THE NARROGIN IWP DEMONSTRATION PROJECT

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ABSTRACT

Farmers in Western Australia have pioneered the replanting of mallee trees to combat dry land salinity. Mallees are able to undergo long-term short-rotation-coppicing. Chipped leaf and mallee wood will be processed in the Integrated Wood Processing Demonstration plant at Narrogin to produce renewable electricity and associated certificates, eucalyptus oil and activated carbon. These multiple products will generate sufficient value for future full-scale plants to operate commercially and to pay adequate stumpage to farmers to allow mallee farming to compete directly with cereal cropping.

1. BACKGROUND

Two major environmental issues confronting Australia today are the degradation of agricultural lands and climate change associated with increasing greenhouse gas emissions.

The salinity crisis threatens 30% of the Western Australian wheatbelt, 30 regional towns and 450 native plant species and is recognised as Western Australia’s greatest environmental threat (State Government of WA 2003). The crisis occurred through the removal of deep-rooted trees and their replacement with annual crops, thereby disrupting regional water balance. The cost to the State in lost agricultural production and damage to infrastructure is estimated at $664 million per annum (Australian Dryland Salinity Assessment 2000). Having already lost 1.8 million hectares to salinity, and faced with losing the equivalent of one football field per hour from now on, the response by farmers will almost certainly be to extract greater productivity from the remaining arable land. However, 80% of farmland already suffers some acidification due to increased use of nitrogenous fertiliser and the removal of organic material (Australian Agriculture Assessment 2001). The sustainability of traditional agricultural systems is in question. While it is recognised that deep-rooted trees planted on farms will avoid some of the adverse effects of dryland salinity, no market mechanism yet exists to encourage their planting, and the scale of planting required is far in excess of farmers’ and the state government’s budgets.

Climate change has also occurred in the south-west of the Western Australia over the last thirty years, as it has globally. There is a definite warming trend, a decline in rainfall, and a dramatic reduction in run-off into dams. Climate change has necessitated the building of the state’s first large desalination...
plant. It is internationally accepted, scientifically and politically, that the burning of fossil fuels for electricity generation is a contributor to global climate change (IPCC 2001).

Large-scale bioenergy projects using farm-grown short-rotation-coppice (SRC) tree-crops would tackle these issues in a number of ways. The trees planted to support the bioenergy plants would lower the water table, thereby abating the spread of salinity. The trees would also provide a sink for carbon dioxide, offsetting some of the State’s growing emissions (eg. Shea et al. 1998). The bioenergy plants themselves would displace fossil fuel generation. Combine these benefits with the provision of livestock shelter belts, soil stability, biodiversity, regional employment and electrical grid support, and it can be easily seen how bioenergy could assist in improving agricultural sustainability. For energy crops though, at the feedstock price required for a reasonable return to farmers, and at the necessarily small scale, the production of bioenergy alone would be too expensive to be viable.

In the early 1990’s, the Department of Conservation and Land Management (CALM) and the Oil Mallee Association (and later the Oil Mallee Company) examined the indigenous oil-producing mallee species for their commercial potentially as a farm tree crop to address the salinity problem. Mallees are an ideal tree crop for the dry wheatbelt, as they can be coppiced indefinitely, are drought tolerant, fire resistant and have very high eucalyptus oil content in their leaves. This oil is of a particularly high quality when compared to other eucalypts. However, if the trees are to provide a commercial return to growers and contract harvesters, the economics of oil production are marginal at best, even combining eucalyptus oil and bioenergy.

In the meantime, however, CSIRO had developed a method of manufacturing charcoal in a fluidised bed specifically designed for recovering energy, and for the extra step of producing activated carbon. Enecon Pty Ltd, which holds the commercialisation rights to the CSIRO technology, approached CALM, Oil Mallee Company and Western Power and the concept of producing three products, renewable electricity, activated carbon and eucalyptus oil, in an integrated process was developed. This became the Integrated Wood Processing (IWP) project. A feasibility study funded by Western Power and Rural Industries R&D Corporation showed that the concept was commercially viable, both for farmers and for the process itself. In particular, samples of activated carbon were made by CSIRO using mallee wood as feed. These activated carbons showed outstanding properties for water treatment in independent tests carried out by the Australian Centre for Water Quality.

The IWP approach can give farmers a commercial return on trees that they plant. Not only is the IWP process energy and water efficient, it also maximises the value-adding potential of the mallee feedstock. Importantly, while the electricity produced will supply a valuable steady revenue stream for the plant, it only amounts to approximately 20% of the total, with the bulk of the revenue coming from the activated carbon. Any future benefits from salinity credits or carbon trading will result in additional returns to the participants. The mallees will, of course, continue to sequester carbon on a cyclical harvesting regime, as their lignotubers and roots keep growing, and there will always be a standing tree crop which has superior carbon sequestering ability than the cereal crops they replace.

The Integrated Wood Processing Demonstration Plant at Narrogin in the Western Australian wheatbelt, has been constructed to demonstrate new technologies to produce the three products from farm-grown mallees. There are sufficient mallee trees planted near Narrogin to supply a demonstration-scale plant, but not sufficient as yet to supply the needs of full-scale commercial plants.

The IWP plant will take up to 20,000 tonnes/annum of chipped whole-tree mallee, delivered by private contractor from farms in the region. The mallees must have been grown on cleared farmland (cleared
prior to 1990) and have been harvested in accordance with the approved Harvesting Code-of-Practice, to comply with the conditions of the Renewable Energy (Electricity) Regulations (2000) and produce Renewable Energy Certificates. The mallees will initially be harvested using conventional forest harvesting equipment. On this small scale though, this is an expensive process and could not be used in a future commercial plant. A prototype harvester has shown that continuous harvesting of mallees with purpose-built equipment is viable. Such equipment is expected to achieve significant reductions in the cost of mallee biomass delivered for processing.

Future full-scale IWP plants would be five times the size of the demonstration plant and require the planting of 20 million trees each to keep them supplied with biomass on a continuous basis.

![Schematic of the IWP Process](image)

Figure 1. Schematic of the IWP Process

2. **THE IWP PROCESS**

For the demonstration project, mallees (or other plantation trees such as blue-gum if required) will be harvested whole and chipped in the field. The leaf and chips will be transported to the project site where winnowing equipment will separate the leaf and the wood into two process streams.

Inside the IWP plant, there are six major components:

- **Charcoaling** plant uses a fluidised bed based on CSIRO technology to recover the heat of partial combustion of the mallee woodchips, producing steam to generate renewable electricity. Additionally, heat from the bed’s flue-gas is recovered to pre-heat the boiler feed water. The CSIRO concept eliminates the troublesome liquid and gaseous emissions common to normal charcoalers, while recovering the energy, which is normally wasted. The plant will pioneer this Australian developed concept, which appears to have great potential for value adding to plantation timber production.
The Activation fluidised bed activates the charcoal using renewably generated steam. The water gas produced in the process is burned out and the heat recovered in the boiler to achieve a net steam surplus – used for renewable electricity generation. The concept, also conceived by the CSIRO, has been developed by Western Power and Enecon to turn the production of activated carbon from a net consumer of energy to a net producer, de-coupling activated carbon production from the local cost of energy. Tests carried out so far indicate that the mallee wood produces a high quality activated carbon with very broad adsorptivity (it can adsorb organic molecules from very low to very high molecular weights) – broader in fact than most commercial reference carbons readily available. The high quality of the mallee activated carbon made via this process provides the potential to make future IWP plants fully economic.

The distillation plant will extract eucalyptus oil from the mallee leaves prior to leaf gasification. The still will be heated by recovered heat from the boiler flue, and by condensing the boiler blow-down water in the still’s jacket. By coupling the still to the waste heat output of the IWP, the project will demonstrate that eucalyptus oil can be extracted economically from any future bioenergy plant that uses plantation eucalypt feedstock.

An Waterwide™ gasifier will be pioneered for generating steam and electricity from the spent mallee leaves. No other plant in Australia has successfully used gasification of biomass for grid-connected electricity generation. The gasifier has the potential to combust renewable biomass cleanly and with low-maintenance, and has been specifically designed to produce a clean, steady heat flow to the boiler, free of any uncombusted volatiles.

The boiler recovers the heat from the gasifier and the activation plant and produces high pressure, high temperature steam for power generation and process steam.

The steam turbine takes steam from the boiler and charcoal plant to generate renewable electricity. A small portion of this is used to power all the motors, pumps and controls in the plant, and the majority is exported to the grid.

Plant operation is designed to be continuous, twenty-four hours per day seven days per week.

3. PROJECT SCHEDULE

The construction phase of the demonstration project is nearing completion.

The plant has been in commissioning mode for many months in the meantime, allowing harvesters and feed-handling systems to be optimised to provide the correct biomass specification for the plant.

A first market assessment of the products has already been undertaken, but it is also necessary to have actual sales during the operating period to demonstrate that expected product sales and revenues will support the viability of a full-scale plant.

The prospects for future full-scale plants will be fully evaluated by the second quarter of 2006.
4. DEMONSTRATION PLANT PRODUCTION FIGURES

Feedstock Requirements
Approximately 2.5 tonnes per hour, or up to 400 tonnes/week at full (24 hour/day) production. This is 10 x 8 tonne trucks per day.

Plant Output Targets:
Activated Carbon at a production rate of approximately 89 kg/hour, or 13 tonnes per week at full production.
Eucalyptus Oil produced at a rate of 16 L/h, or 2.5 tonnes per week at full production.
Renewable Electricity at 1 MW plus Renewable Energy Certificates.

Activated Carbon Quality Targets:
The activated carbon must achieve an Iodine Number (IO)\(^1\) of at least 800 for the process to be regarded as successful.

The project team would seek to produce activated carbon with an IO number of 1,000 at some stage during the proof of concept phase in order to evaluate the balance between quality and cost of production.

5. SHORT-ROTATION-COPPICE BIOENERGY AND THE POLICY ENVIRONMENT

Repeated below
For fully commercial IWP plants in the future though, and for any other bioenergy projects, it has to be recognised that the Mandatory Renewable Energy Targets (MRET) will be completely satisfied by 2010. In fact, most retailers will probably have supply contracts finalised by 2008. So bioenergy plants constructed after 2008 probably won’t be able to sell Renewable Energy Credits and their electricity will have to compete in the wholesale electricity market. Effectively, there will be no mandate for additional renewable energy after 2008.

The two schemes that replace the MRET are the Renewable Energy Development Initiative and the Low Emission Technology Fund (LETF).

The $100 million (over seven years) REDI scheme will support R&D activities by private sector firms (or tax paying corporatised utilities) on a one to one financial basis. REDI can support projects at the proof-of-concept stage and help commercialise renewable energy initiatives. The questions to be asked are, what research needs to be undertaken to make bioenergy directly competitive with fossil generation, and it is this scenario ever likely to eventuate? For the SRC bioenergy industry at least, this is doubtful. For utilities and large corporations, it is extremely difficult to write a business case to invest in R&D activities when, without a follow-up for MRET, there may be no market in which to sell the eventual product.

\(^1\) Iodine Number is a universally used indicator of the surface area of the activated carbon. IO numbers of up to 1,300 are possible. In reality, an array of other (often more useful) indicators such as BET surface area, MIB, tannin, phenol, atrazine, and microcystin adsorption etc will be tested once the IO hurdles have been reached.
The $500 million LETF is designed to support demonstration of low emission technologies, which have substantial national abatement potential, on a one to two financial basis. The stated target for each successful LETF technology is to achieve abatement equal to at least 2% of national energy use with realistic long term penetration. This is equivalent to significantly more CO2 reduction than the entire MRET scheme. Commercial uptake of funded technologies is expected to begin in the decade 2020 to 2030. Again, given that there is no commercial driver to reduce CO2 emissions, and that low-emission technology will almost certainly be more expensive than current technologies, asking corporations to invest in the development of technologies that simply don’t have a market is a difficult task. LETF is a fund though that would suit short-rotation-coppice bioenergy projects. Under this scheme, two options mentioned are geosequestration of CO2 and hydrogen for electricity generation. Bioseqestration of CO2 (simply by planting trees) is not only cheaper than geosequestration but also provides the additional benefit of salinity abatement. Also SRC crops are likely to be an order of magnitude cheaper for the electricity generation than hydrogen.

Whatever support is offered though, SRC projects need to be fully commercial. The collapse of the ARBRE project in Yorkshire is a case in point, where farmers who had planted 1,500 ha of SRC crops, where left stranded by the commercial failure of the plant (Boyle 2002). Whether any up-front support through the LETF would be sufficient to offset the unsupported electricity selling price though is doubtful.

In the current policy environment, the only SRC bioenergy plants likely to succeed are those which have multiple products, with electricity as a secondary income stream. In the absence of any means of monetising any of the broad scale landcare benefits of SRC, distributed generation and renewable energy, the IWP type of project appears to be the SRC prospect likely to succeed in this competitive environment. Co-firing aside, any bioenergy plant that has to purchase fuel will almost certainly be non-viable unless it can monetise other products.

6. EXPECTATIONS

While it must be clearly recognised that the IWP concept is not the sole solution to the salinity crisis in WA, it is seen by most stakeholders as a groundbreaking project that will open up the mallee as a feedstock for other industries, and bioenergy in particular. It will also have considerable local impact on salinity in the district in which each future plant is built and, at the moment, it is one of only few near-term options.

Taking the IWP technologies from pilot and bench scale to industrial demonstration scale has been a long and difficult task. However, all the engineering and design issues that arose during this period have been addressed and the project team is now confident that the process will achieve the engineering milestone of producing the three products during integrated operation.

On the small scale at which the Demonstration plant will operate, the mallee feedstock will be quite expensive to harvest and transport, while still delivering an adequate stumpage to farmers. The modelling done in the IWP Feasibility Study indicated that it would be possible to halve this cost without affecting stumpage if a purpose-built harvest/delivery system could be developed. This is a fundamental requirement, not just for future IWP plants, but for many other mallee end-uses, such as bioenergy or wood-chip. The prototype harvester developed for this project has gone a long way
towards proving the concept of fast, reliable mallee harvesting, but a lot of work still needs to be done in this regard, and it will not be done without government support in recognition of the multiple benefits that such a harvester can provide.

7. ACKNOWLEDGMENTS

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