

OPPORTUNITIES FOR PRIMARY INDUSTRIES IN THE BIOENERGY SECTOR

National Research, Development and Extension Strategy



Further Information

Julie Bird
Senior Research Manager,
National RD&E Strategies
Rural Industries Research and Development Corporation

Ph: 02 62714140
Fax: 02 62714199
E-mail: julie.bird@rirdc.gov.au

Electronically published in July 2011
Print-on-demand by Union Offset Printing,
Canberra at www.rirdc.gov.au
or phone 1300 634 313
RIRDC Publication No 11/079

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July 2011

Acknowledgements

The contributions of the following are gratefully acknowledged. In addition to those listed, thank you to the many industry participants, university research officers, government officials and others who provided data for the resource analysis and consultation responses. The response rate was outstanding.

The Biofuels and Bioenergy National RD&E Strategy Steering Committee

Anne Bennett	DAFWA
Steven Clarke	SARDI
Lesley Dowling	DEWHA
Brendan George	NSW DPI
Paul Grieve	DEEDI
Victoria Haritos	CSIRO
David Hurburgh	TAS DEDT
Zoltan Lukacs	GRDC
Thomas Maschmeyer	University of Sydney
Linda Meisel	DEWHA
Richard Niven	DRET
Roslyn Prinsley	RIRDC (till 2010)
Nathan Rhodes	DAFF
Natalie Sabadasz	DAFF
Bill Salter	APL
Bruce Sawyer	NTDOR
Stephen Schuck	Bioenergy Australia
Helen Scott-Orr	NSW DPI (till 2009)
German Spangenberg	VIC DPI
Annette Sugden	SRDC
Rob Thomas	SARDI
Catherine Viljoen	LWA

Abbreviations and Acronyms

ABRI	Australian Biofuels Research Institute
ACRE	Australian Centre for Renewable Energy
AFSIG	Alternative Fuels Strategic Issues Group
ARENA	Australian Renewable Energy Agency
CO ₂	Carbon dioxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DOE	(United States) Department of Energy
DRET	Department of Resources, Energy and Tourism
FY	Fiscal Year
GHG	Greenhouse Gas
GWh	Gigawatt-hours
H ₂ O	Water
IEA	International Energy Agency
LRET	Large-scale Renewable Energy Target
NSW DPI	New South Wales Department of Primary Industries
PIMC	Primary Industries Ministerial Council
PISC	Primary Industries Standing Committee
PMSEIC	Prime Minister's Science and Engineering and Innovation Council
RD&E	Research, Development & Extension
RIRDC	Rural Industries Research and Development Corporation
SCER	Standing Committee on Energy and Resources

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Executive summary



Bioenergy is already making a substantial contribution to meeting global (including Australian) energy demand, and that contribution could be expanded very significantly in the future. However, bioenergy is a complex topic that impacts a range of important policy areas:

- *Energy security*, through improving the affordability, reliability and/or resilience of energy supply – particularly liquid fuels in a world where future oil prices and availability are uncertain;
- *Greenhouse gas (GHG) abatement*, through mitigation and displacement of fossil fuels, particularly after a price for carbon reduction is established;
- *Land and water use*, in a water limited environment such as Australia and where international experience from direct and indirect land use change has seen adverse impacts on food prices and/or biodiversity concerns emerge due to biomass feedstock production competition for scarce resources; and
- *Rural and regional development*, through new market opportunities for farm-based products, salinity mitigation, soil protection and/or increased biodiversity.

While primary industries will be the major suppliers of biomass feedstocks to the downstream producers of bioenergy products, primary industries – as crucial as they are in the bioenergy value chain – are just the beginning of a complex, *industrial* value chain that results in energy transformation for a range of stationary and transport applications.

Efficient and sustainable production of a wide range of biomass feedstocks in sufficient volume and at costs that will meet the needs of those bioenergy producers are key challenges for primary industries. Adding further complexity are the sustainability challenges across social,

environmental and economic dimensions. Bioenergy systems have the capacity to address environmental issues and social aspects – but to meet these goals requires integrated management of the bioenergy value chain from growing, harvest and transport of feedstocks to their conversion into useful end-products.

The bioenergy industry in Australia has the potential to grow significantly driven by:

- Increased demand for renewable energy for stationary power and transport fuels, as Australia seeks to reduce its GHG emissions.
- A market response to a sustained increase in oil prices in the longer term, as demand increases and supply is constrained.
- The development of a variety of new and existing feedstocks that optimise sustainable use of existing farmland and create new opportunities for marginal lands.
- A variety of new conversion technologies, principally those for production of liquid fuels from lignocellulosic and algae biomass sources.

Primary industry-specific RD&E priorities for Bioenergy were developed through an industry workshop at a Bioenergy Australia meeting in July 2009. These RD&E priority areas are:-

- Sustainability
- Feedstocks
- Supply logistics
- Policy analysis, and
- Outreach, capacity building and networking

There are significant RD&E gaps within these priority areas which require addressing if the primary industries sector is to fully engage in future bioenergy opportunities.

There is a need for greater coordination of RD&E focused on specific needs that will assist Australian primary industries to best engage and pursue opportunities in bioenergy in Australia. Australia's bioenergy sector (including biomass feedstock supply) is relatively immature, and is significantly dependent for its sustainable growth on the stability and direction of future policy decisions and technological advances.

Flexible strategies and coordination mechanisms are required to allow for rapid changes in technology and policy. The importance, and challenge, of aligning and coordinating the Primary Industries Standing Committee (PISC) and the Standing Committee on Energy and Resources (SCER) in their consideration of bioenergy supply/value chain opportunities and challenges thus cannot be overstated.

There is a substantial body of knowledge developed nationally and internationally in bioenergy. Information for communication and extension activities can, and must, be drawn from this knowledge base and transferred to Australian primary industries stakeholders about the opportunities and challenges for them to participate in the growing local bioenergy industry. The key will be to provide credible information and resources so that those stakeholders can assess the reality of opportunities for them from growth in the Australian bioenergy sector.

There is a clear need for an RD&E Advisory Forum focused to PISC's primary industry stakeholders on alignment of policies and RD&E activities relevant to those stakeholders in order to maximise returns to them from their involvement/investment in bioenergy supply chains.

This Forum will be coordinated and supported by the Rural Industries Research and Development Corporation, and will comprise representatives of relevant PISC agencies, universities, CSIRO, federal agencies and funding bodies (including RDCs) and primary industry representatives. Membership will be voluntary, participatory and offer opportunities to negotiate RD&E activities that will benefit both individual research institutions as well as primary industries as a whole. The National RD&E Framework principle of national R, and regional D&E, will guide the activities of the forum.

It is anticipated that after an initial planning and

consolidation phase that the Forum will meet annually face-to-face to coordinate potential collaborations. RIRDC will be required to plan and facilitate this meeting.

It is proposed that the terms of reference for the Forum are to:

- Provide a national opportunity for consultation, coordination and communication amongst Australian research providers, funders, industry and government agencies focused on bioenergy RD&E activities relevant to primary industry stakeholders.
- Encourage collaboration and knowledge sharing in order to achieve greater efficiencies in use of resources and growth in capability.
- Provide input and representation to high-level decision-making fora relevant to the bioenergy sector, including encouragement of increased funding and resources for relevant RD&E activities through methods such as cost benefit analysis of RD&E activities.
- Lead and coordinate the communication of RD&E outcomes to primary industries, the general public and policy makers.
- Coordinate interaction with the other sector and cross-sector National RD&E Strategies.
- Increase collaboration with non-primary industry sectors, including relevant Standing Committees and Federal/State agencies and initiatives.
- Examine and further develop opportunities for international collaborations and innovation sharing that will benefit the Australian bioenergy industry.
- Update this National RD&E Strategy, including RD&E priorities, every three years through consultation with industry and researchers.

While acknowledging the breadth and depth of the respective components in the developing bioenergy sector (viz., technical, social, economic and environmental); and in particular the fast developing processing technology (e.g., significant advances in biorefinery technology and basic science). The strategy needs to limit its scope to adequately address the key issues facing primary industries. The complexity and diversity of the bioenergy supply chain is recognised and a particular focus on the biomass resource and supply systems allows for particular effort on supply suitable biomass efficiently into developing energy options of heat, power and transport.

1. Background and context



Research, Development and Extension (RD&E) in primary industries is a key factor for increasing productivity and ensuring sustainability. RD&E across Australia is a very complex web of research providers and investors who are independent operators with strong interconnections. The 16 rural R&D corporations and industry-owned companies (RDCs) are an integral component of this web, as well as the federal, state and territory governments, CSIRO, universities and private providers. If Australia's primary industries are to improve their productivity and sustainability they cannot afford a fragmented or duplicative RD&E system. Nationally, RD&E investment in primary industries, which exceeds \$1 billion annually, needs to be focussed, used efficiently, effectively and collaboratively.

In April 2005 the Primary Industries Ministerial Council (PIMC) endorsed the concept of 'National R with Regional D&E'. The concept recognises that basic and strategic research (R) can be provided from a distance, with regional adaptive development (D) and local extension (E) required to improve the uptake of innovation by industry.

Subsequently, in April 2006, PIMC agreed to a set of principles to facilitate further cooperation between agencies and industry for improving the efficiency and effectiveness of the national RD&E capability. These principles emphasise cooperation, information sharing, maintaining funding, access to capability and reporting.

The notion of collaborative RD&E between agencies is now well established and in April 2007 PIMC agreed to develop a National Research, Development and Extension Framework as a broad national plan to provide a more comprehensive, structured approach within an agreed timeframe.

On 6 November 2008, PIMC endorsed the National Primary Industries Research Development and

Extension Framework (National RD&E Framework) including the development of an overarching statement of intent. PIMC also acknowledged the significant contribution and progress that has been made by agencies, RDCs and peak industry bodies in developing the fourteen sectoral and seven cross sectoral industry strategies.

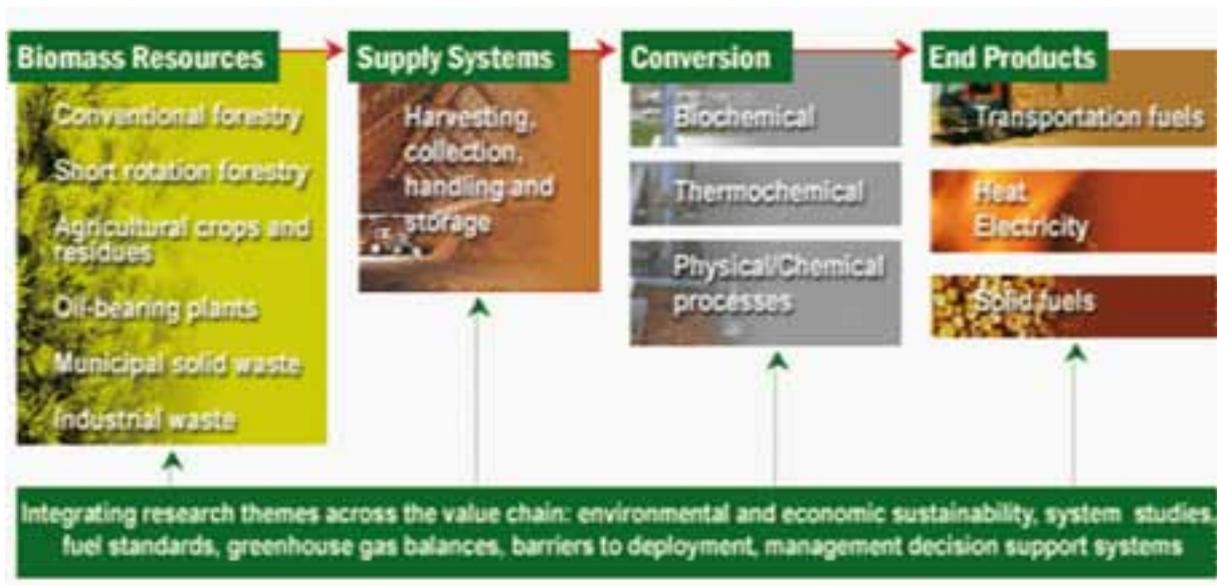
When the Framework is fully implemented, it is expected that:

- research capability will become more collaborative, specialised, have larger critical mass and will be less fragmented across the nation. Efficiency and effectiveness of RD&E will be markedly improved overall, although some additional costs could be incurred providing national linkages and to support delivery of regional development and local extension.
- agencies will retain and build capability in fields strategically important to their jurisdictions and industries. At the same time, it is expected agencies will collaborate with others to provide for a more comprehensive national research capability.
- the national research capability will be an integral component of a wider innovation agenda, supporting development and extension. To encourage rapid uptake of new technologies, research developed in one location would be available nationally for the whole industry.

By ensuring the substantial resources invested by government and industry in research are managed cooperatively, a more efficient, effective and comprehensive capability will be possible.

The Framework comprises of 14 primary industry sector strategies, and 7 cross-industry sector strategies. This report, the National RD&E Strategy for Opportunities for Primary Industries in the Bioenergy Sector, is a cross-industry sector strategy.

2. Industry overview



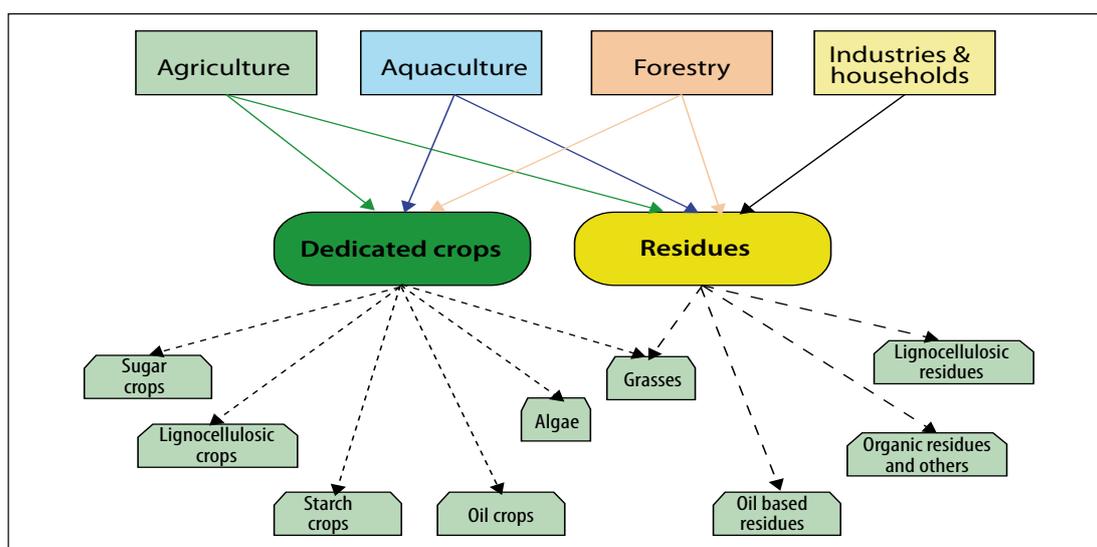
Schematic representation of the bioenergy value chain

Introduction

Renewable biomass feedstocks use the process of photosynthesis in plants to capture the sun's energy by converting carbon dioxide (CO₂) from the air and water (H₂O) into carbohydrates and complex oil and fibre compounds made up of carbon, hydrogen and oxygen. These energy-rich carbohydrates, oils and fibres can be harvested and converted to useful energy carriers (solid, liquid and gaseous fuels; electricity; heat) and/or substitutes for petrochemical and other energy intensive

products for utilisation in a wide range of domestic, commercial, industrial and transport applications (see schematic representation of this value chain above).

Primary industries will be the major suppliers of biomass feedstocks to the downstream producers of bioenergy products. Efficient and sustainable production of a wide range of biomass feedstocks (see figure below) in sufficient volume and at costs that will meet the needs of those bioenergy producers therefore are key challenges for primary industries.



Types of biomass feedstocks and their source²

¹: (<http://www.ieabioenergy.com/OurWork.aspx>, last accessed 07 July 2011)

²: F Cherubini et al, Toward a common classification approach for biorefinery systems, Biofuels, Bioprod. Bioref. (2009)

Bioenergy is already making a substantial contribution to meeting global energy demand, and that contribution could be expanded very significantly in the future. It is the only renewable source that can replace fossil fuels in all energy markets – in the production of heat, electricity, and fuels for transport. A report by the International Energy Agency’s (IEA’s) Bioenergy Implementing Agreement’s members predicts that bioenergy could sustainably contribute between a quarter and a third of global primary energy supply in 2050.³

However, bioenergy is a complex topic that impacts a range of important policy areas:

- *Energy security*, through improving the affordability, reliability and/or resilience of energy supply – particularly liquid fuels in a world where future oil prices and availability are uncertain;
- *Greenhouse gas (GHG) abatement*, through mitigation and displacement of fossil fuels, particularly after a price for carbon reduction is established;
- *Land and water use*, where experience elsewhere from direct and indirect land use change has seen adverse impacts on food prices and/or biodiversity concerns emerge where biomass feedstock production competes for scarce resources; and
- *Rural and regional development*, through new market opportunities for farm-based products,

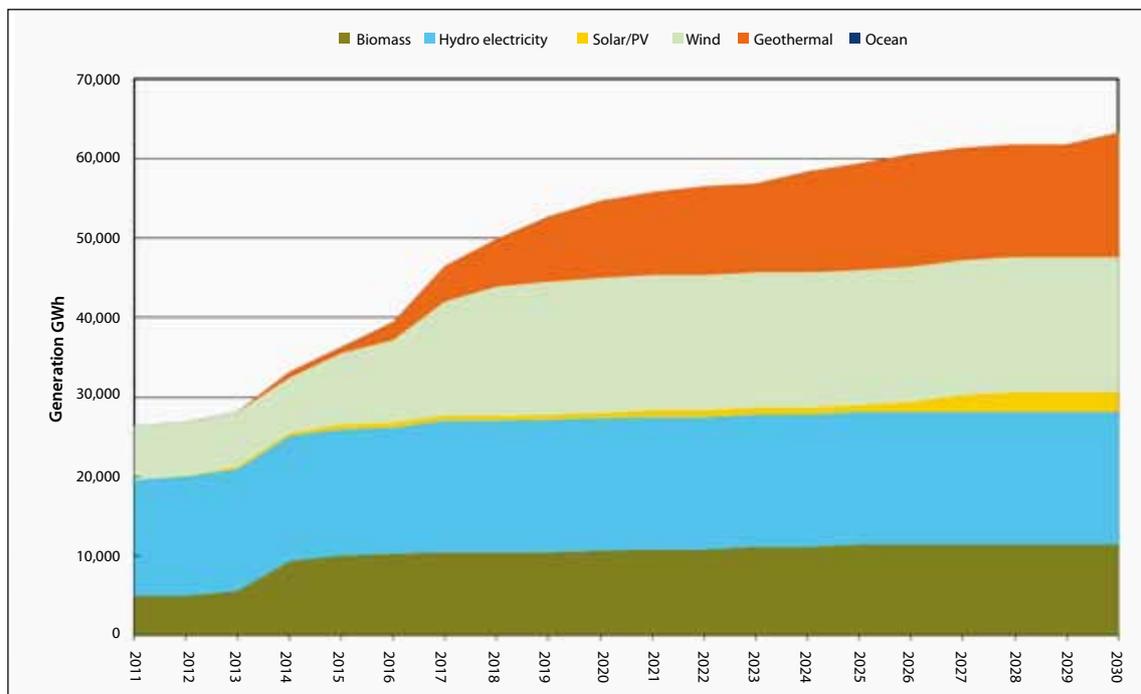
salinity mitigation, soil protection and/or increased biodiversity.

The Australian bioenergy industry today

The Australian Bioenergy Roadmap⁴ noted in 2008 that biomass sources provided approximately 1% of Australia’s total electricity generation. By 31 December 2010, approximately 15% of new renewable electricity generation was derived from biomass sources.⁵ Modelling of the recently established Large-scale Renewable Energy Target (LRET) scheme suggests that biomass sources are likely to further contribute to electricity generation in Australia, as the figure below demonstrates.⁶ In the biofuels sector, ethanol and biodiesel are both produced commercially in Australia. According to figures compiled by the Department of Resources, Energy and Tourism, production in 2009 was estimated to be in excess of 330 megalitres, representing approximately 1% of the estimated 37.6 billion litres of automotive petrol and diesel sold in Australia in FY2009-10⁷.

Australia has a number of well-established industries providing, or capable of providing, feedstocks for bioenergy:

- The sugar and grains industries already provide feedstock for the production of ethanol and biodiesel.



Forecast generation mix (large scale plant) – LRET design

³ *Bioenergy – a Sustainable and Reliable Energy Source: A review of status and prospects*, IEA Bioenergy, 2009

⁴ Clean Energy Council, *Australian Bioenergy Roadmap: Setting the direction for biomass in stationary energy to 2020 and beyond*, 2008

⁵ *Increasing Australia’s Renewable Electricity Generation*, Office of the Renewable Energy Regulator Annual Report 2010, June 2011.

⁶ McLennan Magasanik Associates, *Impacts of Changes to the Design of the Expanded Renewable Energy Target*, Report to Department of Climate Change and Energy Efficiency, May 2010

⁷ Department of Resources, *Energy and Tourism, Australian Petroleum Statistics*, Issue No. 173, (Table 3A), December 2010

- The forestry, sugar and grains industries are all capable of providing cellulosic feedstock for production of electricity and advanced generation biofuels.
- Australia is one of the few countries in the world that already has commercial production of algae, noting that it currently is used for production of chemicals (e.g. nutraceuticals), not for fuels.^{8,9}

Organisations representing Australian bioenergy companies and researchers include:

- **Bioenergy Australia**¹⁰, a forum comprising more than 85 member organisations from government, industry and academia. Its interests include communication and extension of research, development and demonstration activities and commercial projects for electricity, heat and biofuels. It is the body that co-ordinates Australia's involvement in a number of multinational research projects under the IEA's Bioenergy Implementing Agreement.
- The **Biofuels Association of Australia**¹¹ is the main industry body that represents ethanol and biodiesel producers.
- The **Clean Energy Council**¹² is an industry body with more than 400 members. It focuses on low emission generation and energy efficiency within the Australian electricity industry, including an interest in electricity generation via bioenergy.

The potential for growth

The bioenergy industry in Australia has the potential to grow significantly driven by:

- Increased demand for renewable energy for stationary power and transport fuels, as Australia seeks to reduce its GHG emissions.
- A market response to a sustained increase in oil prices in the longer term, as demand increases and supply is constrained.
- The development of a variety of new and existing feedstocks that optimise sustainable use of existing farmland and create new opportunities for marginal lands.
- A variety of new conversion technologies, principally those for production of liquid fuels

from lignocellulosic (predominantly being commercialised overseas) and algae biomass sources.

Power and heat – The Australian Bioenergy Roadmap cites that the biomass resource appraisal undertaken for its development identified that there are adequate supplies of economically and logistically accessible biomass resources to support a target of 11,000 gigawatt-hours (GWh) of electricity production per year (or about 4% of Australia's electricity production) by 2020. Further, the estimated long-term potential to 2050 from the biomass resource appraisal for the Roadmap is to support 73,000 GWh per year, which is about seven times the size of the 2020 target. This potential is in line with an earlier estimate of the Australian Business Roundtable on Climate Change that bioenergy could supply approximately 20% to 30% of Australia's electricity needs by 2050.¹³

Generally the technologies required to implement successful biomass-based stationary energy supply already exist in Australia or elsewhere in the world. Success in this sector thus lies primarily in areas such as communications and extension activities, policy and industry development and technology adaptation and demonstration.

Biofuels - As a variety of new biofuel technologies are commercialised, biofuels could potentially make up an important part of Australia's future fuels for road, sea and air transport – noting that the aviation, mining (logistics and off-grid power generation), heavy-duty road transport, military and marine sectors have a continuing need for liquid fuels, for which biofuels are one of the few low-emission long-term alternatives.

Preliminary modelling by CSIRO for the Commonwealth Government's Alternative Fuels Strategic Issues Group (AFSIG) suggests that by 2050 bio-derived jet and diesel fuels could contribute approximately half of Australia's considerable aviation and diesel fuel demand, depending on assumptions made on future settings of carbon prices, transport task demand, fuel efficiency improvement and price competitiveness.

⁸. <http://www.australianspirulina.com.au/index.html>, last accessed 10 July 2011

⁹. <http://www.bioenergyaustralia.org/>

¹⁰. www.biofuelsassociation.com.au/

¹¹. <http://www.biofuelsassociation.com.au/>

¹². <http://www.cleanenergycouncil.org.au/>

¹³. Australian Business Roundtable on Climate Change, *The Business Case for Early Action*, 2006

The challenges of sustainability

The continuing global increase in population with associated resource development; increasing impacts of climate change; and threats to food, water and energy security place sustainability as a threshold issue for the bioenergy industry internationally.¹⁴

There are two related aspects of sustainability that will have a significant impact on the potential for and realisation of bioenergy in Australia and indeed globally. Firstly, the competition for resources is critical and water is an excellent example of this. Recognised in the recent PMSEIC report *Challenges at energy-water-carbon intersections*¹⁵, an understanding of the interaction between resource availability and capacity to develop low-carbon options for energy supply is paramount in establishing a robust and sustainable bioenergy industry base. Secondly, the balance of energy and food production will be a critical concern in large-scale bioenergy industry development.

Given the extensive nature of the potential supply and use of bioenergy, and its interaction with the agricultural and forestry sectors, all three pillars of sustainability – environmental, economic and social – need to be fully considered and appropriately addressed on policy and implementation levels.

Notwithstanding these challenges, the recently published Sustainable Aviation Fuel Road Map¹⁶ notes:

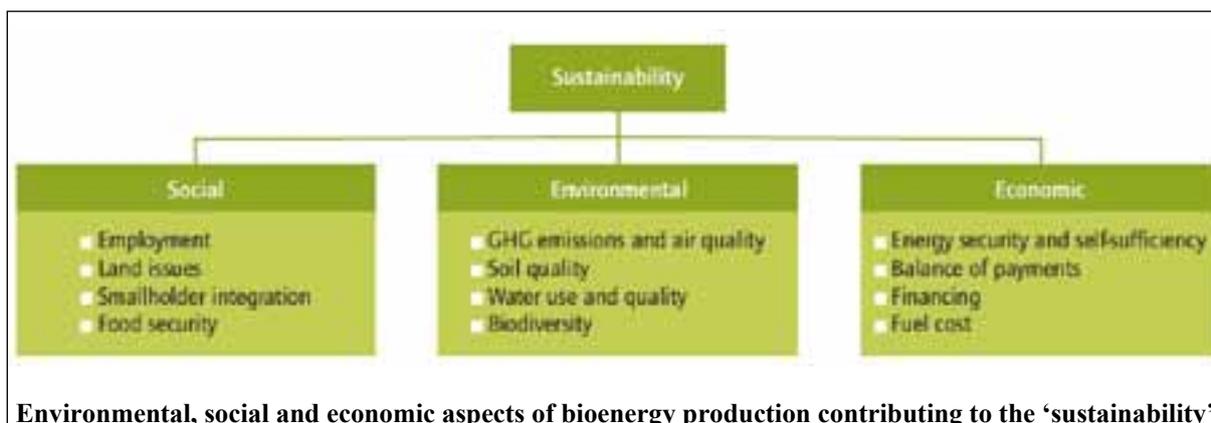
“Australia and New Zealand are in a strong position

with respect to potential bio-derived fuel production. Based on available data it is conservatively estimated that within one decade the region has the potential to supply almost half of the local aviation sector’s fuel needs from biomass and supply all its needs over the long term as various novel resources and production systems become more established.”

Realising bioenergy’s potential in Australia

To stimulate investment on the scale required to realise the potential for deployment of sustainable bioenergy in Australia will require overarching and primary industries-specific actions¹⁸:

- Creation here of stable, long-term policy frameworks to increase investor and supplier confidence and allow for the sustainable expansion of bioenergy production, including:
 - Alignment of low-emission energy and primary industries development policies through promotion and coordination by key agencies such as the Standing Committee on Energy and Resources (SCER) and PISC.
- Support for national and international collaboration on capacity building and technology transfer to promote the adoption of sustainable bioenergy production locally and globally, including:
 - Engagement and involvement of key primary industries stakeholders for their key role in biomass feedstock supply.



Environmental, social and economic aspects of bioenergy production contributing to the ‘sustainability’ framework. Some examples of each aspect are given highlighting the different spatial and temporal scales and impacts of respective components.¹⁷

¹⁴. O’Connell D, Braid A, Raison J et al, *Sustainable Production of Bioenergy: a Review of Global Bioenergy Sustainability Frameworks and Assessment Systems*, RIRDC publication number 167/09 (2009)

¹⁵. *Challenges at energy-water-carbon intersections*, Prime Minister’s Science, Engineering and Innovation Council, 2010

¹⁶. *Flight path to sustainable aviation: Towards establishing a sustainable aviation fuels industry in Australia and New Zealand*, May 2011

¹⁷. International Energy Agency, *Technology Roadmap: Biofuels for Transport*, 2010

¹⁸. Adapted from recommendations made in the International Energy Agency’s *Technology Roadmap: Biofuels for Transport*, 2011

- Continuation of development of internationally agreed sustainability criteria as the basis for implementation of sound certification schemes for bioenergy (particularly biofuels) and related land-use policies on a national level – without creating unwanted trade barriers, especially for developing countries, including:
 - Adoption of an overall sustainable land-use management system that aims to ensure all agricultural and forestry land is comprehensively managed in a balanced manner to avoid negative indirect land-use change and support the wide range of demands in different bioenergy sectors.
- Sustained funding and support mechanisms at the research, development, demonstration and deployment levels required to enable promising advanced bioenergy (particularly biofuel) technologies to reach commercial production within the next 10 years and to prove their ability to achieve cost and sustainability targets, including:
 - Increasing efforts on locally applicable biomass feedstocks (technical characteristics, supply potential, costs, integration with target conversion technologies), land availability mapping and co-production benefits (e.g. soil protection, carbon storage) in order to identify the most promising feedstock types and locations for future scale-up in Australia.
 - Increasing efforts on promising conversion technologies, including adoption and adaption of overseas developments, in order to qualify for commercial deployment the most promising of these for Australia.



¹⁸. Adapted from recommendations made in the International Energy Agency's *Technology Roadmap: Biofuels for Transport*, 2011

3. Bioenergy industries resource analysis



Woodchips

Funding bioenergy RD&E activities

A number of initiatives and programs are underway to support the conduct of Australian RD&E into various aspects of bioenergy.

NCRIS – The National Collaborative Research Infrastructure Strategy (NCRIS) Program has funded strategic research and pilot scale manufacturing facilities, available to researchers, which are focused on advanced generation ethanol and biofuels from algae.¹⁹

RIRDC – The Rural Industries R&D Corporation²⁰ has over the last decade initiated and co-sponsored a wide variety of RD&E projects and studies into various aspects of bioenergy and currently has a program specifically related to bioenergy activities (Bioenergy, Bioproducts & Energy).²¹

CSIRO – CSIRO's bioenergy activities, where these are a team of approximately 30 people working across the bioenergy value chain, include technology development, sustainability investigations, plant and microbial

genetics, and appraisals of biomass for use as bioenergy feedstocks.

Department of Resources, Energy and Tourism (DRET) – In recognition of the need to develop a sustainable biofuels industry and to move away from any impacts on food supply and prices, the Commonwealth Government established the \$15 million *Second Generation Biofuels Research and Development Program* (Gen 2), which supports the research, development and demonstration of new biofuel technologies.²² DRET is the lead agency funding and supporting the activities of ACRE and ABRI (see below) and the newly announced Australian Renewable Energy Agency (ARENA).²³

Australian Centre for Renewable Energy (ACRE) – ACRE has two forthcoming programs: the Renewable Energy Venture Capital fund (\$100 million), which will support venture investment in a range of commercially-prospective renewable energy (including bioenergy) companies; and the Emerging Renewables Program (\$100+ million), which will support meritorious renewable (including bioenergy) demonstration projects.

¹⁹. <http://www.ncrisbiofuels.org/facilities>

²⁰. <http://www.rirdc.gov.au>

²¹. http://www.rirdc.gov.au/RIRDC/programs/new-rural-industries/bioenergy-bioproducts-and-energy/bioenergy-bioproducts-and-energy_home.cfm

²². http://www.ret.gov.au/Department/archive/cei/second_generation_biofuels_research_and_development_program/Pages/SecondGenerationBiofuelsResearchandDevelopmentProgram.aspx

²³. On 10 July 2011 the Commonwealth Government announced its *Cleaner Energy Future* policy. Announced in conjunction then were three new measures to create economic incentives for businesses to invest in low and zero emissions innovation: a \$10 billion Clean Energy Finance Corporation; an Australian Renewable Energy Agency (ARENA) to manage \$3.2 billion in funding; and a \$200 million Clean Technology Innovation Program. To become operational in mid 2012 following passage of enabling legislation during FY2011/12, ARENA will absorb the activities and funding programs of ACRE and ABRI. (<http://minister.ret.gov.au/MediaCentre/MediaReleases/Pages/InnovationandRenewableEnergy.aspx>, last accessed 19 July 2011)

Australian Biofuels Research Institute (ABRI) – ABRI has \$20 million funding to support meritorious biofuel R&D projects.

Department of Agriculture, Fisheries and Forestry (DAFF) – Bioenergy projects are being considered under the \$5 million Forest Industries Climate Change Research Fund administered by DAFF. This fund aims to address major knowledge gaps about the impact of climate change on forestry and Australian forest industries. DAFF is also investing \$1.4 million into biochar research under the Climate Change Research Program, which is a part of Australia’s Farming Future – the Australian Government’s major climate change research program for Australia’s primary industries. This research project will help understand this emerging technology and draw together Australian and international experts in areas of biochar, soil science and emissions management in order to address uncertainties about its use.

State Governments – Australian State governments are supporting a range of bioenergy related projects under particular renewable energy programs. For example, the Western Australian Government has supported bioenergy as part of its long-term initiative to establish commercially viable tree crops in wheat belt areas prone to salinity – while the NSW Department of Primary Industries has undertaken studies on options for lignocellulosic feedstocks, the mitigation benefit of utilising forest residues for electricity generation, the impact of soil carbon stock change on mitigation benefits of bioenergy, and mitigation through utilisation of biochar as a soil amendment.

Resource analysis

To aid in the development of this RD&E strategy for bioenergy, an analysis of the national investment in the field over the last three years was undertaken by RIRDC and NSW DPI. The data for this analysis was collected from all research organisations, including all universities, known to have any possibility of involvement in biofuel or bioenergy RD&E.

Cumulatively, cash and in-kind resources of approximately \$117 million have been invested into biofuel and bioenergy projects across Australia during the period 2007-2010. The Australian Research Council (ARC), AusIndustry, DRET and State government departments dominate (55% of total funding) the public sector investment during this period.

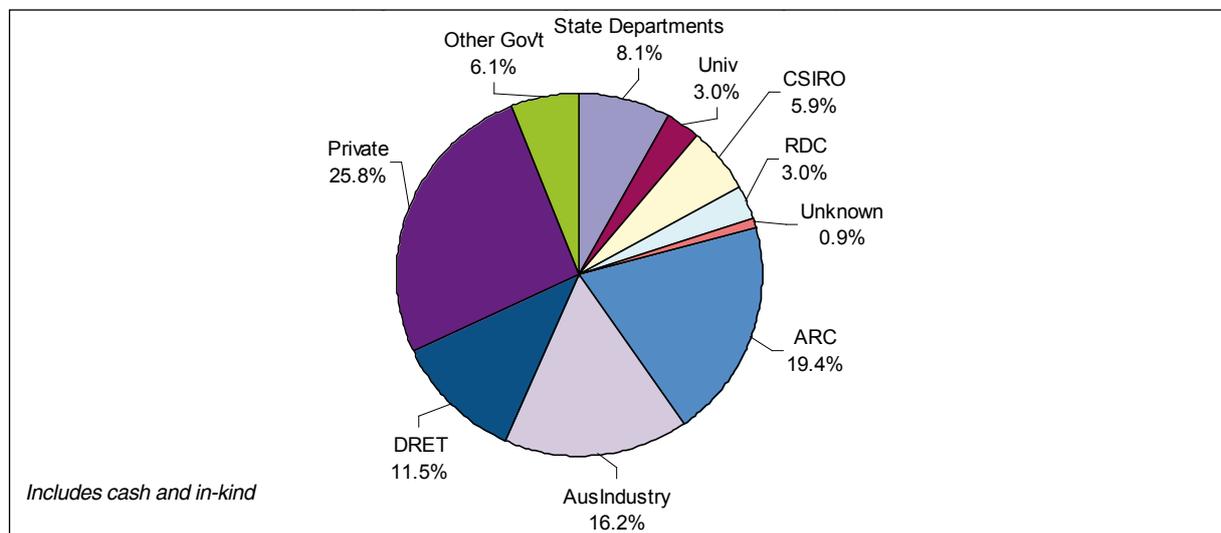
More than 95% of this cumulative funding has been applied to RD&E projects in three areas:

- biofuel conversion technologies (\$50.4 million, with a strong focus on conversion of lignocellulose to ethanol);
- electricity/heat production technologies (\$9.4 million, particularly anaerobic digestion of wastes and electricity/heat generation using the produced methane); and
- feedstocks (\$53.9 million, particularly sugar, algae and woody plants/fibre).

The following graphs provide more detail on the sources and application of this RD&E funding.

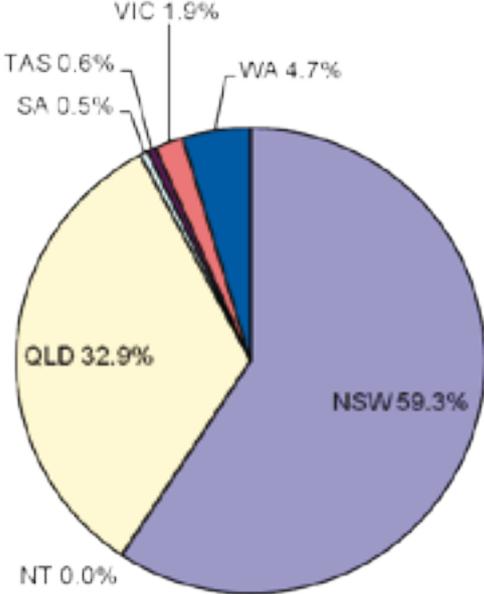
Sources of R&D funding – all projects

All projects – total funding \$117,221,766 (over 3 years)

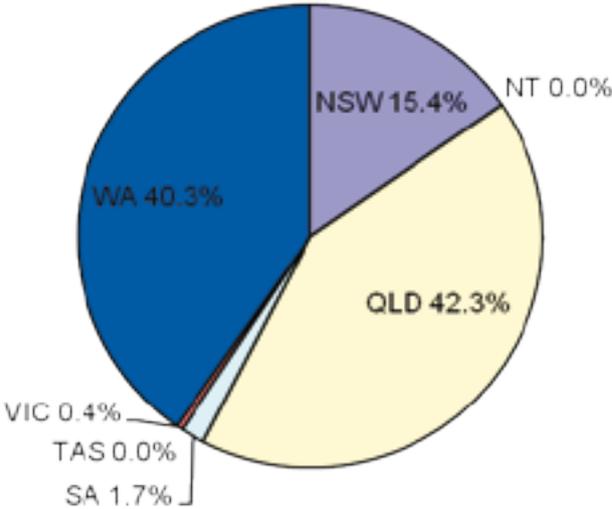


Investment by State (includes various State departments, universities and other research organisations)

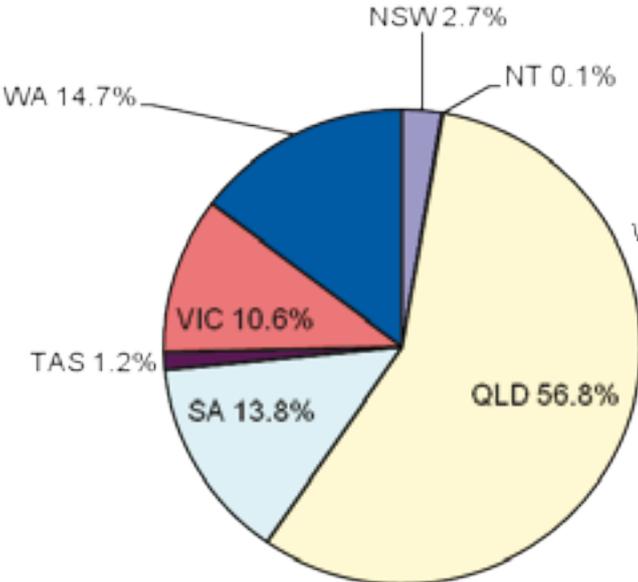
Biofuels projects



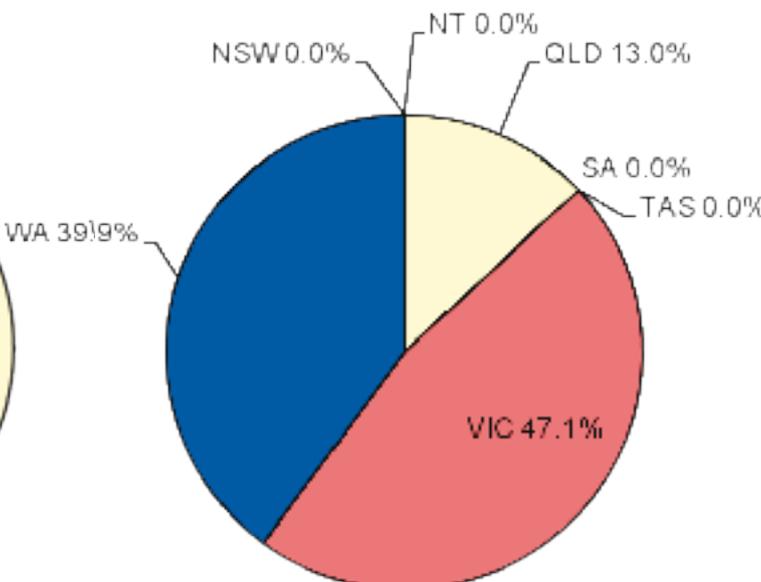
Electricity/Heat projects



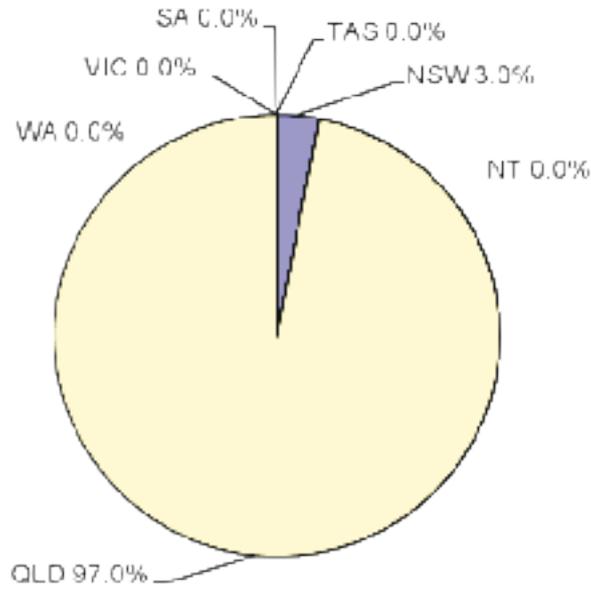
Feedstock projects



Biorefinery and bioproducts projects

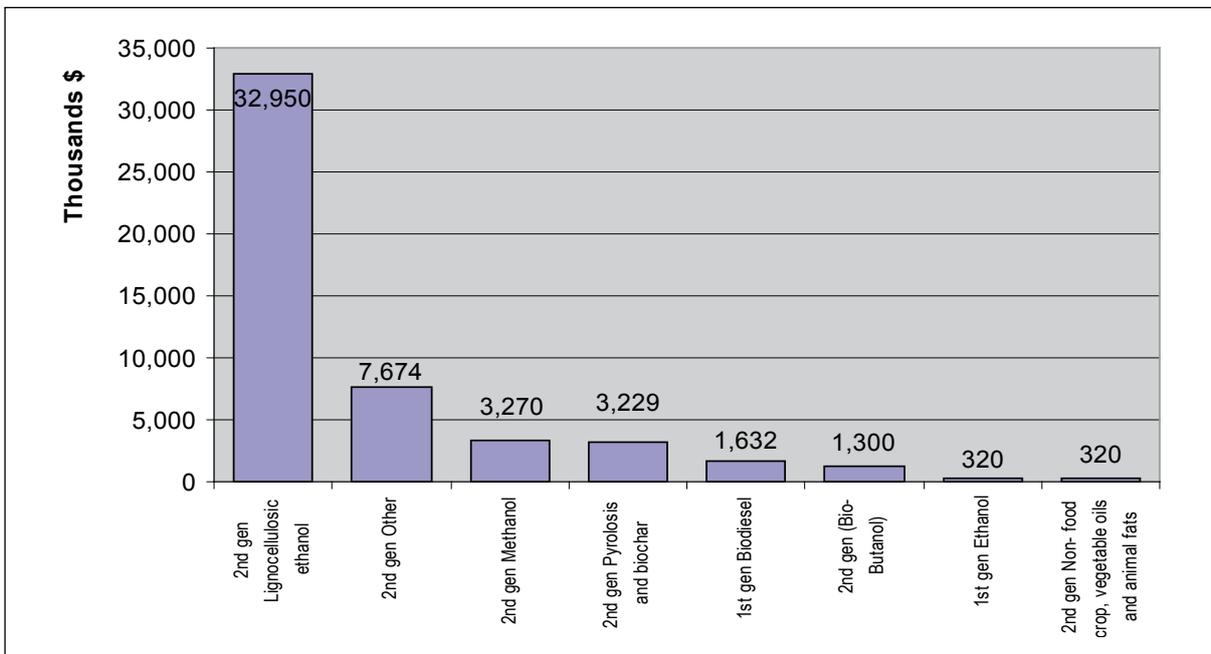


Policy/sustainability projects

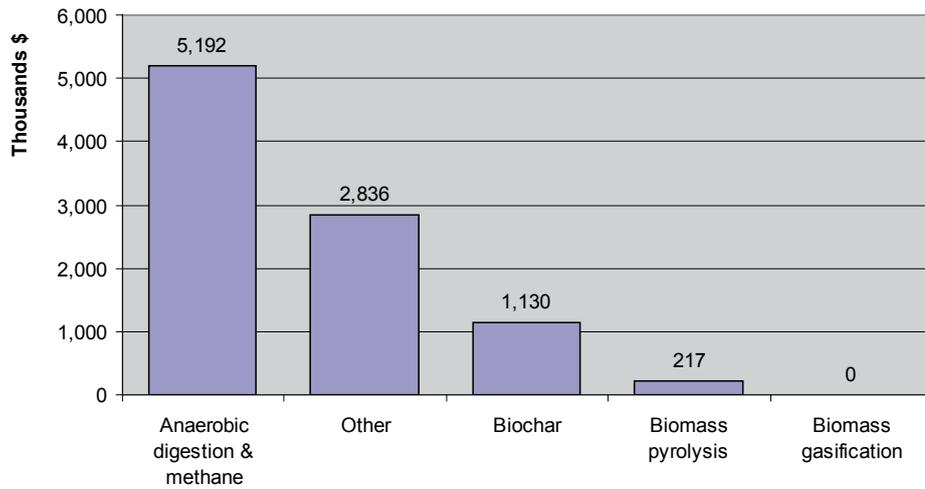


Current funding over three years (cash and in-kind)

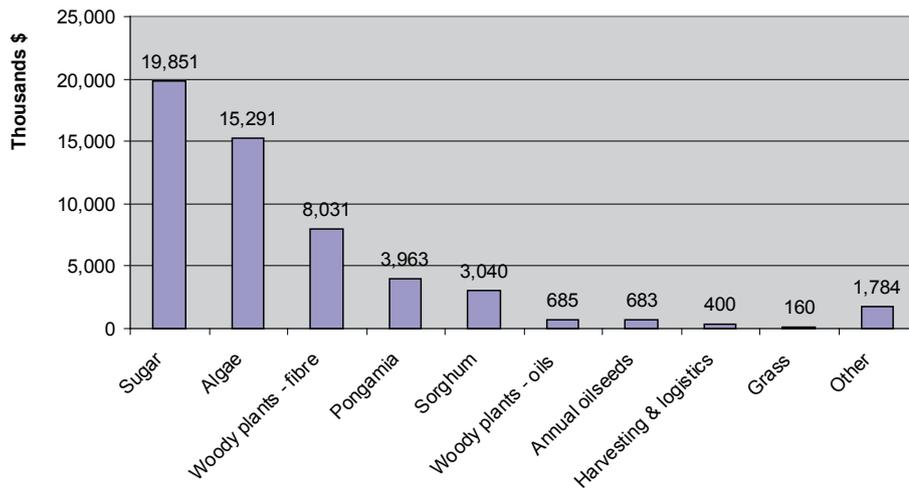
Biofuels projects (\$50,375,640 cash and in-kind)



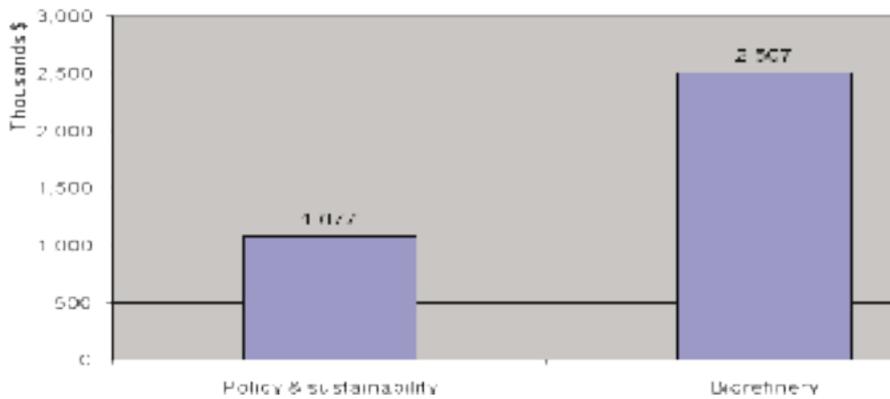
Electricity/Heat projects (\$9,374,875 cash and in-kind)



Feedstock projects (\$53,88,836 cash and in-kind)



Policy and Sustainability (\$1,076,847) and Biorefinery (\$2,506,568) cash and in-kind



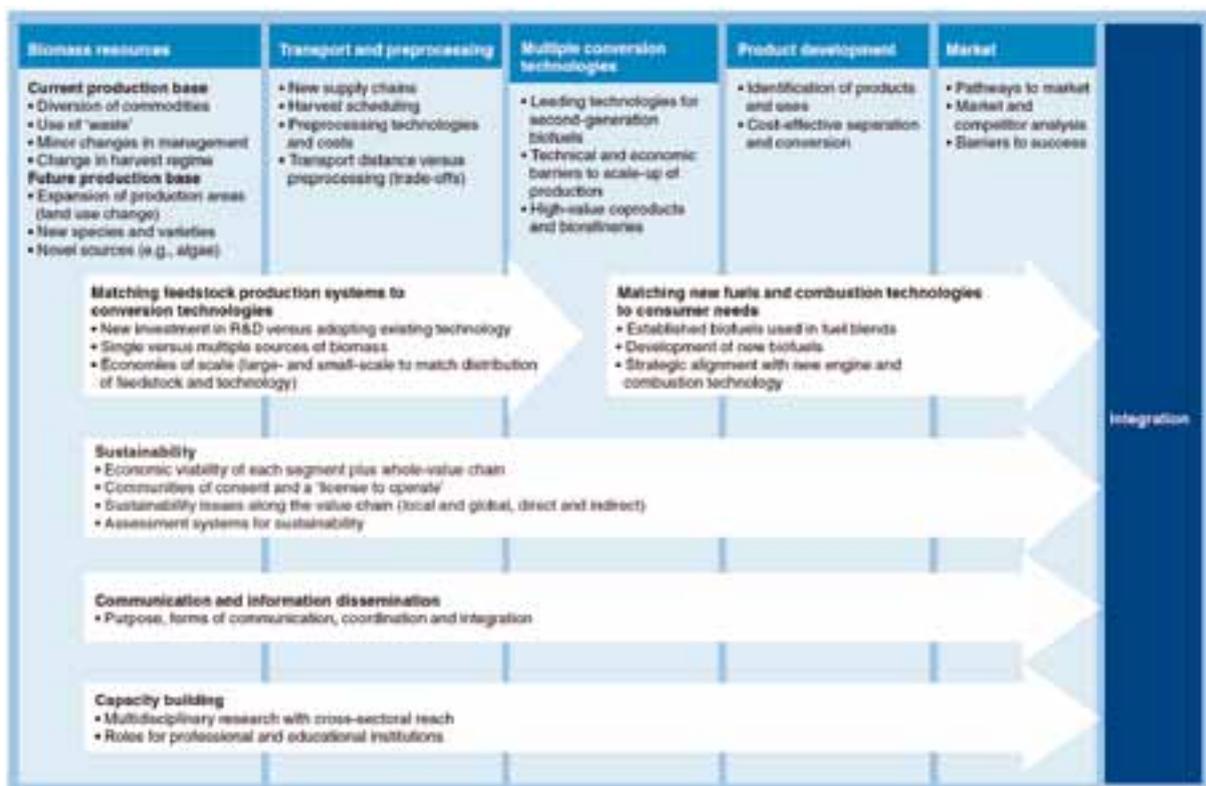
To place Australia's investment in bioenergy research, development and demonstration at least partially in context internationally, analysis of the United States Department of Energy's (DOE) biomass program shows that Australia's investment in bioenergy innovation is (very) modest in comparison to public and private sector investment activity levels in the USA, which are only a proportion – albeit a large proportion in recent times – of the global investment effort to progress research, development, demonstration and deployment in bioenergy. As stated in the DOE's Biomass Multi-Year Program Plan²⁴, “From the 1970s to the present, DOE has invested over \$3.7 billion (including more than \$900 million in [American Recovery and Reinvestment Act] funds) in a variety of [research, development, demonstration and deployment] programs covering biofuels (particularly ethanol), biopower, feedstocks, municipal wastes, and a variety of biobased products.”

Another important comparative dimension is that of time and as an example researchers and industrial companies in China have recently gone from 'bench to market' for cellulosic sweet sorghum conversion to ethanol in a five-year period.²⁵

Current RD&E priorities and gaps

Many government and business organisations around the world are investing effectively to implement various parts of the bioenergy RD&E framework depicted in the figure below.

As bioenergy operates across a wide range of industries and sectors, this can lead to a bewildering array of complexity and competing areas that require RD&E investment. This conceptual framework can be useful for targeting RD&E investment by individual research organisations, sectors, industries or governments and as an aid to partnering to achieve a more comprehensive effort. For bioenergy to be considered as a genuine contender for providing a major contribution to our future energy supply mix without creating unintended sustainability consequences, then all aspects of this RD&E framework must be dealt with at a national and global level. The quantum of bioenergy RD&E funding currently lags vastly behind the annual expenditure of established fossil fuel industries, yet it needs to be at least comparable in magnitude for serious alternatives to fossil fuels to be investigated.



Conceptual bioenergy RD&E framework²⁶

²⁴. http://www1.eere.energy.gov/biomass/pdfs/mypp_april_2011.pdf, last accessed 09 June 2011

²⁵. W Wallace, *US-China Biochemical Collaboration*, 2011 Biochemical Platform Review, 16 Feb 2011 (available at [http://obpreview2011.govtools.us/presenters/public/InSecureDownload.aspx?filename=2011-02-16%20RDD%20Presentation%20China%20Biofuels%20Wallace%20\(2\).pdf](http://obpreview2011.govtools.us/presenters/public/InSecureDownload.aspx?filename=2011-02-16%20RDD%20Presentation%20China%20Biofuels%20Wallace%20(2).pdf), last accessed 06 June 2011)

²⁶. D O'Connell and V Haritos, *Conceptual investment framework for biofuels and biorefineries research and development*, Biofuels (2010)

Primary industries-specific RD&E priorities for bioenergy were developed through an industry workshop at a Bioenergy Australia meeting in July 2009, and re-iterated at the Bioenergy Australia conferences in 2009 and 2010. These priorities, presented in the table below, were analysed against then current RD&E activities to assess gaps.²⁷

Primary Industries RD&E Priorities	RD&E Gaps
<p>Sustainability</p> <ol style="list-style-type: none"> 1. Continue to understand the significant sustainability issues and basic science, e.g. understanding of carbon balance in bioenergy systems; water management. 2. Review national and international development in the approaches to addressing and documenting sustainability relevant to production of bioenergy products in Australia, including relevant government policies and pathways to adoption of future sustainability guidelines. 3. Develop and test processes and methods for assessing sustainability across scales, regions and particular configurations of industry. 4. Undertake Life Cycle Assessments and develop Life Cycle Inventories using common ISO standard methods. 	<ul style="list-style-type: none"> • 2 & 3 • Development of a forum and paper to inform policy on biomass/ bioenergy sustainability for policy makers.
<p>Feedstocks</p> <ol style="list-style-type: none"> 1. Compare and develop options for increasing sustainable feedstock production through: <ul style="list-style-type: none"> – Continued identification of suitable, predominantly native, species. – Identifying and modifying existing crops to improve yield for different regions of Australia – e.g. new oilseed perennials, seeds, grasses, weeds, algae, trees and indigenous species, including their costs of production. – Assessing sustainability issues (including effect of removal of crop and forest residues on ecosystem carbon, and biodiversity as well as cost of production) for new and existing production systems. – Assessing and developing suitable sustainable farming and production systems which complement other land uses (such as integrating with food production crops and systems) e.g. changing the management of harvest regimes of existing production systems, expanding current production systems to new areas, creating new and novel production systems. – Ensuring a balanced portfolio (and limited number) of short and long term/high risk and low risk potential crops. 2. Characterise material properties of novel feedstocks, their variation and suitability for next generation processing opportunities. 3. Identify regions for the sustainable growing of bioenergy/biofuel crops and integrated biomass production (including the impacts of expanding production of lignocellulosic crops), in particular underutilised and low productivity land. 	<ul style="list-style-type: none"> • All priorities still have gaps. Little RD&E in this area. • Need specific demonstration projects.

²⁷ More recently, ACRE has commissioned a major study to provide a comprehensive assessment of advanced generation biofuels technologies and supply chains, drawing on international and Australian research, development and commercialisation activities. Due for completion in late 2011, the results of this study will contribute to consideration of key private and public sector actions for the development of a sustainable biofuels industry in Australia, including key RD&E gaps.

Primary Industries RD&E Priorities	RD&E Gaps
<p>Supply Logistics</p> <ol style="list-style-type: none"> 1. Investigate the scales of economy, logistics and costs of harvesting, storage and processing, risks and suitability of distributed as compared to centralised biomass conversion systems. 2. Investigate use of existing or development of small modular processing plant for distributed production of products &/or energy. 3. Investigate partial local processing options (especially densification) for the most promising new feedstock systems (e.g. harvesting and briquetting/pelletising technology). 4. Identify infrastructure requirements, supply logistics and transitions for regional processing and distribution. 	<ul style="list-style-type: none"> • All priorities are gaps. Little RD&E in this area. • Need specific demonstration projects. • Need projects to develop supply logistics
<p>Policy analysis</p> <ol style="list-style-type: none"> 1. Investigate policy mechanisms which steer the industry towards sustainable development 2. Develop a strategy for policy coordination 	<ul style="list-style-type: none"> • 1 is a gap. Some work, but more needed. • Need suite of papers to inform policy. Need to ensure ties up with IEA Bioenergy work in this area.
<p>Outreach, capacity building and networking</p> <ol style="list-style-type: none"> 1. Maximise the research networking, coordination and information-brokering role of key organisations such as Bioenergy Australia. 2. Identify capacity shortages or barriers to industry development, and develop appropriate strategies to address them 3. Further enhance the networking with industry, government and researchers. 	<ul style="list-style-type: none"> • 1 & 2 are gaps. • Research available skills against expected requirements for bioenergy.

Capability summary

The following analysis was carried out by the Steering Committee using data collected in the resource analysis, as well as tacit knowledge, to map human and infrastructure capability against industry priorities.

Priority	Capability	Availability	Comments
Sustainability	Yes	No	<ul style="list-style-type: none"> • There is good capability, but it is often required to work in other areas (e.g. water and climate change). • CSIRO and some universities have good capability, but it is unavailable for the above reason. • Some capability in the States, but again have to balance other priorities. • Limited extension capacity. • Need skills audit • LCA- limited skills. Need standard tools and data sets.
Feedstocks	Not enough	No	<ul style="list-style-type: none"> • Shortage of specific bioenergy related agronomy expertise. • There is an availability of foresters, but they do not have a specific understanding of biomass for bioenergy systems. • Shortage of entomologists and pathologists in regional areas. • The pulp and paper industry decline may provide infrastructure and people.
Supply Logistics	Yes	Not at this stage	<ul style="list-style-type: none"> • Highly capable people in fuel, mining, private enterprise, that may be able to adapt to this new industry. • Availability is currently restricted, as good money available elsewhere. • Above capability good in supply logistics, transport, but lacking in harvesting and processing. This expertise may need to be sourced internationally.
Policy	Yes	Yes	<ul style="list-style-type: none"> • Expertise within state and federal government departments, as well as private consultants, but the ‘churn’ of staff can be an issue for long-term issues and developments. • Knowledge and liaison is improving over time with the realisation of the potentially important role of bioenergy in the future.
Outreach, capacity building and networking	Partly	Partly	<ul style="list-style-type: none"> • Bioenergy Australia is the main outreach forum for the bioenergy sector. • Some state departments provide bioenergy extension in the form of a website.

4. Improving the coordination of bioenergy R,D&E



The need for greater RD&E coordination

There is a need for greater coordination of bioenergy RD&E in Australia. Whilst instances of duplication of RD&E are not prevalent, increased coordination and collaboration could better utilise the available capability and resources for improved outcomes.

Australia's bioenergy industry is relatively immature, and is significantly dependent for its sustainable growth on the stability and direction of future policy decisions and technological advances. Bioenergy technology development generates high levels of intellectual property (IP), and involves a high level of private sector investment into cutting edge innovation. The commercial nature of a large percentage of RD&E for this sector presents difficulties for collaboration, which need to be examined further.

Bioenergy is a much more complex sector than other new agricultural industries – indeed the primary industries aspects of bioenergy (i.e. production of biomass feedstocks and their pre-processing for transport) – as crucial as they are in the bioenergy value chain – are just the beginning of a complex, *industrial* value chain that

results in energy production for a range of stationary and transport applications.

Adding further complexity are the sustainability challenges across social, environmental and economic dimensions. Bioenergy systems have the capacity to address environmental issues (e.g. reduced reliance on fossil fuels) and social aspects (e.g. regional development), but to meet these goals requires further understanding and development of optimum feedstock selection and management of the value chain from growing to harvest, transport and processing. Sustainability issues need to be further understood to give the 'social licence to operate' for bioenergy systems (i.e. prove that bioenergy systems are not only sustainable in their own right, but contribute to larger social and environmental aspects of sustainability).

Flexible strategies and coordination mechanisms are required to allow for rapid changes in technology and policy. The importance, and challenge, of aligning and coordinating the Primary Industries Standing Committee (PISC) and the Standing Committee on Energy and Resources (SCER) in their consideration of bioenergy supply/value chain opportunities and challenges thus cannot be overstated.

An RD&E advisory forum for primary industry opportunities in bioenergy

There is a clear need for an RD&E Advisory Forum focused to PISC's primary industry stakeholders on alignment of policies and RD&E activities relevant to those stakeholders in order to maximise returns to them from their involvement/investment in bioenergy supply chains.

This Forum will be coordinated and supported by RIRDC, and will comprise representatives of relevant PISC agencies, universities, CSIRO, federal agencies and funding bodies (including RDCs) and primary industry representatives. Membership will be voluntary, participatory and offer opportunities to negotiate RD&E activities that will benefit both individual research institutions as well as primary industries as a whole. The National RD&E Framework principle of national R, and regional D&E, will guide the activities of the forum.

It is anticipated that after an initial planning and consolidation phase that the Forum will meet annually face-to-face to coordinate potential collaborations. PISC agency financial commitment to this strategy will be in the form of providing representation to the Forum, and the cost of this representative attending the annual meeting. RIRDC will be required to plan and facilitate this meeting.

Advisory forum's proposed terms of reference

It is proposed that the terms of reference for the Forum are to:

- Provide a national opportunity for consultation, coordination and communication amongst Australian research providers, funders, industry and government agencies focused on bioenergy RD&E activities relevant to primary industry stakeholders.
- Encourage collaboration and knowledge sharing in order to achieve greater efficiencies in use of resources and growth in capability.
- Provide input and representation to high-level decision-making fora relevant to the bioenergy sector, including encouragement of increased funding and resources for relevant RD&E activities

through methods such as cost benefit analysis of RD&E activities.

- Lead and coordinate the communication of RD&E outcomes to primary industries, the general public and policy makers.
- Coordinate interaction with the other sector and cross-sector National RD&E Strategies.
- Increase collaboration with non-primary industry sectors, including relevant Standing Committees and Federal/State agencies and initiatives.
- Examine and further develop opportunities for international collaborations and innovation sharing that will benefit the Australian bioenergy industry.
- Update this National RD&E Strategy, including RD&E priorities, every three years through consultation with industry and researchers.

Communications and extension

There is a substantial body of knowledge developed nationally and internationally in bioenergy. Information for communication and extension activities can, and must, be drawn from this knowledge base and transferred to Australian primary industries stakeholders about the opportunities and challenges for them to participate in the growing local bioenergy industry. The key will be to provide credible information and resources so that those stakeholders can assess the reality of opportunities for them from growth in the Australian bioenergy sector.

Implementation steps

The next steps in the implementation of this RD&E Strategy are as follows:

Delivery date	Action
Nov 2011	Strategy approved by PIMC
Dec 2011	Negotiate representation for the Advisory Forum
Mar 2012	First Advisory Forum meeting. Major activities include: <ul style="list-style-type: none"> • Finalise terms of reference and governance arrangements • Assess availability and currency of bioenergy industry RD&E priorities relevant to primary industries • Develop a reporting framework • Refine and expand on current coordination negotiations • Develop a schedule for further Advisory Forum activity

OPPORTUNITIES FOR PRIMARY INDUSTRIES IN THE BIOENERGY SECTOR

National Research, Development and Extension Strategy



Bioenergy is already making a substantial contribution to meeting global (including Australian) energy demand, and that contribution could be expanded very significantly in the future. However, bioenergy is a complex topic that impacts a range of important policy areas:

- *Energy security*, through improving the affordability, reliability and/or resilience of energy supply – particularly liquid fuels in a world where future oil prices and availability are uncertain;
- *Greenhouse gas (GHG) abatement*, through mitigation and displacement of fossil fuels, particularly after a price for carbon reduction is established;
- *Land and water use*, where experience elsewhere from direct and indirect land use change has seen adverse impacts on food prices and/or biodiversity concerns emerge where biomass feedstock production competes for scarce resources; and
- *Rural and regional development*, through new market opportunities for farm-based products, salinity mitigation, soil protection and/or increased biodiversity.

While primary industries will be the major suppliers of biomass feedstocks to the downstream producers of bioenergy products, primary industries – as crucial as they are in the bioenergy value chain – are just the beginning of a complex, *industrial* value chain that results in energy production for a range of stationary and transport applications.

Efficient and sustainable production of a wide range of biomass feedstocks in sufficient volume and at costs that will meet the needs of those bioenergy producers are key challenges for primary industries. Adding further complexity are the sustainability challenges across social, environmental and economic dimensions. Bioenergy systems have the capacity to address environmental issues and social aspects – but to meet these goals requires integrated management of the bioenergy value chain from growing, harvest and transport of feedstocks to their conversion into useful end-products. The National RD&E Framework principle of national R, and regional D&E will guide the activities of the forum.