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Fuelling Landscape Repair

A Bioenergy Industry as a Sustainable Land-use and Energy Option for Australia

A report prepared for the Australian Conservation Foundation and Joint Venture Agroforestry Program, with the assistance of the Myer Foundation

by Bruce Howard and Chris Olszak

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Foreword

Australia faces increasing impact on its agricultural productivity, water quality and environmental health as a result of dryland salinity. Much of the effort to date to address this threat has focussed on replacing deep-rooted perennial vegetation in landscapes cleared for agriculture. This in the main presents a direct cost to landholders, land is taken out of production and most revegetation activities are non-commercial plantings. The main drivers for undertaking this investment are the off-farm environmental and social benefits, consequently the level of investment in revegetation by farmers is less than desirable from a community perspective. If a commercially viable option for replacing deep-rooted perennial vegetation can be developed then it is hoped that efforts to address dryland salinity will increase. This report discusses the objective to develop a commercially viable biomass production system that integrates within broadacre farming systems to produce feedstock that can be processed to provide a source of renewable energy.

This project was jointly funded by the Myer Foundation, on behalf of the Australian Conservation Foundation and the Joint Venture Agroforestry Program (JVAP) and JVAP is in turn supported by three R&D Corporations — Rural Industries Research and Development Corporation (RIRDC), Land & Water Australia (LWA) and the Forest and Wood Products Research and Development Corporation (FWPRDC), together with the Murray-Darling Basin Commission (MDBC). These agencies are principally funded by the Australian Government.

This report, a new addition to RIRDC's diverse range of over 1000 research publications, forms part of our Agroforestry and Farm Forestry R&D program, which aims to integrate sustainable and productive agroforestry within Australian farming systems.

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Simon Hearn
Managing Director
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Authors Disclaimer

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Executive Summary

Australia faces increasing impact on its agricultural productivity, water quality and environmental health as a result of dryland salinity. A core strategy in managing the risk of dryland salinity must be strategic land-use change – from traditional annual-based farming systems to the widespread use of deep-rooted perennials. Without a competitive commercial driver, however, this kind of land use change - and its public environmental benefits - is unlikely to occur on the scale required.

Development of a biomass energy industry, with short-rotation tree crops established on cleared farmland, could yield substantial economic, environmental and social benefits across the country by reducing dryland salinity impacts of on water quality, agriculture production, biodiversity and built infrastructure. Such an industry would also help to reduce Australia's dependence on fossil fuels and cut the nation's greenhouse gas emissions, and promote sustainable regional development.

While there has already been significant private investment in Australia's renewable energy industry little of this has reached the biomass energy (bioenergy or biofuels) sector, which at this stage suffers from community misconceptions and industry uncertainty. A sustainable Australian bioenergy industry needs to demonstrate both economic and environmental benefits if it is to enjoy private investor and broad community support. Current efforts to encourage planting of perennial vegetation suffer from the disconnect between private on-farm effects and off-farm social benefits, the same situation will still need to be addressed to encourage investment in a bioenergy industry. The financial value of growing trees is the most important factor influencing individual adoption by farmers, and the start of a new industry in regional Australia.

A business model for bioenergy (and co-products such as eucalyptus oil and activated carbon) face the 'chicken-and-egg' challenge of encouraging landholders to plant tree crops for a processing facility that is yet to be built. Research is needed to better understand and bridge any gap between private returns and social benefits. Government has an essential enabling role to play, especially in these early days of sustainable bioenergy by giving encouragement and creating the conditions for a self-sustaining industry by linking the public benefits from private enterprise. Governments must also recognise that the timeframes needed to develop a healthy sustainable industry and capture the related community benefits will be decades rather than years. The creation of a sustainable bioenergy industry in Australia requires a combination of Commonwealth and State Government initiatives, including:

- reducing perverse subsidies for non-renewable electricity generation;
- integrated natural resource management and energy planning to gain extra leverage from existing NRM investment programs;
- dedicating an institution responsible for the support the development of a biomass industry
- boosting R&D to address technical hurdles to industry development and the creation of markets in environmental services; and
- public consultation, information and marketing to address potential community uncertainty and to attract private investment to sustainable bioenergy ventures.

1. Introduction

A key to putting the brakes on salinity in Australia, restoring groundwater balance and preventing further damage to many of our freshwater ecosystems and our biodiversity, is a major strategic effort to restore perennial vegetation systems to large parts of our rural landscape. Unfortunately profitable options for environmentally sustainable rural land uses are limited at this stage.

A biomass energy (bioenergy) industry potentially has a very significant role in sustainable land and water management. Given the right pre-conditions, growth of biomass for biofuels would provide a substantial commercial driver to re-establishing deep-rooted perennial vegetation, and provide a profitable option for arresting the loss of farmlands and the salinisation of Australia's rivers and natural environments. Perennial tree crops, managed to optimise environmental and commercial returns, could be grown as a viable alternative to leaky annual crop and pasture systems.

Biomass derived from plants can act as a store of chemical energy to provide heat, electricity and transportation fuels, or as a chemical feedstock for bio-based products. Currently some 15 percent of the planet's energy requirements are met from biomass, increasingly for fuelling a growing number of large scale, modern biomass energy plants in industrialised countries. Bioenergy is essentially renewable, or carbon neutral, as the carbon dioxide released during the energy conversion of biomass is reabsorbed in equivalent stores of biomass through photosynthesis (Stucley *et.al.*, 2004 – in print).

Opportunities to marry greenhouse gas reduction strategies with sustainable land and water management will be a substitute for fossil fuel use, offset carbon emissions, and be open to investment via emerging carbon markets. Meanwhile, without deep cuts in greenhouse gas emissions, climate change is highly likely to impact severely on Australia's rural productive base, with prospects of higher temperatures, reduced surface runoff and increased frequency and intensity of extreme climatic events.

Given the large-scale fragmentation of native habitat across Australia's agricultural landscapes, there is also a need to maintain and restore ecological function. The management of tree crops for both commercial and conservation objectives will help ameliorate the continuing decline in biodiversity and ecological health. An opportunity exists to design a dual-purpose package of public policies to drive large-scale development in renewable energy and also provide a viable enterprise to assist farmers replace 'leaky' farming systems in salinity-prone regions.

This report discusses benefits from growing woody biomass to address dryland salinity in target areas. The objective is to develop a biomass production system that integrates within broadacre farming systems in the low to medium rainfall areas to produce feedstock that can be processed to produce commercially competitive energy. A biofuel industry, based on trees grown to address dryland salinity issues will need to provide sufficient environmental and financial benefits to be financially competitive against other renewable energy sources and fossil fuels whilst providing sufficient returns to farmers to change land-use and compete with current agricultural enterprises. The co-values of environmental benefits need to be appreciated, and coupled to the benefits of renewable energy production to maximise the incentive for investment in growing biomass and building biofuel plants.

1.1 Scope and Focus of the Study

This study's scope of work was structured to include the following major elements.

1. A review what is currently known about the economics of bio-fuels production in Australia including assessment of how investment in bio-fuels is likely to be influenced by the cost of alternative energy sources, the economics of production of bio-fuel with key co-products and by-products.

2. A review of what is known about the potential of a large-scale biomass energy industry to reduce agricultural land and public infrastructure degradation due to dryland salinity, protect biodiversity from land and water degradation due to dryland salinity, contribute toward meeting or surpassing Australia's carbon emissions targets under the Kyoto protocol, reduce adverse impacts of revegetation on environmental flows in ecologically endangered river systems, and other adverse environmental consequences.

3. An outline of future scenarios for a sustainable biomass energy industry and major challenges to realising such scenarios.

4. An outline of how a set of integrated policies at the Commonwealth, State and local level could best be crafted to achieve desirable scenarios, including energy/industry policy reforms and market based instruments (MBIs) that have been applied to other issues, and policies to insure against adverse environmental impacts of revegetation / biomass fuel production.

1.2 Structure of this Report

Section 2 - investigates the current structure and position of the electricity market in Australia, the Mandatory Renewable Energy Target, and greenhouse gas policy both in Australia and internationally. The importance of their role in supply is explored and key opportunities and constraints are identified.

Section 3 - examines biofuel generation technology, and the cost to generate biofuel energy products – electricity, and transport fuels, such as ethanol, methanol or bio-diesel.

Section 4 – reviews opportunities for growing woody biomass for biofuel harvesting, and it provides a brief assessment of potential target areas, demand for biomass and tree farming systems. A comparison between returns from agricultural enterprises and potential returns from biomass production is presented along with a detailed description of an oil mallee case study analysis.

Section 5 - describes the social and environmental benefits that a biofuels industry can potentially provide. It also describes potential negative impacts, and a set of guidelines that a biofuels industry may adopt to maximise environmental and social benefits.

Section 6 – provides: a summary of major issues to assist the development of a biofuel industry; outlines opportunities that a biomass based renewable energy industry may provide; and presents considerations for policy development.

2. Energy Market and Policy Environment

This section investigates the current structure and position of the electricity market in Australia, the Mandatory Renewable Energy Target (MRET), and greenhouse gas policy in Australia and internationally. The importance of their role in the supply economics of the industry is explored and key opportunities and constraints are identified and discussed.

2.1 Structure and Operation of the National Electricity Industry

The electricity industry in Australia has been in the process of reform and deregulation for many years, with different states being at different stages. The major change has been the development of a national market for electricity to include South Australia, Victoria, New South Wales, and Queensland. An important aspect of Australia's deregulation includes the privatisation and separation or 'ring fencing' of generators and retailers to encourage competition. Since deregulation, a small number of retailers have grown in their number of customers, and geographic spread.

2.2 Prices in the National Electricity Market

The spot market or pool price for electricity is highly dependent on short-term demand for electricity. On a hot summer's day when demand is high, the pool price can skyrocket towards the market cap of $10,000 per MWh. Under these conditions it becomes profitable for gas peaking plants and hydro-electric plants to operate at maximum capacity and to take the pool price. If biomass developments could be responsive to these changes then their feasibility may also increase, but this is not possible with current technologies. However, a real benefit of biomass is to provide base load generation.

Historical National Electricity Market prices show that generally, but particularly over winter, the pool price has remained reasonably constant (NEMMCO, 2003). The average price is slightly lower than the long-term contract price because of the hedging strategy of retailers to level out summer peaks. The 2003 average Victorian pool price was around $28 / MWh with the monthly peak price averaging $37 / MWh (NEMMCO website, 2003). Wholesale contract prices for electricity are highly confidential. Discussions with several people in the industry suggests that a price of $40 / MWh or higher in Victoria could be achieved, particularly if sold in combination with the Renewable Energy Certificates (REC). There is still some difference in prices between states.

2.3 Demand Management

The cost of electricity generation is not the only determinant of efficiency in supply. Transmission costs can form a major component of the overall cost to provide electricity, and thus methods to manage demand and locate supply can improve overall efficiency. Economic inefficiencies have arisen because Australia's energy generation favours large-scale centralised generation, based on fossil fuel technologies that are an inefficient and environmentally damaging means of distributing our energy needs.

"Already, 10 per cent of network capacity is required for less than 1 per cent of the year. This will worsen if demand continues to get peakier and networks have to invest in new network capacity to meet this demand. Potentially massive increases in network expenditure to meet demand growth highlight the importance of getting demand management right… There are many potential beneficiaries of efficient demand management: retailers can gain through lower exposure to peak price risks for wholesale energy; networks through improved asset utilisation and deferral of network capital expenditures; end-users through lower energy bills and better energy services; and the community through better utilisation of resources and fewer environmental costs" (Inquiry into the Role of Demand Management and Other Options in the Provision of Energy Service, 2002).

The key to this situation is the market failure associated with the varying cost of supplying electricity to different regions and at times when demand varies. The New South Wales Independent Pricing and Regulatory Tribunal (IPART, 2002) undertook a major investigation of demand management, as a means to meet the challenge of:

- investing potentially large amounts of capital in generation and network assets to meet growing, and increasingly peaky demand for energy;
- volatile and rising prices as the demand-supply balance tightens;
- increasing competition from smaller-scale, more flexible, technologies; and
- reducing greenhouse gas emissions and other environmental externalities.

The importance that the role demand management can play in responding to these challenges was noted to stand in stark contrast to the low level of activity in demand management to date. It was the Tribunal's view that there is significant untapped potential for efficient demand management. To a large extent, one of the major obstacles continues to be a culture which favours traditional 'built' engineering solutions and which pays little more than lip service to alternative options (IPART, 2002). IPART also found that not all demand management offers all the potential advantages and the viability or efficiency of each demand management option is likely to depend on its specific characteristics and locations.

2.3.1 Transmission losses

Regional generation has significant transmission loss advantages over centralised large scale generation. Using Victoria as an example and Melbourne as the main user of electricity in the state as having a "transmission loss factor" (TLF) of 1.00, the variation in this transmission loss factor across the state provides an indication of the total loss. Yallourn Power Station, in the Latrobe Valley where the majority of Victoria's electricity is generated has an equivalent TLF of 0.95 while Mildura and Horsham, more remote areas of the state have TLFs of 1.09 and 1.07 respectively (Australian Greenhouse Office, 2003)[1]. This suggests a relative loss of 11 per cent from the Latrobe Valley to Horsham. Incremental losses at the end of lines may be as much as 30 per cent (Schuck *pers. comm.*).

While other factors are important, this shows there is potential for distributed energy generation solutions such as biomass projects to improve overall efficiency. It is expected that in other larger

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[1] All figures from Australian Greenhouse Office's Greenhouse Gas Abatement Program, http://www.greenhouse.gov.au/ggap/round3/emission-factors.html, site accessed 1st October 2003.

states these losses could be higher. Incorporating these efficiency signals in the market would provide an important incentive to renewable biomass industries.

2.3.2 Uniform tariff policies

Uniform tariff policies, currently in place across much of Australia, ensure that all consumers have access to network services at similar prices. The intention of this policy is to promote equity and regional development. However, the cost of providing electricity varies across geographic locations because of the cost of providing transmission infrastructure and transmission losses. These costs are typically higher in low population density areas and in areas further from the source of generation. The policy has the effect of low cost users cross-subsidising high cost users. The cross subsidies inherent in a uniform tariff policy come at a cost to economic efficiency, as illustrated by the following points:

- pricing signals influence investment decisions, such as the location of major consumers (factories etc). Uniform tariffs mean that investors will not necessarily locate in a low cost supply areas;
- uniform tariffs do not send appropriate signals for electricity usage and may encourage over-consumption by high cost, and under consumption by low cost users;
- uniform tariffs do not provide signals for investors to optimize the location of new generation capacity to system demand; and
- uniform tariffs do not differentiate signals on the trade off between new centralized or grid transmission capacity versus local installment of capacity.

For some governments, a move away from price uniformity across regions is a matter of concern. In general there is a legitimate trade off between efficiency and equity considerations. However, the Australian Competition and Consumer Commission (2001), notes that the fairness objectives need not be incompatible with an efficient market. For example, price uniformity could be supported through the payment of direct subsidies to high cost users. The approach has the advantage that it does not distort the behaviour of generators and other network participants (Australian Competition and Consumer Commission, 2001).

2.4 Demand Trends

2.4.1 Total electricity

Electricity demand in Australia is increasing with projected estimates shown in Table 1. This is placing significant pressure on the industry and more installed capacity will be required to meet this demand.

Table 1: Electricity Demand increase (2000 – 2010)

State	Demand increase
Victoria	23%
South Australia	26%
New South Wales	23%
Queensland	45%

Source: Australian Ecogeneration Association (2001)

2.4.2 Green Power

Whilst total electricity demand is growing, there has also been an increase in the availability and demand for renewable energy at a household and commercial level. The Sustainable Energy Development Authority (SEDA) developed the Green Power program whereby electricity retailers can develop certified "green power" products that source only renewable energy with specific environmental attributes (not all renewable energy sources are endorsed under Green Power). It targets consumers of electricity, and allows them to purchase renewable energy. This is a voluntary purchase provided at a price premium. This encourages investment in renewable energy. The total sales of Green Power have increased from 40,000 MWh in the 1997/98 financial year to 455,000 MWh in 2000/01, but declined to 405,000 MWh in 2001/02 (SEDA, 2003). This is approximately 50 MW continuous, by contrast a 5% MRET would be approximately 3,000 MW continuous. Greenpower is considered to be a great idea but it is unlikely to be a major solution.

2.4.3 Uptake of Green Power

Research undertaken by Sharam (2003) surveyed Victoria households to obtain an understanding of consumers' initial experience of full retail competition. The survey revealed extensive customer inertia and argues that customers' attitudes underlay this inertia. In terms of Green Power when respondents were given a list of factors that may have influenced them when considering a choice of supplier, 30% rated green power as very important, 37% as important and 30% as not important. Perhaps predictably, those in full-time work and on higher incomes were more interested in 'Green Power' (renewable energy) deals. During this period, known Green Power offers were more expensive than deemed/standing offers. Social security beneficiaries were three times more likely to say that Green Power was not important rather than very important. Nevertheless, there was still interest. The perception at the time (based in reality) that Green Power was more expensive clearly deterred these customers from switching.

2.5 Mandatory Renewable Energy Target

The Federal government implemented the Mandatory Renewable Energy Target (MRET) in 2001 by legislating the production of an additional 9,500GWh per year of electricity by 2010 from renewable sources. The Government's renewable energy target places an annual legal liability on wholesale purchasers of electricity, and some other large consumers, to proportionately contribute towards the generation of an additional 9,500 GWh per year of renewable energy by 2010, and retain this level until 2020. The measure will apply nationally, with all electricity retailers and wholesale electricity buyers on liable grids in all States and Territories contributing proportionately to the achievement of the measure. The penalty for non-compliance is set at $40/MWh. Penalties will be redeemable if the shortfall is made up within the next three years. The measure will be phased-in through yearly interim targets from 2001 to 2010 and liability will remain until at least 2020. These interim targets have been set to ensure that there will be consistent progress towards achieving the 9,500 GWh/a target by 2010 and that all of the investment does not occur in the final years of the scheme.

2.5.1 The 2% target and future demand

Because energy demand has rapidly increased since MRET was first announced in 1997, the 9,500 GWh/a target is unlikely to achieve what was to be a two per cent increase in additional renewable production.

> *"The latest forecast for electricity generation in 2010 is now 254,000 GWh (Electricity Australia 2000). This figure includes auxiliary power use, transmission losses, and small grid, which were not included in the Government's calculations in 1997. When this is removed the new forecast is 231,000 GWh. So adding the 9500 GWh target to the existing renewables of 16,000 GWh (total of 25,500 GWh) amounts to 11.0 per cent of the latest forecast for 2010. This is little more than the 1996/97 market share of 10.5 per cent and is a long way short of the 2 per cent increase that was intended by the measure. To achieve a 2 per cent increase in market share the target would need to increase from 9500 GWh to 13,000 GWh." (Australia Ecogeneration Association, 2001)*

It is thought that if the MRET quota was raised to 5%, it would be met by 2006 by existing and currently planned projects – mainly wind and sugarcane waste fibre (bagasse). Other mechanisms may be necessary to encourage the development of a biomass based renewable energy that sources material from trees planted to address dryland salinity.

2.5.2 Biomass and MRET

There was some consternation over the inclusion of biomass projects in MRET during the development of the legislation because of suggestions that the legislation may encourage the removal and unsustainable use of native vegetation. Eventually, biomass projects were included in the MRET regulations under *Renewable Energy (Electricity) Regulations 2001 - Regulation 8, Special requirements - wood waste*.

Biomass projects under investigation in this study, *i.e.* perennial crops that also produce salinity benefits, would have to comply with the regulation. To be eligible for renewable energy certificates (RECs) under current legislation, specifically grown plantation projects must also produce other products such as eucalyptus oil (Commonwealth of Australia, 2001). For example, the Narrogin Mallee Eucalypts Plant complies in two ways, with 3b and with 6a. Regulation 8 is seen as key to the legislation from a political perspective. It stems from a compromise with Democrats' and Greens' concerns to disallow as a biofuel wood extracted from native forests and otherwise defined as 'sustainable' under the Regional Forest Agreements process.

At present dedicated energy tree crops are not an eligible source as an energy crop – (Regulation 9 "energy crops" does not relate to wood products) or as a wood crop (Regulation 8 essentially means that energy crops from purpose grown plantations must also produce other products, for example, Integrated Tree Processing to produce eucalyptus oil and charcoal as well as energy).

> *"Industry commentators expect biomass projects (including waste-to-energy) will account for about half of the new generation capacity, with wind providing around 20 per cent, efficiency gains in large-scale hydro and mini-hydro systems 10–20 per cent and solar PV and solar thermal the rest. With such a breakdown, there is an expectation that additional renewable capacities will be biomass 1 500 MW, wind 600 MW, hydro systems 450 MW and solar 450 MW"* (Commonwealth of Australia, 2000).

While this seems promising for biomass, these referenced biomass projects mostly use sugar cane waste product and methane extraction from landfill and much of this expected investment in biomass has not occurred. Currently the demonstration Narrogin Mallee Eucalypts Plant in Western Australia (1 MW of additional generation) (Harrison and Chegwidden 2001) is the only confirmed biomass project using woody perennials as feedstock in Australia (Australian Business Council for Sustainable Energy, 2003).

The MRET program has recently been reviewed. The final report was delivered to Dr David Kemp, the Minister for the Environment and Heritage, and Ian Macfarlane, the Minister for Industry, Tourism and Resources, in September 2003 and at the time of writing has not yet been made public (but is scheduled to be so on 16th January 2004). There have been calls to cancel the MRET program. The outcome of the review will be significant in shaping the future of a biomass industry.

2.5.3 Relationship between MRET and Green Power

Green Power is a separate but related program to MRET. The Green Power program is independent of MRET, as retailers cannot claim Green Power purchases under their MRET target. However, accredited Green Power products also generate RECs, which have to be surrendered separately to SEDA (Sustainable Energy Development Authority of NSW) who manage the Green Power program. No further premium for "Green Power" above the REC price could be assumed as consumer based Green Power programs require that RECs are surrendered, to ensure that this program is additional to MRET and retailers are unlikely to pay more than required for biomass RECs. Not all RECs meet the requirements of Green Power, for example biomass used for co-firing with coal, and the use of native forest for biomass.

2.5.4 Summary of MRET investment environment

MRET is a key policy driver of the renewable energy industry in Australia. It provides a market-based solution to increasing the total amount of renewable energy generated in Australia and has facilitated significant investment in the industry to date. However, biomass projects that utilise woody perennials to also ameliorate salinity have not emerged as a significant player. Other options are more attractive to investors from a financial perspective and within the current timing of MRET.

Electricity retailers will encourage the development of MRET-compliant renewable energy projects up to the point where their requirement is met. Industry reports suggest that there may be no further investment in MRET projects after 2006 – 2007. The expectation is that all the capacity required to meet MRET targets until 2020 will be contracted. This makes it impossible for new biomass plantation projects to become established. For example, if it takes one year of planning and five years of growing until the first harvest, the earliest returns from a biomass project will not occur until 2009 (2 years after the expected end of investment). The long time lag also provides only 11 years of extra financial return from the MRET program.

Changes in the MRET target and extensions of the timeframe would make some difference to this unfavourable investment environment, however the comparative advantage of these biomass projects is the potential for salinity management and greenhouse gas abatement, as well as sustainable regional development, benefits. Unless these are valued separately, it is unlikely that the current policy framework will lead to any private investment in a biomass energy industry based on woody perennial crops.

2.6 Other Australian Renewable Energy Programs

A number of other financial incentives for the production and use of renewable energy are also available at a Federal level such as the Greenhouse Gas Abatement Program. Other major renewable energy programs include:

- Renewable Remote Power Generation Program **-** supporting renewable energy in remote areas;
- Photovoltaic Rebate Program – domestic solar power;
- Renewable Energy Industry Development (REID) **-** supporting the renewable energy industry; and
- Renewable Energy Equity Fund **-** provides venture capital for small innovative renewable energy companies.

With the exception of the Photovoltaic Rebate Program, these programs provide funding opportunities for the biomass industry. In 2003 the Commonwealth Funding for Remote Energy Projects advertised grants for renewable energy projects that replace or prevent new investment in diesel fuelled electricity generation in remote NSW. Up to $280,000 in grants is available for medium demonstration projects or small community based projects. Projects must be at least 10kW in capacity and be remote from the NSW electricity grid. This program does not support research and development.

2.6.1 Public subsidies to fossil fuel industries

Subsidies are defined by Riedy (2003) as comprising all measures that keep prices for consumers below market level or keep prices for producers above market level or that reduce costs for consumers and producers by giving direct or indirect support. Fossil fuel subsidies are in turn interpreted by Riedy as: “any government action, concerning primarily the energy sector, that lowers the cost of fossil fuel production, raises the price received by fossil fuel producers or lowers the price paid by fossil fuel consumers”. De Moor (2001) classifies subsidies on the basis of the method of implementation, they are:

- budgetary subsidies, including direct expenditure and tax expenditure;
- public provision of goods and services below cost;
- capital cost subsidies; and

- policies that create transfers through the market mechanism.

Because markets do not always consider environmental and social objectives, government intervention to meet these objectives is generally accepted – "*subsidies that provide gains in social welfare or environmental improvement that are greater than their economic cost can be justifiable retained*" (Riedy, 2003). Riedy argues that fossil fuel subsidies that reduce the cost of producing or consuming fossil fuels will encourage greater use and greater greenhouse gas emissions and will therefore tend to be environmentally harmful – a case can be made for their removal. Removal of perverse subsidies (those that provide neither economic or environmental benefits) is seen as the highest priority.

There is a great deal of reference in the literature to subsidies to the coal and gas industry in Australia, although not much quantification and detailed examination of the impacts. Riedy (2003) provides a detailed examination of these subsidies, their estimated cost, and their priority for removal based on the extent to which they encourage negative externalities in the form of greenhouse emissions and produce perverse outcomes (adverse environmental and economic efficiency outcomes).

Riedy finds that producer subsidies have an annual cost of between $517 and $555 million of which $408-$446m are greenhouse negative and $186-224m are perverse subsidies. These include non-recovery of public agency costs, petroleum exploration tax concessions, and R&D funding to Co-Operative Research Centres (CRC) and CSIRO. There has been significant debate in the renewable energy sector and environmental movement regarding the research and development funding for three fossil fuel CRCs eg. CRC for Clean Power from Lignite, and the removal of funding from the CRC for Renewable Energy (eg. Diesendorf, 2003).

Riedy (2003) finds that consumer subsidies have an annual cost of $1,674 million of which $1,010m are greenhouse negative and $240m are perverse subsidies. The measure of consumer subsidies includes the Diesel Fuel Rebate Scheme, exemption from excise for alternative fuels (LPG and CNG) ($594m), concessional excises on heating and fuel oil and kerosene, and concessional rate of excise on aviation fuels ($770m).

Subsidies for the generation or use of electricity are not necessarily subsidies to fossil fuels, however fossil fuels are used to generate 91% of Australia's electricity (Riedy, 2003). Correspondingly, Riedy finds that electricity subsidies have an annual cost of $419 - 456 million of which $419 - 456 m are greenhouse negative and $195 – 232 m are perverse subsidies. Electricity subsidies include subsidised supply of electricity to aluminium smelters, and state electricity supply subsidies for low-income householders. Centralised generation is also encouraged *vis a vis* smaller generation because of tax exemptions available to large capital expenditures. This has significant implications for the biomass industry for the same reasons described above in relation to cross-subsidisation.

The paper by Riedy (2003) acknowledges that its estimates made are approximate and incomplete. He suggests that an ACF recommended national enquiry into environmentally damaging government programs and subsidies and environmental tax reform would "*greatly improve current understanding and public awareness of fossil fuel subsidies*". He also suggests that public funds used to subsidise fossil fuel production and consumption could "*justifiably be used to subsidise the emerging sustainable energy industry as establishment of this industry would constitute a public good*".

2.7 International GHG Policy – Australia’s Response and its Implications

There is some potential for the Kyoto Protocol to come into force, even with the United States and Australia opting against ratification. Ratification by Russia would provide a sufficient percentage of total emissions from Annex I Parties for the Protocol to enter into force. Both Japan and the EU have ratified in the last 12 months.

Australia's only position to date is to meet our Kyoto commitments, however we remain against ratification. Australian Environment Minister, Dr. David Kemp, has stated that Australia will work towards achieving its Kyoto Protocol target of 108 per cent of greenhouse gas emissions, against a 1990 baseline, by 2008-2012. Current federal greenhouse initiatives include the Greenhouse Gas Abatement Program, National Greenhouse Strategy, Greenhouse Challenge, a range of renewable energy programs on top of MRET, and a range of energy efficiency programs. However, there are a number of implications if Australia does not ratify the Protocol, as follows.

- Australia will not be able to sell emission credits on the international market, thus potentially missing opportunities, in particular with respect to carbon sinks.
- Australia will not be able to achieve credit through actions jointly implemented and CDM projects in developing countries.
- There is increasing uncertainty in the Federal policy domain in relation to Greenhouse with a range of current mechanisms available for project funding. State-based greenhouse emissions limits such as the NSW benchmark scheme introduce further complexity into compliance. The Parer Report (2002) states that “*an overwhelming theme in submissions to the review was the need for greater regulatory certainty including greenhouse policy certainty*” and recommends eliminating all greenhouse programs including MRET and establishing a national emissions trading scheme.

2.8 State-based Action to Reduce GHG Emissions

Further state-based action on greenhouse may enhance the attractiveness of biofuels, which would contribute to GHG emission reductions by displacing electricity generation from fossil fuels and through carbon sequestration. Currently most state based requirements fall on energy generators and retailers.

2.8.1 Victoria

The Victorian Renewable Energy Support Fund announced a $8.45 million Renewable Energy Support Fund. The Fund is a key initiative of the Victorian Greenhouse Strategy, designed to support innovative applications of medium-scale, renewable energy technologies - such as energy generated from farm waste or mini-hydro projects. Proposals are invited for three project types:

- Demonstration Projects which demonstrate innovative applications of medium scale (20 kW – 5 MW electrical, 70 MJ/hr - 20 GJ/hr thermal) renewable energy technologies in Victoria (the contribution from the Fund will not exceed 20% of the capital cost of the project);

- Access Projects which increase the accessibility of best practice technologies that can be used in medium-scale renewable energy projects; and
- Capacity Building Projects which build capacity to install, service and/or maintain medium-scale renewable energy projects.

The Protocol for Environmental Management (PEM) for GHG Emissions and Energy Efficiency in Industry, an Environment Protection Authority Victoria (EPAV) driven initiative, may signify a departure from voluntary GHG emissions actions and reporting, via such mechanisms as the national Greenhouse Challenge Program (GCP), towards legally binding greenhouse action plans driven by licence conditions.

The Victorian Greenhouse Strategy "*encourages investment in carbon sinks, including nature conservation plantings and sustainable plantations, with an emphasis on maximising multiple benefits such as salinity mitigation and biodiversity enhancement*" (Victorian Government, 2003). This provides clear encouragement for the industry in Victoria, although it is uncertain if this will translate into a significant financial investment.

A Centre for Energy and Greenhouse Technologies has also recently been established to provide an enhanced capacity for identifying and adopting best practice technologies in the generation and use of energy, and in the abatement of greenhouse gas emissions. The primary activities of the Centre will include: targeted Research, Development, Demonstration and Commercialisation of energy supply, energy use and greenhouse gas abatement technologies and processes; and the surveillance, assessment and promulgation of best practice in these areas.

2.8.2 New South Wales

NSW has implemented a number of initiatives to reduce greenhouse gas emissions. In 1997, the NSW Government introduced greenhouse gas benchmarks, through which electricity retailers were asked to reduce per capita CO_2^e emissions. Key legislation that has been introduced or amended as part of the NSW response includes the *Electricity Supply Act 1995, Carbon Rights Legislation Amendment Act 1998, Conveyancing Act 1916* and the *Forestry Act 1916*.

The NSW Government developed the *NSW Government Position Paper on Greenhouse-Related Licence Conditions for Electricity Retailers* (NSW Government, 2003). The NSW Electricity Benchmarks Scheme was enacted by the NSW Government under the Electricity Supply Act. The Scheme requires NSW electricity retailers to reduce their greenhouse gas emission by 5% below 1990 per capita levels by 2007, or pay a penalty of up to AUD$15 per tonne of CO_2^e. Under the Scheme, parties can reduce their greenhouse gas emissions via improving energy efficiency, sourcing cleaner energy and/or investing in carbon sinks. This signifies a move away from a voluntary approach to greenhouse gas emissions reduction and increased power generation from renewable energy sources. Furthermore, the *Electricity Supply Act 1995* was amended in 1999 to allow retailers to take into account net reductions in greenhouse gas emissions resulting from sources such as carbon sequestration from planted forests. The NSW scheme allows RECs to count towards compliance, as well as for the MRET.

In 2003 NSW Renewables Investment Program advertised over $2 million for new projects in solar, wind, hydro, biomass, geothermal, wave and tidal power in NSW. Applicants were invited to bid for funding through low-interest loans, grants or equity placement. Projects must be commercial or demonstrate new commercially sound technologies to be eligible. The program does not support research and development.

The New South Wales Greenhouse Gas Abatement Scheme (see abatement scheme website www.greenhousegas.nsw.gov.au) imposes mandatory greenhouse gas benchmarks, on all NSW electricity retailers and certain other parties, including those who elect to manage their own benchmark, to abate the emission of greenhouse gases from the consumption of electricity in NSW. These parties, referred to as benchmark participants, are required to reduce their emission of greenhouse gases to the level of their greenhouse gas benchmark by off-setting their excess emissions through the surrender of abatement certificates. These certificates are created by accredited abatement certificate providers and can be traded to benchmark participants. The surrender of NSW Greenhouse Abatement Certificates (NGACs) to the compliance Regulator is the main way that benchmark participants will abate their greenhouse gas emissions and reach their individual greenhouse gas benchmark levels. NGACs are transferable certificates that may only be created by accredited abatement certificate providers. NGACs can be created by accredited providers who have engaged in the following activities:

- low-emission generation of electricity (Generation);
- activities that result in reduced consumption of electricity (Demand Side Abatement); and
- the capture of carbon from the atmosphere in forests (Carbon Sequestration).

2.8.3 Other States

Other states also have greenhouse policies, legislation and plans. For example, in response to the National Greenhouse Strategy, the Queensland Implementation Plan (QIP) was developed. It is a strategic framework that presents the State Government's greenhouse policy initiatives. It obliges relevant departments to consider and act on greenhouse gas emissions reduction measures that are within their control and lists a range of Queensland Government strategies and actions.

3. Biofuel Generation Opportunities

This section examines the technology used to convert biomass into electricity, transport fuels and by-products. The growth of perennial vegetation can provide a harvestable and sustainable renewable source of biomass, which with processing or conversion can be used to provide a source of energy and a number of valuable by-products such as activated carbon, charcoal, and eucalyptus oil. Two general types of energy products can be obtained, electricity and transport fuels such as ethanol, methanol or bio-diesel.

3.1 Cost of Electricity Generation

The cost of generation (COG) is a critical criterion in determining competitiveness of an investment in renewable electricity generation. Table 2 presents a comparison of the COG between renewable sources and coal and natural gas. Based on these costs, it is easy to see why coal and gas dominate the industry in Australia, currently generating around 90% of our electricity (Cumpston and Burge 2003).

Table 2: Cost of Generation for different sources

Energy Source	Approximate Cost of Generation per MWhr ($A)		
	Source a	**Source b**	**Source c**
Biomass – Energy Crops		55 – 200	
Biomass (bagasse and landfill)	60	30 – 80 55 – 90**	45 – 70
Coal	35		26 – 45
Geothermal – Hot dry rock	20 – 60	40 – 170 80-130*	
Hydro (new and efficiency gains)	60	40 - 100	50 – 300
Natural Gas	40		38 – 55
Perennial plant biomass – gasification		30 – 110***	
Photovoltaic (solar)	150	130 – 500	>100
Wind	80	50 – 120	65 – 95

Sources below [2]

These data indicate that some biomass plants are among the cheapest sources of renewable energy. However, these are associated with bagasse (sugar cane and sugar beet) and landfill methane collection. Hydro electricity has an advantage over other sources, as its generation is very flexible, meaning that supply can be adjusted to meet demand at peak times. Biomass projects have an

[2] a: http://www.geodynamics.com.au/IRM/content/02_hotdryrock/02.1.5.html.
b: http://www.greenhouse.gov.au/markets/mret/redding.html
c: Cumpston, R., and Burge, A. (2003) Greenhouse Gas Issues Within Australia's Electricity Industry, Presentation at IAAust Biennial Convention 2003.
*Geothermal aquifer, ** Landfill extraction of methane, ***Note that these sources do not indicate whether they include the revenue contribution of other by-products potentially produced from perennial plant biomass

advantage in that they generate electricity consistently and can provide reliable capacity at peak times. However, current biomass plants are inflexible to responses in demand and would have to operate under long-term supply contracts rather than gain advantages from spot or market prices.

3.2 Cost of Methanol and Ethanol Production

Estimates of 2002 costs of producing ethanol are 82 cents per litre as shown in Table 3 (Enecon *et al*, 2003). Foran and Mardon (1999) estimated a cost of $1.91 per litre (see Table 4). Grado and Chandra (1998) evaluated a fully integrated ethanol fuels system from biomass and estimated a production cost of US$0.45 per litre (about 70 cents at exchange rate of 0.65) of ethanol. RIRDC (2002) suggests the 82 cents per litre estimate could fall to 41 cents with potential technical improvements.

Table 3: Estimate of ethanol production costs (200 ML per year output)

Plant details	***Unit***	***Estimate***
Conversion rate	litres ethanol / tonne green feed	140
Quantity of green feed	million tonnes per year	1.43
Unit cost of green feed	$ per tonne	36
Costs		
Total operating costs	$ million	70.3
Capital costs	$ million	470
Selling price ex factory*	$ per litre	0.82

Source: van Bueren and Vincent (2003)

* To generate an IRR on investment of 15 per cent over 15 years

Table 4 provides an indication of the capital, raw material, and operating costs of producing methanol or ethanol using wood as a feedstock, with a sugar cane example for comparison. The ethanol estimates are based on the Rheinau conversion process. Table 5 indicates the sensitivity of the per litre costs shown in Table 4 to the cost of the wood feedstock. Note the analysis for the oil mallee Integrated Tree Processing is based on sourcing feedstock at $30, or $15 on-farm net of harvesting and transport costs.

Table 4: Cost Estimates for Ethanol and Methanol – Wood Feedstock

Fuel	Scale ,000tpa	Capital Cost, $m	Labour Required	Raw Material Cost $/t	Operating Cost, $/t	Capital Charges, $/t	Total Cost, $/t	Cost c/L
1. Methanol	100	172	248	426	257	344	1027	81.3
2. Methanol	16.5	30	38	328	238	362	928	73.4
3. Ethanol	115	387	277	1391	360	673	2424	191.0
E (S.Cane)	119	216	274	508	245	364	1117	88

Source: Foran and Mardon (1999). Note: Costs are presented as cost per tonne of methanol or ethanol. The cost of the feedstock is based on A$82/t, the export price of woodchips (A$164 per tonne dry weight).

Table 5: Cost Estimates for Ethanol and Methanol – Sensitivity to Wood Feedstock Price

	Feedstock Price ($/tonne green weight)					
	$30	**$40**	**$50**	**$60**	**$70**	**$82**
Fuel	**Cost c/L**	**Cost c/L**	**Cost c/L**	**Cost c/L**	**Cost c/L**	**Cost c/L**
1. Methanol	60	64	68	72	76	81
2. Methanol	57	60	63	66	70	73
3. Ethanol	122	135	148	162	175	191

3.2.1 Alcohol fuels or renewable electricity?

Enecon *et al* 2003 suggest that electricity seems to be a more economically attractive product from biomass than ethanol or methanol over the next fifteen years., even when potential advancement in liquid fuel technologies are considered. However increases in the price of crude oil will affect this relativity particularly if crude oil costs go up while electricity cost stay constant.

3.2.2 Price gap with environmental benefits

One method undertaken to assess the merits of biofuels is to estimate the price gap between renewable energy products and alternative products. A summary of results (based on Centre for International Economics' estimates) is provided in Table 6. The implication of that study is that neither ethanol nor methanol (from any renewable source) are currently directly competitive with equivalent products sourced from fossil fuels. Consideration of greenhouse and on farm salinity benefits (only environmental effects included) is insufficient to offset the price gap. Off farm salinity benefits, which can be several times the on farm benefits, were not considered by CIE. However, the situation for electricity appears much better than ethanol or methanol, and is competitive with alternative products with the inclusion of environmental benefits, which are based on a value of $56 per tonne of CO_2 for sequestration benefits -which differs from values used by others groups.

Table 6: Price Gap between Biofuel and Alternative Product

Biomass Product	Project Scale	Before selected environmental benefits	After selected environmental benefits
Ethanol	200 ML	25 cents per litre	13 cents per litre
Methanol	390 ML	26 cents per litre	15 cents per litre
Electricity	240,000 MWh	$60.50 per MWh	-$1.50 per MWh

3.3 Lifecycle Assessment – Carbon Balances

A major benefit of a biomass-based fuel cycle is its potential to reduce CO_2 emissions by recycling carbon. Replacing fossil fuels with sustainably-produced biomass will reduce the net flow of CO_2 to the atmosphere (Gustavsson *et. al*., 1995). The benefits in reducing carbon emissions are indicated by Foran and Mardon (1990) who provide examples of CO_2 reductions gained by biomass based sources of transportation fuels over petroleum fuels – ethanol from biomass (-75%) and methanol from wood (-66%). Gustavsson *et .al.*, (1995) state that substituting biomass for fossil fuels in electricity and heat production is, in general, less costly and provides larger CO2 reductions per unit of biomass than substituting biomass for gasoline or diesel used in vehicles. Furthermore, for transportation, methanol or ethanol produced from short-rotation forests or logging residues provide larger CO2-emission reductions than methyl ester from canola seed, biogas from lucerne (alfalfa), or ethanol from wheat, of these, methanol has the lowest emission-reduction costs.

Lifecycle analyses are required to determine the total CO_2 emissions from the system of growing, transporting and conversion of biomass before an accurate comparison can be made with alternative sources of energy. To obtain a balanced view of various renewable energy technologies, it is most important to consider not only their emissions during operation, but also from all stages of their life cycles from manufacture, construction, deployment, operation and eventual decommissioning (Bioenergy Australia Newsletter, Oct 2000). Harvesting operations and transport to processing plants impact on the energy balance of the overall biomass system. Biomass utilisation produces zero or low net CO_2 emissions as carbon is recycled between combustion and plant growth (renewable energy source). If the true comparison is to be made between bioenergy and the use of fossil fuels then all stages of the life cycle need to be included.

Beer *et .al.*, (2000) provide an good indication of the demands in undertaking life cycle analysis. For example, a full life-cycle assessment of transport emissions takes into account not only the direct emissions from vehicles, but also those associated with the fuel's extraction, production, transport, processing, conversion and distribution. Quantification of the life-cycle then consists of estimates of the: plant-life for the equipment used in each of the steps, and the use of these plant-life estimates to determine weighting factors, energy usage in each of the steps, greenhouse gases associated with each of the steps, and air pollutants (if any) associated with each of the steps. All of these calculations are non-trivial (Beer *et. al*. (2000).

Table 7 below gives life cycle carbon dioxide emissions for a range of bioenergy and other renewable energy sources and is compared to 'best practice coal' and gas combined cycle gas turbines. Sims (2002) also provides (see Table 8) estimates of life cycle emissions for a range of conversion technologies. Energy crops have less immediate potential than using wastes and residues because of their higher delivered costs of available energy (Sims, 2002).

Sims (2002) also provides a measure of investment per tonne of carbon emissions avoided (see Table 9) to compare a range of electricity generating technologies. He also suggests that the difficulty in assessing technologies is very fuel and site specific and requires establishing a set of project assessment guidelines.

Table 7: Life Cycle Carbon Dioxide Emissions for various technologies (g/kWh)

Technology	Emissions (g/kWh)
Coal: Best Practice	955
Gas: Combined cycle	446
Onshore wind	9
Hydro - existing large	32
Hydro – small-scale	5
Decentralised PV- retrofit	160
Decentralised PV – new houses	178
Decentralised PV – new commercial	154
Bioenergy – poultry litter - gasification	8
Bioenergy – poultry litter – steam cycle	10
Bioenergy – straw – steam cycle	13
Bioenergy –straw - pyrolysis	11
Bioenergy – energy crops - gasification	14
Bioenergy – Forestry residues – steam cycle	29
Bioenergy – Forestry residues - gasification	24
Bioenergy – animal slurry – anaerobic digestion	31
MSW incineration	364
Landfill gas	49
Sewage gas	4

(Source *New and Renewable Energy: Prospects in the UK for the 21st Century, Supporting Analysis.* Dept of Trade and Industry, March 1999).

Table 8: Typical Life Cycle Emissions for Range of Conversion Technologies (g/kWh)

Technology	C	SO_2	NO_x
Wood biomass gasification	5-10	0.05–0.10	0.5-0.6
Coal – pulverised IGCC	190-220	11-12	4.0-4.5
Natural gas	90-120	0	0.5-0.6
Onshore wind farms	10-15	0.05-0.10	0.01-0.03
Decentralised solar PV	150-170	1.6-1.9	0.5-0.6

Table 9: Investment per tonne of carbon emissions avoided

Power station type	Carbon emissions (gC/kWh)	Emissions savings (gC/kWh)	Generating costs (USc/kWh)	$/t carbon avoided (US$/t)
Pulverised coal – base case	229		4.9	
CCGT – natural gas	103-122	107-126	4.9-6.9	0-156
Hydro	0	229	4.2-7.8	-31-127
Bioenergy IGCC – wood wastes	0	229	2.8-7.6	-92-117
Wind – good to medium sites	0	229	3.0-8.0	-82-135
Solar thermal and solar PV	0	229	8.7-40.0	175-1,400

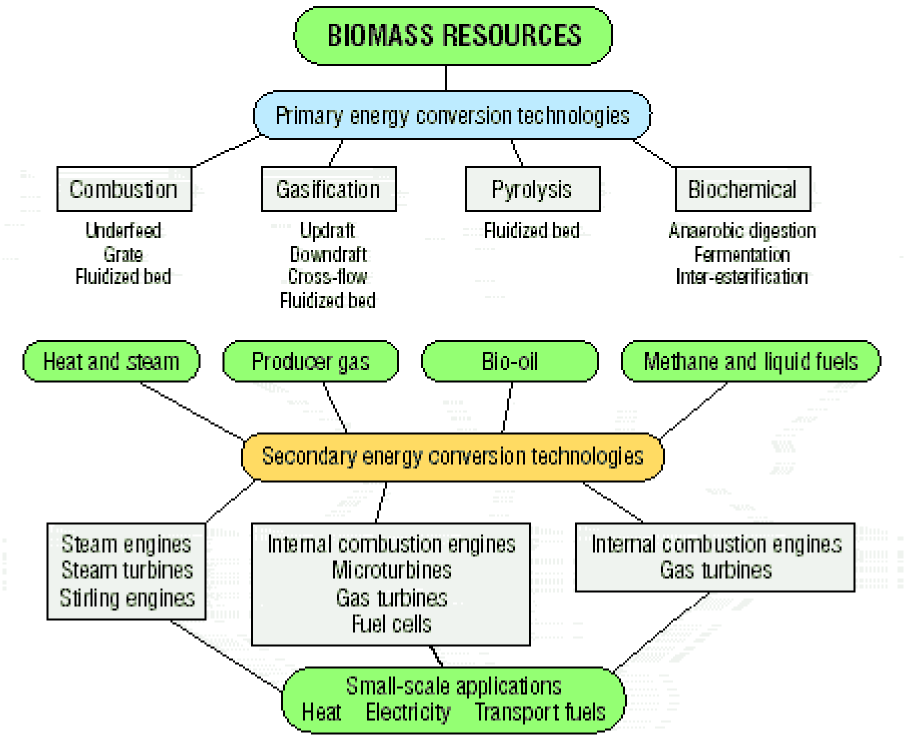
3.3.1 Capture and storage of CO2

The capture and storage of CO_2 from the combustion of fossil fuels is gaining attention as a means to deal with climate change. CO_2 emissions from biomass conversion processes can also be captured and if that is done, biomass energy with CO_2 capture and storage (BECS) would become a technology that removes CO_2 from the atmosphere (Azar, Lindgran, Larson, Mollersten and Yan, 2003). The use of biomass as a renewable energy fuel can become a means to harvest carbon from the atmosphere. The process can have a negative CO_2 balance.

3.4 Technical Options and Opportunities

Sims and Gigler (2002) provide a useful schematic to broadly describe the types of energy conversion technologies and associated energy products (see Figure 1).

Figure 1: Conversion technologies suitable to small-scale biomass projects



3.4.1 Methanol from biomass

The methanol conversion process involves gasification of the wood and then catalytic conversion of the gas stream to methanol (Enecon 2002) Methanol is routinely made from natural gas and it is felt that this technology could be adapted for use with gasifiers to make methanol from wood gas, however no such plants exist, even at the pilot scale. Unlike the production of ethanol the production of methanol from wood is relatively insensitive to the wood quality or species (Foran and Mardon, 1999).

There is potential to process biomass from Eucalyptus species and produce methanol, which could be used as a petrol substitute. Enecon (2002) demonstrate the potential market by highlighting that based on current estimates of system efficiencies, (the industry) would require the supply of more than 10 million tonnes of green wood each year to provide 10 per cent of Australia's liquid transport fuel requirements.

Van Bueren and Vincent (2003) suggest that if greenhouse and other environmental benefits were valued and coupled to financial returns, then the technology could be commercially viable. This assertion needs to be confirmed with further studies across a range of case study environments. Without such additional revenue, they are not likely to be viable with current technologies and prices (Stucley *pers. comm.*). Foran and Mardon (1999) suggest the cost of producing methanol from wood (including pre-drying) is about 81 cent per litre ($1,027 per tonne methanol) for a plant of 100,000 tonnes per annum capacity. This costing is based on paying $164 per tonne dry weight for wood (about $82 per harvested tonne). This significantly more than the $30 per tonne costing assumed for the oil mallee ITP plant estimates (although the $30 estimate is yet to commercially demonstrated).

3.4.2 Ethanol from biomass

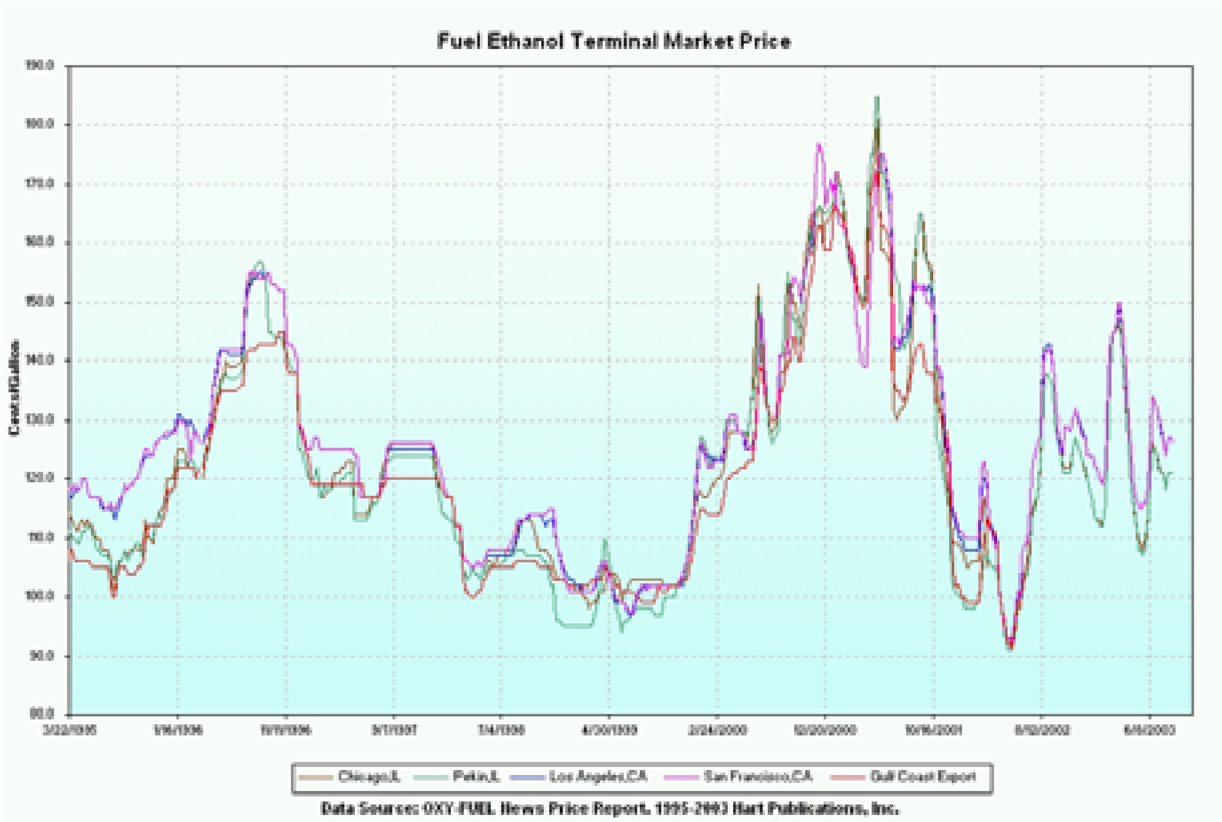
Ethanol can be produced from many other forms of biomass such as raw sugar by-products, sweet sorghum and wheat starch. Technologies to manufacture ethanol from wood generally focus on: hydrolysis of wood to recover sugars using acid (work is underway to develop enzymatic hydrolysis to replace this); and then fermentation of the sugars. There are no full scale wood to ethanol plants operating in Australia or internationally, but more than half a dozen pilot plants have been developed in the USA, Canada and Europe (Enecon, 2002). The yield of ethanol from wood is said by Foran and Mardon (1999) to be defined by the carbohydrate which represents part of the wood substance, and not all the sugars are fermentable. They also state that yield of ethanol is dependant on tree species.

Figure 2 shows the market price for ethanol across the United States. The price is currently around 125 US cents per or at exchange rates (1AUD = 0.64 USD) about A$0.52 per litre. At the peak price in Figure 2 of 180 US cents per gallon, the equivalent price is A$0.74 per litre. Both prices are below the Australian production price of $0.82 per litre.

3.4.3 Ethanol – wood versus molasses

Ethanol production from woody biomass would currently be more expensive than ethanol produced from molasses but it is possible though for the cost of ethanol from wood to reduce to a point that is similar to or even lower than the cost of ethanol from molasses (Enecon *et. al.*, 2003). Environmental benefits from tree planting for biomass to make ethanol are not obtainable when ethanol is made form molasses. Also, ethanol from wood provides significantly better greenhouse gas reductions than ethanol derived from molasses. Whereas ethanol from molasses reduces CO_2 emissions by 20 to 50 per cent over low sulphur diesel, ethanol from wood wastes provides a reduction of some 90 per cent (Beer *et. al.*, 2002).

Figure 2: Market price for ethanol in the USA (1995 – 2003)



3.4.4 Bio-diesel

Bio-diesel is generally produced from oil seed crops such as Canola, Soy and Sunflower through the process of esterification which converts alcohol and fatty acids / oils to bio-diesel. These annual crops do not produce dryland salinity benefits and as such have not been examined in detail in this study.

3.4.5 HYNOL

Hybrid processes of methanol production such as HYNOL seek to combine hydro gasification of the biomass with natural gas. This would avoid the need for an expensive oxygen plant and allows a lower capital cost of the methanol plant than conventional designs, with the aim of producing methanol at prices competitive with current United States gasoline prices (Foran and Mardon, 1999). The HYNOL process is still at the early R&D stage.

3.5 Integrated Tree Processing

The economics of electricity and transport fuel systems can be enhanced with integrated processing technologies to produce saleable co- or by-products. Indeed Lynd *et al.* (1999) in Foran and Mardon (1999) suggest that multi product and integrated refineries which produce fuels, chemicals, power and feed will be essential for the viability of economic systems and will need to be integrated into the broader resource, economic and environmental systems in which they operate.

One example of this is known as integrated tree processing (ITP). ITP has evolved from using Mallee Eucalypts to produce Eucalyptus Oil after it was recognised that production of oil alone would not be sufficiently profitable as to allow large scale planting and a suitable return to growers. Therefore technology that enables the production of multiple products has been conceptualised by Enecon (Enecon *et al*. 1999) and developed by Western Power Corporation. This process converts biomass into oil, activated carbon and renewable energy using a mix of technologies. This has been shown to have a far greater chance of producing profitable outcomes for landholders and investors (Enecon, 1999 and URS 2003). This option will be tested by a demonstration plant, which is being constructed in Narrogin WA, and is due for commissioning in 2004. The ITP Plant assessed by the Enecon (1999) report has design and production parameters as shown in Table 10. The demonstration plant will have a capacity of 20,000 tonnes of green biomass per year.

Table 10: Example Integrated Tree Processing Plant Parameters

Feed consumed	100,000 t/y	
Feed composition	40% wood, 25% bark and twig, 35% leaf, with 50% (including all the wood) going to the activated carbon plant, 50% to the oil extraction plant (including all the leaf).	
Capital cost ±15%	$28.4 million for a steam turbine with an air-cooled condenser plant	
Annual Operation Costs	$7.9 million	
Annual revenues	$17.3 million	
Feed cost, delivered to factory gate	$30/t	
Activated carbon products	GAC	2,720 t/y @ $3000/t ex works
	CAWP	1,090 t/y @ $3000/t ex works
	PAC	294 t/y @ $1000/t ex works
Eucalyptus oil produced	1,050 t/y @ $3000/t ex works	
Electricity produced for export	5 MWe “green” electricity at $60/MWh, 8000 h/y	

Based on the estimates provided in the Enecon (1999) report, revenue was split between the products as shown in Table 11. Activated carbon is the greatest single revenue driver with a total of 65% of the total revenue.

Table 11: Proportion of revenue from each product

Product	Production (/Yr)	Unit value	Total revenue	% of Total
Renewable Electricity	40,000 Mwh	$75 / Mwh	$3,000,000	17%
Eucalyptus Oil	1050 tonnes	$3,000 / tonne	$3,150,000	18%
Activated Carbon – GAC	2720 tonnes	$3,000 / tonne	$8,160,000	45%
Activated Carbon – CAWP	1090 tonnes	$3,000 / tonne	$3,270,000	18%
Activated Carbon – PAC	290 tonnes	$1,000 / tonne	$290,000	2%

3.5.1 Financial viability of the ITP plant

Key variables included in the RIRDC (1999) financial analysis are:

- **Mill door price for biomass** – a price of $30 per green tonne, which is an average of several prices for different land alternatives between $28 and $36 per tonne (about $15/t to the farmer net of harvesting and transport costs).
- **Eucalyptus oil revenue -** Traditional world markets for eucalyptus oil already exist in non-prescription pharmaceuticals, cleaning products and perfumery. Currently, the world market consumes 3000 tonnes per year of eucalyptus oil, most of which is produced in China, Portugal and India (all from Tasmanian Blue Gums), with 200 tonnes produced in Australia for specialty markets (fragrances etc). Eucalyptus oil has many other potential uses if it was available in significant quantities. The biggest potential market is as a solvent, especially for degreasing. This market exceeds one million tonnes per annum. Trichloroethane, a popular petrochemical-based solvent, is currently being phased out internationally, due to its ozone depleting properties. This presents an ideal opportunity to penetrate the solvent market with eucalyptus oil – a safe, stable, biodegradable, environmentally friendly alternative. Such penetration will require oil production at prices substantially below current levels to enable competition with other new solvents such as D-limonene.
- **Activated carbon -** Charcoal produced from the first stage of processing the woody Mallee Eucalypt feedstock can be further activated by steam to produce activated carbon (a high value product). This is the biggest revenue driver for the plant. Activated carbon has various uses but the most important are in water treatment, gas cleaning and in the food and beverage industry. Activated carbon acts to preferentially adsorb chemicals, ions and odours. The world market is estimated to be 700,000 tonnes per annum and is increasing at a rate of approximately 4-5% per annum. Mallee Eucalypt carbon appears well suited, on the basis of recent research, to the high value water treatment market. This market is estimated at 140,000 tonnes per annum. The total Australian market outside the gold industry is as much as 3,000 tonnes per annum and growing.
- **Renewable energy -** power generation creates two sources of revenue for an ITP plant. Firstly, grid connected electricity produced would be sold under a long term contract with an electricity retailer. On top of this, a biomass to energy plant can generate renewable energy certificates under the federal Mandatory Renewable Energy Target (MRET).

Results for the preliminary financial analysis of a large-scale ITP plant, indicate a positive net present value of around $33 million and an IRR of 17.4%. This suggests that the ITP plant investment is a financially attractive investment. This analysis includes the potential benefits of selling greenhouse gas abatement from the offset of fossil fuel generated electricity via RECs

Carbon markets will limit ITP and ten plants in total is an ambitious target. This would require 1 Mt green tree biomass per year – great on a per valley basis but only a small fraction of the total needed for overall salinity management (Stucley, *pers. comm.*). The Enecon study (1999) assumed that ITP commercial operations will only pay farmers for trees on a basis exclusive of the value for environmental benefits. The economics assumed for supply revenues have not been reassessed since 1999 and a lack of research funding for developing the harvester and related supply chain elements means this value is uncertain. The program of supply chain development is critical to success of this and all other bioenergy projects based on short-rotation tree crops in Australia. Unfortunately, the program has stalled due to lack of funding (Stucley *pers. comm.*).

For assessing biomass investments technology is not necessarily the issue of uncertainty, it is the supply chain and the guarantee of feed that is in need of more work. Accurate estimates on costs of biomass power station can be sourced from experienced equipment suppliers, but to get similar accuracy and guarantees on feed supply from new tree crops for that power station could take 18 months and several hundred thousand dollars (Stucley *pers. comm.*).

3.6 Co-generation and Co-location

While the sugar industry and a few wood processors use cogeneration, virtually no significant new opportunities exist for co-location of biomass conversion plants alongside industries that require heat.

3.7 Potential Efficiency Gains

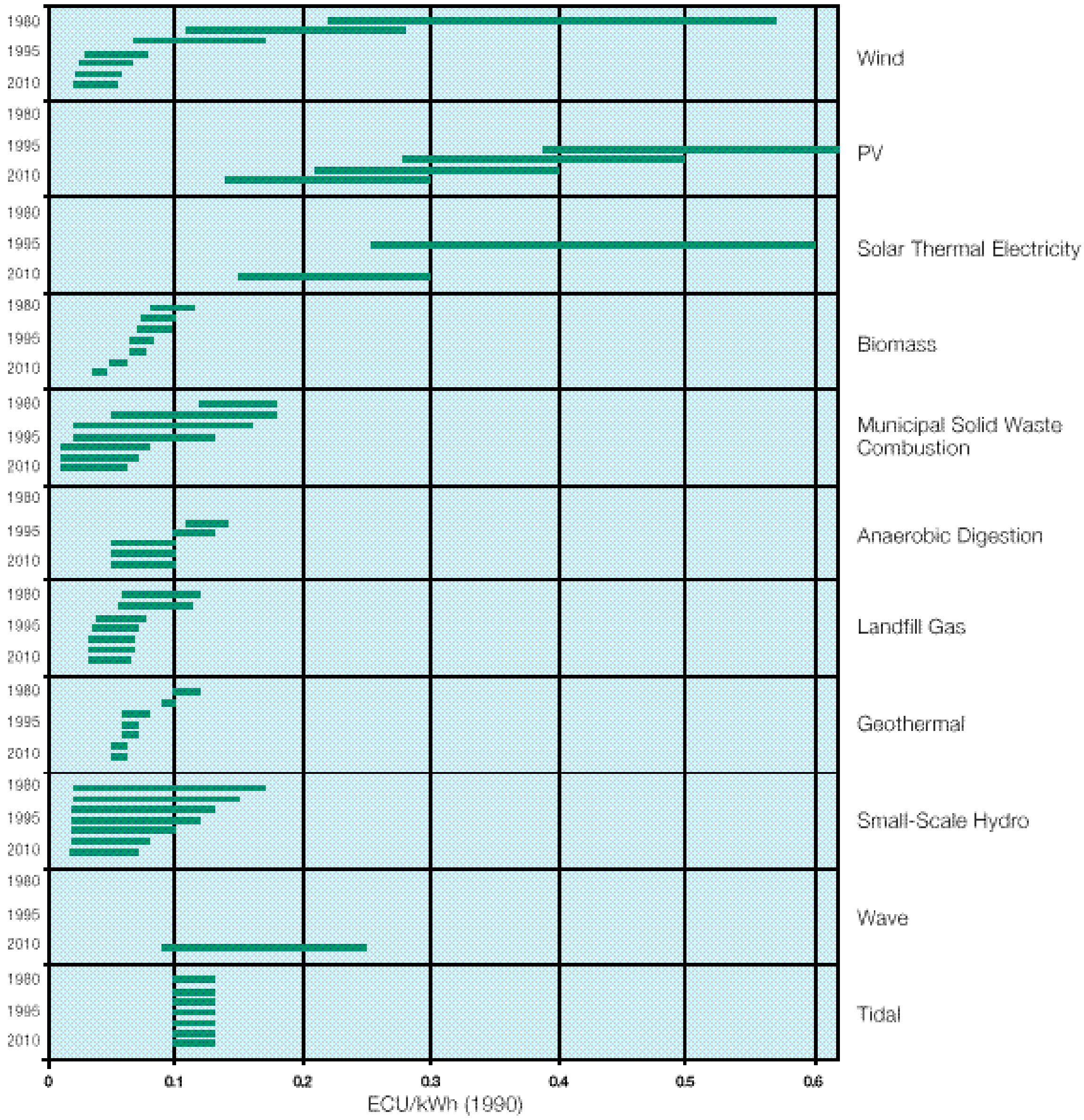
The economics of biofuels, and biomass to energy technologies, are likely to improve over time with conversion efficiency gains. Biomass was one of four renewable technologies that The Allen Consulting Group (2003) described as

> "*already relatively low cost but for which further improvement is expected*". "*Further R&D and demonstration is needed for gasification technologies (to increase efficiencies and reduce costs), and for pyrolysis. Some aspects of fuel preparation and supply, particularly for energy crops, also require further research and technical development*" (European Network of Energy Agencies, 2003).

Many biomass energy technologies are mature, with little improvement possible using existing technologies. What is required with technologies is the step change to biomass integrated gasification combined cycle BIGCC technology. Most improvements will be in the lower cost feedstocks (Schuck *pers. comm.*).

Investment in current technologies is necessary to promote the research and development necessary to produce these efficiency gains in the short to medium term. Figure 3 shows the estimated efficiency increases in Europe of biomass from 1980 to 2010 based on a range of studies and conditions across Europe.

Figure 3: Efficiency gains in renewable technologies



Source: European Network of Energy Agencies (2003)

4. Biomass Production Opportunities

This section reviews opportunities for growing woody biomass in target areas to address dryland salinity, where a commercially viable biomass production system integrates within broadacre farming systems, in the low to medium rainfall areas, to produce commercially competitive energy. It provides a brief assessment of potential target areas, demand for biomass and tree farming systems. A comparison between returns from agricultural enterprises and potential returns from biomass production is presented along with a detailed description of an oil mallee case study analysis. A biofuel industry, based on trees grown to address dryland salinity issues will need to be financially competitive against other renewable energy sources and fossil fuels. This needs to be achieved whilst providing sufficient returns to farmers to change land-use and compete with current agricultural enterprises.

4.1 Dryland Salinity

Salinity occurs as a result of watertables rising with application of water from irrigation (irrigation salinity), and from changes to water balance in due to changes in vegetation cover (dryland salinity). The excess water entering the watertable mobilises salt which then rises by capillary action to the land surface. The National Land and Water Resources Audit's dryland salinity assessment (NLWRA, 2001) defined the distribution and impacts of dryland salinity across Australia (see Table 12). This indicates the areas in each State with high potential to develop dryland salinity. This is a broad indication of the extent of the problem. Some 77 million hectares are potentially available for biomass production (Foran and Mardon, 1999). Of 18 million hectares of wheat belt land in Western Australia, 15 million hectares does not have perennial vegetation (Bartle, 1999).

Table 12: Areas (ha) with a high potential to develop dryland salinity in Australia

State/Territory	1998-2000	2050
New South Wales	181 000	1 300 000
Victoria	670 000	3 110 000
Queensland	not assessed	3 100 000
South Australia	390 000	600 000
Western Australia	4 363 000	8 800 000
Tasmania	54 000	90 000
Total	**5 658 000**	**17 000 000**

4.2 Tree Establishment to Control Salinity

Trees grown in plantation format are effective at lowering local groundwater tables, and hence prevention of salinisation at the surface. However, research has shown that water is not necessarily drawn from the water table direct, but instead the trees were removing water from the soil profile above the water table. Hence the action of trees amounts to a reduction of recharge (George *et al.* 1999). Although not exclusively the case, research indicates that the effect of trees on groundwater tables is very localised – to within 10 to 30 m of the edge of the plantings. Recharge management reduces recharge into the system where it occurs to prevent it re-appearing as discharge.

Discharge management is a reduction in seepage from the catchment to achieve a water quality target. This reduction can be achieved by using the increased discharge before it is able to transport salt into the stream flow. This relies on trees being able to transpire the additional water without succumbing to an increased salt content in the root zone. The planting of relatively small discharge areas is not widely recognised as a suitable long-term approach to limiting the impact of salinity at catchment scale, although it will have a short-term impact and buy time while other technologies are being established. Reducing recharge is likely to be the most effective long-term means of managing salinisation in many if not most high-salinity-risk areas (NLWRA, 2001).

4.3 Target Areas - Where Biomass could Target Salinity

For recharge reduction to be effective, revegetation will need to be strategically located and of sufficient scale to match the particular groundwater system that is influencing the salinisation process. The geological structures and groundwater systems of catchments determine the scale and relative importance of strategic positioning of revegetation for forestry, agroforestry and native vegetation (Williams and Saunders, 2003).

Broadly speaking the potential target areas for using trees to address dryland salinity are in the low to medium rainfall zones of 300-650 mm per year. Farming systems in these areas are generally based on annual cropping and annual pasture production. Dryland salinity may occur across a wide range of rainfall zones, from Mediterranean to sub-tropical and tropical climates. In targeting sites for production of biomass for renewable energy production consideration will need to be given to issues such as:

- trade-offs with revenues from current enterprises;
- timing and extent of potential on and off-farm benefits of addressing salinity;
- the balance of on and off-farms benefits; and
- impacts of trees on current farm management operations.

Ideally this type of analysis would benefit from a GIS analysis that intersects areas at threat from dryland salinity against rainfall isohyets and soil classification maps. This could be further enhanced by detailed assessment of potential for cogeneration and collocation with existing electricity consumers and industries requiring heat.

The methodology and data supporting the Bioenergy Atlas needs to be tested to provide such output – it appears the Atlas could be improved with tabular summaries of potential areas, rather than broad scale indications provided by maps. There is a need for demonstratable evidence of production capabilities and potential financial returns across a range of circumstances, data should enable feasibility decisions to be made at the sub-catchments scale not by region.

4.3.1 Catchment Classification

The Catchment Classification is a rigorous attempt to bring about informed decision making for salinity management. The project aims to classify types of catchments, their salinity risk status, the management options available to the catchment community and the opportunities for risk reduction, see http://www.ndsp.gov.au/catchclass/.

4.4 Potential Demand for Biomass

Table 13 indicates the number of green tonnes of biomass (wood feed) that would be necessary to meet demand for alcohol at a range of transport fuel market shares. An Australian liquid fuels industry using biomass for feed would be a driver for tree planting on a massive scale. Given productivity based on oil mallee production levels (15kg per tree per two years at a density of 2667 trees per hectare) 10% of the fuel market would require some 633,000 hectares of biomass plantation. With a planting density based on 30 metres between the alleys this equates to about 4.43 million hectares of agricultural land combining traditional agricultural enterprises with tree crops for biofuel. In Western Australia some 20 million trees or 7,600 hectares have been planted to oil mallees since 1994 (Bartle and Shea, 2002).

Given efficient conversion technology, production and transport methods, the potential demand has a capacity to greatly change land-use across the Australian broadacre farming landscape. Potential demands for either alcohol based fuels or electricity are large compared to current levels in investment in trial manufacturing plants and or tree plantings.

Table 13: Estimated woody biomass requirements for future manufacture of alcohol fuel

Alcohol as % of total fuel market	Quantity of alcohols (megalitres/year)	Wood feed required (green tonnes/year)	Annual value of wood feed (at $A30/green tonne)
10%	3,500	12 million	$360 million
30%	10,500	35 million	$1 billion
60%	21,000	70 million	$2 billion

Source: Wood for Alcohol Fuels. Using farm forestry for bioenergy, Enecon (2003)

4.5 Commercial Biomass Farming Options

Growing biomass for bioenergy has several advantages that enable it to be integrated within a farming system. The mechanical properties of the material are relatively unimportant. Consequently, species range can be increased to allow greater matching of species and site. Also, mixing of biomass from multiple species will not reduce prices to the same extent as when supplying the reconstituted wood market. The whole plant (stems, twigs and leaves) can be used. This increases returns to growers and whole tree harvesting eliminates trash problems from leaves and twigs stripped from stems on site. Bioenergy plants will be closer to the farms where the trees are grown than are existing ports or wood fibre manufacturing plants.

It is expected that farmers will be unlikely to invest in long-rotation forestry in the mid to low rainfall areas (Stucley *et.al.*, 2003). Short rotation crops are more likely to be attractive for farmers who are likely to be the owners of the relatively smaller plantings to be targeted and integrated within a farming system. It is likely that shorter rotation systems will be adopted on the necessary scale and targeted to specific sites to address salinity.

Short-rotation tree crops are those that can be harvested repeatedly every 2-10 years. They are suited to large-scale application in areas where potential salinity benefits are greatest and can be grown in a configuration to maximise water use in situ. Alley farming would use permanent rows of coppicing species, whilst phase farming systems would use non-sprouting species in rotation (5-6 years) with annual cropping or pasture species. Coppicing mallee species build up below ground carbon storage, and when farmed as alleys integrate well with current farming enterprises. Long rotation tree crops are unlikely to be a commercially-viable option for farmers supplying feedstock to a biofuel plant in most circumstances.

4.5.1 Phase farming with trees

Permanently placed trees in low rainfall areas are generally uneconomic. Phase farming with trees is designed to use trees grown in very short term rotations (3-5 years) to rapidly de-water farmed catchments at risk of salinity, by depleting soil water while producing utilisable products such as wood fibre and biomass. The tree phase would be followed by an agricultural phase of a length defined by the persistence of the hydrological buffer created by the trees. The system would use in situ groundwater recharge instead of relying on water to move (slowly) through the landscape to strategically placed trees. Trees in strips or blocks will be rotated across the landscape at relatively short intervals, using water locally. Because trees are moved across the landscape, optimum tree placement is of reduced importance. Conflicts with farming practice will also be reduced and traditional farming systems can be maintained in the areas not planted to trees.

One of the main concerns landholders have with phase farming is the removal of roots after the tree rotation to enable a return to annual cropping. At the end of the tree rotation large areas of high density tree plantation will need to be converted back to a state suitable for annual cropping, and low cost methods of removing or working around stumps left after harvest need to be developed. If farmers adopt phase farming systems, energy plants will need to ensure they encourage sufficient re-plantings to consistently provide stable throughput of feedstock.

4.5.2 Alley farming

Alley farming means using a planned, managed combination of woody perennials (shrubs and/or trees) in lines, with cropping or grazing in-between. There are two major forms of alley farming being developed.

- **Sandplain alley farming**. Commonly, the 'hedges' are composed of fodder shrubs and sometimes other small to medium sized trees. Pastures or crops (where suitable) are managed in the 'alley'. Perennial pastures are beginning to play more of a role in this system in the medium to high rainfall areas; and

- **Salinity/watertable control**. A common example is on valley floors in the wheat belt that are affected by shallow and saline watertables. The 'hedges', or tree lines, are less likely to contain fodder shrubs.

Alley farming is practised in the south-west of Western Australia (about 10,000 hectares), south-eastern South Australia (several hundred hectares), the mallee and Wimmera of Victoria (less than 100 hectares) and in south-eastern Queensland (less than 100 hectares). Some 5,000 hectares of this has been planted specifically to control rising water tables in the wheat belt of Western Australia, while the rest are multi-purpose plantings for fodder, timber, wind protection and soil improvement. In southern Australia, alley farming is most widely practised using belts of tagasaste (*Chamaecytisus proliferus*) to provide feed stock fodder while simultaneously controlling groundwater.

Alley farming provides a system to utilise short rotation tree crops and target them to address dryland salinity. However, there is doubt about the value of alley plantings to have the required impact on water balance (Bob Nulsen and John Hatton *pers. comm.*). The extent of planting is open to discussion and varies from site to site. The effectiveness needs to be validated across a range of target conditions.

4.5.3 Dedicated energy farms

Dedicated energy farms focus primarily on growing trees. To be most efficient they may have block plantings and be clustered close to biomass conversion plants. This may not be the case with conversion to bio-oil, and piping or tankering at much higher energy densities to power plants remote from the biomass production sites (Schuck *pers. comm.*) Otherwise, proximity to energy plants should enable energy farms to have lower costs of harvesting, transport and management. This approach will not necessarily provide or maximise desired salinity benefits as tree planting is probably undertaken on the basis of proximity to the plant and not on the basis of maximising benefits from addressing salinity within an agricultural farming system. Energy farming would increase forestry enterprises in areas that are not commercially viable because they are either too far from market or port. Internationally the idea has been demonstrated in Sweden (Willows), USA (Switch grass), and Canada (Poplar species) *(*David Brand, Hancock NRG, 2003 *pers. comm.*).

4.6 Potential Biomass Yields

Bartle (1999) suggests total biomass yields from oil mallees of five tonnes per hectare of dry matter are feasible from spaced plantings at a density of 20% of land area. Work by Milthorp *et. al*. (1998) in NSW indicated yields of between 5 and 7 tonnes from oil mallees and blue mallee on an annual harvesting cycle. A figure commonly used in assessing oil mallee production is based on 2667 trees per hectare yielding 15kg every second year, or 19 tonnes per hectare of trees.

4.7 Growing, Transporting and Harvesting

A major factor in minimising transport costs is to obtain biomass in the smallest possible area, in the closest possible proximity to the plant. From a harvesting perspective, the area available for harvest needs to have been planted on appropriate slopes for harvesting equipment, and to be of sufficient area to warrant the associated costs. Harvesting is a critical issue in the development of the industry and there has been limited progress in the development of a prototype harvester to be used in the Mallee Eucalypts industry in Western Australia. This is an area that would benefit from research funding.

4.8 Source Radius to meet Plant Capacity

Transport distance and density of plantings will have a dominant effect on harvesting and transport costs. Table 14 provides an indication of hectares of trees required and the necessary source radius for a 100,000 tonne of feedstock production plant for a range of biomass productivities, and tree farming systems. For example, if trees are planted in double belts with 30 metre inter-belt spacings, and they produce 15kg per tree every two years, then some 36,934 hectares of land will be planted to trees (with cropping or pastures between alleys). If 20% of the agricultural landscape is alley farmed then biomass feedstock will need to be sourced from up to 24.2 km from the plant.

Table 14: Ready Reckoner – Source Radius Vs Planting Density and Productivity

	Blocks	**Blocks**	**Blocks**	**30m inter belt alleys**	**30m inter belt alleys**	**30m inter belt alleys**	**50m inter belt alleys**	**50m inter belt alleys**	**50m inter belt alleys**
Plant Size (t/year)	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
Kg/tree	15	10	10	15	10	10	15	10	10
Trees/ha	2,527	2,527	2,527	361	361	361	230	230	230
Harvests/yr	0.5	0.5	0.33	0.5	0.5	0.33	0.5	0.5	0.33
t/ha/yr	19.0	12.6	8.3	2.7	1.8	1.2	1.7	1.2	0.8
Hectares needed	5,276	7,915	11,992	36,934	55,402	83,942	57,971	86,957	131,752
Landscape tree density	20%	20%	20%	20%	20%	20%	20%	20%	20%
Radius from plant (km)	9.2	11.2	13.8	24.2	29.7	36.6	30.4	37.2	45.8

4.9 Opportunities to Utilise more Species

Opportunities to utilise more species capable of producing higher value products are currently being investigated. The National Heritage Trust 'WA Search' project directly addresses the need to identify commercial options for tree species, products and industries in low-medium rainfall areas. The project has developed some simple selection criteria and indices by which species can be selected for developing new industries. Plant characteristics needed for the biomass energy industry are:

- produce matter that is economical to transport;

- must produce large amounts of biomass and suit short-rotation harvest;
- whole-of-plant usage with multiple product options and be mainly small-dimension material;
- be compatible with grazing and minimal competition with crops; and
- exhibit minimal weed risk and contribute to biodiversity where possible.

4.10 The Oil Mallee example – Lessons from a case study

Lessons learned in WA provide a good indication of practical issues facing oil mallee farmers and energy producers attempting to participate in the development of a wood-based biofuel industry. It provides the best Australian example of a potential industry, and the best estimates of farmer and industry returns. Mallee Eucalyptus or Oil Mallees are made up of a number of native Australian species of hardwood that grow in low rainfall areas throughout southern Australia with between 300mm and 600mm of rain per year. Results of feasibility studies provide a good indication of the best returns a farmer can currently expect from “energy farming” type enterprises, and provide an assessment of the relative merits of this enterprise against current farming operations and environmental impacts caused by salinity. At present returns from the ITP technology are suggested as the most commercially attractive opportunity for farmers growing trees under low rainfall conditions (500mm or less).

4.10.1 Growing conditions and yields

Mallees generally grow in areas receiving between 350mm and 600mm of annual rainfall, they have a competitive advantage over other forestry products at this rainfall and below. They have the ability to draw large hydraulic heads with root zones extending to twenty or thirty metres below ground level so an accessible (moving) groundwater supply is far more important than higher rainfall. To access groundwater, lighter soils are required which do not have natural barriers to groundwater.

There is no direct relationship between increases in profitability of agricultural areas and corresponding increases in growth rates of Mallees. There is an indirect relationship that largely depends on the extent of lateral flows in the provision of water to the trees (personal communication: John Bartle). In Western Australia, the relationship is present in some areas due to the uniform sandy soils with a high degree of lateral movement but in Victoria this is not likely to be repeated.

It has been suggested by Bartle (*pers. comm.*) that in general Mallee Eucalypts grow on country that often has the lowest yielding agricultural soils for annual crops and pastures, they are often light but several metres thick. Mallee Eucalypts are well suited to sloping land, and planting along contour lines. Slightly sloping country is highly desirable but severe undulation makes harvesting difficult.

4.10.2 Mallee farming methods

In WA the suggested method is to grow trees in hedges with two rows of trees per hedge. The distance between plants in the row is 1.5m to provide continuous feed to the harvester. The rows in the hedge are two metres apart and another 1.5 metres on each side of the row which is unavailable for agricultural production. The number of hedges and the distance between hedges varies according to the soil type, landscape position, farmer's aims, and percentage revegetation planned. Alley planting is generally favoured over block planting has it has been found that block planting produces lower productivity. Based on this configuration, there are 2,667 trees per hectare of hedge.

The trees are harvested once they reach a harvestable weight of around 15 kilograms. This is suggested as the weight that achieves the best ratio of leaf (for making oil) and wood. In Western Australia it is currently estimated to take 4 to 5 years to first achieve the harvest weight, but after this first harvest it will only take two or three years to reach harvest weight because of the coppicing properties of the trees.

Based on the spacing outlined above and a 95% survival rate (based on plantations established in WA), first harvest after 4 years with subsequent harvests every second year (a 4/2 harvest scenario), a total of 5,263 hectares of land is needed to produce 100,000 tonnes of biomass per annum required for the ITP plan. Each row is harvested separately leaving one row standing for the subsequent year. This spreads out cash flow and maintains environmental benefits. Planting costs in WA have been approximately $0.50 per tree.

4.10.3 Harvesting and transport

The RIRDC (1999) report provides details of a new system similar to sugar cane harvesting. In-field processing systems for plantation-grown hardwoods provide another model from which a new system of harvesting Mallee Eucalypts could be developed. All these alternatives provide for harvesting and in-field size reduction of the harvested biomass which is deposited into bins. The bins are then delivered to the roadside and trucks used to transport to the processing plant. The RIRDC report estimates that the total cost of harvesting can be about $9 per fresh tonne weight loaded onto trucks.

4.10.4 Financial results

Given the above production parameters and costs, Table 15 (URS, 2003) illustrates the returns from mallee biomass over a range of prices and yields. This is indicated as the average annual return per hectare, based on net present value of the flow net profit over a 25 year period, and a discount rate of 7%.

Table 15: Annual gross returns from Mallee Eucalypt biomass ($/ha)

Equivalent annual returns		**Biomass: kg per tree**					
		15	**16**	**17**	**18**	**19**	**20**
Biomass price ($/t green weight)	**$14**	81	95	190	285	380	475
	$15	96	111	222	333	444	555
	$16	110	126	252	378	504	630
	$18	140	158	316	474	632	790
	$20	170	190	380	570	760	950

Table 16 (from URS, 2003) compares biomass incomes against returns from broadacre agricultural enterprises, and the sensitivity to a range of biomass prices. For example returns from biomass is better than farming options if the farmer receives $15/t and gross margin returns from cropping are less than $100/ha. At $15 returns equate to an annual gross margin of $96/ha, at $20 returns from biomass is $170 per hectare. The financial results are highly sensitive to the harvesting schedule (essentially growth rate/productivity) and the farm gate price for biomass. If it takes five years to get the first harvest and the subsequent harvests are every third year rather than second, financial viability is poor.

Table 16: Comparative annual operating profit from Mallee Eucalypts (4/2 rotation)

NPV relative to current returns from crops		Annual Gross Margin ($/ha)					
		$60	**$80**	**$100**	**$120**	**$140**	**$160**
Biomass price ($/t green weight)	**$14**	21	1	-19	-39	-59	-79
	$15	36	16	-4	-24	-44	-64
	$16	50	30	10	-10	-30	-50
	$18	80	60	40	20	0	-20
	$20	110	90	70	50	30	10

4.10.5 Mallees - greenhouse benefits from CO_2 sequestration

Presently, oil mallees have the greatest potential for CO_2 sequestration in WA's low rainfall agricultural zone (250 - 400 mm) due to the limited range of other commercial perennial species (Shea, 1999). The comparative advantage of oil mallees for carbon sequestration is their ability to be harvested continually whilst retaining large quantities of stored carbon. The above ground biomass can be harvested every two years and the below ground ligno-tubers will continue to grow.

Four-year old *E. plenissima* contained approximately 4.0 tonnes of wood carbon per kilometre of hedge and 2-year old coppice contained 3.11 tonnes of wood carbon per kilometre of hedge (McCarthy, 1998). Similarly, after 30- years, assuming 14 harvests, the above-ground component is 44 tonnes of wood carbon sequestered per kilometre of hedge (Shea, 1999).

4.11 Influences on Farmer Adoption of Trees for Biomass

The financial value of growing trees is the most important factor influencing adoption. Lifestyle and environmental concerns may also form a part of their overall objective but financial security is central to the adoption question. So unless the growing biomass for biofuels is financially competitive and has other benefits that will lead to a perceived increase in financial security, industry development will not occur. Interviews with farmers from across Victoria's North Central region (URS, 2003) were designed to explore issues identified as being relevant to adoption of oil mallees as a land-use. A summary of responses is presented below.

Uncertain productivity - overwhelmingly, the biggest concern of farmers was the uncertainty of the productivity.

Business model - risk and uncertainty - the risk surrounding the lack of detail and structure to the business model, product markets, and lack of guarantee on returns means that currently, this proposition is perceived as far more risky than current operations. There is a significant "catch 22" predicament - energy or ITP plant investors do not want to build the plant until the trees are planted and the farmers do not want to plant trees until the plant is built. In WA, Landcare funding drove some early adoption.

Farm scale adoption required - farmers realise that success is contingent on gaining critical mass of planting. They also want to know the minimum feasible area for any one farm so that it is worthwhile for the harvester to actually come onto their farm. They also want to know the cost implications of harvesting small pockets of trees across dispersed areas of their land.

Capital investment - adoption is linked to capital investment requirements. Larger farms with higher disposable incomes may be more likely to adopt than smaller farms.

No first mover advantage - there is little incentive to be an early adopter in this case, a wise farmer is likely to wait for a couple of years to assess growth rates in soil types and regions similar to their own, and to monitor the success/development of the processing business - a good reason for trial sites.

Compatibility with existing farming system - the compatibility of the technical aspects of alley farming with current agricultural production is important in the adoption decision. Trees are favoured as they are seen as being integrated with current farming systems and having positive effects on land and community.

Reversibility - a significant barrier is the cost of reverting back to annual farming systems at a later date.

Social benefits - the employment associated with the processing plant and the effects in regional towns in terms of new housing, services, population, were seen as a significant positive outcome.

Environmental benefits - in this case, public environmental benefits, particularly salinity and biodiversity, did not figure highly in the motivations for adoption. Farmers stated that there would be limited salinity benefits and did not mention other environmental benefits apart from protection to stock and soil. The lack of salinity benefits, perceived or otherwise, means that there is a distinct contrast to the WA experiences where this is a major driver.

Labour impact - the actual and perceived labour requirements of alley farming are potential barriers to adoption. There could be increased labour requirements per unit area of agricultural production, as machinery must avoid the alleys in preparation and harvesting.

WA experience - the trial ITP project in Western Australia represents a significant benefit to the prospects of developing the idea elsewhere, through observation of the process and results although the distance and different conditions particularly related to salinity may reduce this benefit in comparison to a direct trial.

4.12 Potential business models for development

A business model for developing a bioenergy must consider the chicken and egg situation of encouraging farmers to plant trees for a processing facility that is not yet built. Both sides have risk to manage and to convince funders that the overall project will proceed. Government, as a third party, is also likely to have a necessary role in enabling the inclusion of environmental benefit values to add to financial returns.

Using results of farmer attitudinal surveys and economic analyses, URS (2003) proposed business models for development of an oil mallee industry in Victoria. A summary is presented below in a generic context for the development of a biofuels industry based on tree crops.

4.12.1 Public investment

The need to address basic information requirements for farmers and the potential for public benefits suggests that government expenditure to promote biomass production based on trees is economically justified. Public expenditure should be aimed at catalytic activities and address those constraints on development that are unlikely to be the focus of private investors. It is suggested that government investments will be important to the early stages of industry development. Key priorities would be:

- promote the value of socio-economic benefits of renewable energy, and the value of associated environmental outcomes, primarily salinity and greenhouse gas emission reduction;
- public funding for formal trials of tree crops on farm land in identified key priority regions;
- providing a contact point for education/extension services for farmers that might be interested in planting trees for biomass; and
- building links with possible third party investors – this could include energy plant investors as well as potential plantation investors.

4.12.2 Prospectus companies

Prospectus companies have been very successful in recent years in attracting private funding for new investments in rural areas, particularly in agro-forestry. The prospectus model is generally based on providing taxation deductions to third party investors for new enterprises in rural regions. The models can include purchase of land or lease from existing landholders. The model essentially shifts the risk of new enterprise development from farmers to third party investors who are able to carry the risk. Involving a number of smaller investors the prospectus companies also reduce the total risk to individual investors.

4.12.3 Private investors

It is possible that a range of private investors could provide a source of direct investment in ITP or energy plants. Potential greenhouse benefits could provide a particular source of capital from companies looking to invest in potential greenhouse offsets. Similarly, there are a number of companies actively attracting greenhouse-driven investment in Australia. Developing links with these could provide a vital source of capital. Any such developments would need to be done in close consultation with potential feedstock suppliers - farmers.

4.12.4 Market based incentives

Potential exists to develop linkages between energy companies and other parties who stand to gain value from mitigating salinity. At present, direct financial returns to potential energy producers and farmers from wood based energy or fuel production appears at best marginal. However, direct financial returns exclude non-market values and salinity benefits that may be slow to arise. Wherever possible market based signals should be used to guide investment, the values to be gained from natural resource management benefits, and greenhouse benefits, in additions to RECs, need to be linked to financial signals provided by alternative fossil fuel and renewable energy sources. International developments may well eventually influence a market for CO_2 emissions, however there may be benefit from creating a market for salinity credits. These would operate in a similar manner to renewable energy certificates. Liable parties would be prepared to pay to take appropriate remedial actions (plant trees that can be used for biomass) to offset their obligation to mitigate impacts of salinity.

5. Social and Environmental Effects

This section describes the social and environmental effects that a renewable energy industry based on biomass can provide by reducing greenhouse emissions and addressing dryland salinity. It also describes potential negative impacts, and a set of industry guidelines to ensure environmental and social benefits.

5.1 Potential to Contribute to Australia's Carbon Emissions Targets

A biomass-based renewable energy industry can offset fossil fuel generated electricity by producing energy by recycling rather than releasing carbon and it can also sequester more carbon than the agricultural system it replaces. For example, the emissions intensity of Victorian electricity generation is 1.363 tonnes CO_2 per MWh of electricity produced (Australian Greenhouse Office, 2002). The production of electricity (MWh per annum) at a biomass plant offsets electricity related emissions by this amount, minus any emissions produced in the growing and harvesting of the biomass.

Biomass energy plants also provide an opportunity to adopt embedded generation. Biomass plants can also be located closer to points of consumption and make savings on transmission losses and major investments in transmission infrastructure. This may also avoid construction of transmission infrastructure through environmentally sensitive areas. Distributed energy solutions may offer benefits of more efficient and cost effective electricity distribution, lower peak pool prices, and reductions in major investment in expanding electricity networks and coal power plants.

Renewable energy plantations can be continually harvested whilst they retain larger quantities of stored carbon than the pasture and annual crops they replace. The newly developed National Carbon Accounting System (Richards, 2001) and the associated CSIRO Greenhouse Resources Kit (CSIRO, 2002) are good sources of information in the accounting of greenhouse gas abatement. Measurement of sequestration amounts is a complex and developing field involving land rights, decay rates, and growth rates. It is understood that a methodology for accounting of Mallee Eucalypts is currently being developed in WA for approval under the National Carbon Accounting System, Carbon Accounting Model for Forests in Australia (CAMFor) (Don Harrison, *pers comm.* 2002).

The economic value of one tonne of CO_2^e (Carbon dioxide equivalent – a term used to convert all greenhouse gases into a common unit) is the value to society (in the case of global warming, society is the whole world) of not emitting that tonne into the atmosphere. This value would be related to the contribution to the global cost of adverse affects from climate change. Determining this value is a daunting task with huge uncertainties. As a likely minimum, this value is equal to the current financial price paid for a reduction in one tonne of greenhouse gas emissions. The Australian Greenhouse Office states:

> *"… it is feasible to assume that permits in the first commitment period could be valued at between $10 and $50 per tonne of carbon dioxide (in current-valued Australian dollars). Notwithstanding the uncertainties inherent in the projections exercises, a mid-range estimate*

approaching $30 per tonne would put a value on Australia's first commitment period emissions allocation under the Kyoto Protocol of around $60 billion, or $12 billion per year." (Source Australian Greenhouse Office, 1999)

Based on this assessment and other recent sales in the international field, the price of carbon dioxide equivalents of $10 per tonne could be used in an evaluation. A price of $15 per tonne has been adopted as a maximum penalty amount in the NSW benchmarking scheme (NSW Government, 2003).

5.2 Benefits of Salinity Control

Salinity benefits to farmers will arise from maintained or improved production on affected lands and potential losses avoided on land at risk of salinity. Wind and water erosion should be reduced, and there is some evidence of positive interaction of tree alleys with livestock and crop production - shelter to stock. Downstream benefits will arise from protection of irrigated agricultural production, infrastructure (reduced damage to roads, railways and buildings), reduced impacts assets from household consumption and industrial use of saline water. Protection of natural areas (for example, wetlands and associated biodiversity), and reduced flood risk are other effects.

The existing and anticipated impacts of salinity are well documented, correspondingly so are the benefits if cost effective solutions can be developed. An example from National Land and Water Resources Audit's dryland salinity assessment (NLWRA, 2001) is presented as Table 17. This indicates the assets in areas at high risk from shallow watertables or those with a high salinity hazard.

There is much benefit to be gained by successfully addressing dryland salinity if it can be achieved at the right cost. The value of production benefit is linked directly to the current value of agricultural returns from existing enterprises. The primary need is in developing cost effective solutions to address dryland salinity at local and regional scales. The value of benefits from addressing and avoiding salinity are site specific, the integrated impacts on biological systems and potential solutions differ as a result. Ultimately the task is to match the cost of remedial measures against the benefits to be gained. This requires local assessment of impacts and potential solutions.

Table 17: Assets in areas at high risk from shallow watertables or with a high salinity hazard.

Asset	2000	2020	2050
Agricultural land (ha)	4 650 000	6 371 000	13 660 000
Remnant and planted perennial vegetation (ha)	631 000	777 000	2 020 000
Length of streams and lake perimeter (km)	11 800	20 000	41 300
Rail (km)	1 600	2 060	5 100
Roads (km)	19 900	26 600	67 400
Towns (number)	68	125	219
Important wetlands (number)	80	81	130

The extent and severity of dryland salinity is expected to increase. The impact cost of dryland salinity on agricultural production is estimated to have a net present value of $558 million over the next 20 years. By 2020 agricultural profits will be around $101 million per annum lower than current levels.

Estimates of *in-situ* impacts on infrastructure provide a "best bet" estimate of $89 million per year. The present value of downstream impacts on infrastructure with a 5% increase in water salinity was estimated at $511 million nationally (NLWRA, 2001). Dryland salinity is a national problem that will cause increasing economic and environmental costs. To date most farming system options to address this issue come at a major cost to farmers and the extent and rates of adoption have not generally been sufficient. Identification of a commercially viable option for land-use change would provide major national benefit.

The value of off-site benefits of salinity control has been estimated in a growing array of reports and audits. The ability to achieve these benefits is highly variable, and depends on the hydrogeology, soils, and rainfall of the region as well as the current degree and extent of salinity. A salinity case study, on Kamarooka (north of Bendigo), by Read for the National Land and Water Resources Audit (2001), found that "there is no simple broadly applicable paradigm with which to conceive our responses to salinity and expectations of farm based change leading to salinity control need to be tempered". Responses need to be matched to local and regional situations and optimised to each set of opportunities.

5.3 Biodiversity/ Re-vegetation Benefits

Biodiversity values can be improved by protection of existing remnants from dryland salinity, and by adding to local habitat value with the introduction of additional perennial vegetation across the landscape. Reductions in salinity will also provide improvement of water quality in wetlands and downstream creeks and rivers. Biomass planting can be integrated into existing vegetation networks to provide linkages between remnant vegetation. The scales required to meet the thresholds and targets set for biodiversity appear to be of the same order as those required for management of dryland salinity and water quality (Williams and Saunders, 2003).

5.3.1 Ground rules to ensure desirable biodiversity outcomes

The conservation of biodiversity is increasingly being recognised as a key element of farm forestry management. To achieve complementary benefits from biofuel planting, and to minimise negative impacts a number of management and planning elements should be addressed. However, it needs to be recognised that the primary objective of biofuel plantings will be financial, along with benefits from addressing dryland salinity. A number of principles or ground rules for ensuring desirable biodiversity outcomes have been developed by Carr and Curtis (2000), Lindenmayer (2002), and Dames and Moore (1999), they are presented below. These types of ground rules should be developed into a biofuel industry code of practice, which may include:

- incorporating biofuel plantings into whole farm plans and catchment planning exercises to maximise integrated benefits;
- retaining all existing native vegetation within plantation landscapes - don't replace any natural ecosystems with farm forestry;
- incorporating existing native vegetation into new plantings, link remnants and develop buffers;
- selecting appropriate species, not be an environmental weed, be locally endemic or Australian species;

- aiming to maximise the species diversity of the planting;
- protecting native vegetation along gully lines;
- controlling invasive weeds; and
- adopting cautionary practices for chemical application.

5.4 Regional Employment

Energy sourced from biomass is labour intensive relative to energy from coal and fossil fuels. Jobs would be created in the growing and harvesting of tree crops, the transportation of the biomass, and in the plants converting that biomass to an energy product. Because these plants need to be located close to the source of their feedstock most of these jobs will be in regional areas – which are generally suffering from declining employment opportunities.

MacGill *et.al*. (2002) note that although renewable energy technologies are relatively immature and their employment characteristics, as well as capital costs are likely to change with increased deployment, the economic, particularly regional, development and employment potential of renewable energy is clear. The MacGill study concludes that renewable energy projects appear to make excellent employment generators - the creation of permanent O&M and fuel collection jobs with the biomass plants is particularly notable. In the short term, it seems likely that renewable energy projects will add to rather than substitute for jobs and investment created by the fossil fuel sector. Within the renewable energy industry itself, projects rarely compete with each other. The transition towards a more sustainable energy system seems to promise expanded opportunities, rather than a threat, to regional employment and economic growth. While the difficulties in assessing Australian expenditure have been noted, results nevertheless suggest that renewable energy projects can have high Australian content and, hence, leverage considerable additional economic and employment activity within the community (MacGill *et.al*., 2002).

The Australian Greenhouse Office (2002) estimates that to sustain a tree cropping operation that is producing 1.5 million tonnes of green feedstock per year will require 250 extra direct jobs to plant harvest and transport the feedstock, and 50 full time positions created with the establishment of the biomass processing plant. The NSW Sustainable Energy Development Authority (SEDA) commissioned ACIL Consulting (ACIL, 2000) to conduct a study to quantify employment generated by renewable energy infrastructure developments. The study attempts to provide employment indicators for a range of energy industries, and also for different stages in which companies are engaged (manufacture, installation, operation & maintenance, and in some cases fuel collection/extraction). In summary, the ACIL study findings included the following points.

- Often there was a clear division between larger scale renewable energy companies and those that had relatively small-scale operations. The latter tended to employ more staff per MW and per unit, whereas the larger companies had clearly achieved some economies of scale and had lower employment indicators.
- The popular perception that the renewable energy industries have higher employment indicators than the coal fired power industry was confirmed for most industries, although the size of the difference varied significantly. Even as the renewable energy industry matures it is likely that the

nature of the industry will ensure that it generally employs more people on a per MW or per unit basis.

- Employment opportunities associated with renewable energy projects tend to be concentrated in rural and regional Australia.

In Australia, biomass-fuelled energy production is still relatively limited, hence it was difficult to obtain employment indicators from Australian companies. An Organization for Economic Cooperation and Development (OECD) study provided sufficient data to develop a range for the general indicator for urban wastes, and an Austrian study provided the stage-specific data for the indicators for installation and operation and maintenance for forestry residues and wood wastes. Table 18 summarises the ACIL study's employment indicators for all industries and the stages they are involved in for which a reasonable level of confidence could be established.

Table 18: Employment indicators – jobs per MW

Jobs/MW	General	Manufacture	Install	Operate & Maintain	Fuel Collect / Extract
Solar PV	114 - 129		50*		
Solar hot water	7.3				
Wind large	3 - 8	3 - 6	0.5 – 0.8	0.05 – 0.5	
Hydro large	1.3			0.1	
Hydro small			0.6		
Bio-urban wastes	1.25 - 3				
Bio-forestry/wood	**3.7**	**0.6**	**0.7**	**0.3**	**2.1**
Gas cogeneration	1.5 – 9		5.8	0.13#	
Coal seam methane	2.2	0.9	0.5	0.3	0.5
Coal fired power stns				0.11	0.3

* For small companies only (up to 0.002 MW installation per annum),
# For large companies only (over 100 MW O&M per annum),

Source: ACIL (2000)

Similarly an Australia Institute (2001) paper demonstrates that renewable energy plants will be located in regional Australia and that $3-$4 billion was being invested in some 80 renewable energy projects (as at 2001), and "*even in the absence of effective policies, the development of greenhouse friendly energy industries is creating a large number of jobs in regional Australia*". Crawford and Angel (2000) summarise studies from Europe and America, which also show that renewable energy industries provide more jobs than coal industries. They suggest that coal employs 2-3 persons per installed MW of electricity capacity, whereas biomass (based on agriculture biomass) employs 6-10 persons. Development of an ITP plant of 100,000 tonnes annual capacity, and associated Mallee planting, will provide significant impacts to the regional economy and the community. The plant will directly employ approximately 40 people (Enecon et al 1999) and may spawn many other local small businesses associated with value adding to the eucalyptus oil and activated carbon production.

5.5 Social Benefits

The socio-economic benefits of renewable energy production are another driver of the gaining interest in bioenergy but these values are generally poorly appreciated. Task 29 on Socio-economics is an international collaboration within the IEA Implementing Agreement on Bioenergy that is undertaking research to better understand the value of these effects. The International Energy Agency (IEA) is established within the framework of the OECD to implement an international energy programme.

Bioenergy contributes to many important elements of a country or region’s development including: economic growth through business expansion (earnings) and employment; import substitution (direct and indirect economic effects on GDP and trade balance); and diversification and security of energy supply. Other benefits include support of traditional industries, rural diversification, rural depopulation mitigation and community empowerment (IEA Bioenergy, 2003). Table 19 provides a summary of the types of socio-economic benefits associated with biomass production and utilisation.

Table 19: Socio-economic issues associated with biomass production and utilisation

Dimension	Benefit
Social	• Increased standard of living • Environment • Health and Education • Social cohesion and stability • Migration effects (mitigating rural population) • Regional development • Rural diversification
Macro Level	• Security of supply/risk diversification • Regional growth • Reduced regional trade balance • Export potential
Supply Side	• Increased productivity • Enhanced competitiveness • Labour and population mobility (induced effects) • Improved infrastructure
Demand Side	• Employment • Income and wealth creation • Induced investment • Support of related industries
Institutional Aspects	• Democratic decision processes • Participatory problem solving • Local problem solving

Source: Domac, J. and Richards, K. Final Results from IEA Bioenergy Task 29: Socio-economic Aspects of Bioenergy Systems, 12th European Conference on Biomass for Energy and Climate Protection, Amsterdam, 2002: 1200-1204.

Investing in the renewable energy industry in Australia may provide opportunities to lead the development of new technologies, such as those related to biomass, into other markets across the globe, producing export dollars and local jobs in regional areas. For example, *"wind is the world's fastest-growing energy source on a percentage basis, with installed generating capacity increasing by an average 32% annually for the last five years (1998-2002)"* (American Wind Energy Association, 2003). Danish and German manufacturers dominate this industry, and have flourished because of early investment and subsidies from their respective governments. As an example, Denmark has a 20 per cent target increase in their renewable energy program and Germany has an 8 per cent targeted increase (both are between the period 1997 – 2010) (Australian Wind Energy Association, 2003).

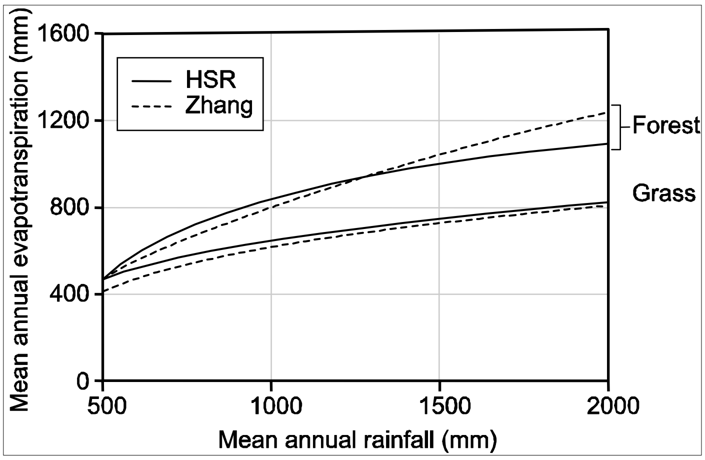
5.6 Reduction in Recharge and Water Yield

When trees are planted to replace annual crops and pastures they generally use more water, often it is intended for the trees to reduce or negate recharge to groundwater (to address an existing imbalance), however a concern is any reduction in surface water flows that may adversely affect the environment or downstream users. This section presents findings of research into the relationship between reduction in recharge and water yield. Generally the effect of tree plantings on runoff is greater in higher rainfall areas. The amount by which revegetation can reduce river flow is predicted to be much smaller, or zero, in mid to low rainfall catchments, which are the main target areas for short rotation tree crops for biomass production.

Revegetation for forestry and agroforestry can reduce the amount of water entering rivers and streams (Williams and Saunders, 2003). Tree planting will reduce river flows and recharge to groundwater and, in certain circumstances, may lead to short-term worsening of river salinity prior to any improvement (Vertessy *et. al.*, 2002). The impacts will not be uniform and are suggested by O'Loughlin and Sadanandan Nambiar (2001) to be influenced by the nature of water flows, landscape features, area and density of plantings, and management. A critical relationship is that between mean annual rainfall and stream flow and recharge. Specific catchment, climate and groundwater characteristics are important considerations in assessing relative benefits.

> "Several recent Australian publications have summarized how mean annual runoff in catchments would be affected by afforestation (Vertessy, 1999; Vertessy, 2001). The foundations of these studies are two sets of curves known as the Holmes and Sinclair (1986) and Zhang *et al.* (1999) curves. Both sets of curves relate mean annual rainfall to mean annual evapotranspiration (and, by difference, mean annual runoff) in forest and grassland covered catchments" (see Figure 4 in this document). Source: Vertessy *et. al.*, (2002).
>
> "Both sets of curves are quite similar, differing significantly only for the case of forests in high rainfall areas (>1200 mm per year). These curves have been tested locally and overseas and have been shown to be robust estimators of mean annual runoff for grassland and forest catchments (Vertessy and Bessard, 1999; Bradford *et al.* 2001; Zhang *et al.* 2001; Zhang *et al.* 2002)". Source: Vertessy *et. al*., 2002).

Figure 4: Relationship between land cover, mean annual rainfall and mean annual runoff



Relationship between land cover, mean annual rainfall and mean annual runoff, as predicted by the Holmes and Sinclair (1986) relationship (HSR) and the Zhang *et al.* (1999) model. Source: Vertessy (2001).

The effect of tree plantings on runoff is greater in higher rainfall areas, as evidenced by Figure 4. The amount by which revegetation can reduce river flow is predicted to be much smaller in mid to low rainfall catchments than for high rainfall catchments (Williams and Saunders, 2003). O'Loughlin and Sadanandan Nambiar (2001) also state that where the mean annual rainfall is less than 500mm the reduction in usable water resources is zero. Given that the majority of target areas for addressing dryland salinity are in medium to low rainfall areas (especially with the use of oil mallees) the impacts on runoff are likely to be minimal.

However, potential negative effects of total runoff need to be considered against benefits of reduced salinity (improved water quality). There is a need to plan for a balanced approach to addressing salinity and maintaining water availability. Where any large scale planting is fostered there will be a need to assess local and regional effects and the relative merits (social and economic values) of improving water quality and any reduced quantity. There are no simple criteria for analysing the potential impacts of revegetation programs on water flows, there is a need to recognise the diversity of ecosystem-specific processes and local and regional contexts O'Loughlin and Sadanandan Nambiar (2001), but "most of the likely hydrological impacts of afforestation can be predicted using current catchment models" (Vertessy *et. al*., 2002). In rainfall areas greater than 500 mm it is possible, with careful planning, to minimize the hydrologic impacts of afforestation. Vertessy *et. al.* (2002) suggest strategies that include:

- Planting in areas with less than 800 mm annual rainfall where yield reductions are lower and salinity is more of a problem.
- Planting in mosaics to spread out the impact. Catchments with less than 20% area planted exhibit little water yield effect.
- Planting away from drainage lines in areas likely to lie outside of the main runoff-producing zones.

They also suggest that a regulatory framework be erected to control the development of new plantations, so as to complement other water resource preservation policies such as the cap on diversions in the Murray Darling Basin and recently introduced farm dam legislation.

5.7 Water use, waste, and by-products from Bio-energy plants

Foran and Mardon (1999) suggest water requirements for cooling to be substantial, about 1,000 m^3 per hour for a production rate of 300 tonnes per day of methanol (1,320t wood wet weight). This equates to 0.76 m^3 of water per tonne of wood throughput. With appropriate cooling towers or ponds actual consumption is less than this, but is some areas water demands may be a critical resource. Appropriate water conservation processes should be a prerequisite requirement to minimise environmental impacts. Dry cooling is quite common for energy production plants and greatly reduces a power plant's water requirements for cooling. As an example of this, the ITP demonstration plant being built near Narrogin has adopted a design philosophy that minimizes water use wherever possible, for example by using air-cooled condensers. Trees on the property are then irrigated with any waste water produced.

Co-products and co-values are very important for the economics of bio-energy plants, for instance ash can be sold as a soil amendment, and one concept that is gaining note is that of a biorefinery with multiple products for sale. This review did not investigate literature describing the quantities and chemical activity of by-products from the biomass conversion plants. However, it is considered to be appropriate that as a general principle resources should be recycled where possible and guidelines be developed to ensure safe management of any harmful substances.

6. Overview, Opportunities and Considerations for Policy Development

This section provides an overview of major issues affecting the development of a biofuel industry in Australia, it outlines opportunities that a biomass based renewable energy industry may provide, and presents suggestions for policy development.

6.1 Overview

Australia faces increasing impact on its agricultural productivity, water quality and environmental health as a result of dryland salinity. Much of the research effort and government investment has focussed on replacing deep-rooted perennial vegetation in landscapes cleared for agriculture. However, because resultant benefits are primarily off-farm environmental and social effects, on-ground investment by farmers, in the main, presents a direct cost to landholders. Land is taken out of production and most revegetation activities are non-commercial plantings. Consequently the level of investment in revegetation by farmers is often less than desirable from a broader community perspective.

If commercially viable options for replacing deep-rooted perennial vegetation can be developed then it is hoped that efforts to address dryland salinity will increase. This report discusses the objective to develop a commercially viable biomass production system that integrates within broadacre farming systems to produce feedstock that can be processed to provide a source of renewable energy. This must consider the chicken and egg situation of encouraging farmers to plant trees, and encouraging investors in a processing facility. The following points provide an overview of major issues affecting the development of a biofuel industry in Australia.

A biofuel industry, based on trees grown to address dryland salinity issues will need to provide sufficient environmental and financial benefits to be financially competitive against other renewable energy sources and fossil fuels whilst providing sufficient returns to farmers to change land-use and compete with current agricultural enterprises. The co-values of environmental benefits need to be appreciated, and coupled to the benefits of renewable energy production to maximise the incentive for investment in growing biomass and building biofuel plants.

Current efforts to encourage planting of perennial vegetation suffer from the disconnect between private on-farm effects and off-farm benefits, the same situation will still need to be addressed to encourage investment in a biofuel industry. Returns from biomass production will assist but it is still unsure whether they will provide sufficient returns to farmers. Further research is needed to better understand any gap between private returns and social benefits.

Changes in the MRET target and extensions of the timeframe would make some difference to this unfavourable investment environment. The comparative advantage of biomass projects is the potential for salinity mitigation and greenhouse gas abatement benefits, as well as the creation of a sustainable rural industry. However, unless these are valued separately – i.e. additional social and environmental benefits are quantified in the decision-making process - then it is unlikely that the current policy framework will lead to any private investment in a biomass based biofuels industry. MRET energy from trees is not commercially viable.

Electricity seems to be a more economically attractive product from biomass than ethanol or methanol over the next fifteen years, even when potential advancement in liquid fuel technologies is considered. Currently, neither ethanol nor methanol (from any renewable source) is directly competitive with equivalent products sourced from fossil fuels. Consideration of greenhouse and on-farm salinity benefits is probably insufficient to offset the price gap. These values are still uncertain and need to be confirmed with further studies across a range of case study environments.

The economics of electricity and transport fuel systems can be enhanced with integrated processing technologies to produce saleable co- or by-products. One example of this is known as integrated tree processing (ITP). ITP converts biomass into oil, activated carbon and renewable energy using a mix of technologies. This has been shown to have a far greater chance of producing profitable outcomes for landholders and investors. Carbon markets will limit ITP and ten plants in total is likely to be an ambitious target. This would be 1Mt green tree biomass per year and only a small fraction of the total needed for overall salinity management. An Australian liquid fuels industry using biomass for feed could be a driver for tree planting on a massive scale.

The economics assumed for biomass supply from high-rotation tree crops have not been reassessed since 1999 and a lack of research funding for developing the harvester and related supply chain elements means this value is uncertain. The program of supply chain development is critical to success of this and all other bioenergy projects but it stalled several years ago. Harvesting – as it best applies to Australian trees and landscapes - is a critical issue in the development of the industry and there has been limited progress in the development of a prototype harvester to be used in the Mallee Eucalypts industry in Western Australia. This is an area that would benefit from research funding.

The financial value of growing trees is the most important factor influencing large-scale adoption. Lifestyle and environmental concerns may also form a part of their overall objective but financial security is central to the adoption question. So unless growing biomass for biofuels is financially competitive and has other benefits that will lead to a perceived increase in financial security, industry development will not occur. A business model for developing a bioenergy must consider the chicken and egg situation of encouraging farmers to plant trees for a processing facility that is not yet built. Both sides have risk to manage and to must convince investors that the overall project will proceed. Government, as a third party, is also likely to have a necessary role in enabling the inclusion of environmental benefit values to add to financial returns.

The economic, particularly regional, development and employment potential of renewable energy is clear, renewable energy projects appear to make excellent employment generators. Renewable energy projects can have high Australian content and, hence, leverage considerable additional economic and employment activity within the community.

To capture opportunities an infant biomass based biofuel industry will need to make the most of synergies between land-use options and a renewable energy options. Catalytic investment must combine benefits from addressing dryland salinity with commercial returns and environmental benefits from having a renewable source of energy. Government policy, and any seed funding, must seek to optimise the combination of these values. Government policy must recognize that the timeframes needed to develop a healthy industry and capture the related community benefits will be decades and not years.

6.2 Opportunities for Biofuel from Biomass

There is significant national benefit to be gained from addressing dryland salinity problems by using biomass for biofuel as a driver of perennial vegetation plantings. Exciting opportunities exist to combine the development of a renewable energy industry based on biomass with a commercially viable mechanism to address dryland salinity. Potentially, there are opportunities to:

- Prevent salinisation and protect downstream irrigated agricultural production, and infrastructure, and avoid potential losses on land at risk of salinity;
- Provide a commercially viable driver for deep rooted perennial vegetation to address dryland salinity;
- Reduce greenhouse gas emissions via replacement of fossil fuel based energy with renewable energy;
- Diversify agricultural income base, improve the sustainability of agricultural land management and offer more long-term job opportunities in regional areas;
- Reduce impacts on household and industrial assets from use of saline water;
- Improve biodiversity values by protecting existing remnants from dryland salinity, by adding to local habitat value, and providing improvement of water quality in wetlands, creeks and rivers;
- Adopt distributed generation, and hence reduce the inherent risk of total system failure that stems from a reliance on a centralised energy supply;
- Reduce the cost of electricity distribution, make savings on transmission losses;
- Improve the quality of power supply in remote rural locations;
- Reduce major investment in transmission infrastructure, electricity networks and coal power plants;
- Avoid construction of transmission infrastructure through environmentally sensitive areas;
- Sequester more carbon than the agricultural system it replaces;
- Capture and store CO_2, use biomass as a means to harvest carbon from the atmosphere and have a renewable energy generating process that has a negative CO_2 balance;
- Be a major source of fuels for developing fuel cell transportation; and
- Provide opportunities to lead the development of new technologies and systems, and generate export dollars.

6.3 Considerations for Policy Development

In general, government can help to kick-start a sustainable bioenergy industry by:

1. Increasing the attractiveness of the biomass industry by linking direct financial returns to non-market values, especially salinity and greenhouse benefits. Wherever possible, market-based signals should be used to guide investment; The values to be gained from natural resource management benefits, and greenhouse benefits needs to be linked to financial signals provided by alternative fossil fuel and renewable energy sources.

2. Developing integrated natural resource management and energy planning. Federal and State governments should integrate biomass-driven renewable energy initiatives with NRM planning initiatives. Government needs to recognise that NRM investments could be offset by commercially driven outcomes from a biomass industry, and recognise private commercial drivers as a legitimate means to deliver verifiable public NRM outcomes.

3. Developing a principle of cost share that accounts for values potentially gained from natural resource management and greenhouse benefits, and link these to financial signals provided by alternative fossil fuel and renewable energy sources.

4. Making the costs of electricity generation, transmission and distribution more transparent and flexible to provide signals for private investors to optimise the location of new generation capacity to supply costs and system demands.

5. Developing a mechanism that maintains consumer price equity objectives whilst removing cross-subsidisation of transmission costs across large distribution network areas - to reduce transmission losses and create opportunities for the development of smaller regional generation.

6.3.1 Federal Policy Development

The Australian Government could:

6. Increase the MRET target - to at least 5% - and permit dedicated energy tree crops within eligible sources. Remove all “higher value” conditions on plantation tree crops. Enable the Office of the Renewable Energy Regulator (ORER) to provide some degree of certainty as to a project’s eligibility before the money is spent on the plant, not after, as at present.

7. Remove all perverse and greenhouse-negative production and electricity generation subsidies by ensuring full cost recovery of public expenditure from the beneficiaries.

8. Endorse the Joint Venture Agroforestry Program’s (JVAP) policy direction and support continued JVAP investments in research projects. Potential issues for further investigation include:
   - Demonstrable evidence of production capabilities and potential financial returns across a range of regions and circumstances;
   - Greater understanding and demonstration of supply chains (harvest, transport, store) which are currently highly variable across Australia, need to be integrated into forestry decisions

and are a far greater source of uncertainty in energy from new tree crops than are the energy technologies.

- Cost analysis – does bioenergy plus co-values provide sufficient benefit to the community to justify the long-term subsidies that will make it work, and where are the best places to capture these benefits?
- Need to do the analysis to locate potential areas – combine spatial and economic modelling to optimise locations on basis of salinity benefits (on and off-farm), farmer return tradeoffs between traditional agriculture and biomass, co-location efficiencies; and
- Ensure that the next generation of bioenergy 'atlases' and salinity hazard maps function at appropriate scales to provide the information required by policy makers and investors.

9. Dedicate an institution responsible for investigating and supporting the development of a biomass industry that combines renewable energy and new renewable products with the environmental and social benefits provided by new tree crops established on previously cleared land. Priority areas of responsibility and actions should be to:

   - Develop an information and marketing package for industry and NRM agencies to raise interest and awareness of benefits arising from using biomass as a renewable energy;
   - Sell the idea to the community to foster their understanding of biofuels as a clean renewable source of energy;
   - Highlight the benefits of distributed energy;
   - Scope and fund a major development program of $20 - $50m for R&D;
   - Develop a revolving fund, or a pooled development fund to share investment risk;
   - Support the development, with environmental agencies and community groups, of a Code of Practice for biomass and biofuel industries to ensure appropriate management and protection of biodiversity, water use, and water and air quality;
   - Address negative perceptions of biomass by the community, such as confusion with using native forests as a feedstock, air quality, and water resource impacts;
   - Provide public funding for trials of tree crops on farm land in identified key priority regions;
   - Provide a contact point for education/extension services for farmers that might be interested in planting trees for biomass;
   - Build links with possible third party investors – this could include energy plant investors as well as potential plantation investors;
   - To improve our understanding of the biomass supply chain as it applies to Australian conditions, and identify the equipment and technological needs for lowest-cost delivery;
   - Develop methods to optimize carbon investments;
   - Promote this work as Australia's commitment to sustainable agriculture;
   - Develop models for grower networks; and
   - Develop models for reducing the funding risks associated with commercial decisions based on as yet unplanted crops, including the commerciality of co-products with tree cropping (eg. activated carbon and eucalyptus oil).

6.3.2 State Policy Development

State Governments could:

10. Educate decision makers as to the environmental, economic and social benefits of tree crops and the negative consequences of doing nothing and letting land and water degradation run their course.

11. Gain leverage from NRM investment programs. In particular, using the regional investment planning and priority investments process under the National Action Plan for Salinity and Water Quality (NAP) as a vehicle for funding the development of a biomass fuel supply plant in a priority region, and using NAP/targeted funds to top-up a commercial investment. Test the NRM market to determine what the public sector needs to invest to catalyse commercial drivers.

12. Test the private investment market by tendering an expression of interest for developing a partnership with government to invest in an integrated NRM program to foster planting of deep-rooted perennial vegetation for biomass, as well as an integrated tree processing facility to produce renewable energy. In particular, the test should determine the:

    - Gaps in policy from a business perspective;
    - Significance of commercial interest in biomass and bioenergy production; and
    - Commercial reality of this type of business risk.

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