



SCIENCE SYMPOSIUM

Next Generation Liquid Biofuels and Co-Products

REPORT AND ACTION PLAN



The attendance of international keynote speakers to the *Next Generation Liquid Biofuels and Co-Products* Science Symposium was supported by MoRST and MFAT through the Science Promotion Fund.

Introduction

Transportation biofuels and co-products derived from grasses, wood, and algae have the potential to displace a significant proportion of fossil-based fuels and chemicals in New Zealand. To fully exploit this opportunity requires a coordinated scientific research effort across New Zealand's research organisations. As a first step along this path, Scion – the lead Crown Research Institute in wood-related bioenergy¹ – hosted a Science Symposium on Next Generation Liquid Biofuels and Co-Products in December 2010. This Symposium was the first of its kind in New Zealand and provided a forum for the New Zealand biofuels research community to share their science, engage in scientific debate, and learn about international developments in the biofuels areas.

The Symposium intended to complement other fora with a policy or commercial focus to ensure that appropriate synergies between research and development activities are built and that collective work remains both leading edge and relevant to the needs of New Zealand.

The Symposium technical programme was put together by a Scientific Organising Committee: Professor Shusheng Pang (University of Canterbury), Dr Rupert Craggs (National Institute of Water and Atmospheric Research), and Dr Michael Jack (Scion). The Committee were asked to choose oral and poster presentations from 40 submitted abstracts based on relevance and science quality.

DAY ONE of the Symposium showcased New Zealand biofuels research and included presentations by the University of Canterbury, CRL Energy Limited, the National Institute of Water and Atmospheric Research (NIWA), Industrial Research Limited (IRL), the University of Waikato, AgResearch, and Scion. In addition, the Ministry of Research, Science and Technology (MoRST) and the Ministry of Foreign Affairs and Trade (MFAT) kindly supported the attendance of three international keynote speakers: Professor Jack Saddler (University of British Columbia, Canada), Dr Jim McMillan (National Renewable Energy Laboratory, United States of America), and Professor Claus Felby (University of Copenhagen, Denmark).

DAY TWO of the Symposium featured presentations by the Parliamentary Commissioner of the Environment (PCE), the Bioenergy Association of New Zealand (BANZ), and New Zealand Trade and Enterprise (NZTE). Workshop sessions then discussed topics relevant to the biofuels research community, including:

- What are the biofuels areas where New Zealand has obvious strengths?
- What are the science capabilities we should be developing in the future?
- What are the next steps for biofuels research in New Zealand?

The success of the Symposium depended on the support and participation of the New Zealand biofuels research community. The event attracted 80 registrations including 36 from Crown Research Institutes, 13 from Universities, 7 from the government sector, 18 from industry and other research organisations, and 6 from overseas organisations. Feedback indicated that delegates greatly valued the opportunity to hear about current biofuels research activities and to participate in broader discussions about the New Zealand biofuels industry.

This Report and Action Plan summarises the Symposium and outlines a path forward for on-going collaborative interactions. It has been written by the Symposium organisers, Dr Trevor Stuthridge (Scion), Dr Michael Jack (Scion), and Dr Katharine Challis (Scion), and has been reviewed by the Scientific Organising Committee. Symposium delegates have been consulted prior to the release of the final version.

¹ Scion Statement of Core Purpose: www.morst.govt.nz/Documents/cri-taskforce/SCPs/SCION%20SCP.pdf.

Technical Meeting

The Technical Meeting on 13 December began with a traditional Maori Whakatau welcoming the international visitors to Rotorua and New Zealand. Dr Trevor Stuthridge (Scion) welcomed delegates and set the tone for the day by emphasising the need to communicate across science areas for the success of biofuels in New Zealand.

The keynote speakers gave an international perspective during the morning session. Professor Jack Saddler (Canada) provided a compelling case for biofuels based on the rising demand for transport fuels and significant progress in technology development during the last decade. He summarised major international biofuel developments and promoted the importance of international collaborations such as IEA Bioenergy – the largest international network of bioenergy researchers. Dr Saddler emphasised the biorefinery concept, where the co-production of high-value products with biofuels provides a means to maximise returns and improve economic performance. He also highlighted the important role of government in biofuels implementation; stressing that policies supporting biofuels need to be part of a strategy to reduce carbon emissions and that policy and technology must work together to bring new forest products to the market. Dr Saddler noted that renewable energy solutions will be country specific and of interest in New Zealand where there is a geothermal source, fresh water, and a substantial forestry sector.

Dr Jim McMillan (United States of America) reinforced Professor Saddler's case for biofuels by highlighting current drivers including science and discovery, economic prosperity, clean and secure energy, and climate change. He emphasised the importance of theoretical modelling to guide research and the need to leverage existing refinery infrastructure to lower the cost of biofuels implementation. Dr McMillan provided an overview of the vast research and development efforts going on in the United States of America. In particular, he described recent initiatives investigating opportunities for drop-in fuels compatible with existing infrastructure. He also emphasised the potential opportunities from hybrid technologies that mix thermochemical and biochemical processes. Dr McMillan also noted that given the current status of the biofuels industry it is important to learn from the successes and failures of others and utilise opportunities like the Symposium that bring the research community together.

Professor Claus Felby (Denmark) explained that 20 % of Denmark's energy comes from renewable sources and that the aim is that 100 % of Denmark's energy will come from renewable sources by 2050. Dr Felby introduced his work on scaling up lignocellulosic biofuel technologies with Denmark energy company Inbicon and their straw-to-ethanol pilot plant facility. Interestingly, increasing production to pilot scale resulted in significant yield improvements compared to laboratory-scale work. A particular highlight of Dr Felby's presentation was the news that Inbicon has been selling a 5 % cellulosic ethanol fuel nationwide in Denmark since October 2010 – a world first. Dr Felby emphasised the need to integrate the agricultural and energy sectors to optimise resource use and demonstrated the value that can be gained in building relationships between academic research, industry, and government.

The afternoon sessions provided an opportunity for New Zealand researchers to share their work. Presentation abstracts are available in the Symposium Programme and Abstract Booklet that can be downloaded from the Events Section of the Scion website: www.scionresearch.com.

Symposium presentations described thermochemical biomass-to-biofuels conversion technologies, such as:

- pyrolysis, and gasification (University of Canterbury, CRL Energy Limited, Industrial Research Limited),

- Fischer-Tropsch synthesis of liquid fuels (University of Canterbury),
- torrefaction (Scion, CRL Energy Limited),
- biomass and coal combinations (CRL Energy Limited), and
- supercritical fluid systems (Industrial Research Limited).

Presentations also covered biochemical approaches, including:

- softwood pre-treatment (Scion, University of Waikato),
- sugar and lignin production (Scion),
- fermentation for lipids and biofuels (Industrial Research Limited)
- rumen, insect, and fungal enzymes (AgResearch, University of Waikato, Scion),
- *in planta* enzyme expression (AgResearch), and
- thermophilic bacteria from geothermal systems (GNS Science).

Researchers also talked about alternative waste to energy technologies, including:

- waste-water algae and municipal waste solutions (National Institute of Water and Atmospheric Research).

Biofuel topics beyond process technologies were also discussed, including:

- co-products from lignin (Scion),
- techno-economic modelling (Scion, CRL Energy Limited),
- analysis of saccharification of lignocellulosics (Scion),
- life cycle assessment (Scion),
- water management (Scion), and
- geothermal integration (Scion, GNS Science, CRL Energy Limited).

The wide range of presentation topics emphasised the breadth of research being undertaken in New Zealand and the multi-disciplinary nature of biofuels research. It was evident that there were significant opportunities for collaboration across research organisations and greater strategic coordination of biofuels research in New Zealand.



Figure 2: International keynote speakers Professor Jack Saddler, Dr Jim McMillan, Professor Claus Felby, and Symposium organiser Dr Michael Jack.

Workshop

The Workshop on 14 December began with three presentations. Dr David Bull (Parliamentary Commissioner of the Environment) proposed that drop-in biodiesel from wood is strategically important for New Zealand. He commented that goodwill for biofuels is eroding and asked what the government should be doing to help. Mr Brian Cox (Bioenergy Association of New Zealand) emphasised that economic growth needs to be the main driver for biofuels and highlighted the need for collective action. He also summarised the New Zealand Bioenergy Strategy, prepared by the Bioenergy Association of New Zealand (BANZ) and the New Zealand Forest Owners Association (FOA), that was published in September 2010. Mr Chris Mulcare (New Zealand Trade and Enterprise) presented a cleantech low-carbon vision for New Zealand. He emphasised the need for an integrated and coordinated plan and promoted regional opportunities that utilise existing energy infrastructure and local resources.

Workshop discussions were then held during the remainder of the morning. The Symposium organisers had three main objectives:

1. To facilitate communication within the New Zealand biofuels research community.
2. To facilitate teamwork across the research community to begin identifying New Zealand biofuels gaps.
3. To achieve a consensus around the next steps for the research community.

The overall workshop process was carried out in three steps as shown in Figure 3.

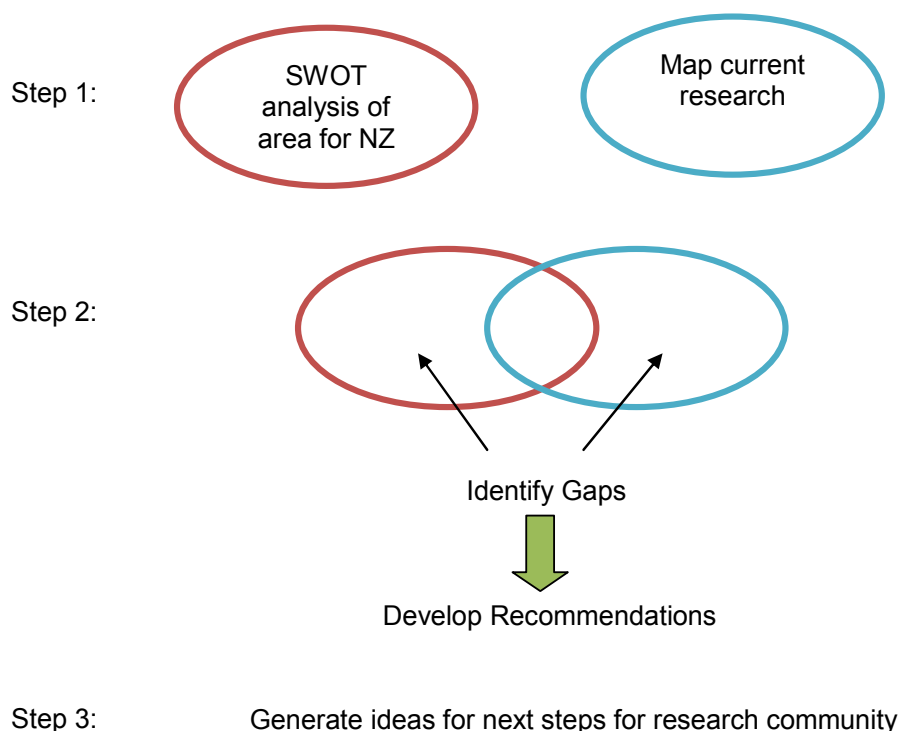


Figure 3: The operational framework for the Symposium Workshop discussions.

Step 1a: SWOT Analysis

Symposium delegates were divided into groups and half of the groups were asked to identify the most important **Strengths**, **Weaknesses**, **Opportunities**, and **Threats** for New Zealand in the area of next-generation biofuels and co-products.

The SWOT analysis results are summarised in the following table:

<p>Strengths</p> <ul style="list-style-type: none"> • Technical capability: agriculture, forestry, pulp and paper, feedstocks and conversion • Diverse resources: land, geothermal, biomass, wind, fresh water, coastline • Kiwi attitude: innovative, pragmatic, unorthodox, free thinking • Commitment to a clean and green image • Established biomass supply chain and processing infrastructure 	<p>Weaknesses</p> <ul style="list-style-type: none"> • Lack of capital and research funding • Lack of government leadership • Lack of research coordination • Lack of alignment between the science community, government, and industry • Risk averse attitude and lack of ambition • Lack of awareness of the biofuels opportunity
<p>Opportunities</p> <ul style="list-style-type: none"> • Live up to the 100% Pure image • Improve energy and economic security • Leverage international knowledge • Utilise science across different sectors and disciplines to achieve breakthroughs • Explore co-benefits and value-added products • Develop integrated industrial clusters and utilise existing infrastructure • Integrate geothermal into biofuel production 	<p>Threats</p> <ul style="list-style-type: none"> • Competition from fossil fuels • Competition for biomass supply • Government policy changes • Intellectual property lost overseas or locked down in New Zealand • Short funding/investment timeframe • Public misperception of biofuels

Step 1b: Current Research

The other half of the delegate groups were asked to identify areas of biofuels research that are currently being carried out in New Zealand and to classify those areas according to high or low excitement science and high or low impact in five years. Although this exercise prompted enthusiastic discussion, the delegates were unable to arrive at a detailed summary or consensus. Therefore, the Symposium organisers have carried out an alternative analysis that captures the current areas of New Zealand biofuels research presented at the Symposium (see Figure 4 on page 9). This analysis does not include research areas that were not presented at the Symposium. For example, the Symposium organisers are aware of fuels testing work and high-temperature yeast research being carried out at the University of Auckland.

Woody-biomass feedstocks Scion	Biological conversion Scion IRL Pretreatment Scion UoW Enzyme discovery/production AgR UoW GNS Scion	Co-products Scion IRL	Biofuel products Petrol replacements Scion Diesel/Jet fuel replacements NIWA CRL IRL UoC Scion
	Thermal conversion Pretreatment CRL Scion UoC CRL IRL Scion		Hydrogen CRL IRL
Algae feedstocks NIWA	Algae harvesting/processing NIWA		
Water and Environment		Scion	
Techno-economic Analysis		Scion	CRL

Figure 4: Current areas of New Zealand biofuels research presented during the Symposium. The following abbreviations are used: IRL – Industrial Research Limited, AgR – AgResearch, UoW – University of Waikato, GNS – GNS Science, CRL – CRL Energy Limited, UoC – University of Canterbury, NIWA – National Institute of Water and Atmospheric Research. No attempt has been made to capture the funding levels of research or the depth of capability.

Step 2: Gap Analysis

Mixing the groups from Steps 1a and 1b, delegates were asked to identify the most important gaps between the SWOT analysis and the current areas of research. The identified gaps can be summarised in five main themes:

- **Science Capability:** Groups identified a need for additional research and development capability. Particular areas suggested for further development included species management, residue harvest and processing, conversion technologies specific for New Zealand, biodiesel from forestry, genetically modified organisms, high-value co-products, and indirect land-use change. Groups also suggested that pilot demonstration facilities were needed to research technologies at larger scale.
- **Funding:** Groups identified a need for funding to transition technologies from the laboratory scale to demonstration scale and to support commercialisation and the development of a biofuels market.
- **Leadership:** Groups identified a need for greater government leadership and policy certainty. Groups also encouraged the development of a long-term national strategy, a cohesive vision across sectors, and closer alignment between national strategies and research and development.
- **Collaboration:** Groups identified a need for better communication of research and more extensive coordination both between researchers and with industry. Groups also recommended that more flexible and collective intellectual property agreements be arranged.

- **Understanding:** Groups identified a need for increased promotion of biofuels to improve awareness of biofuels opportunities and issues. Groups also emphasised the need for a detailed business case for biofuels in New Zealand and for analysis of biofuels taking into account policy, social, economic, and efficiency factors.

Step 3: Delegate Consensus on Next Steps

To conclude the workshop, Symposium delegates were given the opportunity to put forward their ideas for the next steps for the New Zealand biofuels research community. Based on this discussion, and the results of Steps 1 and 2, a consensus was reached. The research community agreed to work together to:

1. coordinate research and development through a research centre,
2. develop a clear and specific value proposition for New Zealand biofuels, and
3. actively engage with industry to develop public-private partnerships.



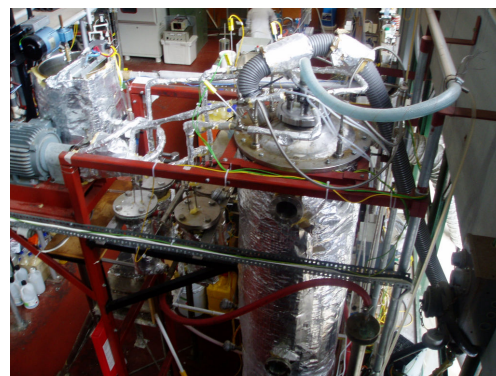
University of Canterbury gasifier



CRL Energy Limited
carbonisation/torrefaction apparatus



GNS Science laboratory



University of Auckland reactor

Figure 5: Four New Zealand biofuels research facilities.

Action Plan

The Symposium attracted a significant proportion of the New Zealand biofuels research community. It fostered enthusiasm and goodwill amongst delegates and culminated in a delegate consensus.

The Symposium organisers consider it a priority to continue the momentum of the Symposium and have drafted an Action Plan in support of the delegate consensus. The aim of this Action Plan is to provide a framework and timetable for establishing systems and structures that will enable the New Zealand biofuels research community to work together to follow through on their consensus. The proposed Action Plan was not developed during the Symposium but is a recommendation by the Symposium organisers on which delegate consultation has been sought. Delegate feedback has been incorporated where considered appropriate by the Symposium organisers.

The Symposium organisers propose the following three-part Action Plan:

1. **Formation of an Advanced Biofuels Research Steering Group:**

Scion will lead the formation of an Advanced Biofuels Research Steering Group. This Steering Group of research representatives will provide a balanced and integrated voice for the New Zealand biofuels research community and will arrange for the implementation and further development of this Action Plan. Scion will chair the Steering Group in its first year of operation.

The Advanced Biofuels Research Steering Group will be established by **30 April 2011**.

2. **Establishment of an Advanced Biofuels Research Centre:**

The Advanced Biofuels Research Steering Group will lead the establishment of a virtual Advanced Biofuels Research Centre. This Centre will be modelled on successful existing bodies, such as the New Zealand Life Cycle Management Centre, the New Zealand Climate Change Centre, and the New Zealand Agricultural Greenhouse Research Centre. Scion will host a website for the Advanced Biofuels Research Centre.

A charter describing the role of the Advanced Biofuels Research Centre will be prepared, a partnership memorandum of understanding will be signed, and the Centre website will go live by **30 June 2011**.

3. **Development of a Work Plan:**

The Advanced Biofuels Research Centre members will extend the initial capability and gaps analysis carried out during the Symposium. This analysis will attempt to include *all* areas of current research in New Zealand (i.e., not only those presented at the Symposium) and will incorporate more detail about current research, including funding levels and whether the research is fundamental or applied. Based on this analysis, the Advanced Biofuels Research Centre members will develop a five-year Work Plan to address identified needs for New Zealand biofuels research.

The Work Plan will specifically include:

- a plan to create an **industry advisory group** and an **international science advisory group** for the Advanced Biofuels Research Centre,
- a plan to develop a clear biofuels **business case** and value proposition, to be submitted to government and industry to gain support for the Advanced Biofuels Research Centre,
- a plan to create **public-private partnerships** enabling collaborative advanced biofuels research and development programmes with industry stakeholders and end users,
- a plan to engage with other relevant stakeholder groups, such as the Bioenergy Association of New Zealand (BANZ) and IEA Bioenergy,

- a plan to develop a **funding proposal** to finance the Advanced Biofuels Research Centre and its on-going operations, and
- a plan to collaborate with industry stakeholders, government, and potential end users to develop a long-term biofuels **research strategy** for New Zealand.

Additional consideration will also be given to the role of the Advanced Biofuels Research Centre in organising annual meetings comparable to the 2010 Science Symposium, publishing a New Zealand biofuels research newsletter, and facilitating communication and coordination of across-sector and across-organisation research programmes.

The Work Plan will be developed by **31 August 2011**.

