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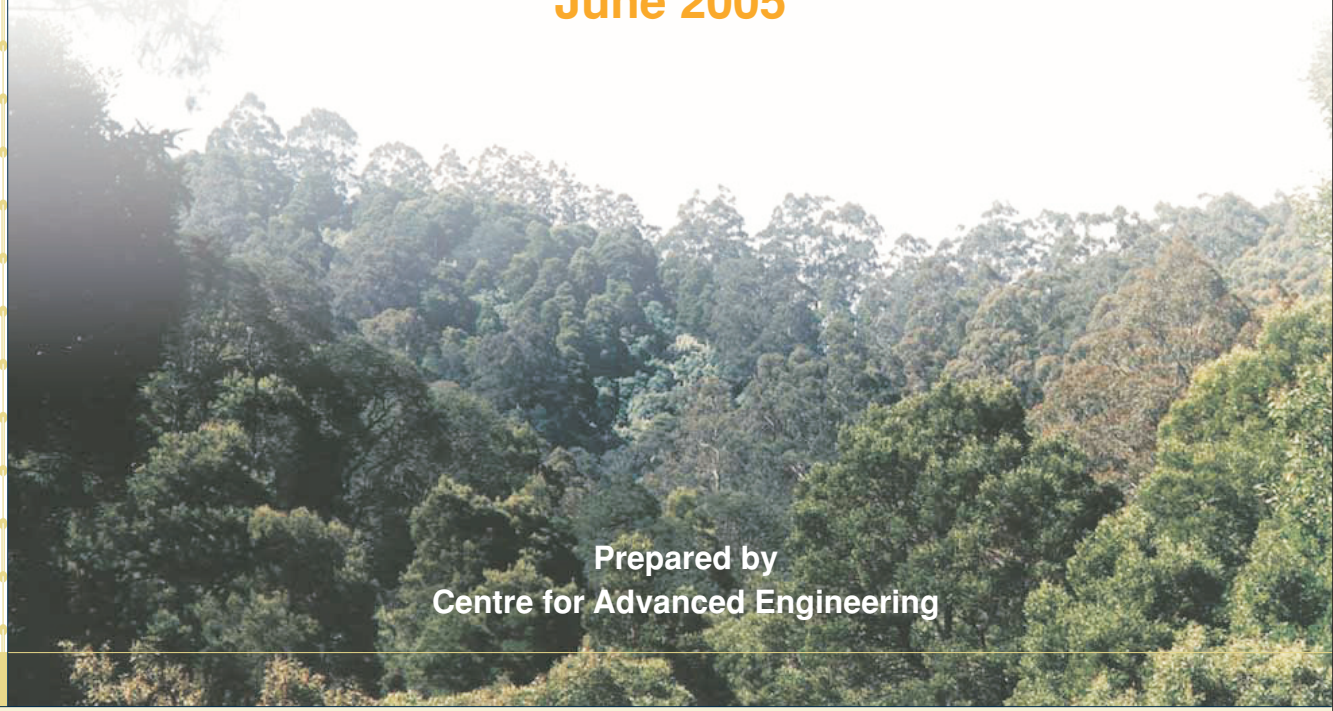
Sustainable Energy: Technology Collaboration Research

Bioenergy

Report for Ministry of Economic Development

June 2005



Prepared by
Centre for Advanced Engineering

Mail: Private Bag 4800, University of Canterbury Campus
Street Address: 39 Creyke Road, Ilam
Phone: 03 364 2478 Fax: 03 364 2069 e-mail: cae@cae.canterbury.ac.nz www.caenz.com

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Contributing Authors

John Gifford	Scion Limited (Lead Investigator)
Jack Rutherford	Department of Chemical and Process Engineering, University of Canterbury
George Hooper	Centre for Advanced Engineering

Acknowledgement is also made of the contributions of Scott Caldwell (CAE) and Jingge Li (CAPE)

Approved by: 

RJ (George) Hooper

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University of Canterbury Campus
Private Bag 4800
Christchurch
New Zealand

Executive Summary

This report examines the nature and extent of technology collaboration in the bioenergy industry in New Zealand. Focus is given mostly to research and industry/research collaborations but, in addition, comment is provided on technology collaboration through international suppliers and commercial relationships. Case studies of successful collaborations are included as a basis for discussion on what is best working and where gaps exist that government intervention might well assist in facilitating technology uptake and dissemination.

A strong research, development, demonstration and dissemination pipeline is very important to successful innovation and technology uptake in the engineering field. Bioenergy development has a strong engineering focus with much of the research and development in New Zealand now focussed on biological processing/innovative engineering solutions to provide process solutions applicable to the New Zealand circumstance. This is a significant shift away from earlier research in the field which tended to concentrate more on the supply side and resource management issues. This shift reflects current Government policy towards economic growth and innovation.

Interviews of many of the major players in the bioenergy sector cover a number of core themes that should underpin any industry/government action to improve collaboration and technology transfer mechanisms. In summary, these are:

- It needs to be recognised that the bioenergy sector has a broad industry base, spanning a wide range of disciplines, technologies and energy forms. Collaboration thus requires cross boundary activity and multi-disciplinary approaches.
- The Bioenergy Association of New Zealand offers an important means of end-user and industry engagement. Beyond this, New Zealand participation in IEA Bioenergy provides a highly cost effective mechanism to access international information on bioenergy. A key challenge is to ensure that access to these sources are effective and timely so as to raise awareness of bioenergy opportunities to a wider audience.
- The diverse nature of the industry presents its own special challenges. Connections between members are generally good, albeit largely informal. Networks are also relatively strong within the different research fields, but less so across the different sector components. This needs special attention.
- Industry participants are somewhat sceptical about the value of collaboration from a technology uptake perspective. Views differ, depending on individual experience, but clearly in the eyes of the industry participants collaboration will follow as a consequence of improved market opportunities and not the other way around. In the absence of strong industry leadership the drive for better collaboration comes mostly from within the research community.
- New Zealand has established significant international links in several key areas of bioenergy application. These include supply chain logistics, biofuel management and supply, new generation energy crops, novel engineering applications and integrated bioenergy systems. Respondents noted that the countries they saw as leaders in bioenergy uptake had a more conducive business environment for investment due to mandated targets and specific government interventions in support of pricing.
- New Zealand has an opportunity to leverage off its primary sector industries and to use existing expertise and capabilities within these sectors in order to widen bioenergy development. In this respect, respondents saw improved collaboration and international links as an important means for raising awareness of new opportunities.
- Capability building and human capital development are important issues limiting the capacity of the sector to grow. Whilst the universities in particular offer specialist courses in the area, there are minimal opportunities for employment with the bioenergy industry. This is an area that could be assisted through conventional research funding channels.

In summary, therefore, the above issues suggest that a vibrant bioenergy sector will be dependent on a range of factors; active research and development, a broadening understanding of non-bioenergy opportunities, the identification of appropriate industry needs to improve the dissemination of information, and collaborative effort to facilitate the uptake of these technologies.

It must be remembered that, generally, in most applications bioenergy technologies are well proven (especially overseas) and are readily available through licensing and other commercial arrangements. The opportunity for New Zealand lies in the development of novel applications or new approaches to meeting society's future needs.

In this respect New Zealand has some leading edge science areas, including integrated land use applications, bioprocessing for the production of new biomaterials and other value-added products, and engineering innovation in bioconversion technologies. These areas deserve better recognition and support. Collaboration, particularly with industry partners, will help tailor research towards providing solutions more in line with national needs and expectations.

At the moment the bioenergy sector is characterised by its diversity, small scale, lack of market opportunity and, too often, fragmented effort. Government intervention to better formalise this market will be an important precursor to the emergence of a new and potentially vibrant industry.

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1 Introduction

The Ministry of Economic Development has commissioned the Centre for Advanced Engineering (CAE) to undertake a study on the nature and scope of technology related collaboration for bioenergy within both New Zealand and internationally. The primary objective of the study is to document the nature and extent of technology collaboration in the field of bioenergy and the influences that these are having on technology uptake. This will provide MED with a better understanding of the linkages and collaborations between research, development, investment and, ultimately, the implementation of sustainable energy technologies. This understanding will be used to identify any potential problems that might require government intervention in order to make better use of technology innovation in this country.

1.1 A Definition of Bioenergy

Bioenergy is the production of energy derived from material that is directly or indirectly produced by photosynthesis and where such materials are utilised as a feedstock in the manufacture of fuels and substitutes for petrochemicals and other energy intensive products. Bioenergy includes the use of fuels from forests, agriculture, municipal and industrial solid and liquid wastes and incorporates the production of heat, electricity, gas, and liquid transport fuels.

Specifically the forms of energy that are considered in this study include:

- Energy from forest residues and wastes.
- Energy from agricultural crops and wastes including both solid and liquid materials (arable and forage crops, straw, bagasse, waste effluents, waste products).
- Energy from Municipal wastes (combustion and or gasification of solid wastes and the digestion of liquid organic wastes).
- Energy from landfill gas.

Bioenergy can supply energy into a broad range of energy markets including heating, electricity, transport and domestic and industrial applications. The bioenergy supply chain and options are shown in Figure 1.

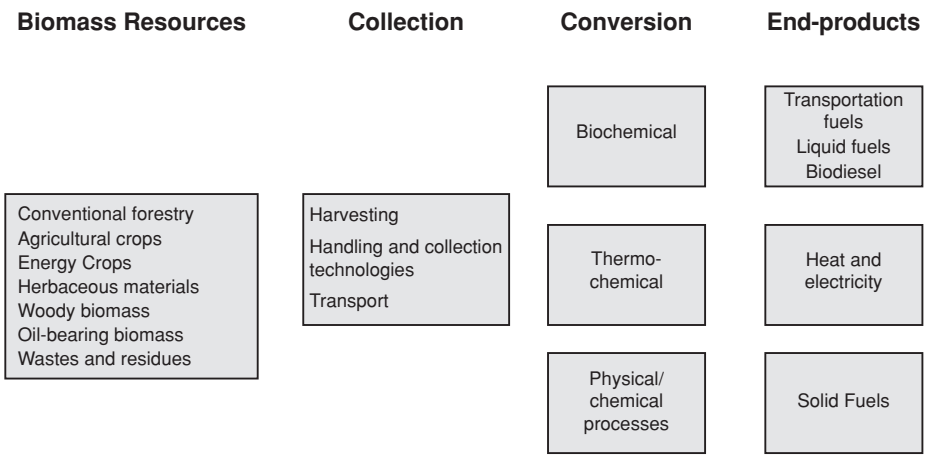

Figure1: Bioenergy Supply Chain

Given the potential scale of the bioenergy opportunity in New Zealand, the flexibility bioenergy offers, and the level of energy contribution that might be made, NZ has the potential to build on these strengths to derive both enhanced domestic energy supply and new commercial opportunities through development of technology and integrated energy supply systems.

1.2 Overview of Bioenergy Use in New Zealand

Currently biomass contributes around 5% of New Zealand's total primary energy supply with the largest contribution coming from the forest industry through the use of forest residues and black liquor for heat, and to a limited extent electricity production. This is complemented by an increasingly important contribution from non-forest sources such as landfill gas. The more traditional use of wood for domestic heating is reducing as a result of more stringent environmental standards. The potential to further develop New Zealand's bioenergy opportunity has been recognised as being substantial, but it is important to first understand the patterns of energy use.

In the 2003 year around 26% of New Zealand's consumer energy was from renewable sources. In primary energy terms hydro accounted for 40%, geothermal 36% and wind, biomass and wastes made up the balance of 24%. Biomass (mainly as woody biomass) contributes around 34PJ on a primary energy basis and this provided about 29PJ of consumer energy.

Based on estimates of energy consumption within the wood processing industries around 86% (25PJ) was used within this sector. The pulp and paper industry used approximately 21PJ largely for power and heat, panel and veneer industries used 1 PJ and the saw milling industry used around 3PJ for timber drying. Electricity generation from cogeneration facilities accounted for around 1PJ; in other words, a very small proportion of the total energy contribution. Of the biomass consumed, 52% was sourced directly from the use of solid woody biomass waste derived from wood processing, the remainder was from black liquor in the pulp and paper industry.

New Zealand use of bioenergy is underpinned by a significant forest industry with the current planted area for plantation pine being about 1.8 million (M) ha and an annual harvest of 22 Mm^3 roundwood. This harvest is expected to increase to about 30Mm^3 by 2010. The rapid increase in harvest of production forest will give rise to a large potential forestry-derived woody biomass source, the nature of this waste stream however, will depend very much on the relative mix of pulp and paper, MDF and panel production, sawn timber and log exports. Currently there is little new investment in the industry despite relatively high commodity prices.

The installed capacity of biomass energy plant at the larger wood processing sites is around 550MW_{th}, excluding the black liquor recovery boilers at Kinleith and Kawerau. There is currently no exclusive electricity generation using wood or forest residues in New Zealand, and no immediate prospect of any such plants being built for economic reasons. In addition, few wood production cogeneration projects have been able to be commercially justified. Heat production is the primary reason for investment in boiler plant and although cogeneration is becoming closer to commercial under certain conditions, investment by wood processors in such facilities is not occurring.

Work completed by the forest industry in 2000 indicated that most growth for bioenergy in the foreseeable future was likely to be in the heat market and largely within the wood processing sector. Preliminary scenario modelling (based on a business-as-usual scenario taking into account a marked increase in forest harvest) suggests that the amount of consumer energy sourced from wood process residues within the industrial sector (largely wood processing) could potentially change from around 15PJ now to about 23PJ in 2010 and increase further to 25PJ by 2020 (note: these figures exclude the contribution from black liquor). The most significant growth is envisaged being in the lumber drying market where the energy consumption was projected to increase from about 4PJ to 9PJ. There is also a marked increase in the amount of new potential energy sources that could be recovered from an increase in the quantity of wood process residues that would be surplus to the anticipated requirements for the wood-processing sector. This potential increase is from 1.4PJ now to around 5PJ by 2020.

The availability of this waste material provides a significant opportunity for further expansion of bioenergy into alternative industrial sectors other than wood processing. However, current industry performance indicate that such assumptions may well be optimistic.

In addition to forest sources, New Zealand has an expanding bioenergy contribution from biogas derived from a variety of sources from landfills to sewage sludge. Currently Mighty River Power has three generation facilities that are using landfill gas. These sites have a total of 12 engines rated at 920 kW each, giving a total installed capacity of 4.6MW. WaterCare Services Ltd operates a large water treatment facility which use a novel 'sludge lysis' technique to decompose sewage sludge into biogas. The plant has 6.8 MW of installed capacity on site and generates around 40 GWh/yr. Other projects known to the authors involve the conversion of on-farm wastes in digesters to biogas. Total contribution from this source is probably significantly under-reported as it is mostly 'off-grid'. We have not sought to review this in the study. Equally, we have not considered the very small quantities of biodiesel substitutes being produced in pilot facilities and other small facilities based on food waste, etc.

2 Study Objectives

The aim of the study is to provide The Ministry of Economic Development with a better understanding of the linkages and collaborations that exist between research, development and implementation of bioenergy systems in order that it might assess if more action is required in this area. The ultimate aim is to better realise these opportunities and to provide the means for making a greater contribution to the delivery of sustainable energy.

This report provides an overview of collaboration in the bioenergy sector and future research opportunities based upon the study methodology as set out below.

2.1 Study Methodology

The information presented in this report has been compiled from a range of sources, including:

- Knowledge and experience of the project team.
- Interviews with key stakeholders as listed below.
- Reviewing appropriate websites and other literature.

It was sometimes difficult to fully establish the range of stakeholder interest. Technology collaboration, of course, is dependent on having strong affiliate relationships. In Appendix 1 we have provided a very basic stakeholder map. This should be viewed as a quick and incomplete snapshot that can be used as a starting point for more detailed work if it is deemed necessary. It is in no way to be taken as complete or necessarily the best way to display the relationships, in particular the level of interest or commitment to bioenergy and the drivers involved.

A list of Stakeholders interviewed during the course of the work is shown in Table 1 (overpage).

In addition to these interviews, the study team thought it important to provide a number of case studies as working examples of the ways in which technology collaboration occurs in the sector. These studies are presented in Section 8. Again, these were selected on the basis of our prior knowledge of the different groups involved, and are not meant to be representative of the sector as a whole. However, the insights provided are important signposts as to what is working, and what is not.

Organisation	Name	Nature of Business
East Harbour Management Services	Brian Cox	Consultant
Lake Taupo Development Company	Kevin Snowden	Economic Dev.Agency
Easteel Industries	David McGregor	Equipment Supplier
HRL Energy	Steve Wilson	Equipment Supplier
Climate Change Office	Robin Brasell	Government
Energy Efficiency and Conservation Authority	John Stewart	Government
Anchor Ethanol	Tim Mackle	Industry
BP Oil NZ	Barry Blackett	Industry
Carter Holt Harvey	Lyndon Haugh	Industry
Meridian Solutions	Mike Suggate	Industry
Mighty River Power	Bob Jones	Industry
Natures Flame	Steve Cunningham	Industry
Solid Energy	Andy Matheson	Industry
Watercare Service Ltd	Raoul Viljoen	Industry
Canesis	Murray Taylor	Research
CRL Energy	Tony Clemens	Research
Massey University	Ralph Sims	Research
NIWA	Rupert Craggs	Research
NIWA	Andrew Mathews	Research
University of Auckland	Mohammed Farid	Research
University of Canterbury	Shusheng Pang	Research
Waste Solutions	Jurgen Thiele	Research
Biodiesel Fuels Ltd	Barry McDonald	Technology Company
Engenius	Ian Bywater	Technology Company
Living Energy	Rob Mallinson	Technology Company

Table 1: List of Stakeholders interviewed during the course of the work

3 Summary of Interview Feedback and Comment

The following section draws together the anecdotal evidence obtained from the interviews. All the selected individuals are prominent in, or associated with bioenergy in New Zealand. This commentary provided here are the opinions of the investigators and is formed on the basis of the feedback provided by the surveyed individuals.

3.1 Issues affecting Collaboration in Biomass Research and Development

3.1.1 Research and Development Climate

- Overall, there is a high activity level across the bioenergy sector as interviewed, but the domain is also quite broad covering heat, power and solid and liquid fuels, a broad range of technologies, and a diverse range of industries. This presents its own special issues around collaboration.
- The total funding on bioenergy research has been increasing since 1996 and this has encouraged a marked increase in the level of end user and industry engagement through a range of mechanisms including establishing the Bioenergy Association of New Zealand (BANZ). Research effort, however, still appears to be somewhat fragmented with some of the early collaborative activity no longer functioning.
- No major R&D programmes were identified that are currently supported by industry alone. Although there is significant private sector investment in bioenergy systems this is typically small scale and based on a single technology route.

3.1.2 Collaboration

- Connections between researchers are strong, with coordination occurring through a variety of mechanisms. Internal networks are also relatively strong within the different research fields, but perhaps less so across fields. Generally, good connections also exist between researcher and industry – though industry often expresses concern about access to information. Agencies such as BANZ and EECA have been influential in improving coordination across research programmes and progress has and continues to be made in these areas.
- New Zealand's participation in IEA Bioenergy provides a highly cost effective mechanism to access international information on bioenergy; ensuring NZ research is relevant and of international quality. NZ has been a member of IEA Bioenergy since its inception in 1978, it pulls well beyond its weight within the organisation in terms of Task participation, and active involvement. There is a constant flow of highly relevant information from IEA Bioenergy. A key challenge is to ensure that access to it is effective and timely so that the most important components can be disseminated to other researchers and industry.
- Industry participants are somewhat skeptical about the value of collaboration within a New Zealand market context. While clearly the views expressed by respondents were variable depending on the individual's experience and history, the drive for collaboration seemed to come largely from the research providers.

3.1.3 What is happening in New Zealand

- There is no obvious correlation between R&D effort and increases in bioenergy utilisation. Based on a study on the energy use for the wood processing sector in 2002 (Forest Research 2003) there was a 10PJ increase in energy derived from wood waste between 1997 and 2002 largely driven by expanding wood processing sectors. However, over the last two years such growth has stalled and, in fact, according to the Energy Data File the contribu-

tion from woody biomass appears to have decreased. This may be simply due to changes in the industry structure.

- Existing R&D programmes are undertaken by a range of research providers e.g. Scion and Canterbury University for woody biomass and Industrial Research and NIWA for waste to energy to name a few. These programmes are funded though FRST and most involve industry co-funding and support. Massey University (Centre for Energy Research) has undertaken considerable R & D in the past and still has ongoing interests in this area. CRL Energy was a key collaborative player in an earlier programme with Scion, but currently has no active bioenergy research – though it continues to undertake commercial servicing. Technology for Business Growth has been used to fund energy projects in the past. Examples include fuel testing for the Convertech process and sub-surface dip irrigation systems for untreated effluents for bioenergy crop production. The Convertech process has not been commercialised and work is continuing on the sub-surface irrigation system.

- A broad range of bioenergy related technologies are currently deployed in New Zealand with most of these being related to handling wood processing residues, combustion systems, landfill gas and anaerobic digestion. The technologies deployed at sites are often customised to meet site-specific conditions. Such customisation processes have lead to a number of technology innovations – for example the installation of a volatile gas collection system at a fibre processing mill and combustion of these gases in a burner by Easteel. The development of these systems are usually completed in house and involve either modification of existing technologies or deploying existing technologies in new configurations.

- Large scale (higher tech) technologies are available to New Zealand industries largely through licensing arrangements with larger international companies. Examples of this include Easteel and the use of Babcock & Wilcox fluidised boilers, Waste Solutions providing access to waste to methanol technology through Best Biofuels and HRL has access to IDGCC technology for large scale power generation based on high moisture content fuels such as lignites and biomass.

The above examples represent just a few major examples of Bioenergy technologies that exist in New Zealand. It is not a comprehensive list of activities.

3.1.4 What is happening Internationally

- New Zealand has established significant international links in several key areas of bioenergy. These include biofuel supply assessment and modelling, biofuel management and supply, optimisation of waste to energy systems, new generation energy crops and engineering applications offering integrated bioenergy systems.

- The involvement of industry players in accessing overseas technology for stakeholder transport fuels is an emerging area. Although New Zealand has established strong technical expertise in some of these areas it would not be regarded as a market leader, especially in terms of having developed international commercialisation success.

- New Zealand is somewhat unique among developed countries, with around 4-5% of its total primary energy supply being sourced from biomass. As previously commented, this is largely based on the use of wood processing residues for process internal heat requirements. Finland and Sweden would be countries most similar to New Zealand.

- Respondents noted that the countries they saw as leaders in the adoption of bioenergy technologies generally had a more conducive economic environment for them due to mandated targets and specific government subsidies.

3.1.5 Capability Development

- It was noted by several respondents that New Zealand has an opportunity to leverage off its primary sector industries and research capabilities within this sector to significantly advance bioenergy development.

- Investment in new capability is occurring at the research provider level, though this is being

constrained by funding. Scion has engaged new science staff from overseas, and Canterbury and Massey Universities provide undergraduate and graduate courses on bioenergy technologies. But there are minimal long term opportunities for graduates to be employed with the "bioenergy" industry. Thus science collaborations "across" industry sectors will be important for the future.

3.2 Issues affecting the implementation and commercialisation of bioenergy

3.2.1 Industry Collaboration

During the interviews a number of issues and comments arose which indicate issues impacting on the uptake of bioenergy. These issues are briefly summarised below.

- Collaboration and technical innovations are being constrained because the economic drivers have not been so strong until recently. Collaborative partnerships will begin to form as companies recognise the economic potential of getting involved, and then recognise that the potential partner can add value versus a "go-it-alone" approach. There is a role for Government in supporting such partnerships.

- A factor holding back investment in bioenergy technologies is the higher capital cost compared to conventional energy sources. Despite current government programmes (Projects Mechanism etc) these remain relatively ineffectual due to the practicality of converting relatively small parcels of carbon credits to cash. There is not yet a developed industry view on the benefits of current incentive programmes. Typically, industry respondents saw the need for stronger economic incentives.

- Collaborations between equipment vendors, energy end users, and project developers are driven by commercial opportunity - technology innovation is only relevant if it improves the project economics and is bankable. Technological risk remains a significant barrier to the uptake of new technology.

- The current economics of bioenergy use and in general the uncertainty of biofuel supply makes it difficult to get any commercial project off the ground. It should be remembered that this is bioenergy technologies are generally well proven (especially overseas) for most applications. Technology collaboration is not a precursor to successful commercial uptake. For example, technology license arrangements are a very effective form of technology transfer.

3.2.2 Desired Improvements in Collaboration Linkages

The factors above suggest that a vibrant bioenergy sector will be dependent on a range of factors, active R&D, development of new bioenergy opportunities, the development of appropriate structures to disseminate information and facilitate commercial uptake.

- Respondents saw the benefits of any improvements in collaboration and international linkages as generally in the context of a raised awareness of new opportunities. When asked how the government could assist in improving collaborative linkages greater funding was the general answer. Particularly in those areas where other countries, often Australia, offered greater government support. For example respondents requested seed grants for the construction of biodiesel facilities, mandated targets for biodiesel, and/or price support mechanisms.

- Basically it would seem from industry respondents, that collaboration would follow as a consequence of improved market opportunities (see below) and not the other way around.

As an observation from the study team, John Gifford having returned from Europe recently from an IEA Bioenergy Executive Committee meeting, notes that it is increasingly clear that different countries are establishing well developed bioenergy policies which are rapidly promoting the development of bioenergy related industries. For example, in Denmark the policy is that large power generators are to be using 1.2 million tonnes of biomass by 2007. This policy is now driving a rapidly expanding wood pellet industry in Denmark along with a supporting service

industry, the development of coal/wood pellet firing technology, and technologies to improve the efficiency of solid fuel combustion power facilities. The energy that is being produced in Denmark may be very expensive, but through a combination of financial instruments, a coordinated energy policy and the development of stronger technical collaborations between government, technical universities and industry, significant commercial success is being achieved along with technology innovation.

A very similar scenario is developing in the Netherlands with its focus on technologies related to fossil fuel/biomass co-firing, gasification, and pyrolysis. The Netherlands is also leading a international programme on biomass and biofuel trade, which is largely driven by a similar policy to Denmark, where there is a requirement to achieve targets for biomass use for energy.

4 Overview of Bioenergy-related Research in New Zealand

4.1 Woody Biomass

Bioenergy research focused on woody biomass is predominantly undertaken by Scion (formally Forest Research), Canterbury University Department of Chemical and Process Engineering, the Centre for Energy Research at Massey University and CRL Energy with other contributions from a variety of consultants. Research tends to be research driven though increasingly such research is being developed with significant end-user input. Industry engagement is not well developed and programmes develop in a somewhat fragmented manner.

It is clear from this study that to achieve a more effective uptake and implementation of research requires closer interaction between research providers and users. There needs to be a better mix of commercial, applied and fundamental research, which supports short, medium and long-term industry objectives. Ideally, such a mix needs to be supported with a blend of public and private funding with the private funding perhaps having a more short- to medium-term focus, and the public funding supporting longer-term fundamental research with higher risk. However the large numbers of medium/small companies, who are eager to develop bioenergy opportunities rarely have the financial resources to assist in funding required research or to complete the investigations required for commercialisation.

Work undertaken in 2002 as part of the Wood Processing strategy indicated that one constraint to bioenergy uptake is the limited public funding available to support small targeted research projects for specific components of the commercial sector. For example the lack of funding sources for say a boiler manufacturer to get $20,000 to undertake some assessments of ash deposition on boiler grates when co-firing biomass and coal, or for a fuel handler to obtain $15,000 to test the abrasion of wet sawdust on pneumatic ducting. Furthermore it identified that no funding was available to support the preparation of handbooks, good practice guides or case studies for wood processors who need this type of information for decision making. The study concluded that here is a need for contestable funding for near-to-market applied research to assist small operators to overcome such technical hurdles. Alternatively, one could envisage such work being undertaken by BANZ or other agencies on a collaborative basis. That collaboration has not yet occurred in the industry.

The activities of the main research organisations are briefly summarised below.

4.1.1 Scion (Formally Forest Research)

Scion has been involved with bioenergy research for close to 30 years with its research interests covering firewood production and use, wood to ethanol, biomass to heat and power, energy demand and socioeconomic assessments of bioenergy. Scion has been a major contributor to bioenergy research in New Zealand and has been a lead provider since 1996 when it was successful in securing FRST funding for a small bioenergy programme in collaboration with CRL Energy. Since 1996, Scion has maintained a FRST-funded bioenergy research programme, worked collaboratively with a range of other stakeholders to support the establishment of the Bioenergy Association of New Zealand and supported ongoing involvement for New Zealand in the IEA Bioenergy Implementing Agreement. In addition to woody biomass, Scion also has research interests around anaerobic digestion for biogas production, growing purpose grown energy crops for sustainable feedstocks, genetic improvement of plant based feed stocks and the development of biorefineries.

4.1.2 Centre for Energy Research, Massey University

Research lead by Massey University's Centre for Energy Research is well respected domestically and internationally following over 25 years of activity in the biomass area. Funding has been

obtained for a range of applied studies in parallel with accelerating international research and development. Current and recent projects have included gasification of comparative wood species; field trials on the production of short rotation energy crops to maximise GJ/ha/year; year round harvest to reduce storage costs and losses; transport and operational logistics of forest arisings and energy crops; land treatment of effluent on to energy crops; carbon sequestration; methanol production; and small scale biomass plants.

Dr Peter Read, (in association with CRL Energy and Victoria University) has undertaken research on long range scenarios for joint bioenergy and forest product outputs from long and short rotation plantations, with consequential impacts on prices and carbon in the atmosphere. A series of studies of distributed generation for rural communities using renewable energy, both in New Zealand and in developing countries, has also included the potential for bioenergy production.

4.1.3 CRL Energy

CRL Energy focuses its research on the combustion characteristics of bioenergy. CRL Energy has worked in collaboration with Massey University and Scion on FRST funded research. Current research focuses on identify the causes of increased slagging and environmental impacts that may arise when biomass residues are co-fired with coal. CRL Energy also has a strong interest in gasification and has been involved in some preliminary trials related to the gasification of biomass.

4.1.4 Canterbury University (the Department of Chemical and Process Engineering)

The Department of Chemical and Process Engineering (CAPE) has undertaken research in biomass energy over the last 30 years. Their research interests include combustion and gasification for thermal energy and electricity, and fermentation for ethanol and methanol. Studies have mainly been focused on technology development and improvements involving fundamental and experimental studies on the conversion processes. Various laboratory and pilot facilities have been constructed and tested. In addition, teaching courses and postgraduate projects have been offered to educate undergraduate and postgraduate students for the biomass energy industry. Currently, CAPE is running three biomass energy programs including; combustion, bioconversion and gasification. International linkages are strong especially in relation to bio-gasification.

4.2 Summary of Other Research Activity

A range of bioenergy research is being undertaken at various other centres throughout the country. Currently NIWA have projects on the anaerobic digestion of on-farm wastewater solids, on growing algae for pyrolysis and transformation into biodiesel, and on the utilization of algae for flue gas scrubbing. Canesis Networks do not have any current projects but prior projects included developing Lanolin combustion to full commercialisation, experimenting with paper waste pelletizing for combustion and developing methods for tallow combustion. Auckland University has current research in the fields of biodiesel and the production of ethanol. Focus is on the mathematical modelling of conversion of woody biomass to fuel ethanol and lignin, and the reaction kinetics of a continuous reactor for turning various low-grade feedstocks to biodiesel.

Private sector research includes the conversion of wood to sugar for ethanol production, the production of biodiesel from tallow, conversion of algae to biodiesel, waste pyrolysis, development of pellet fuels from woody biomass, novel esterification processes for the conversion of fats to oils, plus anaerobic digestion of wastes. The success rate of the research is generally variable and has not been assessed as part of this study. More can be done to more fully evaluate the competencies and capabilities within these programmes.

5 Research Collaborations

On the basis of the assessments done here and from information gleaned through interview, it is apparent that research collaborations exist at four levels, namely:

- formal collaborations through historic and existing contracted research and development;
- informal collaborations and information exchanges through organisational and individual contacts;
- formal and informal collaborations with industry; and
- international research collaborations.

Examples of these are described in some detail in the following sections. We make the comment that there are no better or worse forms of collaborations; all are important in supporting research effort.

5.1 Formal Collaborations in Research and Development

5.1.1 Scion (Formally Forest Research)

Scion established an early collaboration with CRL Energy in 1996 with the joint development of a research programme evaluating the supply and conversion of biomass based on New Zealand fuel supplies and energy systems. The goal of this project was to provide more information to optimise the performance of existing systems and the development of technology to cope with high mineral content fuels. Some components of this work also involved industry (Tachikawa Industries, Rotorua) as part of the programme involved calibrating the laboratory trials to field situations. The work with Tachikawa involved air and ash emission testing.

In 1998 this contract was subsequently expanded to include Massey University (Prof Ralph Sims), Lincoln University (David McNiel) and CRL Energy (Tony Clemens) with a subsequent funding increase from around $100k to $396k further increases in funding were achieved through to 2002 to a total of $450k per year. During this time the scope, depth and involvement of industry organisations expanded significantly with a focus on:

- the development of data on the combustion performance of a range of biomass fuels and biomass and coal blends,
- modelling of combustion systems to improve the prediction of combustion performance of biomass fuels,
- preliminary work on the gasification of biomass and ways to enhance biomass char reactivity,
- the development of guidelines for the transport and delivery of biomass fuels, and the development of a biomass fuel supply model (BioTRANZ) to predict the delivered cost of fuel under different supply scenarios.

Other collaborations underpinning the programme involved Waikato University, the Centre for Advanced Engineering, and the IEA R&D Programme for Greenhouse Gases based in the UK. Industry collaborations included PB Power, East Harbour Management Services and Rolls Royce Combustion. These collaborations were largely informal and were based on commercial areas of competency. In addition work was completed on improving systems for predicting biomass fuel supplies, improved assessment of forest residues from cutover areas and an evaluation of short rotation crop productivity on an effluent irrigated site where the biomass can be used for bioenergy production. This study involved close association with a District Council and URS

consultants.

Important technology transfer developments which occurred during this initial programme included the formation of the Bioenergy Association of New Zealand (BANZ), the hosting of a number of one day bioenergy seminars for industry, and participation in the Forest Industry Engineering Association seminars on "Wastes to Revenues," which had a central focus on bioenergy opportunities. The Waste to Revenue seminars typically were attended by over 100 key industry personnel and were a key feature of the industry technology transfer programme.

At this level of activity the programme was also attracting significant levels of co-funding from the Rotorua Energy Charitable Trust, Ministry for the Environment, and a Central Power and Meridian Energy Consortium. Opportunities were also being developed for Technology for Business Growth funding through FRST, which included some work on the Convertech process. URS Consultants moved ahead with the development of a new subsurface irrigation technology, which could be used for the irrigation of effluent onto land to grow bioenergy crops.

In 2001, a reduction in funding from $450k per year to $260k per year occurred through priority being given by FoRST to competing programmes. The outcome of this was a significant downsizing of the programme. (Note: bioenergy research nation-wide actually increased.)

The current bioenergy R&D programme is funded at a level of $260k and has a focus on upgrading biomass fuels to extend the markets that they can be used for (i.e. is underpinning much of the wood pellet development work), assessment of energy demand and supply scenarios to develop techno-economic solutions for bioenergy projects, and assessment of the socio-environmental implication of bioenergy. A key outcome of the current work has been the development of biomass supply models based on GIS systems to better predict both availability and costs of biomass fuels at a national and regional level. Technical collaborations are primarily with BANZ and industry contacts with input into projects involving pellet manufacturing, re-designing boilers to utilise pellets, energy supply and demand analysis for wood processing facilities, schools and other public utility buildings. The existing technology collaborations have a focus on commercial implementation rather than on R&D, which reflects industry priorities.

5.1.2 University of Canterbury

The Department of Chemical and Process Engineering (CAPE) at the University of Canterbury has undertaken research into combustion and gasification for thermal energy and electricity, and fermentation for ethanol and methanol.

Combustion

CAPE has been involved with combustion research for over 30 years and has resulted in a fluidised-bed combustion burner having been developed and built for the purpose of research. This research has focused on developing a burner that is more efficient and which reduces air emissions. The research on combustion of solid fuels is now moving towards the development and testing of wood fired burners to reduce emissions and improve thermal efficiency with the goal of reducing pollution and improving air quality in cities. Currently, two undergraduate students are conducting research on efficiency and emissions respectively.

This work was funded by research grants within the University.

Bioconversion

CAPE has also been involved in a two-year project looking at the conversion of biogas methane to hydrogen to drive fuel cells. In this case technical collaboration were established with Waste Solutions Ltd, Dunedin and Industrial Research Laboratories (IRL), Christchurch. CAPE's work involved the scale up of the microbial process of converting methane to methanol in a continuous bioprocess reaction system and testing the feasibility of recovering this alcohol in a suitable form for reformation to hydrogen. The main accomplishments included building and operating the continuous recycle fermentor, measuring the production rates and concentrations of methanol and identifying the bottlenecks in the system. The main technical constraint identified was an insufficient methanol concentration in the fermentor for economic recovery.

The on-going work is investigating the underlying fundamental microbial limitations that restrict the methanol concentration.

Gasification

In 2004 CAPE initiated work to transfer a biomass integrated gasification combined cycle (BIGCC) system to New Zealand for generation of electricity and thermal energy. This programme is funded by the FRST at $475,000/year for four years.

Work on BIGCC has received significant international investment over 15 years with a number of major demonstration plants having been established in Sweden, Italy and USA. A major constraint with the technology has been the development of appropriate gas cleaning systems and achieving reliability for running gas turbines economically. An international review of gasification technology has just been completed by Task 33 of the IEA Bioenergy programme.

This research programme involves:

- evaluation of BIGCC technologies developed overseas;
- transfer and development of gasification technologies for radiata pine residues;
- modeling of woody biomass supply and energy demand in regional forests and wood processing plants.

This research programme has lead to collaborations being established with the Energy Group of University of Otago, Page Macrae Engineering Ltd., Meridian Solutions, the Selwyn Plantation Board Ltd, and Delta S Technologies. The successful funding of this programme lead to New Zealand becoming a member of IEA Bioenergy Task 33 (Thermal Gasification of Biomass). Additional collaboration has been established with the School of Forestry (University of Canterbury). This programme has a focus on the commercial deployment of gasification technologies hence the linkages with industrial players are critical in establishing pathways to market.

To date, a study has been carried out to evaluate existing technologies and to identify key technology elements that need further development for New Zealand. A lab-scale 150 kW gasification rig has been built at CAPE, which facilitates testing of different feedstocks and optimizing gasification conditions. In addition Page Macrae Engineering Ltd has an operational 2MW (approx) gasifier, which is used to generate process steam.

Currently four academic staff members, two contract engineers and four postgraduate students in the College of Engineering and Forestry are engaged on this programme.

5.1.3 Other Organisations

Because of the limited scope it was not possible to cover in any further detail the other organisations mentioned previously in this document.

5.2 Informal Collaborations and Information Exchange

There is a wide range of informal collaborations and information exchanges occurring within the bioenergy area. Some of these are briefly summarised below. While these examples involve Scion, they are reflective of the nature of collaboration that typically takes place within the wider research fraternity. This is normal business and can be expected to occur without any government or other form of assistance. In essence it is the nature of research.

- AgriGenesis and Scion are having discussions regarding a joint project related to the development of fast growing tree species in the Taupo Catchment for biofuel production. This project also involves Auckland University as they are undertaking work on hydrolysis of woody biomass.
- Scion is in discussions with Crop and Food and Canesis regarding the use of arable crops for bioenergy production. Crop and Food would contribute experience on the growing and harvesting of arable crops and Canesis has experience in the development of thermochemcial conversion technologies based on the pyrolysis of agricultural wastes.

- Scion maintains a relationship with CRL Energy through direct information exchanges between senior science staff.
- Scion has initiated discussions with AgResearch related to the use of forage crops for biofuel production.

Such linkages are important and are vital for the health of the New Zealand science and research sector. Supporting such collaboration should be seen within the context of New Zealand Science investment, and not specifically as a bioenergy research issue.

5.3 Commercial Collaboration and Information Exchange

Technical research collaborations and relationships exist between all research providers, and a diverse range of commercial organisations. The nature of some of these are summarised below based largely on Scion experience:

- CRL Energy undertakes fuel testing and air emission evaluations for a range of commercial clients, typically wood processing facilities and Regional Councils. Historically, this type of work was also undertaken for boiler manufacturers, but this has diminished recently.
- Scion is working with Wrightsons on a feasibility study for a biogas plant facility in the Hawkes Bay area.
- Scion works with a number of forestry companies in developing advanced biomass fuel supply models. The companies provide key forestry data which is then used calibrate models and provide information on optimising biomass fuel recovery operations.
- Scion provided advice to NZ Fire Logs on the Project Mechanism which was subsequently successful in obtaining carbon credits to off set the capital cost of establishing an new pellet manufacturing facility in Hawkes Bay.
- Scion has informal contacts with Waste Solutions related to enhanced microbiological processes for waste to energy conversion systems.
- Scion provided advice to Golden Bay Cement on the addition of biomass to their calciners for the production of energy and to save on the combustion of coal. This systems is now operational.
- Scion collaborates with Alan Escourt (energy plant designer) on combustion plants – a joint project evolved around the use of waste sludge to dry sawmill residues for pellet manufacture.
- Scion provides information to McKenzie Boilers on wood pellet systems. McKenzies has developed a new boiler system for small scale commercial heating applications.

Again, it can be commented that without exception in New Zealand the Crown Research Institutes and Universities have a very strong focus on industry engagement. In the absence of a successful (and well funded) research effort these can be difficult to maintain. Research by others suggests that the private sector in New Zealand does not as a matter of course approach the NZ Science Sector for technology information; relying instead on information sources derived from parent companies, international affiliates and trade associations and other sources.

This an area where there is significant room for improvement. The Bioenergy Association of New Zealand (BANZ) plays an important facilitating role in this regard.

5.3 Commercial Technology Collaborations

5.3.1 Bioenergy Association of New Zealand

www.bioenergy.org.nz/index.asp

The Bioenergy Association of New Zealand was established in 2001 to promote and co-ordinate the development of a bioenergy industry in New Zealand. The Association provides a central

focus point for liaison with Government agencies, the dissemination of information amongst the industry and long-term positioning of bioenergy into New Zealand's energy system. The Association was formed with assistance from the following founding organisations:

- Energy Efficiency and Conservation Authority;
- Forest Research (Now Scion);
- Meridian Solutions;
- CHH Biogrid (now disbanded);
- East Harbour Management Services;
- Renewable Energy Corporation (now disbanded); and
- Massey University.

The objectives of the Association are to:

- Assist Government develop policies supportive of bioenergy projects and the development of export business opportunities.
- Advocate policy issues to local, regional and central government, as well as to regulatory bodies, industry groups and other interested organisations to promote the benefits of bioenergy.
- Promote the recognition of biomass as a sustainable energy resource.
- Encourage and support research activities related to bioenergy technologies, biomass utilisation and the collation of industry data and industry statistics.
- Identify, evaluate and, where appropriate, promote the development of markets for liquid and gaseous biomass fuels for the transport sector.
- Encourage further uptake of waste-to-energy processes, in particular the use of landfill gases, biogas and municipal green waste.
- Promote the economic, environmental and social benefits of biomass use (including employment opportunities particularly in rural communities).

BANZ covers woody biomass, purpose grown crops, forest residue, pellet technology, gasification, pyrolysis combustion and anaerobic digestion, as well as transport biofuels which includes biodiesel and ethanol. The management Board of BANZ spans, research organisations, universities, consultancies, electricity and energy producers, equipment suppliers, and biofuel producers and managers. EECA is also represented on the Board in an ex-officio role.

Information and material available through BANZ includes, newsletters that provide updates on domestic and international activities, seminar presentations, submissions, research papers and reports prepared on bioenergy which have been undertaken as part of the BANZ work programme. This information can be accessed through the BANZ website www.bioenergy.org.nz/bioenergyInfo.html

The development of BANZ has been a key initiative of mainstream players to improve networking, improve coordination of research, ensuring groups remain well informed on national developments and projects. Furthermore it provides a one 'go-to-place' for industry coordination and liaison to markedly simplify access to the many stakeholder groups and organisations. BANZ has established good credibility with industry, government agencies and research providers. BANZ's role has significant space to expand and over time is likely to become increasingly influential in facilitating collaborations, research and development projects, input to policy development and enhancing the dissemination of information.

A range of private companies also exist in New Zealand that provide, bring or have access to specific technologies for bioenergy applications. In a number of cases these are subsidiaries of

existing overseas companies or have license arrangements in place, which allow companies to offer the technology in New Zealand.

5.3.2 Forest Industry Development Agenda

FIDA is a new relationship between the forest and wood processing industry and the Government. The agreement provides a means for the Government and the industry to develop a strategic approach for future growth. It will see the Government invest $18.1 million (GST excl) to develop the forest industry, starting this year with a further $3.8 million (GST excl) contribution expected from industry. Areas to be funded under the agenda include market access ($1.2 million over five years), market development ($8 million over four years), bio energy ($2.5 million over five years), skills and training ($4.4 million over five years) and wood design ($2.0 million over five years). The availability of the market access, market development and wood design funding is dependent on securing industry co-funding of approximately $3.8 million (excl GST).

FIDA is also about enhanced collaboration within and between industry and government agencies. It should help make government policies more effective by ensuring that their impact on the forest and wood processing industries is well thought through. The suite of currently proposed bioenergy projects will consist of:

- *Theme A:* information provision (survey of cogeneration options and establishment of a Knowledge Centre for commercial implementation of wood biomass/bioenergy solutions.
- *Theme B*: Engineering Solutions (Customising bioenergy harvest and handling equipment for conditions typical of NZ forests
- *Theme C*: Pre-Commercial assistance:
  - Bioenergy demonstration projects
  - Feasibility studies on bioenergy

5.4 International Research Collaborations

5.4.1 IEA Bioenergy

www.ieabioenergy.com/ (Further information in Appendix 2)

IEA Bioenergy is one of five renewable energy Implementing Agreements of the International Energy Agency (IEA). IEA is the energy forum for 26 industrialised countries which provides a mechanism for the member governments to take joint action to address oil supply issues, share energy information, coordinate energy policies and for the development of appropriate energy programmes. The main objectives of IEA are to develop systems for coping with oil supply disruption, promote rational policy development, improve world energy supply and demand structures and the integration of environmental and energy policies.

IEA Bioenergy was established in 1978 as the IEA Forestry Energy Agreement, however in 1986 the scope of the Agreement was broadened to include non-forestry related bioenergy. The agreement currently has 21 member countries which includes Australia, Austria, Belgium, Brazil, Canada, Croatia, Denmark, Finland, France, Ireland, Italy,, Japan, the Netherlands, New Zealand, Norway, South Africa, Sweden, Switzerland, United Kingdom, USA, and the European Commission.

Tasks within the IEA Bioenergy programme are:

- Socioeconomic aspects of bioenergy
- Short rotation crops for bioenergy systems
- Conventional forest ecosystems for sustainable production of bioenergy
- Biomass combustion and co-firing

- Thermal gasification of biomass
- Pyrolysis of biomass
- Energy from integrated solid waste management systems
- Energy from biogas and landfill gas
- Greenhouse gas balances of biomass and bioenergy systems
- Liquid biofuels
- International trade of biofuels and biomass.

New Zealand currently participates in three of these Tasks:

- Short rotation crops for bioenergy systems
- Thermal gasification of biomass
- Greenhouse gas balances of biomass and bioenergy systems.

By participating in the IEA Bioenergy and these three Tasks, New Zealand effectively has access to much of the research, development and technology being undertaken in OECD countries. The information is made available through a range of mechanisms, which includes participation on the Executive Committee (currently represented by Mr John Gifford of Scion), participation of the National Team Leaders for each of the Task New Zealand participates in, international conferences, public & member only web sites, and publication of a range of information booklets and monographs. The National Team leaders are:

- Mr Ian Nicholas (Ensis) - Short rotation crops for bioenergy systems.
- Prof Shusheng Pang (Canterbury University) - Thermal gasification of biomass.
- Ms Kimberly Robertson (Force Consulting) - Greenhouse gas balances of biomass and bioenergy systems.

New Zealand's contribution to IEA Bioenergy is funded largely by the participating organisations, though some financial support is currently provided through the Climate Change Office and the Ministry of Economic Development. The total country contribution to IEA Bioenergy is around $100k of which approximately $30k is funded directly from Government agencies.

An example of New Zealand collaboration with a Task is a case study on the 'Greenhouse Gas Benefits of a Combined Heat and Power Bioenergy System in New Zealand'. This study uses the methodology developed by the Task to provide a life cycle analysis of the greenhouse mitigation benefits of the CHP plant at wood processing site in the central North Island. The case study has been used by New Zealand industry to illustrate the benefits of bioenergy systems. To date 9 such case studies have been conducted for a range of bioenergy systems globally www.joanneum.at/iea-bioenergy-task38/projects/task38casestudies. A stakeholders group has been established as part of the New Zealand work programme and involves participants from Government agencies, biomass fuel producers, research organisations, and consultants. This ensures that information derived within the Task is made widely available to appropriate end users.

Although it is difficult to place a clear economic value to being a member of IEA Bioenergy, this international collaborative network provides access to something in the order of $US 500 million of other bioenergy related R&D occurring internationally, significantly enhances access to diverse range of demonstration projects, and direct access to world leading experts in the bioenergy field. Furthermore, increasingly IEA Bioenergy is focusing on improving technology uptake by industry and the development of both national and international policies that facilitate more rapid implementation of bioenergy projects and systems.

New Zealand has belonged to IEA Bioenergy since its inception in 1978 and during that time Forest Research (Scion) has been the Contracting Agency. This is a formal role, negotiated and

largely paid for by Scion. Over the years Scion has disseminated information via a number of vehicles – with perhaps the most effective being, in more recent years, through the Bioenergy Association of New Zealand (BANZ) website, newsletters and annual meetings. The IEA Bioenergy, BANZ linkage has contributed significantly to the development of bioenergy information flows in New Zealand.

6 Options for Innovation, Commercial Deployment & Business Opportunities

In view of what is occurring internationally and what has and continues to occur in New Zealand in terms of bioenergy implementation and technology development, critical questions are:

- What are the areas that New Zealand can provide international leadership?
- What are the niches that can be seized upon to develop commercialisation projects and national business opportunities?

Possible areas are discussed in the following section. These areas, or the addition of others, should be developed through an ongoing iterative process of discussion and consultation with key stakeholders.

- Biomass feedstock assessment

  A critical issue for any bioenergy project is securing fuel supply and being able to predict its availability into the future. It is essential for an energy company to secure its fuel supply prior to investing in capital for processing or conversion plant. Biomass fuel supplies are inherently variable as they are often derived as by-products of other sectors, from industrial activity or as waste streams. Given these factors, then tools, systems and models are needed to provide energy markets with the confidence that secure fuel supplies exist, both short and long term. Research and development of technologies for predicting wood biomass residues from forestry and wood processing activities based on Geographic Information Systems have been specifically developed for New Zealand situations. As there is increasing competition for biomass fuels internationally, more bioenergy projects are developed in countries and defining biomass fuel supplies become critical, then the transfer of this expertise offshore offers an opportunity. The approach adopted in New Zealand is somewhat unique as forest derived biomass is almost exclusively from plantation pine forests.

- Fuel Management Supply Systems and Models

  The means of recovering and transporting biomass fuels has major impact on the final cost of delivered fuel to an energy plant. As the supplies of wood processing residues becomes constrained and greater reliance is placed on forest residues to meet increasing demand for biomass fuels, systems and models will need to be developed to optimise fuel delivery. Work in this area spans the integration of gathering, transporting, size deduction, and onsite fuel segregation and handling systems. By combining the skills of researchers from the modelling perspective with the engineering capabilities of domestic companies, New Zealand could offer a unique package. Although initially the focus in NZ has been on forest biomass, the skills and expertise available from other work (and in collaboration with other sectors) could easily be transferred to other biomass feedstocks. This area of technical innovation looks increasingly attractive internationally as the production of liquid biofuels becomes more critical. Such technology innovation could build off an existing strong agricultural and forestry engineering capability that exists in this country.

- New generation bioenergy crops

  For biomass to be a long term viable energy solution the bioenergy feedstocks of tomorrow are likely to look significantly different to the ones of today. These will be required to more efficiently produce biomass and to do sustainably. New Zealand already has world leading technology for forest and plant breeding, genetics, and propagation and to leverage off this into new bioenergy feedstocks is well within the existing R&D capabilities of the country. New Zealand has a track record in the pastoral, arable and horticultural crop areas as well

as for plantation forests so building on this strategic advantage for the sustainable production of bioenergy crops is a realistic opportunity for a country so dependent on land based industries.

- Biological processing

  The utilisation of wastes, in particular agricultural wastes, provides an ideal platform for technical innovation for waste to energy systems via anaerobic digestion, fermentation and other biological processes. Coupling this driver with New Zealand's research focus on biotechnology, in particular on microbiology, offers further opportunity for expanded effort. Waste to energy technologies are readily available internationally so the emphasis of this programme would need to be on improving the conversion efficiencies and costs for New Zealand technologies to remain competitive. Research collaborations between CRIs and private companies already exist in this area, but these need to be enhanced and better resourced to maintain the advantages already established. An action identified in the Waste Solutions case study was the need for formal sector workshops that encourage frequent and early exchange of information and the development of partnerships for prototyping and commercialisation of technologies.

- Biorefineries

  New Zealand is one of the few developed countries that generate a large proportion of its income from primary production, which signals that New Zealand has a potential strategic advantage in converting biomass to value added products. The concept of using plant and animal based materials as feedstocks for the production of a range of both advanced industrial and consumer products is not new but is receiving considerable attention internationally as countries examine options for moving away from conventional feedstocks.

  Biorefining systems integrate the technology from plant science, materials science, chemical and process engineering and manufacturing systems. As an example of this type of technology, Cargill Dow has invested $ US 750 million and 10 years of R&D into the development of processes for converting corn starch to polylactic acid (PLA). PLA is used in the manufacture of biodegradable plastics and Cargill Dow is targeting the production of over 2 million tonnes of PLA by 2010. A number of waste streams derived during the processing provide potential feedstocks for energy production. R&D in this area has been reinforced in New Zealand through the establishment of the Bioploymer Network and energy programme at Scion. Other providers also have an active engagement in this emerging area.

- Innovative Engineering

  The delivery of the above opportunities or the implementation of existing technologies (combustion, gasification, waste gas utilisation) are all dependent on an inherent engineering capability not only in terms of engineering design and construction but also in the process engineering to ensure that technologies and process applications can be modified and further developed to meet market and business requirements. The development of the R&D programmes at Canterbury, Auckland and Massey universities provide a critical link in this area.

In addition to the areas identified above there are a number of other relevant areas and potential technologies that have strong domestic relevance and which provide opportunity to integrate across a range of Government policies, including; sustainable development, Maori development, growth and innovation, regional development and energy and greenhouse gas actions.

Two particular areas of emerging interest are:

- Integrated land and energy management; and
- Liquid biofuels.

Increasingly there is an opportunity to integrate the use of land more effectively. Technologies exist that potentially allow for example, integrating diary farming with energy production whereby

riparian planted zones are used to strip nutrients from agricultural runoff and the biomass is subsequently harvested for energy production. The biomass produced, can both substitute for fossil fuels if used for energy or if managed sustainably long term could be counted as a carbon sink. Farm forestry also provides an existing example of this type activity, especially where the harvested wood is used for both wood products and energy. As environmental costs become increasingly internalised and greater demands exist for sustainable development technologies, then this area of technology and system development will become more important. Adequate R&D collaborations are in place within New Zealand to allow this technology to evolve effectively. The Taupo Development Agency in collaboration with a number of research organisations has just announced a successful Sustainable Farming Fund application to establish coppice willows in the Taupo catchment for both energy and water quality improvements.

Liquid biofuels are gaining significant attention, both domestically and internationally from the points of view of fossil fuel substitution, the desire for increased self reliance from imported oil, and the need to adopt more sustainable materials and cleaner technologies. Historically, New Zealand has placed significant effort into evaluating the liquid biofuel opportunities through a comprehensive programme run by the Liquid Fuels Trust Board during the early 1980s. As already described there is limited effort (R&D and technology development) occurring in this area although the technology is well established internationally. The near term opportunities for biofuel deployment in New Zealand are likely to be the production and use of biodiesel through the use of tallow oils and bioethanol petrol blends with ethanol being domestically sourced as a by-product of milk processing derived by the fermentation of whey. Given the drivers for substitute transport fuels it is timely for New Zealand to explore opportunities and develop an overall strategy for a biofuel in this country. Such a strategy would require extensive engagement of a diverse range of stakeholder groups including, science, engineering, fuel suppliers, government and business interests. It is likely that sufficient incentives already exist for a greater encouragement of biofuels investment based largely on existing technology routes.

7 Conclusion

In the short time frame and limitations of this study it was not possible to explore in depth all facets of the bioenergy sector in New Zealand. It is thus likely that some important contributions and industrial research effort has been missed in this review. And it is not surprising — as the hallmarks of the New Zealand bioenergy sector are its:

- diversity (science participation and broad range of sector interests);
- concentration on application for internal heat requirements (and thus not typically reported in national energy statistics);
- historical domination by forest-derived biomass sources (again largely for internal consumption); and
- strong reliance on licensed technology from international suppliers (proprietary knowledge and know-how).

It is, however, a sector open to transformation. Signs of this are already apparent from: the increasing contribution from biogas, strong emerging interest in farm-based energy systems driven by sustainability objectives, the emergence of wood gasification technology as a competitor to conventional combustion systems, renewed interest from industry in combined heat and power, and the wide-spread interest in biodiesel as a substitute transport fuel.

Moving beyond this emergent phase, however, will require new approaches and thinking. The development of new fields of science endeavour in bio-processing, integrated land use applications, and non-conventional bioenergy sources, will all require cross-sectorial approaches, new collaborations and thinking that spans current discipline boundaries. This is the major challenge for the sector.

The lessons from this study suggest that New Zealand can learn a lot from its international links through the IEA and other arrangements. Our review of these linkages shows that elsewhere effective national programmes are characterised by:

- a robust and enduring bioenergy industry;
- government programmes that facilitate a strong research, development, demonstration and technology dissemination pipeline;
- technology collaboration and information sharing at both national and sector levels that are targeted at raising awareness and improving technology uptake; and
- strong industry engagement and investment in research and development that builds sector capacity and human capital.

Finally, and in conclusion, we would like to thank all those who contributed to this study. Whilst the opinions expressed in this report are those of the authors, without the individual contributions from all who were interviewed or approached for information, this picture of the bioenergy sector would not have been brought together in such a coherent fashion. New Zealand's opportunity in the bioenergy sector goes well beyond conventional technology and process applications. The insights offered by this report, from both the industry case studies and international research links, provides an important contribution to national thinking on future research direction and priorities for technology collaboration.

J Gifford
G Hooper
J Rutherford

8 Case Studies

BIGAS (Bioenergy Integrated Gasification Application Systems)

Technology collaboration through a university and industry research consortium

Integrated Woody Biomass Gasification Applications

Wood biomass from waste streams has been recognised as a significantly sustainable energy resource in New Zealand. Technologies for the conversion of such feedstocks to energy are the key to commercial bioenergy utilization of this resource. Members of Wood Technology Research Centre in the Department of Chemical and Process Engineering (CAPE) and the School of Forestry at the University of Canterbury are leading a research consortium on development of integrated woody biomass gasification applications. The industry partners and research collaborators in the consortium are the Energy Group of University of Otago, Page Macrae Engineering Ltd., Meridian Solutions, the Selwyn Plantation Board Ltd, and Delta S Technologies. Internationally the consortium is a member of IEA Bioenergy Task 33 (Thermal Gasification of Biomass), which allows close contact with other international experts.

Under the leadership of Associate Professor Shusheng Pang of CAPE, the research started in July 2004 and will span four years. The programme is sponsored by New Zealand Foundation for Research, Science and Technology and involves the development of gasification technology for commercial applications, ranging from heat only to combined heat and power plants. With this focus, the consortium will evaluate gasification application technologies developed here and overseas for small to medium scale deployment.

Mr Ian Gilmour, a Senior Lecturer in CAPE, leads an objective to transfer and develop gasification technologies suitable for radiata pine residues. Ms Jingge Li, an experienced engineer currently working in CAPE, is leading, with assistance from Associate Professor Bruce Manley of the School of Forestry, the consortium's efforts on the modelling of woody biomass supply and energy demand in regional forests and wood processing plants. Dr Chris Williamson of CAPE is directing research on modelling and process design of a pilot scale integrated gasification combined cycle system (BIGCC).

To date, a study has been carried out to evaluate existing technologies and to identify key technology elements which need further development for New Zealand situation. Thanks to the College of Engineering a capital grant has allowed a lab-scale 150kW gasification rig to be built in the Department of Chemical and Process Engineering. This will facilitate testing of different feedstocks and optimising gasification conditions. Research is also in progress to establish a biomass feedstock supply model and energy demand model for feasibility assessment and location selection of a biomass power plant. With a medium term target to build a BIGCC pilot plant in New Zealand, research has been planned and conducted to provide a process design based on an approved BIGCC system and to establish a technical and economic model of the BIGCC system, which can be used for feasibility analysis.

Within the College of Engineering and School of Forestry, four academic staff members, two contract engineers and four postgraduate students are working with the consortium. Outside the University of Canterbury, collaboration with the Energy Group in the Department of Physics at the University of Otago and Delta Technologies adds strengths to the team in terms of energy systems thinking and addressing the wider range of energy issues facing this country. Furthermore valuable input from industrial partners enables the research team to deal with practical issues such as feedstock availability and costs, and power plant location.

In parallel to this, demonstration and development of a 2MW gasifier, one of the largest in New Zealand, is being undertaken at Page Macrae. Currently the Page Macrae gasifier is used to

generate process steam and provides a demonstration of how gasification can offer an alternative technology to standard steam boilers. The progress at Page Macrae offers a real prospect of having a commercially viable demonstration gasifier-boiler technology at the 0.5 to 5 MW_{th} scale available within the next year or two.

To transfer the research to end users, the Wood Technology Research Centre and the Centre for Advanced Engineering have planned an Industry Workshop towards the end of this year (2005). The theme of this workshop will be on thermal-chemical conversion technologies for biomass energy. At the workshop, invited international experts and the team members will give presentations on the latest R&D in biomass gasification to power generation.

Conclusion

A strong research, development, demonstration and dissemination pipeline is a very important attribute of the BIGAS consortium. Utilisation of this pipeline offers a very real vision of sustainable timber/energy sites using integrated biomass gasification technologies. The strong industry involvement offers strong prospects for successful commercialisation of the research team's efforts.

Commercial Bioenergy Systems and Applications (1)

Technology collaboration through product licensing from international suppliers and domestic commercial relationships.

Easteel Energy Systems

Easteel Industries Ltd was established in 1953 as a steel bridge fabrication company. Today it has diversified into a substantial organisation with a heavy engineering facility in Dannevirke, sales and service offices in Auckland New Zealand and also in Melbourne and Sydney, Australia. As its core activity, Easteel is focused on providing energy systems to industry. This encompasses steam, high temperature hot water, thermal fluid (hot oil), and direct and indirect hot air systems. Fuels include, gas, oil, coal, and wood residues. Areas of application of Easteel plant comprise the dairy, meat, food, oil and gas, and forestry processing applications; institutions such as hospitals, military bases, research institutes and universities.

In this role the company provides solutions for any fuel, or heat transfer media, from 1MW to 400MW output. In addition to their own range of Steampac energy plant, Easteel is also licensed to design and manufacture the Stirling, Towerpak, and a range of large industrial boilers by the internationally recognised Babcock & Wilcox, USA.

Easteel has been involved in many of the larger bioenergy projects in New Zealand over the last 13 years including new boilers for Pan Pac Forest Industries, Napier; Nelson Pine, Nelson; Juken Nissho, Kaitaia; and the Carter Holt Harvey laminated veneer facilities, Whangerei. Easteel offer a complete energy solution, which includes specification, design, build and commission. Furthermore, through the use of license agreements, Easteel has brought a range of new product to the New Zealand market, which provides a comprehensive range of products to meet a diverse range of energy situations. Pan Pac required an additional 36MW of steam to meet their new kiln requirements and projected mill growth. Pan Pac also needed to minimise their natural gas consumption and to manage significant quantities of wood waste. These residues were a mixture of bark, sludge, sawdust, dry shavings and green chip with high moisture contents (over 60% moisture on a wet basis). Easteel provided a bubbling fluidised bed combustor to burn this variable biomass blend and a Towerpak boiler to generate high-pressure steam which provided the flexibility to retrofit a steam turbine at a later date. The fuel required a fuel management system that could handle, store and deliver on a metered basis, a wide range of site-produced wood residues. This was the first application of fluidised bed technology in New Zealand.

In the process of developing energy solutions, Easteel has also established a number of New Zealand based commercial relationships that have improved solution delivery. These have included Windsor Engineering for timber drying kilns and Brightwater Engineering for fuel management and feed systems. Other license arrangements exist with Babcock and Wilcox an international industrial and utility boiler manufacturing organisation, Innovative Steam Technologies a world leader in once through steam generators based in Ontario Canada, and Detroit Stoker Company, a specialist in coal, biomass and waste combustion systems.

Easteel has also been successful in extending its business internationally with projects in Australia (CHH Panels, Oberon MDF mill; Hyne & sons, Tuan sawmill).

Easteel is one of the best examples of a commercial company that has effectively diversified from its traditional heavy steel-manufacturing base to the development and implementation of energy systems. Furthermore, Easteel has been able to leverage off its generic combustion experience to specifically focus on bioenergy solutions, primarily for the forest industries. In the period 1999 – 2003, Easteel was involved in many of the major bioenergy projects at industrial wood processing sites in New Zealand, which if considered together probably contributed around an additional 4-5 PJs of biomass derived energy (industrial heat). Expansion within the wood processing industry has slowed somewhat since this time and Easteel currently have no new major bioenergy projects in New Zealand. Easteel is dependent on an active and expanding forest industry to build on its capabilities and technology collaborations in the bioenergy domain.

Although Easteel can apply its experience to other industries the availability of appropriate fuel

supplies, from the forest industry are likely to be critical for such projects to be initiated. Furthermore, the company reports that in the absence of any major projects in New Zealand, biomass installations are at the small end of the market (i.e. less than 2 MW). In these situations, price is a major driver for technology selection and investors in such new plant are often opting for 'low tech' systems at the lowest cost, rather than seeking to invest in integrated energy systems with overall higher performance.

Conclusion

This case study illustrates that for New Zealand to fully take advantage of technology collaboration (either in the form of product licensing or the establishment of commercial relationships) a robust and enduring domestic bioenergy industry is required.

In a low investment environment (especially within the bioenergy or forestry sectors) New Zealand seems to be moving backwards on technology innovation opportunities and, as demonstrated here, companies that have historically invested in new technology and product innovation are seeing diminishing returns.

Commercial Bioenergy Systems and Applications (2)

Technology collaboration through product licensing from international suppliers and domestic commercial relationships.

HRL Limited

HRL Limited is an Australian owned energy, technology and project development company. The company was established in 1994 when the research and development businesses where acquired from the State Electricity Commission of Victoria and the Coal Corporation of Victoria, and now employs more that 600 people in its operations throughout Australia. Through its subsidiaries (ACIRL, ETRS and HRL Technology), HRL provides process engineering, coal testing and combustion evaluation, environmental and materials technology services to industry in Australia and internationally.

HRL owns and operates a number of energy plants, including a 170 MW power station/cogeneration facility in Morwell, Victoria (through its subsidiary Energy Brix Australia) and several energy facilities in regional Victoria. These operations, together with new project developments, are underpinned by high level technical service capabilities, particularly relevant to the coal, power generation and other heavy industries, including petrochemical, oil and gas refineries and the mining industry.

HRL is engaged in furthering the commercial application of its advanced gasification technology for power generation called Integrated Drying Gasification Combined Cycle or "IDGCC"

This technology generates electricity at a significantly higher efficiency and as a consequence, produces significantly less CO_2 when compared to current brown coal thermal technology. For every single megawatt (MW) hour of electricity produced using IDGCC, 30% less brown coal is used and hence 30% less CO_2 will be emitted as compared to the most efficient current Latrobe Valley generation plant. The IDGCC technology has been developed over the last decade at an investment of over $120M. It is currently at the stage of commercialisation, having been proven at the 10 MW scale with electricity generated into the Grid. HRL Developments has been granted an Exploration Licence in the Driffield coalfield in the Latrobe Valley for the development of a new commercial power station utilising IDGCC technology.

The IDGCC technology although typically used for high moisture content coals such as lignite it may also has be used for biomass fuels with similarly high moisture contents. In such cases the biomass may be used as a single feedstock or alternatively as a supplementary feedstock through co-firing. HRL do not currently see biomass energy, at a scale that would justify investment in the IDGCC technology, as being economical.

HRL involvement in New Zealand is through being a partner for the NZ Refining project where it is proposed that a new biomass boiler be installed to produce steam for process requirements allowing the off-gases, which are currently used as fuel, to be diverted to a gas turbine

for electricity generation. The project is currently on hold until the NZ Refining makes a decision regarding expansion, as this is a prerequisite to making the project financially viable.

Meridian Energy

Meridian Energy has been involved in a number of bioenergy related projects over the last 10 years including gasification technologies, assessment of rural power systems, and through Meridian Solutions the development of a combined heat and power facility at the Blue Mountain Wood processing facility. Meridian Energy's key focus is now on wind and is not actively involved in any bioenergy related projects. Meridian Solutions has little involvement in collaborating with institutions but does collaborate frequently with Easteel. In particular, close collaboration was undertaken in developing a pulp drying plant. Other technologies of interest from Easteel are licensed technology from Babcock and Wilcox and the grate technology from Detroit Stoker. The company has used sludge drying technology from Germany. Meridian Solutions indicated that it is not a company that specializes in the technical aspects; it is more focused on accessing people with experience and knowledge to pull together what we need to meet customers requirements.

Conclusion

Where mature technologies are sufficient to meet industry requirements, then the issues are not so much about innovation but technology risk. In the instances described by the two cases above this risk is managed via license and vendor arrangements which offer the necessary technical and commercial backing to manage the technological and completion risk components of any bioenergy project investment decision.

Technology Commercialisation

Technical collaborations between researchers, manufacturers, energy distributors and the market

Natures Flame - Development of a wood pellet manufacturing industry and market
www.naturesflame.co.nz/index.html

Since 2000, the international wood pellet market has grown significantly due to demand for processed biomass fuels. Wood pellets (i.e. compressed wood sawdust or shavings in the shape of a pellet, similar to stock feed) have a range of significant advantages over other biomass fuels, in particular:

- Pellets are dry and therefore easily burned;
- Less variable and easier to handle;
- Contain less contaminants (i.e. lower ash content) which results in cleaner burning and reduced air emissions;
- Easily transported and have a higher energy content per load compared to unprocessed fuels like wood chips or loose shavings;
- Adaptable to use for a wide range of markets including industrial and domestic applications.

Up until 2002 there was one wood pellet manufacturer in New Zealand based in Christchurch. This was a small manufacturing facility producing around 3000 tonnes of pellets per annum for the New Zealand domestic market predominantly for the South Island. The private company, NZ Pellet Fires was established after a previous attempt to develop the pellet manufacturing plant by South Power and the Christchurch City Council during the mid to late 1990s, which failed due to lack of experience in pellet manufacturing, the ability to produce quality pellets, and poor market development. NZ Pellet Fires was developed as part of a complementary business involving wood waste disposal and management for a number of wood processing operations in the Canterbury region. During the time of establishing the business, NZ Pellet Fires invested significantly (for a small business) in modifying and undertaking a range of technical improvements – many such improvements were based on trial and error and the initiative of the operators, however the final outcome was an effective plant producing a high quality product. Such technical improvements included modifications to the drying system, the heat plant, which was fired on waste wood, and the pellet machine itself.

During 2000 – 2002, the potential market for pellets and the domestic fire places was looking good as energy prices had started to increase, there was concern about the continued use of coal for domestic heating in the Christchurch area, and energy shortages were starting to become a reality. However, a major constraint impeded progress for NZ Pellet Fires, Environment Canterbury imposed stringent air discharge conditions to restrict the use of solid fuel burners, which included wood burners and were favouring the use of electricity or LPG for new domestic heating systems and. The impact of these regulations imposed significant constraints on NZ Pellet Fires, resulting in significant additional compliance costs.

In early 2003, NZ Pellet Fires was taken over by Solid Energy, which has brought technical, marketing, and sales expertise to the company. However, in addition to this Solid Energy has provided significant scale and market positioning that has improved the ability of the company to address a range commercialisation issues. Solid Energy has also brought a range of new capabilities and collaborations. Through Solid Energy's link to CRL Energy a range of technical expertise is readily accessible to the company and Solid Energy is currently investigating the use of imported technology for complementary boiler systems that may significantly extend the market for pellets into a range of light industrial and commercial situations.

Over the period 2001 – 2005, Scion (formally Forest Research) has also developed an active programme, which has directly supported the pellet manufacturing industry. Scion identified in 2000 that a prerequisite to extending the use of biomass fuels into new markets (domestic and

commercial heating & light industrial applications) a processed fuel was essential. A senior researcher at Scion had been involved in the fledging European market and had seen the influence of pellet fuels in a number of Scandinavian countries. This culminated in a group of New Zealanders attending an international pellet conference in Sweden in 2002 and Forest Research hosting a Bioenergy Association of New Zealand (BANZ) seminar on developing the New Zealand pellet market in late 2002.

Since Solid Energy took over NZ Pellet Fires and rebranded the company to "Natures Flame" there has been significant growth in the company turnover (over 300%) for last year and similar growth is expected for 2005. One of the major constraints for continued growth of the company is the availability of suitable qualified staff especially installation and sales personnel. Another important issue for the company is the development of competing producers bringing an inferior product to the market. Such activities cause "in-market failures" which detract new consumers taking up the pellet technology.

The company currently reports that with the developing market place more attention needs to be given to the introduction of industry standards (fuel and appliances) rather than perhaps, as previously, investment in further innovation. Industry standards are an obvious area for collaboration and government intervention to ensure domestic firms are not disadvantaged by "cheap" imports.

Conclusion

This case study illustrates that the development of bioenergy opportunities is 'hard work' in the absence of scale; significant commitment, often by corporate agencies; the establishment of collaborations and partnerships for information sharing and technical support. There are a number of significant barriers that small operators are unlikely to have the resources to address and to endure long enough to bring such barriers to an appropriate conclusion, and this may apply especially in the case of new or emerging technology where there is little market familiarity and acceptance.

In the above case, the introduction of a corporate investor has helped reposition a fragile industry to one with significant growth potential. To accelerate the uptake of new and emerging bioenergy technologies, then a process of identifying developing companies and actively connecting them to 'larger corporate mentors' may provide significant benefits.

Technology Commercialisation - Biogas

Technical collaboration within a private company undertaking research, development and commercial solutions

Waste Solutions Ltd

www.wastetechnz.com/portal.asp

Waste Solutions Ltd and the wider group under the umbrella of Waste Technology Group Ltd had its beginning in the Ministry of Agriculture and Fisheries. The Group was initially established to study energy and environmental issues following the oil price shocks of the 1970s. In the mid 1980s, the Group began to focus on wastewater issues and specifically the potential for producing energy (biogas) from wastewater. From there, the Group began a successful research programme to improve anaerobic digestion of difficult wastes, particularly those with high lipid concentrations.

The Group also developed expertise in the area of general wastewater treatment at the same time. Late in 1993 the New Zealand Government decided to sell the Group as it did not fit well with AgResearch's (New Zealand Government's Agricultural Crown Research Institute) core research activities. The Group was sold to a private consulting engineering company and has continued to operate both with that company and in its own right ever since.

Waste Solutions Ltd provides comprehensive consulting services in municipal and industrial wastewater treatment process and plant design and environmental issues relating to wastewater treatment and disposal. Waste Solutions Ltd undertakes wastewater treatment research and development in its own laboratory and provides research services to industry and government.

One of the company's key areas of business is to provided waste to energy solutions based on anaerobic digestion. Anaerobic Digestion is a process carried out by bacteria in the absence of oxygen. The process produces substantially less sludge than aerobic treatment and converts organic matter to energy-rich biogas, which can be used as a versatile fuel (heat, power and a feedstock for liquid fuel production). Its principal application is in the digestion of sewage sludge but many industrial wastes (solid & liquid) are suited to treatment by anaerobic digestion. Anaerobic treatment has been applied to a wide variety of solid and liquid organic wastes, including waste from food and beverage production (sugar, soft-drink, potato, vegetable, distillery and brewery wastes), meat, dairy and wool processing, and pharmaceutical and chemical industries. The significant advantages of anaerobic processes are low energy use and reduced sludge production, generation of biogas and the ability to extract valuable fertilisers from the digested residue. Other spin-off products and services offered by Waste Solutions include Industrial Waste Treatment, process development and pilot plants, instrumentation, control and automation, laboratory services and organic bio-waste resource recovery.

Waste Solutions employs a team of specialists with long-standing scientific and practical experience in anaerobic treatment processes. The company has extensive experience in research activities related to advances in anaerobic digestion, particularly in wastes with high fat content. Waste Solutions blends its scientific knowledge base with process design skills to produce highly effective and reliable anaerobic digestion facilities. With rising international energy costs, anaerobic digestion offers an alternative energy source.

Waste Solutions has taken conventional technology (largely anaerobic digestion) and continually made incremental improvements to achieve more energy production for less cost and for effective waste treatment. Furthermore, this process has allowed Waste Solutions to extend its business opportunities into the application of new technology for liquid fuel production. The opportunities for liquid fuels is being developed in collaboration with Best Biofuels in Austin Texas USA which owns North American patents for technology for the conversion of methane to methanol and this company has interests in commercial methanol production plants using this patented technology and piggery wastes as a feedstocks www.bestbiofuels.com/index.html. Waste Solutions is in a position to utilise license arrangements to gain access to the patented technology, but can then couple in its own technology to develop customised waste to energy solutions for New Zealand or other appropriate markets.

The company has established a number of research related collaborations which include with CRIs (e.g. Industrial Research and Scion), however to date these have not extended into industry. Other technical related collaborations cover working closely with other commercial companies to improve commercial offerings to potential clients – as stated by the company these usually take the form of "hunting" partners and to date these have not evolved into formal joint ventures.

Waste Solutions believe that an important component of technical collaboration is the opportunity to engage in regular informal exchanges involving face-to-face meetings, building relationships, identifying synergies and formulating joint projects. According to Jurgen Thiele, a senior consultant with the organisation, the development of such sector workshops in Germany over the last 20 years provide a model that could be adopted in New Zealand. An important barrier to collaboration identified was the significant duplication of effort in New Zealand, which although providing some competition tends to fragment expertise and organizations. It was suggested that it is timely for a more strategic overview of research and development and better coordination and development of collaborative frameworks for researchers and commercial practitioners. Waste Solutions also indicated that there is need to support demonstration projects so potential customers can experience first hand the advantages and disadvantages of equipment configurations and to provide tangible operational experience.

WaterCare Services Ltd

WaterCare Services currently have a large sludge lysis plant at Mangere water treatment plant. The plant uses an ultrasonic treatment of sludge in order to break down cell walls, increasing biogas production and reducing mass. This has duel benefits of producing biogas and reducing a waste stream. The Mangere plant has 6.8 MW of installed capacity for generating electricity from the biogas and produces around 40 GWh/yr. This places the facility at the higher end of bioenergy plant in this country.

Technology Commercialisation - Biomass Gasification

Technical collaboration within a private company undertaking research, development and commercial solutions

Fluidyne Gasification

www.fluidynenz.250x.com/

Fluidyne Gasification is a New Zealand based gasification technology that has been under development and production for about 25 years and during this time Fluidyne has developed and commercially implemented a number of gasification technologies (the Pacific class gasifier, Mk2 Mega Class Gasifier). Much of the development, testing and commercialisation has been undertaken by Fluidyne independently and with its own or other private sources of funds. In September 2000, Fluidyne's first large-scale engine gasifier was commissioned for testing in Canada and continued operating until September 2003. On completion of these tests, a new MK II Mega Class was developed and successfully test fired in 2004. This new gasifier has been increased in size again from the original one tonne to two tonne per hour providing sufficient gas to generate approximately 2 MWe/hr from an engine generating system. The design of the gasifier was achieved with the assistance of an associated company Innovation Technologies Ireland (ITI) and the fabrication was undertaken in Winnipeg, Canada. Parallel development of gas cooling, waste heat recovery and gas cooling components are also being developed. The company is also investigating a multiple engine concept that involves the use of spark ignition engines specifically modified for producer gas to overcome the cost of singular large engines.

AB Powerhearth Limited

www.3ialternativepower.com/perf3i.htm

The Powerhearth is a biomass gasification system designed to convert wood fuel into producer gas. The gas may be used for numerous applications including fuel for engines boilers and turbines. The Powerhearth is the product of over thirty years of commercial gasifier design and fabrication experience. The Powerhearth is an automated system. The gasifier and each of its

ancillary components may be monitored and or controlled manually or remotely by a Powerhearth Management System. Further work is required to determine the current status of this technology.

Page Macrae

Page Macrae Engineering is a firm dealing in power generation, petrochemical, ship repair, pulp and paper, food processing, mechanical handling and water treatment. Page Macrae currently have one of the largest operational Biomass gasifiers in New Zealand, which can produce up to 2MW approximately. The gasifier is a fixed bed up-draft gasifier, which produces process steam for a nearby production facility. Page Macrae are demonstrating that gasification technologies can be effective in providing process heat requirements and has the capability to compete with combustion for the provision of process steam.

They are an active participant in the BIGAS consortia and development of their steam system and heat recovery system has been undertaken in conjunction with the host site.

Conclusion

Waste Solutions is an example of a small company endeavouring to deliver innovative solutions for waste to energy in a relatively competitive market. For their technologies to be successful it is important that they improve system efficiencies at reduced cost. This type of company needs ready access to the best information available and the ability to develop relationships with organisations that can rapidly advance their concepts, either through pre-commercial testing, prototyping, and demonstration phases. A programme of sector workshops or focus groups may be a mechanism to accelerate this process and for companies like Waste Solutions to identify potential partners.

If such a programme was formalised at industry level, then this could also provide a greater overview of research and development and lead to better coordination between researchers and commercial practitioners across different disciplines.

International Multilateral Agreements

International Expert and Research and Development Collaboration

IEA Bioenergy
www.ieabioenergy.com/

NZ's involvement in the IEA programme has been extensively covered elsewhere. The tasks NZ currently participate in are described in Appendix 2. Of particular interest in this case study is the views of the international community in respect to future R&D priorities. A paper has just been completed reviewing bioenergy R&D status and future R&D trends. The Chair of IEA Bioenergy completed the paper with input from other contributing countries including the NZ Task leaders. Some of the main conclusions from this study were:

Short term needs

Short terms needs for bioenergy focus on two primary areas, to make available relative cheap feedstocks at large quantities for the uptake of a dedicated market of biomass fuels that can be traded locally, nationally and internationally and to further increase the efficiency of some basic processes while reducing their costs. The former necessitates the development of standards and norms on the fuel quality to be traded in the market while the later requires innovative approaches that may focus more on materials rather than conversion technology improvements. It has been recognised that a functional international market for biofuels is a prerequisite for the global development of bioenergy and there is need for large quantities to be traded internationally.

Medium term needs

Medium term needs for bioenergy should address the opportunities that might be offered by bio-refineries by which a variety of products including energy can be produced. Such products can be bio-polymers, food additives and energy from process residues. Such applications would significantly increase the overall efficiency of the processes, increase the economic benefits and promote sustainability. Dedicated crops could be developed that tailor the needs for bio-refineries by maximising the concentration of certain chemicals in the crop such as sugars or starch.

Long term needs

In order to propose long term R & D priorities it is necessary to define a long term vision of the energy supply. At present this vision is focused on a hydrogen economy. As it has been shown in Figure 2 there are several pathways for the production of hydrogen. At present it is expected that gaseous (biogas or bio-methane) and liquid biofuels (ethanol and eventually methanol) could be used as a safe carrier for hydrogen.

Conclusions

Interestingly the conclusions from this international work are very applicable to New Zealand; furthermore this paper provides insights to the international priorities that would enable New Zealand to more effectively identify products, technologies or economic development opportunities. A copy of the full report has been provided separately with this report.

Appendix 1: Stakeholder Map

This table is by no means inclusive or complete. It is intended to be used only as an illustration of the diversity of the bioenergy sector.

Supply chain component	Forestry	Agriculture -Meat -Dairy -Pasture -Arable	Waste Management -MSW -Sewage treatment	Energy suppliers	Others -Algae -Tyres	Research -Supply -Conversion -Markets -Environmental	Technology supply	Consultancies and servicing -Technical consultants -Industry associations	Government
Biomass production	• Forest Research and Agrigenesis (Research) • CHH and Forest Research (Research) • FRST and Forest Research (Research) • FRST and Forest Research (Composting & linked to other substrates) (Research)	• NIWA – biogas production (Research) • AgResearch (Meat processing and waste management) (Research) • AgResearch (forage crop production) (Research) • Canesis – animal waste management (Research) • Foneterra Alcohol	• Waste separation (logistics of supply) • Landfill management (sites, location, construction, management) • Waste gas production	• Fire wood producers (growers and distributors)		• Forest Research • AgResearch • NIWA • Crop & Food	• AgriGenesis	• BANZ • Waste Solutions • SKM (incineration	
Biomass recovery and logistical supply	• FRST & Forest Research (supply of forest residues) (Research) • Massey University (biomass supply models) • Golden Bay Cement (Biomass utilisation) (Commercial implementation)		• Waste management		• Cement companies – burning waste (tyres /oil products)			1.	
Biomass processing and conversion	• FRST& Forest Research (combustion & gasification, biorefining, pulp and paper, Tall oil, wood volatiles) • CRL Energy (biomass combustion and gasficiation) (Research) • Canterbury University (Shusheng Pang) Biomass gasfication (Research) • Brightwater Engineering (Hugh Grey) (Servicing) • Easteel (David McGregor) (Equipment supplier) • Alan Estcourt • Malcolm McKenzie	• Waste Solutions	Waste water consultants	• Solid Energy (pelletised fuels- link to Living Energy) – Production and distribution • Firelogs Limited (Duncan Wattie) • Golden Strand wood fibre (Danny Glozier) • Bruce Clow				• Ian Bywater (Convatec process) • Alternative Energy Solutions (Auto Tech – Gavin Hedley) Gasification • BioDeisel fuels (NZ) Ltd (Barry McDonald)Biodiesel production • Biodiesel Oils Ltd (Tom McNicholl)) biodiesel production	
Energy distribution	• FRST & Forest Research Pelletised fuels (Research)			• Solid Energy (pelletised fuels- link to Living Energy) – Production and distribution				• CAE (distributed generation) • IRL (small scale systems	

				• Eastland Infrastructure (Bioenergy implementation • BP (Biofuels) • Mobil (Biofuels) • Gull (Biofuels)					
Energy users	• FRST & Forest Research (supply and demand analysis) (Research). • CHH • Waste management co • Sawmills (Pacific Pine – new biomass plant)			• Line companies purchasing renewable energy					
Policy	• MAF • Regional development agencies (eg Taupo)								• EECA • MAF • Climate Change office • MED (International agreements)
Research									• FRST • EECA • FIDA

Appendix 2: IEA Bioenergy

www.ieabioenergy.com/

Tasks that New Zealand currently participate in are described below.

Short rotation crops for bioenergy systems (Task 30)

Involvement in this Task future proofs New Zealand's involvement in bioenergy as a considerable body of work has shown that over time the use of different biomass fuels will change with the initial focus being on wood processing residues, but once demand surpasses supply then the focus will move to the recovery and use of in-forest residues. However, in the medium to longer term there is likely to be a need to access purpose grown biomass fuels as these will provide a hedge against variable feedstocks from forestry operations or other waste streams, provide materials where required, and the option of producing high performing crops that reduce the overall cost of biomass supply. This Task has established links with the agricultural sector in New Zealand, though the research priority for this area nationally is relatively minor.

Thermal gasification of biomass (Task 33)

The objectives of Task 33 are to monitor, review and exchange information on biomass gasification research, development and demonstration (RD&D) and to promote co-operation among the participating countries and industry to eliminate technological impediments to advance thermal gasification of biomass. The ultimate objective is to promote commercialization of efficient, economical, and environmentally preferable biomass gasification processes, for the production of electricity, heat, and steam, for the production of synthesis gas for subsequent conversion to chemicals, fertilizers, hydrogen and transportation fuels, and for co-production of these products. New Zealand has only been a member of this Task since the beginning of 2004, consequently is only now starting to capitalise on the membership through the access to information and international expertise. This Task recently produced an excellent overview of the status of gasification technologies and routes to markets for these systems. This paper is available on request as a pdf file.

Greenhouse gas balances of biomass and bioenergy systems (Task 38)

The focus of this Task is on developing tools to aid in the implementation of bioenergy and forest carbon sequestration options for greenhouse gas reduction. The global nature of the Task provides New Zealand policy analysts, scientists, forest industry and the bioenergy industry the opportunity to collaborate/learn from people within this field globally. Task 38 provides a window to what is happening regarding bioenergy and carbon sequestration in other countries. It enables New Zealand to see which systems 'work' best technically to reduce GHG emissions in other countries and ascertain if they are applicable here. The Task also enable the analysis of what policies are best at encouraging GHG reductions in different countries and why.