

Potential non-wood tree products for low-medium rainfall areas

This report covers a small range of products mainly in the energy area. Climate change is a focal point in Europe with resources being used to implement emerging technologies to reduce greenhouse gas (GHG) emissions.

The potential Australian non-wood products, based on observations in Europe, are:

- Energy
 - Electricity generation
 - Bioenergy plantations
 - Liquid transport fuels
 - Ethanol
 - Methanol
 - Pyrolysis oil

- Pyrolysis products

- Naval stores

Some additional background information on ethanol is included based on the author's earlier visits to Brazil and the USA and pyrolytic tars from visits to Finland and Brazil.

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Executive Summary

Objective

To investigate potential non-wood products from tree species grown in low-medium rainfall areas suitable for farm forestry in Australia based on a visit to a number of European Countries.

Key Results

The author travelled to the European countries of the United Kingdom, Austria, Czech Republic, Poland and Romania during March to April 2001 to conduct visits to forestry, forest products and bioenergy research institutes, universities, companies and a trade association and to participate at the 40th International Union of Forest Research Organisations, board meeting. The Rural Industries Research & Development Corporation funded part of the cost of travel and requested a short report on potential opportunities based on European experiences.

The non-wood products considered in this report are fast growing, short rotation energy plantations for energy, electricity generation, liquid transport fuels:- ethanol and methanol, pyrolysis oil, pyrolysis chemicals and naval stores.

Application of Results

For these systems to be applicable and succeed in Australia, the actions that must be undertaken are:

- determine suitable tree species with a high yield, sustainable production and adaptable to short rotation
- ensure profitable production by way of selling price of the tree biomass and/or other benefits produced in growing the trees that can deliver a monetary return eg: synergistic salinity control, carbon sequestration and photosynthetic oxygen production, landscape and biodiversity. Some of these products are obviously essential but not saleable.
- investigate available markets for the products: local, national and global or the development of latent markets
- ensure market acceptance of the product
- investigate suitable conversion technologies which may need to be developed by way of financial incentives such as capital grants on RD&D projects
- investigate growing, harvesting, transport, storage and handling technologies to reduce costs and minimise losses.

Further Work

This report indicates observations based on the overseas visit. More detailed studies can be conducted on these and other ranges of products.

TABLE OF CONTENTS

INTRODUCTION	1
EXECUTIVE SUMMARY	2
Objective	2
Key Results	2
Application of Results	2
Further Work	2
TABLE OF CONTENTS	3
ENERGY	4
Electricity Generation	3
Liquid transport fuels	4
Ethanol	4
Pyrolysis oil	5
PYROLYSIS CHEMICALS	6
NAVAL STORES	6
RECOMMENDATIONS AND CONCLUSIONS	8



ENERGY

Europe is very concerned about climate change, which has been attributed to excessive accumulation of GHG in the atmosphere causing global warming and more volatile weather patterns. The UK has an ambitious program to cut GHG to 20% of 1990 levels by 2010. An important part of its strategy is to develop renewable energy and increase its contribution to replace fossil energy sources, which is responsible for the emissions of the GHG - carbon dioxide CO₂.

Electricity Generation

In the UK, electricity generation is a major source of CO₂. It has set a target to increase the contribution of renewable energy in electricity generation by 10% of the total by 2010. They have concentrated on offshore wind and bioenergy where they believe that these resources require a financial boost to improve their commercial viability and narrow

the gap between research, development and commercial implementation. In bioenergy their focus is on the establishment of sustainable energy crops, new conversion technologies, a guaranteed market share and electricity pricing for the first new renewable energy sources to come on-stream. Their estimates show that bioenergy is around 90% greenhouse neutral when produced sustainably, taking into account the greenhouse emissions from site establishment, growing, harvesting, transport and conversion, thereby justifying their strategy. Conversion technologies for bioenergy are combustion, gasification and pyrolysis. Combustion technologies are available which can be adapted to use a range of biomass fuels. Funding for the adaptation of combustion systems has produced a significant bioenergy generation capacity coming on stream. Under



Figure 1. ARBRE 10 MW power station in Leeds, UK using new gasification technology with combined cycle gas turbine and steam turbine electricity generation. Short rotation intensive culture coppicing willows will be used for fuel. The project is currently being commissioned.

the new initiatives, as of 30 June 2000, an extra 834 MW of new generation capacity from 331 projects has been created since the introduction of the Non-Fossil Fuel Obligation (NFFO). Gasification and pyrolysis technologies are still in the development stages (Figure 1). These systems have certain advantages such as the potentially higher electricity generation efficiency of combined cycle gasification systems and the ease of transport of “bio-oil” fuel produced by pyrolysis. These advantages have resulted in capital funding grants to projects on gasification and pyrolysis.

Bioenergy Plantations

Bioenergy yield is an important consideration in the economics. In the UK fast growing plantations of willow clones are being established. Current yields of 8-11 tonnes/ha/y are being achieved with hopes to increase this to 17 tonnes/ha/y by 2010. Other high yielding C4 grasses are also being investigated as a bio-fuel source such as switchgrass and miscanthus. There are comprehensive information guides available to assist the industry to establish bioenergy farms backed by government subsidies.

Virtually all wood species can be burnt for energy production. In Australia, the challenge would be to select, or develop, suitable species, which will grow well in the medium to low rainfall areas that will produce good yields of biofuel. If they can deliver other benefits, it would more likely produce an economically viable bioenergy resource. The author believes that this business should be considered alongside what technologies and practices need to be used in the whole value

chain namely: growing, harvesting, fuel preparation, transport, delivery, storage, conversion marketing and selling of the electricity produced. Opportunities may also exist in selling the waste heat to local industries under a cogeneration system framework.

Liquid transport fuels

Ethanol

There is interest in ethanol as a transport fuel in the UK and it was mentioned to the author that tax breaks are available for ethanol produced from cellulose resources. Ethanol is a proven transport fuel for spark ignition engines and is used as a mixture of up to 10% with petrol and sold commercially in Australia and overseas. In a visit to Brazil in 1988¹, the author found that a proportion of vehicles use “Alcool” which is mixture of 95% ethanol and 5% water. These require specially tuned engines while the ethanol/petrol mix will run interchangeably with normal petrol in ordinary engines. Currently, all transport grade ethanol is manufactured from starches and sugars. In Brazil, the largest user of ethanol fuel, Alcool is made from sugar cane.

Sugars and starches are carbohydrates that generally have higher values as food products than as a fuel. They are expensive to produce in relation to their fuel value as they generally form a small proportion of the plant biomass material. In Australia, fuel ethanol produced from these sources (eg potato peeling wastes) has been subsidised by way of excise exemption and an ethanol bounty (which is no longer available to new schemes). However, cellulose is the most abundant



¹ Fung, P.Y.H. *Eucalypts in Brazil for charcoal, fibres and energy and the IUFRO All Division 5 Conference*. 12 May-6 June 1988.



resource found in biomass. Cellulose can be broken down (hydrolysed) to fermentable sugars. Unfortunately, cellulose in woody plants occurs with other plant substances such as lignin, hemicellulose and extractives. The lignin must be separated to unlock the cellulose. The most costly steps in the conversion process are the pretreatment and hydrolysis.

Industrial production of ethanol by the acid hydrolysis of wood began in Germany during the war years to supply transport fuel. This industry continued in Russia for some time afterwards. However, ethanol production ceased in Russia in the early 1990's because of its poor economics. The process did not utilise byproducts such as lignin.

If other valuable coproducts can be made from lignin, extractives and hemicellulose, there is perhaps a better opportunity for commercial ethanol production from lignocellulose feedstocks for transport fuel. The author visited a pilot plant ethanol plant using sulphuric acid hydrolysis at the National Renewable Energy Laboratories in Golden, Colorado USA in 1997². Commercial plants have been planned in the USA. A semi-commercial plant using a combination enzyme and acid hydrolysis has been built in Canada. Acid pre-hydrolysis gives better accessibility, and prepare the cellulose for the enzymes to work. There is European interest in these developments in North America.

Methanol

Methanol has also been considered as a transport fuel derived from wood. The pathway is gasification and purification of the gaseous product to produce synthesis gas (carbon

monoxide and hydrogen) followed by catalytic conversion to methanol. In theory, this process can utilise all the woody material. However, methanol is not used as a transport fuel. One oil company visited has indicated that it will not consider its use for this purpose. In New Zealand, methanol is commercially converted into petrol and diesel fuel using a Mobil zeolite catalyst with the methanol produced from natural gas. This avoids the toxicity hazard.

Pyrolysis oil

This is produced by the fast pyrolysis of small wood particles. Pyrolysis involves the heating of the wood to thermal decomposition temperatures usually in the absence of oxygen. Under ideal conditions, up to 75% of the dry wood feedstock is converted into "bio-oil", a non-condensable gas and charcoal. The charcoal and gas are normally burned to provide heat for the process. The bio-oil is a liquid, containing a high proportion of water of up to 30%, with a gross calorific value of 16-19,000 kJ/kg. Its main attraction is its ease of transport compared with wood fuel. In the UK, there is a project to produce commercial quantities of bio-oil and to fire the fuel in a 2.5 MW gas turbine generator.

The disadvantages of the oil are:

- its instability - it has a relatively short shelf life due to its reactivity;
- it has variable properties depending on the feedstock, production method and pyrolysis conditions;
- it cannot be heated to reduce viscosity as it could solidify; and
- it is corrosive and has a strong pungent odour.

² Fung, P.Y.H. *Forest biomass energy research and development in USA & the IUFRO Conference on Forest Products for sustainable forestry*. FFP Client Report No 194, August 1997.

Pyrolysis Chemicals

Pyrolysis liquids have been used commercially for cold smoking of meats and food flavouring in many countries including Australia. Pyrolytic tars (wood creosote) were produced in the past for the preservative treatment of wood. For example, the tar industry was important in Scandinavia in the period between the 16th and 19th Centuries. In 1863, 227,000 barrels (30 million litres) of tar was exported to England from Finland³. This corresponded to the period after Christopher Columbus discovered America and a new wave of wooden shipbuilding followed. The wood tars were extensively used to protect wooden ships and rope rigging from decay and marine organisms.

The bio-refinery concept originated from the wood distillation era when chemicals such as acetic acid, methanol (wood alcohol) and solvents were distilled from pyrolysis liquids. In Australia, wood distillation chemicals started in Western Australia in 1958 from pyrolysis liquids produced from Lambiotte retorts⁴. When synthesis and production of many of the chemicals from oil and coal sources became more profitable, production from wood ceased.

Currently, there is interest in producing high value fine chemicals such as levoglucosan, levoglucosenone, hydroxyacetaldehyde and phenols. However, cost of bio-oil is between 10% to 100% more than that of fossil resources. Other bulk chemicals of interest are resins for adhesives and fertilisers.



Figure 2. Traditional method of tapping oleoresin exudate from Scots pine trees in Austria



³ Fung, P.Y.H. 1995 *Travel Report. XX IUFRO Congress. Study tour of energy forestry and forestry practices in Finland, Sweden and Denmark. CSIRO carbon technology transfer.* CSIRO Divisional Report N. FP 451, 9 November 1995, p 31.

⁴ Harris, A.C. *Charcoal production for industry in Australia.* Proc. Forest Products Research International Conference. Pretoria South Africa 22-26 April 1985. Vol 5, Paper 12-20, 11pp.



Naval Stores

Naval stores refer to oleoresin which is a solution of resin acids (rosin) in turpentine. The turpentine fraction contains valuable α - and β -pinene. The oleoresins are derived from pines and can be obtained by a number of ways namely: processing tall oil, a byproduct from the Kraft pulping industry; extraction of pine stumps; or tapping the oleoresin exudate from the living tree. The latter source is a more valuable product but the tapping of the living tree is labour intensive (Figure 2). There is no production in Australia.

Some uses for oleoresins are:

- paper industry as paper sizing
- rubber industry
- adhesives
- printing
- perfumes
- soaps
- pharmaceutical industry
- coatings

The current markets for oleoresin should be investigated and if these are significant, the possibility of lowering the cost of harvesting the exudates should be studied.

During the author's travel in Europe, it was mentioned that the production from oleoresin exudates has diminished because of the high labour cost of tapping. However, there is a demand for the oleoresin by the local rubber industry in Poland, which had to rely heavily on imports. The traditional practice in was to tap Scots pine (*P. silvestris*) six years before the tree was harvested for sawlogs. Productivity was poor, as the tree was optimised for wood production and not resin production. Younger trees could be more productive.

A superior species for oleoresin production is Maritime pine (*P. pinaster*). Native to the Mediterranean, it has been adapted to grow well in the low-medium rainfall areas of Western Australia.

RECOMMENDATIONS AND CONCLUSIONS

For these systems to be applicable and succeed in Australia, the actions that must be undertaken are:

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