the relatively narrow mallee plantings. The model takes account of assumed levels of productivity reduction and the width of impact into the agricultural area. The assumed distance that roots would impact in the case studies is five metres and the reduction in agricultural production within this zone is assumed to be 10 per cent. These are estimates only in the examples given and further work is required to better understand these impacts. The effect will vary with age, soil type and harvest regime applied. It may also be possible to ameliorate these impacts in the short term by ripping the roots along the drip line of the trees, but this may also have a negative impact on tree growth.

Resource management and community value benefits

The model also has provision to include resource management benefits (on-farm benefits from addressing salinity, provision of shelter belts etc.) and community benefits (benefits to roads and other infrastructure from addressing salinity, regional employment benefits etc.) that might arise with extensive oil mallee plantings. Input values might need to be estimated as a per hectare contribution, and on-farm estimates linked to land sale values.

5.2.2 Oil mallee biomass production

Oil mallee production systems were modelled to estimate the net value of mallee biomass production and associated rates of carbon sequestration on a per hectare basis. Costs, productivity and revenues can be calculated for two row, four row and block planting configurations. The model can account for different productivities and competition zones from each configuration.

Establishment and management costs

Upfront establishment costs and ongoing management cost estimates are required on a per hectare basis. The establishment and ongoing management costs assumed for each of the case study areas are presented in Table 5-3. These costs are estimates based on contracting a third party contractor to establish the trees. Costs are likely to be lower if operations are undertaken by the landowner.

Table 5-3: Establishment and management costs (\$/ planted ha)

Cost	(\$/ planted ha)
Establishment cost	\$1,650
Yr2 management costs	\$200
Annual mgt costs – thereafter	\$60

Harvest and transport costs

Harvest and transport operations are considered independently in the supply chain to allow clearer definition of the process. Costs can be defined with a component of fixed cost per hectare and variable costs per tonne of harvested or transported biomass. For the case study, harvest costs were assumed to be \$18/gmt and transport costs were \$0.17/gmt/km.

Transport distance

One of the biggest challenges for the industry will be the timing associated with building the necessary resource requirements for fulfilling market requirements. To determine the on-farm returns from tree planting, the average transport distance necessary to supply an industry of a particular size must be calculated. Factors taken into account are:

- proportion of available agricultural area that can be planted to mallees
- maximum proportion of available agricultural area that can be planted to mallees and still achieve maximum yields
- yield in case study area
- linear transport distance calculated from collection area radius - the average linear road transport distance of all biomass produced within a feedstock collection area is approximately 2/3 of the feedstock collection radius
- tortuosity factor – increment to estimate distance travelled by road from calculated straight line distance - assumed to 1.3 for rural areas (Yu, Bartle and Wu, 2007).

As yield and the proportions of available land vary for each case study analysis, so will the estimated average transport distance and associated costs. In the case study analyses, the

required average transport distance for Region 1 was based on the area necessary to fuel a 25 MW bio-electricity plant (280,000 tonnes of biomass per annum). The average transport distance for Regions 2 to 4 was based on the area necessary to fuel a 5 MW bio-electricity plant that requires 60,000 gmt pa of wood fibre. The average distance assumed for each case study region is presented in Table 5-4. It was calculated using the expected yields and maximum planting area in each region.

As yield and the proportions of available land vary for each case study analysis, so will the estimated average transport distance and associated costs. In the case study analyses, the required average transport distance for Region 1 was based on the area necessary to fuel a 25 MW bio-electricity plant (280,000 tonnes of biomass per annum). The average transport distance for Regions 2 to 4 was based on the area necessary to fuel a 5 MW bio-electricity plant that requires 60,000 gmt pa of wood fibre. The average distance assumed for each case study region is presented in Table 5-4. It was calculated using the expected yields and maximum planting area in each region.

Table 5-4: Transport distance

Region	Average transport distance (km)
Region 1	30
Region 2	16
Region 3	19
Region 4	19

Biomass production

Oil mallee productivity must be estimated and it is also necessary to specify the assumed percentage of soils in a particular area that will be suitable for mallee production and the proportion of these soils that could be planted to achieve the assumed productivity. The assumed biomass yields for 2-row plantings in each case study region, the area of suitable soils, and the proportion of soils that could be planted to achieve the assumed yield are shown in Table 5-5.

Table 5-5: Mallee yields and available planting areas

Region	Mallee yield (gmt/ha pa) based on two row plantings	% of total cleared area suitable for tree crops	% of suitable area planted to achieve max yield (2 and 4 row plantings)
Region 1	16	50%	10%
Region 2	12	50%	10%
Region 3	9	50%	10%
Region 4	9	50%	10%

In the case studies outlined in this section, the base yields were adjusted to allow for four-row belts which are consistent with current guidelines for creating carbon offset credits. This adjustment was made by assuming 75% of the yield from two row belts (see Section 2.5).

Harvesting regime

The harvest regime can be adjusted in the model, but the time between harvests is constant for the first and subsequent harvests.

Carbon sequestration in harvested plantations

Carbon sequestration with biomass harvesting is split into below and above ground estimates. Both are derived from a growth curve which defines annual increments for an unharvested plantation. The user defines the number of years that below ground biomass (and sequestered carbon) is maximised under a harvested regime (assumed to be seven in the base case).

The value of carbon sequestered above ground is assumed to be half the total amount sequestered each year until the point of the harvest. The value then remains constant. This reflects the contribution of carbon value in each planting year to an even-aged estate.

The number of years to achieve maximum below ground carbon sequestration under a harvest regime in the case study was assumed to be seven years and the full carbon value is recognised as the below ground biomass is not harvested.

5.2.3 Price and policy settings

A range of price settings is required for the factory gate value of biomass (\$/gmt), and the value of carbon (\$/t CO₂-e). Neither of these prices is well defined in any existing market in Australia.

The results of the case study analyses are presented as a sensitivity analyses over a range of commodity prices. The method of policy application for valuation and measurement of sequestered carbon will also need to be taken into account. For example the model provides equal treatment for carbon sequestered in two row and four row plantings – existing guidelines under the Greenhouse Friendly program only recognise four row plantings as a sink.

5.3 Case study results

Table 5-6 shows the value of returns from biomass over a range of factory gate prices for mallee biomass and the value of carbon sequestered (\$/t CO₂-e) based on the assumptions described above. The estimates of returns are presented as annualised values which are based on the net present value of returns from biomass plantings harvested regularly over a thirty year period. These returns should be compared against returns from agriculture (see Table 5 2) or other land uses that might be achieved in each rainfall zone.

In the analysis, the value of CO₂-e impacts directly on the value that the resource has as a carbon offset. In the case of wood fibre being supplied to a domestic energy producer, the value of CO₂-e will also have an impact on the factory gate value, as will the value of RECs and the value of any capacity credits²⁴. The potential interaction between markets for CO₂-e, RECs and capacity credits is complex (see Garnaut 2008). ACIL Tasman (2008) estimates that returns from renewable energy generation on the SWIS could more than double between 2007 and 2010/11 based on a combination of outcomes (see Section 3.3.3). However, the extent to which the energy producer passes this value on to the grower will depend on supply and demand factors at any point in time. As a general guide it can be assumed that as the value of

24 A capacity credit is a measure of an electric power generator's expected or actual contribution to meeting system reliability goals.

CO₂-e increases, so will the factory gate price that can be paid by an energy producer for the mallee biomass.

As an example of how the values in Table 5-6 could be interpreted, consider a region with 550 mm of annual rainfall that is near the SWIS and considered suitable for the development of a 25MW bioelectricity plant (e.g. Region 1). We then assume that the market price of CO₂-e is \$40/t CO₂-e and future policy settings are such that the combined value of CO₂-e, RECs and capacity credits enable an energy producer to pay \$45/gmt of biomass delivered to the plant. If 10% of land is established to mallees, the annualised net returns from mallee tree crops planted as four row belts are expected to be \$126/ha. This can be compared with the historical values of agricultural production in Region 1 from Table 5-2 which average \$110/ha, but range from \$20/ha to \$200/ha. A land owner that is achieving average returns from contemporary agriculture in Region 1 could consider the establishment of mallees as a competitive land use option.

In making comparisons between agricultural returns and the returns from tree crops under various values of CO₂-e, it needs to be noted that there are also likely to be changes in agricultural production values that result from carbon trading if agriculture becomes a covered sector under the CPRS. These impacts are likely to be in the form of liabilities incurred by agricultural production and will make any advantages of tree crops more favourable.

Table 5-6: Annualised on farm returns from biomass (\$/ha pa)

		Factory gate value (\$/gmt)				
Region 1		\$35	\$40	\$45	\$50	\$55
	\$0	-\$3	\$21	\$44	\$67	\$90
	\$20	\$39	\$62	\$85	\$108	\$131
Carbon value (\$/t CO ₂ -e)	\$40	\$80	\$103	\$126	\$150	\$173
	\$60	\$121	\$145	\$168	\$191	\$214
	\$80	\$163	\$186	\$209	\$232	\$255
Region 2						
	\$0	-\$8	\$10	\$28	\$46	\$64
	\$20	\$24	\$42	\$60	\$78	\$96
Carbon value (\$/t CO ₂ -e)	\$40	\$56	\$74	\$92	\$110	\$128
	\$60	\$88	\$106	\$124	\$142	\$160
	\$80	\$120	\$138	\$156	\$174	\$192
Region 3						
	\$0	-\$41	-\$28	-\$15	-\$2	\$11
	\$20	-\$18	-\$5	\$8	\$21	\$34
Carbon value (\$/t CO ₂ -e)	\$40	\$5	\$18	\$31	\$44	\$57
	\$60	\$28	\$41	\$54	\$67	\$80
	\$80	\$51	\$64	\$77	\$90	\$103
Region 4						
	\$0	-\$36	-\$23	-\$10	\$3	\$16
	\$20	-\$13	\$0	\$13	\$26	\$39
Carbon value (\$/t CO ₂ -e)	\$40	\$10	\$23	\$36	\$49	\$61
	\$60	\$33	\$46	\$59	\$72	\$84
	\$80	\$56	\$69	\$82	\$95	\$107

5.4 Sensitivity analysis

Sensitivity analysis has been undertaken to demonstrate the impact of variations in planting density and the extent of competition from the mallees on the annualised returns.

Planting density

If planting densities are reduced such that the average transport distances shown in Table 5 4 are doubled, then average returns in each case study area will be reduced by the following amounts:

- Region 1: \$24/ha pa
- Region 2: \$9/ha pa
- Regions 3 and 4: \$8/ha pa

In the example discussed above for Region 1, this would reduce the annualised returns from mallees to \$102/ha pa – below the average returns from agriculture.

Impact of the competition zone

In the case study analysis, the assumed distance that mallee roots impact on agricultural production is up to five metres and the assumed reduction in agricultural productivity within this zone is ten per cent. If the reduction in agricultural production within this zone is increased from ten per cent to 30 per cent, then average returns in each case study area will be reduced by the following amounts:

- Region 1: \$33/ha pa
- Region 2: \$30/ha pa
- Region 3: \$20/ha pa
- Region 4: \$23/ha pa

In the example discussed above this would also reduce the annualised returns from mallees to below the average returns from agriculture in Region 1.

6. Future directions for the industry

Strategies for the WA oil mallee industry can be developed with the knowledge that there are commercial markets for wood and non-wood products that can be produced from mallees, and that tree crops have already been established in WA based on the prospect of these markets being developed further.

There is now a universal focus on global warming and climate change that provides further opportunities to develop financially viable industries through the instigation of new policies and regulation favouring low carbon fuels and sustainable land management practices. An economy that is increasingly carbon constrained will give preference to less carbon intensive, and eventually carbon neutral sources of energy and commodities. At the same time oil prices are increasing, which provides clear economic opportunities for alternative fuels.

The mallee system is ideally structured to meet these needs. It focuses on the planting of belts of trees across the landscape, fully integrated with cropping and livestock production. This design enables the continuation of contemporary farming between the mallee belts. Mallees therefore create a unique opportunity for the development of sustainable products, including wood products and bioenergy, as a dedicated carbon sink, or even providing both products from the same planting. The potential scale of planting that is possible in the WA wheatbelt means that future supplies can be adequate for multiple users (or large individual users).

The natural resource management benefits of mallees are recognised by landowners who have previously established the trees, but these non-monetary benefits alone cannot be relied on as the basis for tree crop development. For the industry to develop, the trees will need to provide at least an equivalent financial return to existing farm enterprises.

Table 6 1 provides a SWOT (strength, weaknesses, opportunities and threats) analysis of the mallee processing industry. The SWOT provides the basis for a plan that encourages new industries, through policy development, and strategic actions that can be implemented.

Table 6-1: Future directions of the mallee processing industry - SWOT Analysis

Strengths	Weaknesses
<ul style="list-style-type: none"> The "Carbon footprint" and net energy production of mallees is more favourable than alternative biofuels. This makes cellulosic wood fibre a favourable option in the food-fuel debate, particularly when trees can be integrated into the landscape. 	<ul style="list-style-type: none"> Uncertain yields from mallee tree crops. Technology and cost of harvesting still to be improved.
<ul style="list-style-type: none"> Opportunity for a commercial return over a short rotation compared to other tree crops 	<ul style="list-style-type: none"> Competition for water between trees and adjacent crops is not clearly understood.
<ul style="list-style-type: none"> Bio-physical adaptation of native plants to low rainfall and drought conditions. 	<ul style="list-style-type: none"> Prospective technologies that may enable development of large scale markets (e.g. Ethanol) are not yet well developed.
<ul style="list-style-type: none"> Ability to create a carbon pool (on both a harvest regime and as a dedicated sink). 	<ul style="list-style-type: none"> Current low energy prices in Australia and lesser need for heating do not create the same opportunities as there are for woody biomass in international markets.
<ul style="list-style-type: none"> Significant resource already established that provides opportunities for further R&D. 	<ul style="list-style-type: none"> Resource size and capacity of the SWIS favours low capacity energy generation in most locations. Low capacity generation has considerably higher unit costs than high capacity plants.
<ul style="list-style-type: none"> Production cycle decreases competition with adjacent crops (vs dedicated sinks). 	<ul style="list-style-type: none"> Lack of markets for environment services.
<ul style="list-style-type: none"> NRM values through shelter, biodiversity enhancement and salinity management. 	<ul style="list-style-type: none"> There has not been sufficient resource established to support the development of processing facilities.
<ul style="list-style-type: none"> Maximises the use of farm capital by providing a use for labour and equipment at times when farming activity is slower. 	
<ul style="list-style-type: none"> The development of new tree crops benefits from the innovation of farmers. 	
<ul style="list-style-type: none"> Passionate advocates in OMC, government, industry and regional groups. 	
<ul style="list-style-type: none"> There are multiple potential products and markets that will assist with the creation of a sustainable and efficient industry. 	

Opportunities

- Sustainable socio-economic development in regional areas.
- A CPRS is being developed as a result of an increased focus on global warming and climate change.
- Increases to oil prices, may make biofuels an increasingly viable option.
- There is increasing pressure to diversify Western Australia's energy supplies.
- Bioelectricity can be produced at a range of scales and a dedicated energy supply can be developed in remote locations (off grid).
- Commonwealth Government's target of 20% renewable energy by 2020, represents a five-fold increase in the rate of new renewable electricity generation over the next decade.
- Reduced availability of large dimension solid timber products will create more opportunities for engineered lumber/ wood panels.
- Development of second generation processes that enable the production of ethanol and diesel from cellulose.
- Potential for export of wood pellets, leveraging off higher energy costs in international markets than Australia
- Production of biochar may be complementary to other farm enterprises.
- New markets would provide diversity to farm businesses and a steady income stream that is not impacted by annual weather cycles.

Threats

- Lower cost sources of renewable energy e.g. wind farms
 - There is a current debate over the benefits of trees as a driver to reduce salinity. The debate creates uncertainties (for both investors and landowners) over the environmental benefits of trees and the value of these trees to the farming enterprise.
 - Increasing returns from agriculture may increase the cost of land and the opportunity cost of planting trees.
 - The establishment of mallees as a non-harvest sink will provide competition for the same land that could be used to establish trees for a processing industry.
 - Reliance on industry development via products with small market size or value.
 - Industry reputation may be impacted by further delays and failure of new projects (industrial or carbon).
 - Local government planning frameworks may develop that are not supportive of tree crops.
 - The CPRS may not recognise the carbon stored in wood products or displaced through use of mallees as an alternative to fossil fuels as an offset credit.
-

Strategies for industry development and associated actions must seek to overcome three key impediments to the development of new industries based on mallees.

- The technologies and markets associated with the processing of mallees into industrial products on a large scale are not yet developed to the stage where any single product, or combination of products, provides a clear basis for economically viable development.
- If clear opportunities were currently available, current mallee plantings are not at a sufficient scale for a processing industry to be developed.
- The current demand for mallees as part of a dedicated carbon sink that is not intended for harvest is far greater than that for industrial production. Under current 'Greenhouse Friendly' requirements, this could result in suitable land being 'locked up' on a non-harvest regime for more than 70 years, although arrangements under the proposed national Carbon Pollution Reduction Scheme (CPRS) seem likely to be different. In any case, an opportunity for better long-term land use through the production of wood-based energy and industrial products may be foregone if large areas are planted as carbon sinks on a non-harvest regime.

The first two impediments result in a 'chicken and egg' scenario where the commitment from processors towards developing an industry is tempered by the lack of resource in the short term, and potential growers are looking for clear evidence of future profitability before they develop tree crops.

These impediments can be overcome by capitalising on the opportunities that can be provided by carbon trading and the further development of policies that encourage sources of renewable energy. Such policy developments have the potential to provide a 'circuit breaker' and a way forward for the industry. However, at the time of writing, policy settings under the CPRS have not been finalised, and potential issues linger, associated with dedicated 'no-harvest' carbon sinks and failure to encourage the optimal establishment of mallees for biomass production. These issues must be addressed through strategic actions.

The strategies and actions should also seek to recognise that the manner in which future industries develop will be dependent on the scale of planting that can be achieved and the infrastructure that is available in specific regions.

With this background there are two key strategies that emerge for the WA mallee industry.

Key strategies

- 1) Develop diverse regional industries based on mallees that match the biophysical characteristics of a region and available infrastructure with the type and scale of operation that is most economically viable.
- 2) Assist the development of these new industries by leveraging off the current interest in tree crops as carbon offsets. This should be done by encouraging flexible policy frameworks, which allow the objectives of minimising greenhouse gas emissions to be achieved by harvesting trees for the production of bioenergy and wood products AND by creating a carbon sink from the same crop, thereby enhancing the socio-economic value of carbon sinks.

6.1 Actions required

Policy frameworks that are important to achieving these goals are currently being developed or reviewed. The mallee industry has a unique opportunity to secure a viable future by influencing these developments and supporting the new frameworks with ongoing research and development that provides a positive investment climate.

6.1.1 Federal Government policy initiatives

To a large extent, policy initiatives which support development of new products based on the mallee resource are already in train, particularly the federal Government's proposed increase in renewable energy targets and the development of a national CPRS. Investors, processors and energy producers are expected to respond to these initiatives. Hence any proposed changes to policy need to be focussed on the development of a mallee resource that is available to be utilised by project proponents as technologies develop over the next five years.

To do this, it is necessary to break the 'chicken and egg' scenario of industry development versus resource development described above. Carbon trading provides the circuit breaker, but current carbon trading settings do not encourage optimal establishment of mallees for biomass production and carbon sequestration from the same area of land. This can be changed through initiatives that recognise that the objective of minimising greenhouse gas emissions can be achieved by both harvesting trees for the production of bioenergy or wood products and by creating a carbon offset credit from these products as well as the standing tree biomass.

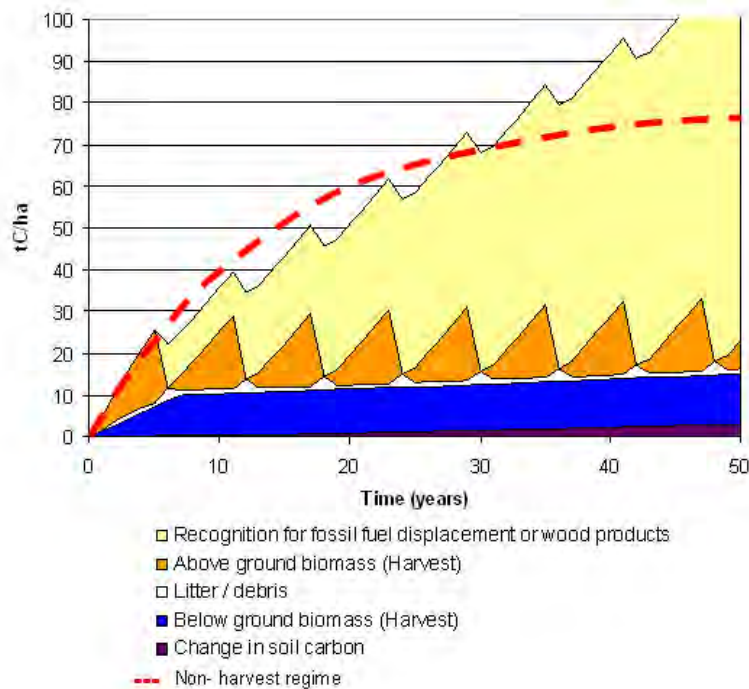
Recognition of fossil fuel displacement as an offset credit

As discussed in Section 3.7.1 the Government is proposing that forestry activities initiated post-1990 should be included in the CPRS, but on a voluntary basis. Forest owners who 'opt-in' to the CPRS will be offered units for the carbon sequestered on their land but will also need to surrender permits when carbon is released through harvest or fire.

There is increasing support for the inclusion of carbon stored in harvested wood products as offset credits. However, it is unclear whether the production of woody biomass for uses where it displaces fossil fuels, or the use of biochar as a soil additive, will generate an offset credit for the grower in the same way that some stakeholders are proposing for wood products.

Figure 6-1 describes the process of sequestration via fossil fuel displacement. The figure shows that there are ongoing greenhouse benefits from the biomass production process, in the same way that carbon can be sequestered in a dedicated sink. Furthermore, the greenhouse benefits of a harvesting regime that leads to the substitution of fossil fuels or the retention of carbon in wood products can be greater over the long term (per hectare planted), and more permanent, than the development of tree crops as dedicated carbon sinks.

Figure 6-1: Cumulative sequestration via fossil fuel displacement versus non-harvest sinks



Note: Quantities and timeframes are for illustrative purposes only

Source: Adapted from Enecon (2008)

The use of woody biomass as a substitute for fossil fuels in energy production is likely to be recognised as a carbon neutral source of energy that reduces the potential liability of energy producers. Growers would expect these benefits to be recognised financially through the value of RECs, the penalties to energy producers for carbon emissions under a future CPRS, or as a combination of the impacts of both factors. However, values under this implicit market will be dependent on the interaction of a number of supply/demand factors and energy producers will not necessarily pass on the full market value of carbon to the grower.

Without direct recognition of wood products or fossil fuel displacement as an offset credit, large emitters of carbon dioxide (such as oil and gas producers) that establish mallees for offset credits will need to forego their accumulated credits at the time of harvest. They will then need to buy another offset on the market to meet their obligations under any future emissions cap. This exposes the organisation to a price risk associated with future carbon trading that they were seeking to avoid through the early action of planting mallees.

The development of an Australian CPRS should encourage parties wishing to establish offsets via tree crops to also participate in a future industry based on biomass harvesting. Under such a framework the resource owner would retain carbon credits at the time of harvest that are equivalent to the net greenhouse benefit from the carbon stored in wood products or by replacing fuels that release more CO₂e in the production of energy or commodities.

The advantages of such an initiative are significant and numerous.

- Investors in carbon sinks would have an incentive to keep their options open for future harvesting.
- A mallee resource would be created as a result of the demand for carbon offsets that also provides the basis for a future processing industry.
- Periodic harvesting controls the height and spread of the mallee belt, keeps them in the more physiologically active young coppice stage of growth and moderates the competition imposed on adjacent crops and pastures.

- In addition to environmental benefits, there is also the potential for new jobs and industries and associated socio-economic benefits in regional communities as a result of processing industries that would not arise from dedicated sinks.
- An increase in offsets/ sequestration per hectare planted.

Recognition of narrow belts

The discussion in Section 2 of this IDP indicates that the most recent (and as yet unpublished) research suggests that mallee productivity (per hectare planted) can be greater by planting two row belts than wider configurations such as four row belts or block plantings. As productivity is increased, so are the financial returns to the landowner and mallees have the best opportunity of being considered as a complementary addition to contemporary farming. Current best practice is to plant the rows 2.5 metres apart, providing an effective width at the time of harvest of approximately 5 metres (as measured from crown to crown).

For tree-based projects to be eligible as an approved abatement under the current Greenhouse Friendly Scheme, the planting must have a minimum width of 10 metres (typically greater than most two row belts planted to date). This creates a disincentive to establish trees in the most financially viable configuration. It is understood that the reason for this policy is to ensure that the belts can be assessed using remote imagery. However, remote sensing technology is constantly improving and there are now examples to demonstrate that such a policy could be changed without affecting the ability of regulators to monitor sinks.

Action 1

Industry participants should provide input to the future Carbon Pollution Reduction Scheme that includes:

- 1) recognising sequestration via harvested wood products or fossil fuel displacement as an offset credit against emissions. Recognition of wood products should include charcoal returned to the soil
- 2) defining tree-based sinks in such a way as to include two row belts of mallees.

6.1.2 WA planning frameworks and local government planning approvals process

In Western Australia the *Planning and Development Act 2005* – Department of Planning and Infrastructure gives rise to State Planning Policies which have the force of a regulation, including *State Planning Policy 2.5: Agricultural and Rural Land Use Planning*. This Policy applies to all rural land in WA and details requirements for local government planning strategies and policies, including the zoning of land. The policy does not currently refer to tree crops as a land use. However, the Department of Planning and Infrastructure (DPI) is currently reviewing the policy with a view to including a reference to tree crops. The revised policy may list tree crops as a permitted, discretionary or not permitted use for specific zones.

The implementation of State Planning Policy 2.5 could be guided by *Planning Bulletin 56: Farm Forestry Policy* (PB 56). These guidelines in PB 56 relate to the level of planning approval required for plantation development applications, and the need to prepare plantation management, harvesting and transport plans. PB 56 is also currently being reviewed. The current policy suggests that in a General Agriculture Zone, local planning schemes should provide for plantations and agroforestry as a discretionary use (planning approval required),

with indication that the use is 'as-of-right'²⁵, subject to the submission and approval by the local government of a transport strategy prior to any commencement of work.

As the Farm Forestry Policy is only a guide that can be used by local government planning officials, amendments to the policy alone are unlikely to be enough to give growers the comfort they need to ensure that plantations can be established at a suitable scale to develop an industry. A State Planning Policy that provides the necessary 'as-of-right' assurance is required.

There is currently a lack of clear criteria for assessing applications and stakeholders are concerned that local governments may be inconsistent in their treatment of applications or develop an unreasonably bureaucratic assessment process.

The *Wildlife Conservation Act 1950*, controls the sale of both wild and cultivated native plants in WA. Under this legislation a licence issued by DEC is required for the sale of products from WA native species planted on private property, but a licence is not required to *harvest* the trees. It is unclear why a licence should be required for sale of products from trees planted with the intent of harvest and sale. Industry development might be better facilitated if rights to sell harvested products were incorporated at the planting approval stage, rather than falling under another, separate statute or process (ie, it should perhaps not fall under the Wildlife Conservation Act).

Action 2

Input should be provided to the current review of local planning policies by stakeholders that promotes:

- 1) agreement on the criteria used to define a tree crop, including scale (suggested greater than 40 ha on any land holding) and definition of land holding (e.g. land title versus land holding of one owner)
- 2) the development of a State Planning Policy specifically targeting farm forestry
- 3) in consideration of the emerging nature of the industry and lead times between planting and harvest, notification of a transport plan should not be required until 12 months prior to the commencement of harvesting
- 4) guidelines for management plans, fire protection and chemical use that are consistent with other codes of practice, including *Guidelines for Plantation Fire Protection and the Code of Practice for Timber Plantations*
- 5) recognition and support for tree crop development that is integrated with contemporary agriculture as a legitimate land use in the General Agricultural zone
- 6) a process for authorisation of sale of products from harvest of mallee crops from private property that provides approval at the time of crop establishment in order to favour the use of native species and to reduce risk for large scale investment.

6.1.3 Research and development

Mallee cropping on the scale envisaged for industrial biomass feedstock supply is an entirely new concept and will require intensive, long-term research and development to develop the species, the agronomic practices and the production systems necessary for a sustainable

²⁵ As-of-right means the use is permitted provided it complies with the relevant development standards and the requirements of the Local Planning Scheme.

industry. On the biomass supply side there are four high priority areas that need to be better understood before investors in mallee tree crops can make well informed decisions. These are:

- empirical data on growth rates and biomass yields
- the impact of mallee belts on adjacent cropping or pasture systems
- changes in below ground biomass under cropping regimes
- efficient harvest, handling and transport equipment and systems.

Empirical data on growth rates

Several researchers have identified that reliable empirical data is needed to improve current models and their predictive ability (eg Cooper et al 2005, Groves et al 2007, Bartle et al 2007). This data is expensive to obtain, often not done adequately and there is consequently a large variation in reported productivities. This exposes the industry to reputational risks if investors commit funds on the basis of higher growth rates than are ultimately achieved. Alternatively, growth of the industry may be constrained because the estimated yields from harvesting are too conservative.

There are three primary steps in any forest inventory.

- The establishment of allometric equations that relate easily measurable parameters to tree volume for a particular species.
- The measurement of these parameters across the full geographic range via plot sampling.
- Stratification of the resource to reflect differences in age, species, soil type and management regime.

The work currently underway by the DEC/DAFWA on the season and frequency of harvest (see Sections 2.1.1, 2.5 and 2.6) is a good start but it is not adequate. It will go some way towards the development of allometric equations. However, the data collected as part of the study, even with 19 sites and 8,000 trees subject to measurement, does not systematically sample the area over which mallees could be established to develop an industry. A cooperative industry-wide inventory is required that involves all managers of mallee tree farms and the data should be pooled in order to better understand the relationships between species, site, planting configuration and climate. Such an inventory could be undertaken on all plantations aged five years or greater – equivalent to an area of almost 10,000 hectares.

The impact of mallee belts on adjacent cropping or pasture systems

Under some conditions there is an impact of mallee belts on adjacent crops and it is understood that this competition effect varies by soil type and rainfall zone. However, where it does occur there will be a further financial cost that needs to be considered when evaluating land use alternatives. This cost will be related to the period of the rotation over which this competition occurs, the width of the area where competition occurs and the extent of the decline in crop or pasture productivity. None of these factors are clearly understood at the present time. It may be possible to ameliorate these impacts in the short term by ripping the roots along the drip line of the trees, but this operation may also have a negative impact on tree growth.

The DEC/DAFWA project mentioned in the preceding section includes annual crop yield measurements in combination with each of the harvest regime treatments. This will provide data related to the harvest cycle, but the definitive results will not be delivered for another several years. There is a pressing need to also systematically sample competition zone effects across a large number of sites to provide data in the short term on how impact varies with soils, crop type, mallee species, season and stage in the mallee harvest cycle.

Changes in below ground biomass

The amount of below ground biomass associated with mallees becomes important when estimating the value of this biomass as an offset credit under carbon trading systems. Current estimates for below ground biomass are that it ranges from 20-50% of the above ground biomass and this range has a significant impact on the financial viability of the tree crops when compared to other land uses. Under a coppice harvesting regime, the below ground biomass becomes particularly important as a carbon sink because it remains in situ even after the above ground biomass has been harvested.

Just as competition zone effects will vary with the harvest regime, so will root biomass. There is the same imperative for short term data but long term harvest cycle data is also required. It is likely that steady positive root system growth rates will be a feature of the most productive harvest regime. Hence all three of these R&D areas indicate the need for an expansion of the existing DEC/DAFWA project but for this to be complemented by strategic short term data collection to provide early guidance to industry development.

Action 3

Research programs should continue to be supported that focus on:

- 1) delivery of valid short term data on above and below ground yield estimates and competition zone effects. This should be a co-operative whole industry project that will pool existing data for consolidation and provide whole-of-industry access
- 2) expansion of the whole harvest cycle research initiated in the DEC/DAFWA project to provide long term data on above and below ground yield and competition zone effects
- 3) efficient harvest, handling and transport equipment, including optimal planting strategies to minimise the delivered cost of biomass.

6.1.4 Implementation of the IDP strategy and actions

The Oil Mallee Association of WA (OMA) was established in 1995 as an industry association to promote mallee industry development. It is an incorporated body and its constitution directs it to represent the common interests of the industry. It has become the peak industry body for the Oil Mallee Industry, representing growers and industry participants.

Through Western Australia's Strategy for Plantations and Farm Forestry, the State Government has allocated the FPC the lead role in supporting the forest products industry in relation to agroforestry. In this role the FPC will collaborate with the DEC, DAFWA and other Government stakeholders on the implementation of the strategies and actions associated with this IDP. Other key stakeholders include the FFI CRC. It is important that these stakeholders work together and form an Implementation Taskforce that is adequately resourced to ensure priority actions are implemented and a successful industry developed.

It is important that a strong industry body continues beyond the implementation of this IDP to further the ongoing development of the industry.

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8. Limitations

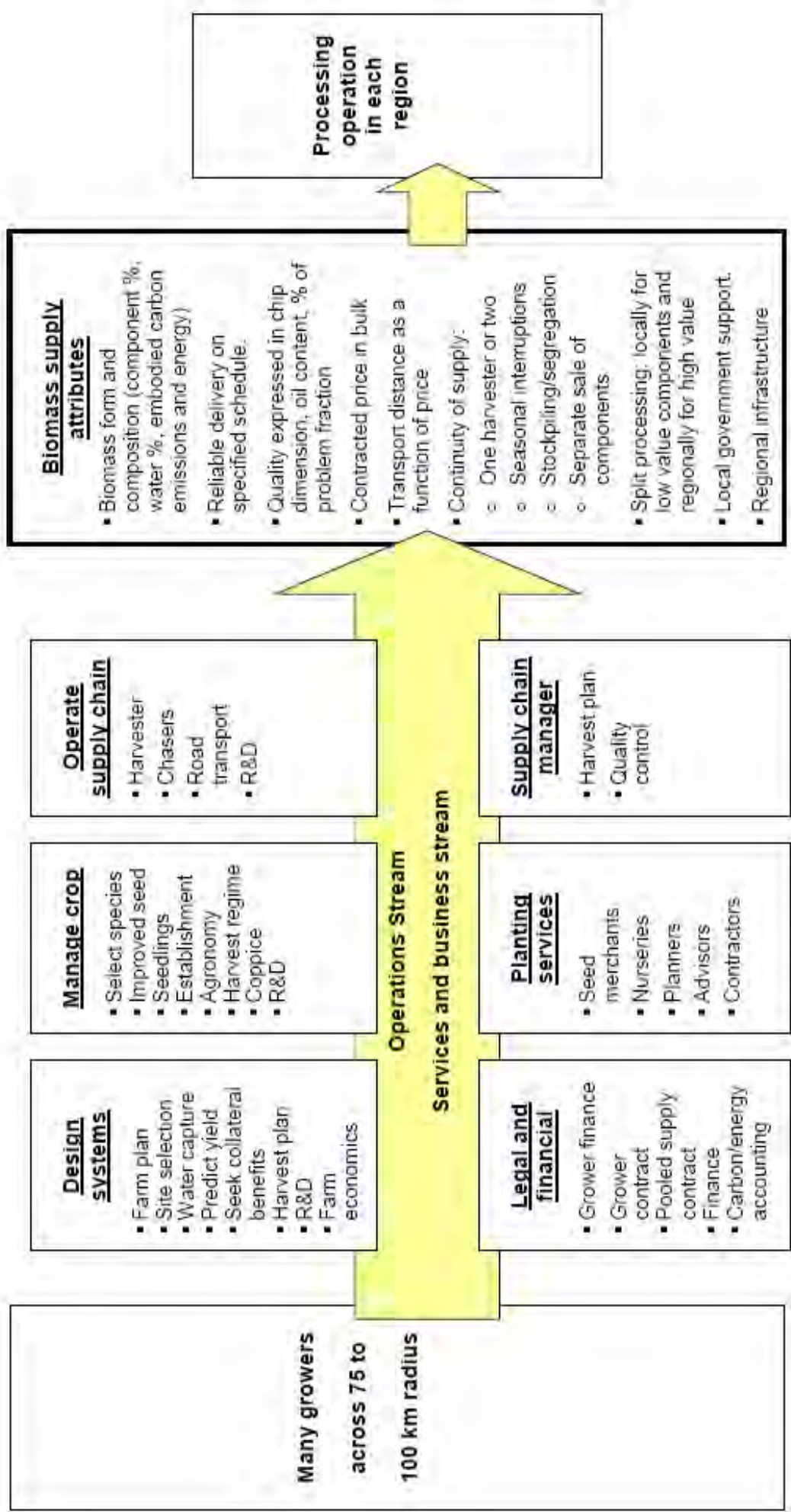
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The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

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Appendix A: The mallee biomass supply chain



Source: J Bartle, Department of Environment and Conservation.

Appendix B: Area planted by local Government area

Shire	Hectares (using 2000 SPH)
Dalwallinu	1,993
Wickepin	753
Mt Marshall	743
Koorda	701
Narrogin	699
Narembeen	579
Wongan Ballidu	532
Morawa	531
Wagin	524
Esperence	425
Mullewa	412
Cuballing	385
Pingelly	324
Mingenew	316
Brookton	249
Kulin	236
Dowerin	230
Katanning	221
Kellerberrin	198
Bruce Rock	185
Corrigin	179
Dumbleyung	154
Kent	134
Merredin	134
Kojonup	133
Nungarin	122
Woodanilling	117
Coorow	103
Beverley	103
Quairading	90
Williams	89
Cunderdin	79
Nabawa	77
Three Springs	76
Kondinin	74
Geraldton	71
Moora	68
Wandering	62
Victoria Plains	62
Lake Grace	60
Tammin	56
Yilgarn	46
Trayning	45

Shire	Hectares (using 2000 SPH)
Perenjori	42
Wyalkatchem	34
Goomalling	37
Plantagenet	29
Toodyay	26
Yalgoo	25
Ravensthorp	24
Dandaragan	23
Chittering	22
Carnamah	19
Westonia	17
Gnowangerup	15
Tambellup	15
Albany	14
Boyup Brook	10
Bunbury	9
Harvey	8
Jerramungup	8
Broomhill	8
Northampton	7
York	4
West Arthur	4
Northam	3
TOTAL	12,777

Source: OMA

Appendix C: The South West interconnected system



Source: <http://www.westernpower.com.au/documents/swismap.pdf>

Glossary

Acronym	Term
bdmt	Bone dry metric tonnes
BtL	Biomass to liquid
CALM WA	Department of Conservation and Land Management
CCX	Chicago Climate Exchange
CH ₄	Methane
CHH	Carter Holt Harvey
CO	carbon monoxide
CO ₂	carbon dioxide
CO ₂ e	Carbon dioxide equivalents
CPRS	Carbon Pollution Reduction Scheme
CRC PBMDs	Co-operative Research Centre for Plant-based Management of Dryland Salinity
DAFWA	Department of Agriculture and Food WA
DCC	Commonwealth Department of Climate Change
DEC	WA Department of Environment and Conservation
DME	dimethyl ether
ESL	Engineered Strand Lumber
EU	European Union
EU ETS	European Union Emissions Trading Scheme
FFI CRC	Future Farm Industries Cooperative Research Centre
FGB	Felton Grimwade and Bickford
FPC	Forest Products Commission
FT	Fisher-Tropsch
GGAS	Greenhouse Gas Abatement Scheme
gmt	Green metric tonnes
H ₂	hydrogen
ha	hectare
IPCC	Intergovernmental Panel on Climate Change

ITAA 1997	Income Tax Assessment Act 1997
IWP	Integrated Wood Processing
JVAP	Joint Venture Agroforestry Program
LSL	Laminated Strand Lumber
LVL	Laminated Veneer Lumber
MDF	Medium Density Fibreboard
ML	megalitre
MRET	Mandatory Renewable Energy Target
MW	Megawatt
NAP	National Action Plan for Salinity and Water Quality
NHT	Natural Heritage Trust
NOx	nitrogen oxides
NRET	NSW Renewable Energy Target
NRM	Natural Resource Management
NSW	New South Wales
OMA	Oil Mallee Association
OMC	Oil Mallee Company of Australia Pty Ltd
OSB	Oriented Strand Board
pa	per annum
PB 56	Planning Bulletin 56: Farm Forestry Policy
REC	Renewable Energy Credit
RIRDC	Rural Industries Research and Development Corporation
SOx	sulphur oxides
spha	stems per hectare
SWIS	South West Interconnected System
UNFCCC	United Nations Framework Convention on Climate Change
VRET	Victorian Renewable Energy Target
WA	Western Australia

Further information

Further information on this Industry Development Plan and the WA oil mallee industry can be obtained from:

Forest Products Commission

Phone: (08) 9475 8888

Department of Environment and Conservation

Phone: (08) 9334 0333

The Oil Mallee Association of Western Australia Inc

Phone: (08) 9433 1244

The Future Farm Industries CRC

Phone: (08) 6488 2505

