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The Place To Be

Second Generation Feedstocks for Biofuels Suitable for Production in North West Victoria

Raymond Cadmore

ISS Institute/Italy (Veneto) Fellowship

Fellowship funded by Skills Victoria,
Department of Innovation,
Industry and Regional Development,
Victorian Government

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Executive Summary

Skills deficiencies exist in the biodiesel industry in both experience and qualification pathways. Furthermore, the rapid introduction of new technologies also means to a significant extent that we don't know what we don't know. Maintaining an engagement across the sector will require continued interest and exploration by those in industry and education and training sectors including TAFE. The ability to be able to engage in the discussion and nomenclature of innovation is essential to sector knowledge and decision-making. The design of new vocational skills sets, training and industry capabilities will occur most fluidly and comprehensively when knowledge opportunities are actively sought and made available to the wider community.

There is limited technical training opportunity in Australia. An expansion of this industry will highlight the absence of extensive knowledge in biodiesel production; sourcing, selection and grading of suitable feedstocks; product grading and quality assurance mechanisms.

Biodiesel has advantages over other biofuels in that there is no over riding need for new infrastructure or engine design. Any transfer of fuel source to biodiesel is easily accommodated by existing engine technology and design.

Tree crops such as Jatophra may fill some of the feedstock gap that becomes more apparent as the industry expands. The utility of some of these crops in utilising degraded rangelands is attractive though remains largely unexplored in South Eastern Australia.

We do not have a clear understanding of the requirements of second generation feedstocks such as microalgae. Microalgae offers real promise for regional and major cities in Australia to utilise municipal waste, sewerage and agri wastes as CO_2 sources for microalgae lipid production. These processes also offer significant protein, pigment and carbohydrate co-product cost efficiencies. Microalgae, when under reasonable cultivation conditions, may yield up to 27 tonnes oil, 30 tonnes carbohydrate and 40 tonnes of protein per hectare per year.

To address these skills deficiencies comprehensively, the Fellowship program included meetings in Rome, Florence, Verona and culminated at the *Second International Symposium on Energy from Waste and Biomass* in Venice.

Findings arising from this Fellowship will be disseminated through a variety of means over the course of 2009 including presentations to the Mid Murray Agri Business Group, a public presentation at the Mildura Sun Festival, a presentation to the Operations Committee of Sunraysia Institute of TAFE, and provision of the report to stakeholders, supporters and public bodies such as municipal councils. The Fellow maintains his interest and activity in this area and in early 2009 participated in a biofuels tour of Western Victoria with the Department of Primary Industries Victoria, Peter Crisp, Member of Legislative Assembly for Mildura (MLA) and Sunraysia Institute of TAFE staff. Also of significance to knowledge transfer is the Fellow's recently secured appointment as a Director with the Mildura Regional Waste Management Group.

The recommendations in this report are based on research and knowledge obtained, both prior and subsequent to the Fellowship. This knowledge affirms the need to ensure that Victoria engages in technologies such as microalgae to oil technologies. These technologies are suited for exploitation in regional Victorian economies where climate, saline water and

Executive Summary

carbon sources can be sourced. The use of saline ground water, sewerage sludge, olive waste, microalgae carbohydrate and almond waste as sources of CO_2 for fertilizer make rapid growth microalgae possible in open raceway systems in the Mildura, North West Victoria region. In addition, coproduction of lipid (oil), protein, carotene, carbohydrate and polymers are possible in the Mildura, North West Victoria climate.

Within this field of study skill deficiencies exist at all levels. There needs to be a *catalyst facility* (trial farm) where skills can be transferred from academic research to production techniques. Industry collaboration will be necessary as the body of knowledge expands and mainstream/common processes are developed.

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Glossary

Agri waste
Organic matter surplus to requirements in livestock husbandry, agricultural and horticultural pursuits.

Biodiesel
Biodiesel is a vegetable oil fuel of characteristics similar to mineral diesel. In Australia it is most commonly used in blends of 5-20%. However other nations, mainly those from the European Union, promote biodiesel as both blended and 100% product. The city of Graz in Austria runs its bus fleet of 150 buses on 100% biodiesel sourced from used cooking oil.

Biomass
Biomass is an umbrella term used to describe vegetable or animal (biological) sourced energy mass, for example canola and lard.

CO_2
Carbon dioxide.

Feedstock
Biodiesel can be produced from oil seeds such as canola, used cooking oils or microalgae and these inputs are known as feedstocks.

H_2
Hydrogen.

Lipid
Oil derived from organic matter.

Microalgae
Microalgae is an extremely efficient sequester of CO_2. It has a high mass/oil ratio and has the potential to provide a sustainable source of biodiesel feedstock that does not impinge food crops.

Second generation feedstock
Feedstock that has been expressly developed or derived for biofuel production.

VET
Vocational Eductaion and Training.

Acknowledgments

Ray Cadmore would like to thank the following individuals and organisations who gave generously of their time and their expertise to assist, advise and guide him throughout the Fellowship program.

Awarding Body - International Specialised Skills Institute (ISS Institute)

We know that Australia's economic future is reliant upon high level skills and knowledge, underpinned by design and innovation.

The International Specialised Skills Institute Inc (ISS Institute) is an independent, national organisation, which has a record of nearly twenty years of working with Australian industry and commerce to gain best-in-the-world skills and experience in traditional and leading-edge technology, design, innovation and management. The Institute has worked extensively with Government and non-Government organisations, firms, industry bodies, professional associations and education and training institutions.

The Patron in Chief is Sir James Gobbo AC, CVO. The ISS Institute Board of Management is Chaired by Noel Waite AO. The Board comprises Franco Fiorentini, John Iacovangelo, Lady Primrose Potter AC and David Wittner.

Through its CEO, Carolynne Bourne AM, the ISS Institute identifies and researches skill deficiencies and then meets the deficiency needs through its *Overseas Skill Acquisition Plan (Fellowship Program),* its education and training activities, professional development events and consultancy services.

Under the Overseas Skill Acquisition Plan (Fellowship Program) Australians travel overseas or international experts travel to Australia. Participants then pass on what they have learnt through reports, education and training activities such as workshops, conferences, lectures, forums, seminars and events, therein ensuring that for each Fellowship undertaken many benefit.

As an outcome of its work, ISS Institute has gained a deep understanding of the nature and scope of a number of issues. Four clearly defined economic forces have emerged out of our nearly twenty years of research. The drivers have arisen out of research that has been induced rather than deduced and innovative, practical solutions created - it is about thinking and working differently.

A Global Perspective. 'Skills Deficiencies' + 'Skills Shortages'

Skill deficiencies address future needs. Skill shortages replicate the past and are focused on immediate needs.

Skill deficiency is where a demand for labour has not been recognised and where accredited courses are not available through Australian higher education institutions. This demand is met where skills and knowledge are acquired on-the-job, gleaned from published material, or from working and/or study overseas. This is the focus of the work of ISS Institute.

There may be individuals or firms that have these capabilities. However, individuals in the main do not share their capabilities, but rather keep the IP to themselves; and over time they retire and pass way. Firms likewise come and go. If Australia is to create, build and sustain Industries, knowledge/skills/understandings must be accessible trans-generationally through nationally accredited courses and not be reliant on individuals.

Our international competitors have these capabilities as well as the education and training infrastructure to underpin them.

Addressing skill shortages, however, is merely delivering more of what we already know and can do to meet current market demands. Australia needs to address the ***dual*** challenge – skill deficiencies and skill shortages.

Acknowledgments

Identifying and closing skills deficiencies is vital to long-term economic prospects in order to sustain sectors that are at risk of disappearing, not being developed or leaving our shores to be taken up by our competitors. The only prudent option is to achieve a high skill, high value-added economy in order to build a significant future in the local and international marketplace.

The Trades

The ISS Institute views the trades as the backbone of our economy. Yet, they are often unseen and, in the main, have no direct voice as to issues which are in their domain of expertise. The trades are equal, but different to professions.

The ISS Institute has the way forward through its 'Master Artisan Framework for Excellence. A New Model for Skilling the Trades', December 2004. The Federal Government, DEEWR commissioned ISS Institute to write an Australian Master Artisan School, Feasibility Plan.

In 2006, ISS Institute Inc. set up a new ISS advisory body, the **Trades Advisory Council.** Members are Ivan Deveson AO; Martin Ferguson AM, MP, Federal Labor Member for Batman; Geoff Masters, CEO, Australian Council of Educational Research; Simon McKeon, Executive Chairman, Macquarie Bank, Melbourne Office; Richard Pratt, Chairman, Visy Industries and Julius Roe, National President Australian Manufacturing Workers' Union.

Think and Work in an Holistic Approach along the Supply Chain - Collaboration and Communication

Our experience has shown that most perceive that lack of skills is the principal factor related to quality and productivity. We believe that attitudes are often the constraint to turning ideas into product and a successful business; the ability to think laterally, to work and communicate across disciplines and industry sectors, to be able to take risks and think outside the familiar, to share – to turn competitors into partners.

Australia needs to change to thinking and working holistically along the entire Supply Chain; to collaborate and communicate across industries and occupations - designers with master artisans, trades men and women, Government agencies, manufacturers, engineers, farmers, retailers, suppliers to name a few in the Chain.

'Design' has to be seen as more than 'Art' discipline – it is a fundamental economic and business tool for the 21st Century

Design is crucial to the economic future of our nation. Australia needs to understand and learn the value of design, the benefits of good design and for it to become part of everyday language, decision making and choice.

Design is as important to the child exploring the possibilities of the world, as it is to the architect developing new concepts, and as it is to the electrician placing power points or the furniture designer working with a cabinet-maker and manufacturer. As such, design is vested in every member of our community and touches every aspect of our lives.

Our holistic approach takes us to working across occupations and industry sectors and building bridges along the way. The result has been highly effective in the creation of new business, the development of existing business and the return of lost skills and knowledge to our workforce, thus creating jobs - whereby individuals gain; industry and business gain; the Australian community gains economically, educationally and culturally.

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Fellowship Sponsor

The Victorian Government, Skills Victoria is responsible for the administration and coordination of programs for the provision of training and further education, adult community education and employment services in Victoria and is a valued sponsor of the ISS Institute. Cadmore would like to thank them for providing funding support for this Fellowship.

Supporters

- Sunraysia Institute of TAFE
- John Molenaar, Executive Director, Manufacturing and Engineering Skills Advisory Board
- Ian Nicholson, Executive Officer, Victorian Food Industry Training Board
- Milê Soda, Managing Director, BioMax Fuels
- Clive Williams, Alternative Technology Association (Mildura)

Australian Organisations Impacted by Biodiesel Expansion

- National Greenhouse Office
- EPA Victoria
- Sustainability Victoria
- Skills Victoria
- Victorian TAFE Association
- Victoria Waste Management Groups
  (Mildura, Barwon, Central Murray Desert Fringe, Gippsland, Goulburn Valley, Grampians, Highlands, Metropolitan, Mornington, North East Waste Reduction Group)
- Sunraysia Institute of TAFE
- Mildura Economic Development Board
- Mildura Rural City Council
- Victorian Food Industry Training Board
- Manufacturing and Engineering Australia
- Sunraysia Area Consultative Committee
- Peter Crisp, Member of Legislative Assembly for Mildura (MLA)
- Mildura Regional Waste Management Group

Biodiesel expansion will also have a broader public policy and commercial impact in relation to:

Government

- AgriFood Skills Australia
- Regulatory, policy focus and investment
- Greenhouse and carbon offset policy
- Local and State Government site management and industry approvals
- Environmental approvals and data collection

Acknowledgments

Industry

- Existing investors and innovators
- Primary Industry, especially grain feedstock producers
- Pumice users (beef feed lots)
- Coal powered electricity generators as microalgae feedstock producers
- Transport and logistics
- Automotive and manufacturing industries
- Retail fuel industry, fuel distribution industry and fuel refining industry

Community

- Effective use of municipal waste, sewerage and agri waste
- Utilisation of saline ground waters
- Carbon sequestration or closed loop carbon cycle efficiencies

About the Fellow

Name: Raymond Cadmore

Employment

- Coordinator, Vocational Pathways and Articulation, Sunraysia Institute of TAFE
- Director, Mildura Regional Waste Management Group

Qualifications

- Certificate IV Dairy Technology, University of Melbourne, Institute of Land and Food Resouces, 1998
  - Cheese Maker, Cheddar and Italian Varieties
  - Milk Fat Products (oil) and Butter Making
- Principal Food Safety Auditor, William Angliss Institute of TAFE, 2000
  - Food Retail
  - Food Service High Risk
  - Dairy Products
  - Fruit and Vegetable Processing
  - Intensive Horticultural Operations
- Graduate Diploma Vocational Education and Training, La Trobe University, 2005
- Certificate IV Occupational Health and Safety, Sunraysia Institute of TAFE, 2005
- Certificate IV Food Processing, Sunraysia Institute of TAFE, 2006
- Certificate IV Quality Management and Assurance, Sunraysia Institute of TAFE, 2006
- Certificate IV Assessment and Workplace Training, Sunraysia Institute of TAFE, 2007
- Advanced Diploma Business Management, Sunraysia Institute of TAFE, 2008

Memberships

- Principal Food Safety Auditor, RABQSA
- General member (past Treasurer, past Secretary), Mildura Sun Festival
- Member, Alternative Technology Association (Mildura)
- Member, Victorian Food Industry Network
- Member, Victorian Food Industry Sustainability Training Package Working Group

For the past eight years Cadmore has been with the Sunraysia Institute of TAFE in teaching roles across a range of domains including Food Processing, Occupational Health and Safety, Business and Management. During this period he has also undertaken extended roles as Acting Manager, Robinvale Campus and Acting Education Manager, Land and Water. The Fellow has an extensive work history including the Dairy Industry as a cheese maker and later as a Food Safety Auditor. In 2009 the Fellow was appointed as a Director of the Mildura Region Waste Management Group, which is responsible to the Department of Sustainability Victoria.

Cadmore's passions lie in regional Australia with a particular emphasis on the Greater Murray Valley and North Western Victoria. The sustainability of these regions in the face of challenges from climate change and diminishing fuel stocks will be severely tested.

About the Fellow

Fuel independence and supply reliability will not be found in any one new alternative or renewable source. Rather, the utilisation of renewable fuels in specific sectors is the most likely scenario. He sees biodiesel as a product which will fill a need in heavy transport, rail and agriculture. Biodiesel offers significant promise as a product suitable for regional manufacture and demonstrates positive carbon offsets. New innovations in microalgae feedstocks are being explored and may enhance these benefits exponentially.

The need for the VET industry to address looming skills deficiencies in the biodiesel sector drives the Fellow's desire to ensure the development of specialist skills in the sector. Our lack of parity with Europe and now principally the USA in biodiesel uptake and innovation will hamper Australian industry and agricultural products globally. Cadmore sees the possibility for microalgae to provide oil, carbohydrate, protein and pigment as very proximate to the needs of North West Victoria. The ability to sequester carbon and utilise saline waters are compelling facts.

Aims of the Fellowship Program

The purpose of the Fellowship was to undertake an overseas study program in:

- The field of biodiesel.
- Sustainable technologies and low carbon emission fuel sources.
- Feedstock selection and culture including microalgae culture, selection and processing.
- Vocational training pathways applicable to the biodiesel industry in Australia.
- Identifying potential for the development of vocational training relating to the emergent microalgae industry.

The benefit of gaining an understanding of the biodiesel industry globally will be evident in the ability of the Fellow to report to the ISS Institute, Skills Victoria, Victorian Government, industry sectors, government, VET/University sectors, other supporters such as Manufacturing Skills Australia and the Victorian Food Industry Training Board. The need to identify and confirm either skills deficiencies or training gaps will enable a more cohesive response to sector training and knowledge needs.

The development of microalgae as an efficient carbon sink and as a non-food production replacement feedstock offers real hope of a sector niche place for biodiesel. The need for the VET sector to have a contemporary understanding and initialised networks in this sector is critical.

The development of the industry is hampered by the variability of feedstock types and the susceptibility to price instability due to seasonal and market conditions. Materials handling knowledge, pre-production storage and handling, production characteristics and post-production utilisation of pumice and meal products are required in any industry expansion phase. This knowledge as it exists may not be ‘state of the art’ and exists in disparate locations and enterprises.

Transport, distribution and logistics will be challenged by the new renewable fuels regimes that will form a matrix of fuel types available. Biodiesel has properties that make some aspects of storage and handling more difficult than mineral diesel. Knowledge of materials handling suitable for this sector will enhance product viability and customer acceptance.

Pathways for vocational training in this sector are not apparent. Although some cross utilisation of existing Training Package competencies may be available it is not likely to be comprehensive. A rapid uptake of sector specific growth will be retarded if the vocational sector does not have contemporary vision.

The Australian Context

A Brief Description of the Industry

The biodiesel industry in Australia is characterised by high risk venture capital seeking to establish a market hold prior to a wider adoption of this technology. There have been widely reported failures of biodiesel plants in the recent past, which is reflective of the high capital cost of green fields plant and equipment. Traditional feedstock sources such as grains are currently commanding premium prices attributable to drought and global demand. Product variability and quality concerns have significant impacts on market perceptions. Unreliable product quality will impact on engine efficiency and cost structures in the logistics chain.

Debate also ranges over the food or fuel equation primarily in Western spheres. Western countries disapprove of developing nations clearing forest and savannah for fuel feedstock production. However, this distaste of environmental exploitation by Western nations is likely to be ignored as food chain production needs for fuel supply assurance expands laterally.

Innovative technologies such as biodiesel production from microalgae hold significant promise for the future. This technology may be able to effectively harness cogeneration efficiencies and carbon mitigation from in the coal powered fuel generation sector. Secondary use of CO_2 to inoculate coolant ponds and rapidly grow out microalgae, provide a CO_2 neutral and food chain positive footprint for biodiesel. Indeed there may be protein based animal feeds derived as a byproduct of this process.

The Hazelwood Power Station in the La Trobe Valley of Victoria is currently undergoing an initial trial in microalgae production. Success in this trial and others being undertaken around the globe is essential for ensuring the development of a food positive, greenhouse footprint mitigated fuel source. Significantly microalgae fuel production is not limited to biodiesel and has promise for the hydrogen and ethanol fuel sectors also. The potential for optimising a nexus between these two fuel types further enhances the attractiveness of this technology.

Research and development in the biodiesel industry, out of necessity, engages high end technical researchers and managers. Chemical and bio engineers are at the cutting edge of innovation and product realisation. At the operator level training is essentially conducted by plant and equipment manufacturers as a commissioning responsibility within new facilities.

To be in advance of industry uptake, the higher education sector, particularly TAFE, needs to be able to address probable skill functions that will be required as the industry expands. Skills sets over existing production process components are valid. However will these be adequate to encompass, (in the case of coal) CO_2 cogeneration for micro algae culture? Or sufficient to cover the feedstock to fuel production, reactor and logistics considerations including transportation, storage and holding, weather and feedstock variability. With regard to units of study, common units will be found in a range of Training Packages including:

Food Processing Training Package FDF03

- FDFZPRSEP2A Operate a separation process
- FDFZPRFP2A Operate a filtration process
- FDFZMHDT2A Operate a bulk liquid transfer process

Hydrocarbons Training Package

- PMAOPS201A Operate fluid flow equipment
- PMAOPS205A Operate heat exchangers
- PMAOPS307A Transfer bulk fluids into/out of storage facility

Biodiesel is an essential component of a fuel development strategy that TAFE must engage with. Whilst it is likely that light motor transport will utilise ethanol and in time hydrogen fuels, bodiesel will be required for the production and transportation of these fuels both on farm and in most transit, commerce and bulk transport arrangements.

SWOT Analysis

A SWOT (strengths, weaknesses, opportunities and threats) analysis provides a useful avenue for summarising the current situation and the implications of addressing, or not addressing, the need for ongoing skills associated with the development of biofuels in Australia.

Strengths

- Support from BioMax – trials of microalgae rapid reactor generation have/are about to commence at the Hazelwood Power Station.
- Microalgae technology has the benefit of utilising carbon emissions from coal powered electricity generation systems.
- There are already extensive international reseach activities being undertaken.
- There may be commonalities in the microalgae production of biodiesel and hydrogen fuels.
- Other micro-organisms may likewise be sources for fuel.
- Europe and the USA are moving to develop the biodiesel and biofuels sectors.
- Ethanol products are also a growing component of the biofuels segment in Italy.
- Cogeneration of bioenergy through waste utilisation is a developing sector.
- Contact with the Veneto Chamber of Commerce and the Melbourne Consulate.
- Increase in emphasis on investment into a move to renewable energy.
- Renewable commodities such as pigment, carbohydrate, protein and oil.
- Support of employer.
- TAFE is abreast of current technologies in this field through this Fellowship and the report will provide findings to the Industry Skill Councils, particularly AgriFood Skills Australia.

Weaknesses

- Limited understanding of renewable fuels such as biodiesel in the wider community and their role in extending rather than replacing oil.
- Lack of consistent quality of biodiesel from the various manufacturers.
- Lack of knowledge from large users of biodiesel as to determining quality and how to know what is being bought.
- Concerns regarding the economic viability of biodiesel.

The Australian Context

- Entry of other fuel types to the biofuel market.
- Drought and water scarcity limiting traditional feedstock supplies.
- Lack of government support.
- Development of industry in other countries may limit capital available for development in Australia.
- An expansion of this industry will highlight the absence of extensive knowledge in the sourcing, selection and grading of suitable feedstocks, production, grading and quality assurance mechanisms.
- Currently expertise in this industry sits with the high end tertiary qualified chemist or bio-engineer.
- There is a lack of knowledge at the line manager level who is equipped to deal across the range of production issues with critical assurance and confidence.
- This shortage will be exacerbated by the limited training applied to production staff by this industry. Capital and effort are principally tied to plant and equipment. The nexus between training and knowledge and plant viability seems not to be evident to the venture capitalists developing the industry. This may have been a factor in some of the production difficulties faced by those enterprises in Australia which recently failed.
- Understanding, skills and experience of VET teaching staff in this field is limited.
- Supply chain dynamics for the feedstock, warehousing, distribution and retail storage of biodiesel and other biofuels is not fully explored.
- Legislative and regulatory considerations across all sectors of the biodiesel/biofuels industry, is not yet rigorous enough to support expansion of the sector.
- Mandating of fuel blends appropriate to industry viability.

Opportunities

- Differentiate the range of source materials for biodiesel.
- To gain skills and knowledge of microalgae rapid reactor technology.
- To gain skills and knowledge of the agricultural sector tie in with the biodiesel/biofuels sector in Italy/Europe
- To identify other technologies that may compete with biodiesel.
- To explore whether Italy and other European countries subsidise biofuel firms.
- To learn what training is available for those working in the biodiesel industry.
- To gain an understanding of the role of tertiary education.
- The Commonwealth Government to provide programs and related funds to enhance opportunity to develop biodiesel or other biofuel sources.
- To convince main user groups of quality assured viable biodiesel supply.
- To develop a centre of excellence in the Mildura region.
- To expand professional networks in Australia and overseas.
- To develop an understanding of the scope of biodiesel uptake in the Veneto Region and elsewhere in Italy.

The Australian Context

- To develop an understanding as to what the focus of research for second and third generation biodiesel technologies is.
- To explore the skills and knowledge related to production processes that are currently used in Veneto.
- International mineral oil price/supply restricted (political unrest/leveraging and civil unrest).
- As instability and oil supply become more problematical, opportunities for alternative fuel sources will become apparent. Supply shortage or inefficiency will drive cost ratios to a point of parity with alternative options.
- Biodiesel has possible applications in carbon trading/sequestration.
- Develop technologies and processes for use of glycerine byproducts as fuel source.

Threats

- Withdrawal of Commonwealth Government excise support for biodiesel.
- Other nations accelerate uptake of biodiesel technologies and gain market dominance.
- Skill deficiencies will limit ability to best employ new technologies.
- TAFE sector unprepared for engaging in these technologies.
- Lack of quality will turn main buyers to other products.
- Failure of rapid reactor microalgae technology to meet product quality and supply volume demands.
- The price of mineral oil is directly related to the perception by the oil companies of viable reserves and as yet, although becoming more expensive, does not reflect looming scarcity.
- Farmers not supporting biodiesel development as it calls upon grain which they use for other purposes – this will potentially drive up the price for grain.

Identifying the Skills Deficiencies

Skills Deficiencies

Currently expertise in this industry sits with the high end tertiary qualified chemist or bio-engineer levels.

Legislative and regulatory considerations across all sectors of the biodiesel/biofuels industry are not yet rigorous enough to support expansion of the sector.

How will the new focus on renewable energy by the Commonwealth Government affect industry development?

It is important for the TAFE sector to:

- Gain an understanding of the most promising second generation feedstocks such as microalgae.
- Gain an understanding of leading innovations in biodiesel.
- Be a contributor as these technologies gather market/regulatory emphasis.
- Identify commonality between biodiesel production and other biofuels processes.
- Understand the nexus between developing a proven industrial technology. Coproduct and byproducts such as glycerine, pigment, protein and carbohydrate will be important components of pilot to production plant viability.

Cogeneration of bioenergy through waste utilisation is a developing sector and will become increasingly used as enterprises move to self managed environmental solutions.

There is little general community understanding of biomass as an umbrella term covering all bioenergy and fuel sources. Therein, a marketing campaign is required to inform those along the Supply Chain from farmers to end users.

Identifying and Defining the Deficiencies

Microalgae Cropping and Culture

- Carbon inoculation ratios
  - Carbon density per air/mass volume
  - Carbon storage and handling prior to inoculation
  - Rates of inoculation
- Flows and temperature requirements
  - Rapid reactor farming, flow rates/yield
  - Pondage farming/still/flow/saline
- Harvest methodologies
  - Pondage
  - Rapid reactor
- Micro-algal selection

  Strains suited for open pondage, rapid reactor, saline environments, environmental performance-sun, heat, temperate and Mediterranean climates

Identifying the Skills Deficiencies

- Storage of harvested algae
  - prime timelines for algal feedstock oil extraction ratio
  - suitable bulk storage
  - temperature/humidity of bulk stored product
  - suitable transfer mechanisms – pump types or other transfer-conveyor
- Algal oil product reliability and stability
- Glycerine yield ratios and impurity of product
- What use will microalgae pumice have?
  - Animal feeds?
  - At what protein value?
- Incineration for heat or waste, cogeneration of grid or plant electricity
- What are the commonalities of biodiesel micro algal technologies and micro algal hydrogen technology? Is there an opportunity for cogeneration operations?
- What are the prospects for micro algal biodiesel production in regional areas where there are limited CO_2 sources?
- Is saline ground water in a low carbon environment suitable for commercial exploitation?

Biodiesel Oil Feedstock Acquisition

Specific issues for exploration:

- Limiting the variability of feedstock/oil characteristics
- Quality issues in feedstock reliance
- Seasonal variabilities in feedstock acquisition

Key questions:

- Why is batch processing more successful in Australia?
- What is the most efficient and yield positive feedstock?
- What holds promise of a greater cost effective, efficient and yield positive feedstock source?
- Will microalgae meet production requirements and at what conversion ratio?
- What are the requirements for microalgae production, climate, water quality, fertilizers and culture techniques?

Storage, Distribution and Retail

- Post production shelf life – what are the degraded product energy values?
- Heat and cold – temperature stability of biodiesel varies with feedstock source.
- Transportation
- Fuel outlet storage – B100, B20 etc
- Temperature and moisture controls
- Emissions standards – international requirement/national regulation
- Retail storage facility – is current retail storage suited?

Identifying the Skills Deficiencies

- Industry is resistant to biodiesel due to poor quality assurance (quality can also be a problem with cheaper blends of mineral diesel)
  - Blending of proprietary biodiesel brands with generic/cheaper fuel. Quality-glycerine and particulate contamination leading to poor industry uptake.

Organisational, Management and Quality Assurance

- Continuous and batch manufacture in line sampling
  - biological contaminant
  - chemical contaminant
- Quality assurance
  - Lean manufacturing
  - Product traceability
- Product standards and regulation
  - Australian standards
  - International
  - USA, Europe
- Skills shortage in general affects career choice. Laboratory and technical options expanding

Government

- Government support
  - Suitable discounts to price parity scheme
  - Research and development, especially into microalgae technologies
  - Effective product standards and regulations
  - Develop mineral diesel/biodiesel blends
- The regionalised nature of the formative biodiesel industry in Australia is an opportunity for government to encourage new technologies at source of product
- Strategies for promoting biodiesel

The International Experience

The Fellowship involved a series of discussions and interviews with leading innovators in the second generation feedstock innovation field and attendance at the *Second International Symposium on Energy from Biomass and Waste* (Venice Symposium 2008).

Eni S.p.A

Divisione Refining & Marketing, Monterotondo Research Centre

Contacts: Dr Ezio D'Addario, Manager, Eco Management & Environmental Production Systems, and Dr Federico Capuano, Researcher

Eni S.p.A is a significant company involved in petro chemical production across the supply chain in Italy. They have significant interests in retail fuel outlets and in production, refining and distribution. They were particularly interested in the geographic and climatic zone of Mildura and spent considerable time discussing the viability of microalgae lipid production there.

Eni have achieved success in producing laboratory scale biodiesel from microalgae culture production using 4% CO_2 hot water boiler flu gas from the Monterotondo site. Eni is constructing a pilot to industry scale plant at the Eni refinery in Sicily. Use of flu gases from petroleum refining will be the fertilizer fraction of the production phase. Unfortunately this site was not ready for visitation at that time.

Dr D'Addario and Dr Capuano endorse the development of microalgae technologies in Mediterranean climatic zone/semi arid zones, and use of saline ground waters as key components of a microalgae system. They see a limited future for biodiesel using soy or rapeseed (canola) as feedstocks. Cooking oil residues are useful as is oil seed but limited in availability.

During discussions, mention was made of non microalgae feedstocks, particularly Jatophra. Dr D'Addario and Dr Capuano were surprised to learn that Jatophra is a prohibited plant in Australia. They questioned why a sterile selection hasn't been developed to address concerns about invasive woody weeds. The suitability of Jatophra across arid zones and degraded agricultural areas is very proximate to the types of rangelands found across North Western Victoria, Western NSW and South Australia.

Dr D'Addario also believes there may be scope for macro algae (seaweed) culture in lipid production, or as biomass for incineration as a CO_2 source.

Skills Sets Required for Microalgae Production

- Laboratory technologists on shift to monitor and interpret in line system management data
- Assets maintenance skills (electrical & photo bioreactor construction and maintenance
- Irrigation technologists
- Horticultural skills for microalgae cultivation
- Laboratory/horticultural/biology skills for maintaining culture stock for inoculation into production chain

The International Experience

Critical Components of Microalgae Systems

- Strain selection
- Suitable skills base
- Site/climate/region selection
- Fertilizer selection and availability

System: Open Raceway

- Open raceway is not capable of sterile maintenance of the culture system
- Open raceway is easily invaded by non selected microalgae
- Open raceway requires a local strain to limit feral species
- Open raceway is best suited to dry sunny climate zones (such as North West Victoria)
  - Limit rain dilution of system
  - Limit infection by feral species
  - Optimal sun days per year
  - Availability of saline ground water; microalgae viable in 30-49 grams per litre salt
  - Availability of fertilizer/CO_2.
  - In general, lower biomass is achieved in this system

System: Photo Bioreactor

Not yet proven at industrial scale.

- Technology is considered to be sufficient
- Needs investment
- Most issues are in simple terms plant development and establishment/commissioning related
- Is capable of high yields
- Excessive chlorophyl will limit system yield
- Controlled loop systems/photo bioreactors allow:
  - Air/CO_2 mix control
  - Inoculation control
  - Biomass concentration
  - Possibility of light provision over 24 hour period
  - Light penetration can be maximised in a photo bioreactor (say 5cm)
  - Excessive chlorophyll production (too much green in the growing solution) will inhibit lipid production

Note. Spectrum of light is only 10% used in the photosynthesis process.

Microalgae

Dunaliella is identified as suitable for lipid production. Comprised as follows:

- glycerol, lipids, proteins, beta carotene

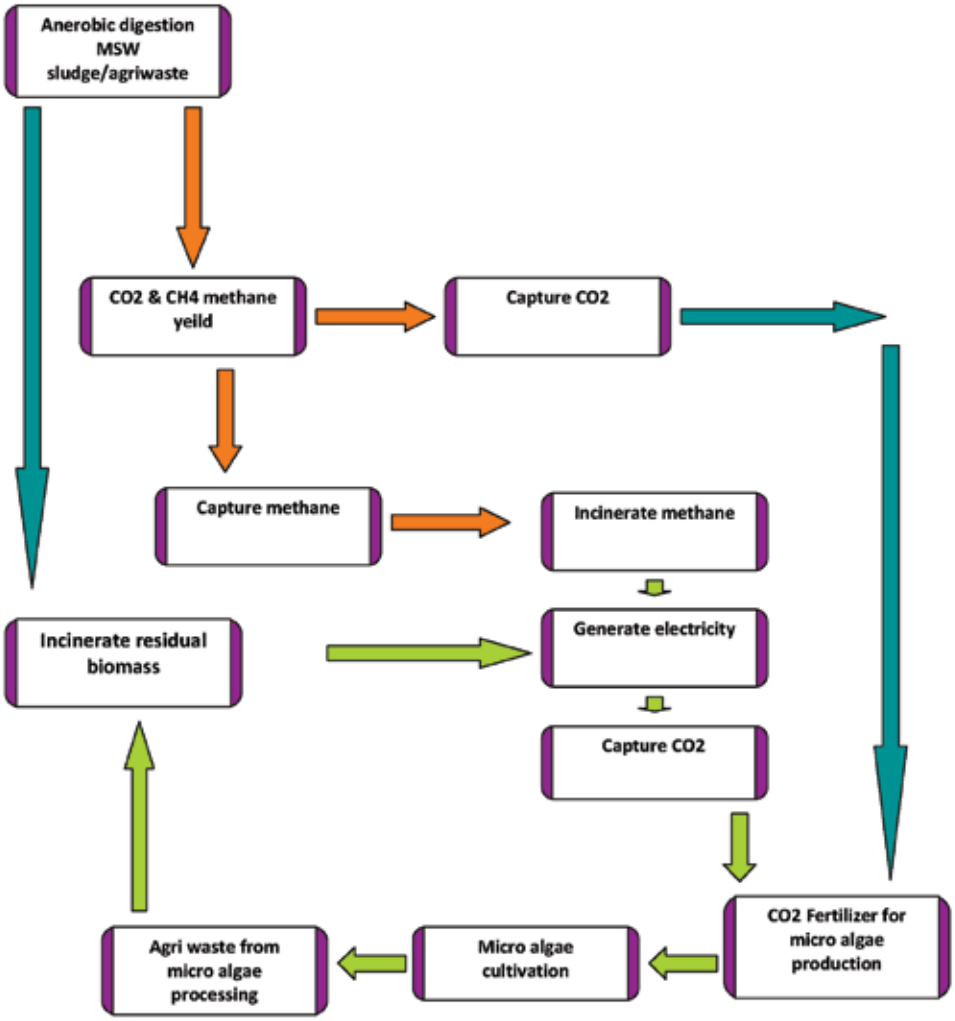
Saline tolerant and specialist microalgae such as Dunaliella are suitable for development in local systems, particularly where they are naturally found in local ecosystems.

The International Experience

Fertilizer

For regional areas CO_2 is the limiting factor. However, the availability of sewerage sludge and agricultural wastes in regional cities may be a source of this.

Anaerobic digestion of sewerage and agricultural wastes to produce methane for incineration to generate electricity for on site use or for sale to electricity grid is one option for sourcing CO_2. Biomass used in this way can also provide additional carbon if the spent biomass from the anerobic digestion process is then used as a fuel source for incineration with electricity and CO_2. The process is outlined in the following diagram.



The International Experience

Dr D'Addario and Dr Capuano used the following factors to demonstrate rough calculations for a microalgae lipid production plant with the following features:

Fertilizer

- Anaerobic digestion of MSW (municipal solid waste – sewerage), agri waste (manure) or other biomass such as olive mill waste, almond hulls etc.

Climate Variables/Assumptions

- Climatic temperature range -2°C to 48°C
- 300 sunny days per annum
- 3 months cool, 3 months very hot, 6 months 25 to 35°C

MSW Sludge Anerobic Digestion will Yield

- 30-40% CO_2
- 60-70% Methane

Microalgae, when under reasonable cultivation condition, may yield up to 27 tonnes oil, 30 tonnes carbohydrate and 40 tonnes of protein per hectare per year

Processed MSW prior to shipping for composting

Firenze University/DNR National Research Centre

Contacts: Professor Mario Tredici, Faculty Agraria, Dipartmento Bio Technologie, Firenze University, and Dr Giuseppe Torzillo, Design Engineer

Professor Tredici is a passionate environmentalist who is very concerned about population density and human viability. He believes that biodiesel is not quite viable yet, but that this is due to cost constraints, and a lack of proven at scale plants.

He expressed concerned that the current surge in interest in the field will lead to failures of ill-conceived and ill-managed projects. He believes that investors will look to other fields if this were to happen. He spoke about a prominent example of alternative technologies in the USA that were not successful and now leave investors wary. Professor Tredici believes that government at all levels need to support emergent microalgae technologies. Government is required to invest. Technologies to industry trials are too limited. The technology needs to move from research to industry.

The use of anerobic digestors as a component of a biodiesel production system accentuates environmental and CO_2 values, through the production of methane for electricity generation for supply to the electricity grid and incineration of biomass for CO_2 innoculate for microalgae culture.

Professor Tredici considers that at scale production should be achievable over the next five years. The requirement now is for research to scale production facilities to be established to allow the accumulation of practical implementation skills and knowledge.

DNR Research Facility, Pisa. The cover tray at the rear is the first environmental trial ex laboratory for mcroalgae generated biohydrogen. It is hooded to collect hydrogen gas produced.

The International Experience

Microalgae photo bioreactor, Pisa

System: Open Raceway

This is the most cost effective in short term. This system has benefits where cheap land is available and most effective where a strong local strain has been identified and used.

Professor Tredici agreed with the Fellow's view that in a production environment several selections of culture may be required to provide biological security in the event of phage or bacterial infection of the system.

This may also be necessary where system infection from feral species has occurred.

- 5-10% of the pondage system will be required for culture production.
- Need to attain 20-40 grams microalgae per litre.
- Harvest through sedimentation and flocculation.

System: Photo Bioreactor

Photo bioreactors are the most efficient production mechanism due to density of microalgae in volume. They also provide easier maintenance of fertilizer, carbon and inputs. However Professor Tredici believes that currently photo bioreactors are energy deficient, or put another way, too much carbon is locked in the production machinery and plant. He sees this as a design challenge for engineers and designers.

The Fellow visited the photo bioreactor at Firenze University, which is at the Italian Government DNR National Research Centre, near Pisa. Due to the late time of the year the system was in reduced production.

At this point in time photo bioreactors are most suited to culture production for open pond system inoculations.

The International Experience

Hydrogen Production Using Photo Bioreactors

In the same facility the Fellow was also able to view photo bioreactor for H_2 production being developed by Professor Roberto Bassi of University Verona. This is the first time they have trialed this technology outdoors.

Dr Giuseppe Torzillo is the design engineer responsible for implementing technical trials. He is the engineer responsible for implementing trials and plant and process development. He spent some time with Cadmore covering the culture of microalgae and Hydrogen production for the trial. Dr Torzillo thinks 10 years for effective H_2 production is achievable with sufficient government support. Dr Torzillo believes the biggest difficulty facing hydrogen technologies from this point is not in the transport and storage of product but efficient production. Therefore, the transfer of laboratory technologies to outdoor trials and then at scale is critical, as is the need to develop appropriate skill sets.

Skills Sets Required for Microalgae Production

- Laboratory Technologist
- Bio engineers
- Horticulture-microalgae culture - handling, harvest, storage
- Irrigation-water transfer – suitable water quality

Alternative Carbon Sources for Regional Economies, 50-60,000 People

- Sewerage sludge
- Municipal waste
- Agricultural waste such as manure, olive waste and almond husk etc
- Anerobic digestion and use of methane for electricity production to grid and site
- Use of biomass as a combustible material for electricity production and use of CO_2 as a carbon source for microalgae production

Fertilizer Controls

A balance exists in the application of nitrogen application and starvation as a means of accelerating optimum lipid production.

Application of phosphates may be possible through agricultural waste waters and a coproduct.

Nitrogen fertilizer needs to be available from waste water sources to reduce associated market costs. Euro 2, 3, 4, 5 per unit is too much for commercial operation. This may be sourced from sewerage sludge, feedlot effluent or in some intensive farming recycled waters.

Suitable Strains

There is critical need to identify local flora to maximise production efficiencies and limit invasion by feral species. One strain that has shown promise is Dunaliella salina which is a saline variety. Others that have been investigated for lipid production include Chlorella and Spirulina strains.

Professor Tredecci was very interested to learn that 'pink salt' is produced in the Mildura region and, as a result, encouraged the Fellow to explore the presence of Dunaliella in North West Victoria. Professor Tredecci also asked if it were possible for the Fellow to forward some local water samples of 20ml for analysis.

Project Commencement and Rollout

Professor Tredecci discourages the establishment of stand-alone full scale production of microalgae for biodiesel. In the early stages of developing at scale technologies and process know how time will be needed to develop a range of processes:

- Mass culture cultivation
- Methods of responding to feral specie invasion
- Weather optimum conditions
  - Responses to less than optimum conditions
  - Seasonal variation and unseasonal variation
- Selection of optimal species for culture
- Inoculation of fertilizers and CO_2
  - Identification of cost effective nitrogen sources
- Suitable saline water
- Harvesting techniques
- Storage of biomass

Plant commissioning would need to be conducted over a period of three to four years. The exploitation of coproducts during this time will support a robust operation once fully functional.

Meeting: Professor Roberto Bassi

University Verona

Professor Bassi is renowned in the field of microalgae and very familiar with lipid production being explored by Tredecci, D'Addario, Capuano et al. Professor Bassi's central study is the production of biohydrogen from microalgae.

As already mentioned, the Fellow viewed the trial photo bioreactor for Bassi's work at the DNR Research Laboratory near Pisa. Professor Bassi believes we have had the basic micro biology for 15 years, though not so at scale. The imperative is to move from laboratory to environmental trials and from there to industrial scale.

Skills

- Microbiologist
- Bio technologist – constant monitoring-physiological state of culture and crop
- Engineers for photo bioreactor plant design etc
- Laboratory Technicians

The International Experience

Biohydrogen

The biomass of microalgae is not harvested as such, as a constant population for gas production is required. Biomass may be a coproduct but unlikely to be a major component.

Israeli technology in this area is very good, though not yet commercial.

H_2 is being harvested from unused alpine chalets with solar voltaics systems and transported to H_2 stations at several locations across Northern Italy. He believes that delivery and storage technologies are adequate. However, H_2 production in a carbon balance is not and biomass processes need to be developed to provide carbon effective supply. The challenge now is for engineers to develop this/these processes.

Photo Bioreactor

Energy balance is not satisfactory with existing photo bioreactors. There is an upper limit of CO_2 concentrations which is 27/30% for microalgae capacity.

During a visit to the Italian Government DNR National Research Facility, the Fellow sighted the outdoor trial of microalgae in a photo bioreactor. This was discussed earlier in this report. This H_2 bioreactor is Professor Bassi's concept and design engineering is being conducted br Dr Torzillo.

Bio H_2

Bio H_2 requires additional levels of engineering compared to coal gas conversion.

Professor Bassi discussed lines of investigation that may assist in biomass to H_2 conversion. They are somewhat advanced in developing an automated process for this exchange. The addition of a few drops of nickel solution in laboratory samples has proven to inactivate microbial activity. Alternately an O_2 resistant hydrogenase has been identified in Thermal Guyers near Naples and operant at temperatures ranging between 80ºC and 120ºC. These have indicated results of 20 times greater efficiency than current research.

Italian researchers are working on a mutant strain to accelerate H_2O to hydrogen production systems. Genetic cloning, (not engineering), will be required to ensure the vigour of selected strains. There is no requirement for genetic engineering as the natural spread of selection offers many as yet undescribed strains and varieties.

Investment

Israel and France are investing in these technologies as is Italy, but on a smaller scale.

Saline Ground Water

Saline water is a good medium.

Biodiesel Yields

Yields from 20 tonnes per year per hectare are achievable from microalgae pondage systems.

Hydrogen Yields

Yields of up to 10-20 cubic metres per hectare per day are considered viable.

Meeting: Dr Giovanni Riva

Comitato Termotecnico Italiano (CTI), CTI Energy & Environment, Milano

Dr Riva is a leading figure in renewable fuels in Italy. He is the Chairman of CTI and a prominent researcher with Ancona Polytechnic. CTI advises the Italian Government and liaises with the European Union on matters of energy. Dr Riva has undertaken extensive research and on ground work in the Third World and has a critical eye for the achievable.

Dr Riva expressed the view that second generation feedstocks are until now a theory. There is no truly commercial example. Gasification plants producing synthetic fuels will also figure as significant sources in the future. Dr Riva noted, *"We have the technology and components we need, but no political will; same for ethanol."*

Dr Riva considers hydro cetane cracking of vegetable oils to be the most easily adopted technology for the biodiesel manufacturing sector. Eni S.p.A has conducted studies of this process as have some other companies in Italy. Brasil is currently expanding their biodiesel research and capacity in line with a higher standard of living.

Ancona Polytechnic is exploring ultrasound technology. Capacity from 1-10 cubic metres per day equals 300-3000 tonne per year. Ultrasound technologies can reduce trans esterification to about three hours. Ancona Polytechnic is also assisting a Brasilian company installing a plant producing 10 cubic metres per day.

Dr Riva was impressed that on farm diesel in Australia is excise free. He sees this as the kind of mechanism that is needed in Italy. In Italy both excise and VAT are applied to on farm diesel including on farm produced biodiesel.

Italian Production Costs

- Italy has the capacity to produce 250,000 tonnes biodiesel per year or 300,000 cubic metres.
- Dr Riva sees the removal of €20 cents tax as essential for competitive pricing.
- Within the European Union there is a mandatory 5% B5 blend of mineral diesel.
- Gross production/tax costs per litre €1.30 (AUD $2.60)

The main difficulty is production cost. Coproducts are required to return viable revenues. One example of coproduct/cogeneration is the use of flu gases at 400°C to produce steam generated electricity as a coproduct. Most electricity production (in Northern Italy) is by coal generators.

Many companies in Italy invested heavily as a result of government mandated biofuel rebates and tax concessions. These companies are reported to see the withdrawal of support as a waste of research and development funds. Dr Riva sees this reaction as a real threat to emerging technologies as investors become wary of the possibility of unforseen policy change.

Biodiesel has often been used as a heating oil source for public schools and in bus fleets throughout Europe which has given the industry some traction at local levels.

The International Experience

Biogas Production

Cogeneration opportunities exist in the use of sewerage sludge and municipal waste to produce methane biogas.

Methane production from municipal wastes provides electricity generation opportunities through an ongoing use of biomass over several energy production stages. These are:

- Fermentation of methane for incineration and electricity production
- Incineration of by product biomass for electricity production
  - Production of turbine steam
  - Use of silicon oil for low temperature (without) super heating
  - Possible generation from 250KW to 1 megawatt
  - Efficiency from 15-18% electricity over biomass input

Gasifying plants are common in the European waste management system. A new gasifiier plant is being established in Milano. This will have a capacity of 500 megawatts. Feedstocks are woodchip and corn cobs.

Ethanol

Dr Riva considers ethanol to not be a preferred fuel source due to the lack of carbon balance and low efficiency of ethanol. He states that Brasil is now investing in biodiesel technologies in part due to the relatively low cetane value of ethanol.

Skills Deficiencies

- Skill transference
- Quality control
- Laboratory technologists
- Chemical analysis, chemical catalysts

For production staff:

- Chemical handling – alcohol and catalysts-safety standards
- OHS and dangerous goods, explosives
- Non spark technologies, chemical analysis

Microalgae training:

- Culture propagation
- Identification of species
- Toxicology

CTI intend to organise small scale conferences for biofuels to enhance general discourse and understanding of issues arising as the technologies advance.

Second International Symposium on Energy from Biomass and Waste

Venice Symposium, November 2008

The Venice Symposium was conducted over three days with many papers delivered. Of particular interest were the biodiesel, ethanol and biofuel sessions. During the course of the Symposium the Fellow was able to meet with several presenters and have ongoing contact with several of these. Among the sessions attended were presentations on microalgae, the use of olive waste and sewerage sludge and the recycling of glycerine as feedstocks for biomass power plants.

More than 18 Australians attended the Symposium. All participants received a CD of the papers presented. This CD will be domiciled in the Sunraysia Institute of TAFE library for open access.

During discussions with a researcher from Venice University the Fellow was informed that they are in the initial stages of constructing a microalgae facility. He was very helpful and very interested in maintaining contact.

The last day of the Symposium was a site tour of an anerobic digestion facility, located about 40 minutes from Venice. This plant produces methane gas from municipal waste and animal manure sourced from the surrounding district. The gas is incinerated and sold into the electricity grid five days per week. Residual biomass is on sold for composting. There is no re-use of CO_2 emissions from the plant.

Annerobic digestor, Venezia

The International Experience

The over arching impression Cadmore gained from the Venice Symposium was that in Australia we do not make enough of opportunity to utilise assets such as waste. The utilisation of waste in production of biodiesel through both further oil extraction techniques and carbon cycling for microalgae culture are both examples of what is possible.

Dr Rebecca Willson from the Ben Gurion University of the Negrev presented a paper on the extraction of oil from sewerage sludge and olive mill wastes. They have achieved reasonable success in this research which will be of interest to olive processors in North West Victoria where there are 8,000 tonnes of olive mill waste expected to be generated annually going forward from 2009.

The University of Otago was represented by E A Ehimen who presented papers on microalgae for oil techniques. Food or fuel concerns were debated and discussed throughout the Symposium. Other papers included waste to ethanol and biofuels certification schemes.

The primary observation from the Venice Symposium experience is that Australia does not make enough opportunities to utilise assets such as waste. The utilisation of waste in production of biodiesel through both further oil extraction techniques and carbon cycling for microalgae culture are both examples of what is possible.

Discussion throughout the Symposium raised many issues and the following question raised from the floor was challenging and inspired considerable discussion: "*…with all we have managed to develop and bring to industry why are we still discussing these innovations as new and needing commercialisation? Why aren't we discussing the next generation of developments? Why is there a failure to move to sustainable energy production when we know why we need to and ways in which we can begin?"*

The general response was that there is no excuse, but without the support of government worldwide, such leaps of imagination and practice will not find sufficient impetus to germinate. This opens an opportunity for Australia to be a leader in this field.

A CD containing papers presented at the Symposium is attached to this report.

Outcomes

As has been stated in the various meeting reports, the Mildura region has the essential climate, fertiliser and water resources required to consider microalgae lipid production as feasible. These components are:

- Saline water
- Available land
- CO_2 available through the incineration of sewerage sludge, feed lot manure, olive pumice waste, almond hull waste, etc.

Further exploration of microalgae production for lipids needs to be developed by government to develop suitable technologies for Victoria. Research into the quantities of agricultural wastes that are available in the region needs to be undertaken.

Knowledge Transfer: Applying the Outcomes

Conduct a presentation to the Mildura Sun Festival.

- The Mildura Sun Festival is an organisation promoting sustainable living in the Mildura Region.
- Membership of the Mildura Sun Festival is very wide and includes representatives from across the business, Local Government, TAFE and education sectors.
- This presentation was made in early 2009.

Conduct a presentation to the Mid Murray Agri Business Council

- The Mid Murray Agri Business Council is a collaborative body that endeavours to bring agri business and local communities to common purpose such as civic/regional planning and advancement. As such this organisation is well placed to consider issues such as waste management, carbon balance and sustainability.
- This presentation is not confirmed but could be conducted in 2009.
- The Fellow is a member of the Mid Murray Agri Business Skills and Training Sub Committee and may use this as the forum of his presentation.

Cadmore is to utilise these learnings in his role as a Director of the Mildura Regional Waste Management Group.

Boundry Bend Olives, a corporate farm with more than 2,500,000 olives trees in North West Victoria has expressed interest in the Fellow's report.

Particular attention will be given in providing a copy of the Fellowship Report to Mildura Economic Development Corporation and to members of Parliament, as well as government agencies.

Household and commercial MSW prior to digestion. Note plastic residuals

Recommendations

Overview

The use of saline ground water, sewerage sludge, olive waste, microalgae carbohydrate and almond waste as sources of CO_2 for fertilizer make rapid growth microalgae possible in open raceway systems in the Mildura, North West Victoria region.

Coproduction of lipid (oil), protein, carotene, carbohydrate and polymers are possible in the Mildura, North West Victoria climate.

Skills deficiencies exist at all levels. There needs to be a catalyst facility (trial farm) where these skills can be transferred from academic research to production techniques. Industry collaboration will be necessary as the body of knowledge expands and mainstream/ common processes are developed.

Development of this facility should progress in a staged manner over three or four years to enable a body of knowledge and process savvy to be developed. The points below are indicative of a staged and integrated production development:

1. Protein production (animal/human feed, etc).
2. Pigment production. High value pigment for cosmetic and natural health industry
3. Polyunsaturated fats for human consumption and animal feedstock:

   Introduce biodiesel production when satisfied that the plant commissioning process supports continuous production of coproducts.

   a. Plant has a variety of revenues
   b. Plant has learned to managed microalgae culture and production techniques
   c. Staff have had time to evaluate plant and be comfortable in the operating parameters

   Polymer production is a possible from microalgae lipid production where suited to the systems in use

Government of Victoria

Cadmore's principal recommendation is to develop collaborations and partnerships with suitable organisations to bring this technology to trial farm at scale status.

- A research to scale facility be developed in the Mildura region

A secondary recommendation is that leading innovators and scientists who are interested in bringing these technologies to scale be invited to a round table event in 2009/2010 in Mildura. This round table may anticipate a 'Microalgae Technology to Scale Development Cluster' in North West Victoria. Such a meeting may consider:

- Use of sludge and agri wastes as CO_2 and nitrogen fertilizers
- Suitability of local micro flora
- Operating systems
- Skill scoping – what do we need to know next?

Recommendations

Sunraysia Institute of TAFE

It is recommended that the basis and modes for future training types be developed at this development facility. It is also recommended that existing specialist areas such as production horticulture, irrigation, and laboratory technology form or develop a core of knowledge from which to further identify skills deficiencies and develop training formats.

Traditional trade areas such as plumbing, engineering and electrical will have important roles in this development.

It is also recommended that Sunraysia Institute of TAFE:

- Develop effective pathways are to engage industry, workers and prospective participants across the skill domain and to higher learning.
- Utilise 'think tank' sessions with leading figures to ensure knowledge is disseminated from the academic domain to the practical domain. These sessions could include design considerations for a trial farm layout and capacity, plant and equipment requirements, skills and knowledge sets.
- Develop a renowned expertise in this field and export this knowledge to Victoria and across the globe.
- Undertake a pivotal role in the development of a broad based 'Microalgae Technology to Scale Development Cluster'.

Community

Regional communities have much to be gained from engaging in the sourcing of energy sources from within their own regions. The old Australian tyranny of distance is as relevant to a fuel deprived future as it was in the past. The utilisation of waste biomass to produce fuel must be considered as a part of any regional response to fuel security.

ISS Institute Inc

It is recommended that ISS Institute approach Professor Mario Tredici at Firenze University with a view to offering a Fellowship to visit Australia. Professor Tredici is globally renowned for his knowledge in the field of microalgae for lipid production.

It is also recommended that ISS Institute support a workshop in the Mildura region to explore a suitable site and operating system for an open raceway microalgae production facility.

Further Skills Deficiencies

There is a need to further explore waste handling, incineration, CO_2 sequestation and gasification technologies as a part of any energy future skill requirement.

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  - *Energy Transformed; Modelling of the future of transport fuels in Australia*. P. Graham, L Reedman, F Poldy, 2008
  - *Fuel For thought. The future of transport fuels: challenges and opportunities*, 2008
  - *Biofuels in Australia – issues and prospects*. D Connor et al. CSIRO 2007
- *Moving Forward*, The Government of Victoria, 2008 to 2010
- *Driving Growth. A Road Map and Action Plan for the Development of the Victorian Biofuels industry,* The Government of Victoria, 2007
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- *Single Vision; Prospects for a viable grain based Australian Biofuels industry. There is no single solution*, Grains Australia Green Paper 2007
- *The Challenges and Opportunities facing Renewable Energy Industries: Public education and Technical Training*, Association of Canadian Community Colleges, 2004
- *Administrative Perspective to start a Biodiesel Plant in Italy*, Dario Soria. Assocstieri Unione Produttori Biodiesel (Italy) 2008
- *Hydrogen Fuel Cell Technology*, John Van Cleef. International Specialised Skills Institute TAFE Fellowship Report, 2006

Dr Riva referred the Fellow to the following training information:

- Corso e learning ‘suite bioenergy’. Produced by Bio Energy International.
  More information: divulgazione.formazione@venetoagricultura.tiscali.it
  Ph: 049 8293 862/904/920

Attachments

Index to Attachments (Refer to CD)

- *Reduction of Corrosion Risks by Biological Pre-treatment of Fuels*
  G. Hoffmann, C. Wünsch, A. Schnapke, D. Schingnitz and B. Bilitewski
- *Biogas Potential in Biowaste Through Different Ways of Wet Pretreatment*
  B. Bilitewski , C. Dornack , A. Schnapke and P. Kullavanijaya
- *RDF Ozone Disinfection*
  R. Palazzolo, F. Coda, F. Coggiola, G. Porto and R. Giudici
- *Oxygen Enriched Biomass Gasifier*
  G. Bettella, G. Porto and R. Giudici
- *Environmental Compatibility of Energy Production at Global, Regional and Local Scale*
  G. Genon, E. Brizio, D. Russolillo and F. Becchis
- *(Dis-) Continuous Production of Biohydrogen and Biomethane from Organic Raw and Waste Materials by Fermentation*
  D. Rechtenbach, M. Meyer and R. Stegmann
- *Situation of Energy from Public Waste in Hungary*
  G. Eörsi-tóta and I. Tóth
- *Generating CO_2-credits Through Landfill in Situ Aeration*
  M. Ritzkowski and R. Stegmann
- *Practical Experiences in The Production of Biogas and Energy from Wastes*
  P. Bozano Gandolfi
- *Systematic Comparison of Mechanical and Thermal Sludge Disintegration Technologies*
  B. Wett, P. Phothilangka and A. Eladawy
- *Sustainability Standards for Biomass: Status in Germany, The Eu, and Global Perspectives*
  K.J. Hennenberg, U.R. Fritsche, C. Dragisic, S. Haye, J. Hewson and A. Jering
- *Decentralised Anaerobic Digestion of Kitchen and Market Waste in Developing Countries – "State-of-the-art" in South India*
  Y. Voegeli And C. Zurbrügg
- *Energetic Valorization in a Bubbling Fluidized Bed of Biomass Waste Generated from Herbal Extracts Industry*
  A. Bahillo, L. Armesto, R. Ramos and R. Perez

Attachments

- *Anaerobic Semi-dry Process Implementation in Industrial Scale for Organic Waste Under Thermopile Conditions*
  M.molena and R.goeeschl

- *Synergies of Biomass and Waste Co-firing of Biomass from Wood With Plastics Rich Waste in Europe*
  F. Mark, A. Schanssema and K. Wittstock

- *Co-combustion of Solid Recovered Fuel and Solid Biofuels an a CHP Plant at Seinäjoki, Finland*
  M. Frankenhaeuser, A. Klarin-henricson, A. Hakulinen and F. Mark

- *Biodiesel from Microalgae: Investigating Reaction Conditions for In-situ Transesterification.*
  E.A. Ehimen, C.G. Carrington, Z. Sun and J. Eaton-Rye

- *An Integrated System Approach to Study Biodegradable Municipal Solid Waste (BMSW) as Biomass*
  A. Li and M. Khraisheh

- *Environmental Impact Assessment of Land Use Change Due to Increased Energy Crop Use – A Bavarian Case Study*
  K. B. Greiff, G. Weber-blaschke and M. Faulstich

- *Flight Characteristics and Combustion Behaviour of Refused Derived Fuels (RDF) in a Cement Kiln*
  T. Marzi, P. Danz, A. Mrotzek, L. Di Matteo and G. Marotz

- *The Application of a Fuzzy Logic Control (FLC) Strategy for Production of Renewable Energy from Biomass Through Anaerobic Digestion Process*
  P. Scherer and B. Demirel

- *Efficiency of Energy Recovery from Municipal Solid Waste*
  A. Bonoli and M. Nanni

- *Available Biomass Resources in Romania for to use as Renewable Energy*
  E. David

- *Homogeneous and Heterogeneous Reactions of Pyrolysis Vapour from Biomass Gasification Over a Bed of Hot Char*
  P. Gilbert, C. Ryu, V. Sharifi and J. Swithenbank

- *Improving Access to Information on the Environment*
  Marnane and C. Fahy

- *Biogas Thermoeletric Plants in a Developing Country*
  F. Oliveira, M.A. Avelino, A.C. Delbin and T. Nascimento

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- *Estimating Landfill Gas Generation and Utilisation in South Africa*
  S. Bhailall, S.J. Piketh, J.E. Bogner, K.E. Ross, J. Shamrock, E. Gombault and S. Devine
- *Life Cycle Assessment of Woodchips*
  A. Bonoli and F. Pantaleoni
- *Comparison the Environmental Impacts Between Woodchips and Pellet*
  A. Bonoli and F. Pantaleoni
- *Composition and Heating Value of Municipal Waste in Asturias (Spain)*
  E. Marañón, Y. Fernández-nava, L. Castrillón, V. García and J. Rodríguez-Iglesias
- *Characterization of Waste from Poultry Farms*
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